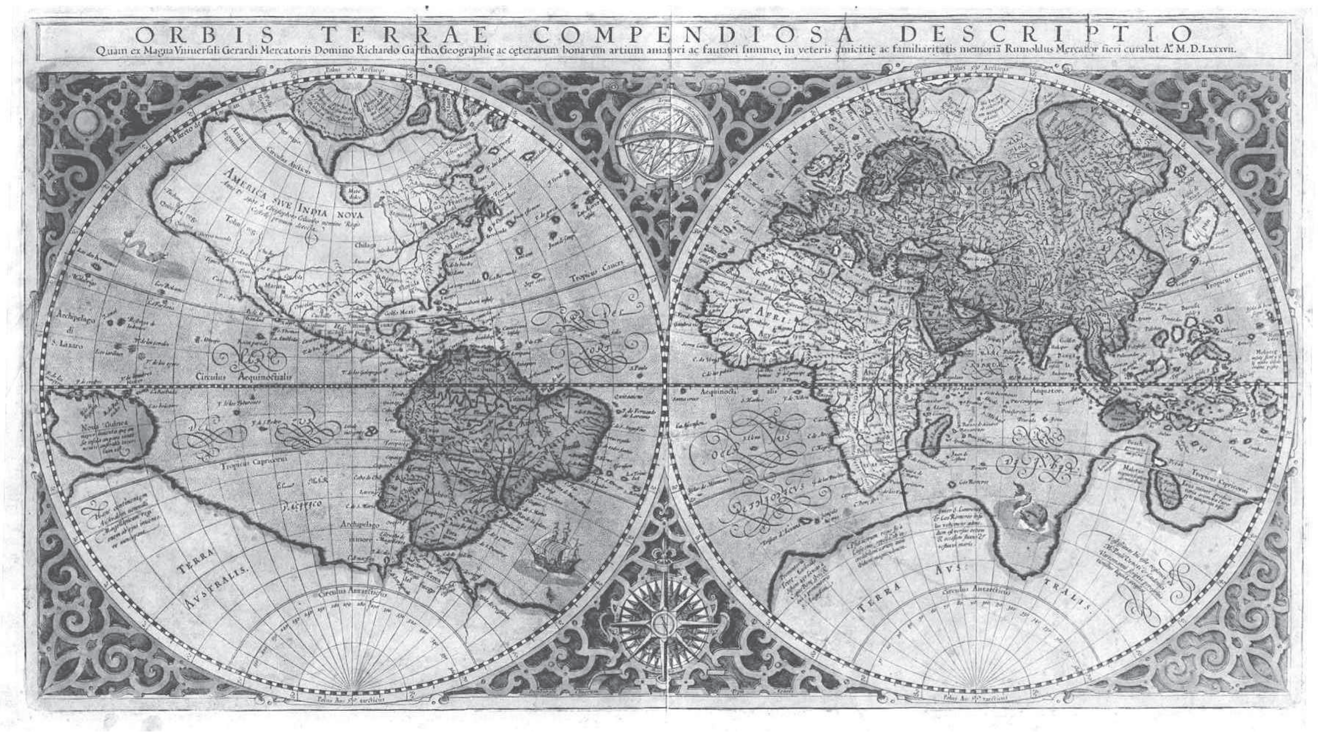
# CONSTANTA MARITIME UNIVERSITY

# ANNALS




YEAR XIV, 19th issue

Editura NAUTICA

CONSTANŢA 2013

## SCIENTIFIC COMMITTEE

# CONTENTS


## SECTION I – NAVIGATION AND MARITIME TRANSPORT

1. **CATHODIC PROTECTION BY SACRIFICIAL ANODES OR IMPRESSED CURRENT, COMPARATIVE ANALYSIS**
[1]ACOMI NICOLETA, [2]ACOMI OVIDIU
[1]Constanta Maritime University, [2]GSP Offshore Constanta, Romania……………………….... 13

2. **STEPS TOWARDS THE ENERGY EFFICIENT SHIP**
[1]ACOMI NICOLETA, [2]ACOMI OVIDIU
[1]Constanta Maritime University, [2]GSP Offshore Constanta, Romania………………………… 17

3. **THE INFLUENCE OF LIQUID FREE SURFACE ON SHIP STABILITY**
[1]ANDREI CRISTIAN, [2]LAMBA MARINEL-DANUT, [3]HANZU-PAZARA RADU
[1,2,3] Constanta Maritime University, Romania.................................................................... 21

4. **ENHANCING MANAGEMENT CAPACITY OF THE MARITIME INDUSTRY PERSONNEL**
[1]ARSENIE PAULICA, [2]HANZU-PAZARA RADU,[3]BOYAN MEDNIKAROV, [4]KALIN KALINOV
[1,2]Constanta Maritime University, [3,4]"N. Vaptsarov" Naval Academy Varna, Bulgaria……….. 27

5. **EXTREME WEATHER CONDITIONS DUE TO EX-TROPICAL CYCLONE OSWALD**
BOSTINA ALINA-LUCIA
Constanta Maritime University, Romania........................................................................ 33

6. **MODELATION OF THE OSCILLATORY MOTIONS OF THE SHIP FOR THE MEDITERRANEAN SEA NAVIGATION CONDITIONS, USING THE OCTOPUS SOFTWARE**
[1]CHITU MIHAELA-GRETI, [2]MANEA EMIL, [3]BORMAMBET MELAT
[1,3] Ovidius University of Constanta, [2] Over Seas Manager Ship Repairs & Conversions Projects, Constanta Shipyard, Greece Representative Office, Romania………………………. 37

7. **STANDARD MARITIME VOCABULARY PHRASES**
[1]GHETU PAULA CLAUDIA, [2] RUSEI ALEXANDRU-FLORIN
[1]Liceul Panait Cerna Brăila, [2]Constanta Maritime University, Romania................................... 45

8. **ANALYSIS OF THE OPERATING REGIMES OF POWER PLANTS FOR DIFFERENT SITUATIONS NAVAL NAVIGATION**
LUPCHIAN MARIANA
"Dunarea de Jos" University of Galati, Romania...................................................................... 51

9. **THE GENERALIZATION OF THE QUADRANTAL ZENITH ANGLE COUNTING RULE**
[1]LUPU SERGIU, [2]POCORA ANDREI, [3]LUPU ELENA-CARMEN
[1,2]Mircea cel Batran Naval Academy, Constanta, [3]OvidiusUniversity of Constanta, Romania.. 53

10. **SHIPS NEW BUILDINGS, REPAIRS & CONVERSIONS OUTLOOK 2009-2012. 2013 TRENDS**
[1]MANEA EMIL, [2]CHITU MIHAELA-GRETI
[1]Over Seas Manager Ship Repairs & Conversions Projects, Constanta Shipyard, Greece Representative Office, [2]Ovidius University of Constanta, Romania…………………………… 57

11. **IMPROVED THE MARITIME ONLINE TEACHING BY USING THE KNOWLEDGE MANAGEMENT CONCEPT**
[1]RAICU ALEXANDRA, [2]RAICU GABRIEL, [3]LAMBA DANUT
[1,2,3]Constanta Maritime University, Romania.......................................................................... 65

12. **AN ASPECT REGARDING THE NAVAL HISTORY OF THE HELLENISTIC WORLD: THE FLEETS OF AGATHOCLES**
[1]STAICU GEANINA, [2]NEDU DECEBAL
[1,2]University "Dunarea de Jos" of Galati Romania................................................. 69


## SECTION II – MECHANICAL ENGINEERING AND ENVIRONMENT

13. **THE CONTRIBUTION OF MAINTENANCE ACTIVITIES TO THE OPERATIONAL STATUS OF A TECHNICAL EQUIPMENT**
[1]BUS CAMELIA-GABRIELA, [2]CARLAN MILTIADE, [3]BOCANETE PAUL
[1]Ministry of Transport, [2]S.C. Formenerg S.A, [3]Maritime University of Constanta, Romania…. 73

14. **AN THE ASSESMENT OF THE MEAN OF OPERATIONAL TIME-INTERVALS FOR A TECHNICAL EQUIPMENT DESCRIBED BY A WEIBULL TEMPORAL EVOLUTION**
[1]BUS CAMELIA-GABRIELA , [2]BOCANETE PAUL , [3]COSTEA MARIUS AUREL, [4]CÂRLAN MILTIADE
[1]Ministry of Transport, [2]Maritime University of Constanta, [3]The University of South- East Europe Lumina, Romania, [4]S.C. Formenerg S.A……………………………………………… 77

15. **THE MAINTENANCE TEAM STATISTICAL AND CYBERNETICAL ANALYSIS**
[1]BUS CAMELIA-GABRIELA , [2]COSTEA MARIUS-AUREL , [3]BOCANETE PAUL, [4]CARLAN MILTIADE
[1]Ministry of Transport, [2]The University of South- East Europe Lumina, Romania, [3]Maritime University of Constanta, [4]S.C. Formenerg S.A…………………...…………………………….. 83

16. **SEISMIC LOADS NUMERIC CALCULATION FOR A NUCLEAR CLASS 2 PIPING SYSTEM**
[1]CALIMANESCU IOAN, [2]STAN LIVIU-CONSTANTIN
[1,2]Constanta Maritime University, Romania.......................................................................... 91

17. **DOES THE "AVERAGED RESPONSE" OF A CHAOTIC SYSTEM EXHIBIT NEAR-PERIODICITY?**
DELEANU DUMITRU
Constanta Maritime University, Romania………………………………….............................. 99

18. **CHAOS SYNCHRONIZATION OF SPROTT K AND ACT SYSTEMS USING BACKSTEPPING DESIGN**
[1]DELEANU DUMITRU, [2]PANAITESCU VIOREL
[1,2]Constanta Maritime University, Romania……………………………………………………. 103

19. **IMPACT EVALUATION OF A LARGE PELAMIS BASED ENERGY FARM ON THE WAVE FIELD IN THE ROMANIAN NEARSHORE AREA**
[1]DIACONU SORIN, [2]RUSU EUGEN
[1,2]Dunarea de Jos University of Galati, Romania………………………………………………. 109

20. **MODAL ANALYSIS OF NATURAL FREQUENCIES AND MASS PARTICIPATION COEFFICIENTS OF SIMPLY SUPPORTED THIN PLATES WITH DAMAGES**
[1]HATIEGAN CORNEL, [2]NEDELONI MARIAN-DUMITRU, [3]TUFOI MARIUS, [4]PROTOCSIL CARLA, [5]RADUCA MIHAELA
[1,2,3,4,5]„Eftimie Murgu" University of Resita, Romania............................................................ 115

21. **MODAL ANALYSIS THROUGH SOLIDWORKS SOFTWARE OF CLAMPED THIN PLATES WITH DAMAGES**
[1]HATIEGAN CORNEL, [2]TUFOI MARIUS, [3]RADUCA EUGEN,[4]PROTOCSIL CARLA, [5]MITULETU CORNEL
[1,2,3,4,5]„Eftimie Murgu" University of Resita, Romania............................................................ 121

22. **THE INFLUENCE OF SHELL'S SHAPE IN SHIP DESIGN**
[1]NECHITA MANUELA, [2]MOCANU COSTEL-IULIAN, [3]POPESCU GABRIEL
[1,2,3]"Dunarea de Jos" University of Galati, Romania………………………………………… 125

23. **RESEARCH REGARDING THE CAVITATION EROSION RESISTANCE OF THE STAINLESS STEEL WITH 13% Cr AND 4% Ni USED TO MANUFACTURE THE COMPONENTS OF KAPLAN, FRANCIS AND PELTON HYDRAULIC TURBINES**
[1]NEDELONI MARIAN-DUMITRU, [2]NEDELCU DORIAN, [3]CAMPIAN VIOREL-CONSTANTIN, [4]CHIRUS DANIEL, [5]AVASILOAIE RAOUL-CRISTIAN,[6] DANUT FLOREA
[1,2,3,4,5,6]„Eftimie Murgu" University of Resita, Romania……………………………………... 129

24. **THE TEMPERATURE FIELD OF THE EXHAUST VALVE AT A SLOW SHIP'S ENGINE**
OMOCEA ION
Constanta Maritime University, Romania.................................................................................... 133

25. **THE MODELING OF THE CYCLE OF THE COMPRESSION IGNITION ENGINE ON THE GROUNDS OF THE EXERGETIC METHOD OF THERMODYNAMIC ANALISYS**
OMOCEA ION
Constanta Maritime University, Romania.................................................................................... 137

26. **EVALUATION OF THE ENVIRONMENTAL CONDITIONS IN THE VICINITY OF THE ROMANIAN PORTS AT THE BLACK SEA**
[1]ONEA FLORIN, [2]DIACONU SORIN, [3]RUSU EUGEN
[1,2,3]Dunarea de Jos University of Galati, Romania…………………………………………… 143

27. **STUDY REGARDING THE INFLUENCE OF TRIBOLOGYCAL FACTORS ON THE SUPERFICIAL LAYERS OF STEELS TREATED WITH PLASMA NITRIDING**
PAPADATU CARMEN- PENELOPI
"Dunarea de Jos" University of Galati, Romania...................................................................... 151

28. **NUMERICAL MODELING OF DOUBLE BOTTOM PANEL IN THE CENTER OF THE VESSEL**
[1]PAVEL ADRIAN, [2]CRISTEA ANIŞOARA-GABRIELA
[1,2]"Dunarea de Jos" University of Galati, Romania………………………………………..… 157

29. **ORTHOSIS "COMARNA" – CALCULATION OF THE SHEAR RIVETS AND MATERIALS USED**
[1]RANCEA ADY, [2] MACUTA SILVIU
[1]„Gheorghe Asachi" Tehnical University of Iaşi, [2]University "Dunarea de jos "of Galati, Romania……………………………………………………………………………………… 163

30. **STUDY OF INJECTION INFLUENCE ON DIESEL ENGINE COMBUSTION**
SABAU ADRIAN
Constanta Maritime University, Romania.................................................................................... 167

31. **USING PROFESSIONAL SOFTWARE TO CALCULATE THE DRAG**
[1]TICU RODICA-IONELA, [2]BOCANETE PAUL
[1,2]Constanta Maritime University, Romania............................................................................. 173

32. **NUMERICAL SIMULATIONS OF THE CURRENT FIELD IN THE BLACK SEA BASIN**
[1]TODERASCU ROBERT, [2]RUSU EUGEN
[1,2]"Dunarea de Jos" University of Galati, Romania………………………………………….. 177

33. **VERTICAL STRUCTURE OF THE CURRENTS IN THE BLACK SEA BASIN**
[1]TODERASCU ROBERT, [2]RUSU EUGEN
[1,2]"Dunarea de Jos" University of Galati, Romania………………………………………….. 185

34. **LINEAR OSCILLATING SYSTEM WITH IMPULSE EXCITATION IN CASE OF NAVAL AND MARITIME SPECIAL PRODUCTS**
VLADU GABRIEL-LIVIU
Constanta Maritime University, Romania…………………………………….......................... 189

**SECTION III – ELECTRONICS, ELECTRONICAL ENGINEERING AND COMPUTER SCIENCE**

35. **NOTES REGARDING ALGEBRAIC ANALYSIS OF P-TIMED PETRI NETS**
[1]BORDEA GHEORGHE, [2]DINU SIMONA
[1,2]Constanta Maritime University, Romania.................................................................................. 193

36. **APPLICATION CONSIDERATIONS — CVT ELECTRICAL CHARACTERISTICS DURING LINEAR AND NONLINEAR LOADING**
[1]CIUCUR VIOLETA-VALI, [2]MARZHANGUL KULIMANOVA
[1]Constanta Maritime University, [2]Caspian State University of Technologies and Engineering named after Shahmardan Esenovici Esenov, Kazakhstan……………………………………… 197

37. **HARMONIC FREQUENCIES MANAGEMENT**
[1]DORDEA STEFAN, [2]ZBURLEA ELENA
[1,2]Constanta Maritime University, Romania.................................................................................. 201

38. **LOWER HARMONIC DISTORTIONS BY USING TUNED FILTERS**
[1]DORDEA STEFAN, [2]ZBURLEA ELENA
[1,2]Constanta Maritime University, Romania.................................................................................. 205

39. **ANTENNA ANALYSER**
[1]GRIGORESCU LUIZA, [2]DIACONESCU IOANA
[1,2]"Dunarea de Jos" University of Galati, Romania……………………………………….……. 209

40. **CONTRIBUTION TO TREATMENT SYSTEM DEFORMED HIGHLIGHTED A NETWORK CONNECTION POINT OF MEDIUM AND HIGH VOLTAGE**
MARZHANGUL RAKHASHOVNA KULIMANOVA
Caspian State University of Technology and Engineering named after Sh.Yessenov, Aktau, Republic of Kazakhstan…………………………………………………………………….... 215

41. **BACKUP COMMUNICATION SYSTEM FOR EMERGENCY SITUATIONS IN ELECTRICAL ENERGY DISTRIBUTION NETWORKS**
[1]SUSNEA IOAN, [2]VASILIU GRIGORE
[1,2]University "Dunarea de Jos" of Galati, Romania..................................................................... 219

**SECTION IV – MATHEMATICAL SCIENCES AND PHYSICS**

42. **OPTIMIZED DETECTION OF AMPHETAMINES BASED ON PRINCIPAL COMPONENT ANALYSIS**
[1]CIOCHINA STEFANUT, [2]PRAISLER MIRELA
[1,2]"Dunarea de Jos" University of Galati, Romania..................................................................... 223

43. **SELECTIVE AMPLIFIER USED FOR THE EFFICIENT DETECTION OF AMPHETAMINES**
[1]PRAISLER MIRELA, [2]CIOCHINA STEFANUT
[1,2]"Dunarea de Jos" University of Galati, Romania........ 231

**SECTION V – ENGLISH FOR SPECIFIC PURPOSES**

44. **INSIGHTS INTO SPECIALIZED TRANSLATION. THE CASE OF MARITIME TEXTS**
COJOCARU OLGA
"Dunarea de Jos"University of Galati, Romania........ 237

45. **ANTAGONISTIC TERMS FOUND ON LAND AND OFFSHORE**
GEORGESCU MIRCEA
Constanta Maritime University, Romania…… 243

46. **CHARACTERISTICS OF THE LANGUAGE USED IN NAVAL ARCHITECTURE ADVERTISING**
[1]TRISCA ANCA (IONESCU), [2]CROITORU ELENA
[1,2]"Dunarea de Jos" University of Galati, Romania…….. 247

47. **ON NOMINALIZATION IN MARITIME DISCOURSE**
VIŞAN IOANA RALUCA
Constanta Maritime University, Romania........ 251

**SECTION VI - TRANSPORT ECONOMICS**

48. **THE STRATEGIC ISSUES – STRUCTURAL ELEMENTS OF STRATEGIC MANAGEMENT**
BALTA CORNELIU
Wales University, Romania……. 255

49. **QUALITY ASSESSMENT OF STRATEGIC MANAGEMENT IN ORGANIZATIONS – A MATURITY MODEL**
BALTA CORNELIU, ROSIORU NICOLETA DIANA
Wales University, Romania…….. 259

50. **IMPORTANCE OF STUDYING CHRONOLOGICAL SERIES FOR THE ANALYSIS OF TRANSPORT ACTIVITY**
BRANZA GRATIELA
Constanta Maritime University, Romania........ 263

51. **SUSTAINABLE TRANSPORT' S INDICATORS. COMPARATIVE STUDY: EU-27 AND ROMANIA**
[1]BRANZA GRATIELA, [2]CRISTEA VIORELA-GEORGIANA
[1,2]Constanta Maritime University, Romania........ 267

52. **ASSESSMENT OF STRUCTURAL INSTRUMENTS IMPACT UPON SUSTAINABLE DEVELOPMENT**
CIOBANU CARMEN-LILIANA
„Alexandru Ioan Cuza" University of Iasi, Romania........ 271

53. **THE PRICE SISTEM IN ROMANIAN MARKET ECONOMY**
DRAGAN CRISTIAN
Constanta Maritime University, Romania........ 275

54. **THE TAX SYSTEM IN ROMANIA**
DRAGAN CRISTIAN
Constanta Maritime University, Romania........................................................................................ 279

55. **COMPUTER MANAGEMENT SYSTEMS IN MARITAIM ORGANIZATION**
[1]GEORGESCU STEFAN; [2]MUNTEANU VALENTİNA
[1]Constanta Maritime University, Romania; [2]Andrei Saguna University, Constanta, Romania... 283

56. **COMMUNICATION'S MANAGEMENT IN CRISIS AND CONFLICT SITUATIONS. APPLICATION OF COMMUNICATION'S SKILLS IN MARITIME INDUSTRY**
[1]IMASHOVA ZHULDZ, [2]KARZHAUBAYEVA ONAICHAN, [3]FELICIA SURUGIU, [4]SIMONA MINA
[1,2]Caspian State University of Technologies and Engineering, Kazahstan,
[3]Maritime University of Constanta, [3]University Ovidius of Constanta, Romania……………... 287

57. **SUPPLY CHAIN MANAGEMENT IN SHIPPING**
[1]IORDANOAIA FLORIN, [2]IMASHOVA ZHULDUZ, [3]KARZHAUBAYEVA ONAIKHAN
[1]Constanta Maritime University, Romania,[2,3]Caspian State University of Technologies and Engineering, Kazahstan……………………………………………………………………… 293

58. **THE PEOPLE'S IPO - THE MODERN TREND OF STRENGTHENING OF KAZAKHSTAN'S BUSINESS**
KARZHAUBAYEVA O.ZH.
Caspian State University of Technologies and Engineering Named after Sh.Esenov, Aktau city, Kazakhstan………………………………………………………………………..…….. 303

59. **TECHNOLOGY OF TEACHER AND STUDENT "PORTFOLIO" IN PRIMARY SCHOOL AS EDUCATIONAL INNOVATION**
KARZHAUBAYEVA O.ZH., KOKSHEEVA Z.T.
Caspian State University of Technologies and Engineering Named after Sh. Esenov, Aktau city, Kazakhstan……………………………........................................................................ 305

60. **THE IMPACT OF THE ECONOMIC CRISIS ON PORT DEVELOPMENT**
NECHITA DANIELA
"Dunarea de Jos" University of Galati, Romania......................................................................... 309

61. **FUTURE DEVELOPMENT OF EUROPEAN MARITIME REGIONS**
[1]PANAIT CORNEL, [2]STANCA COSTEL, [3]BUZU GEORGIANA
[1,2,3]Constanta Maritime University, Romania................................................................................ 315

62. **PERFORMANCE INDICATORS FOR SMEs ACCESING EU FUNDS**
POPA ADINA-SIMONA
University "Eftime Murgu" of Resita, Romania.......................................................................... 319

63. **INTERNATIONAL IMPLICATIONS CONCERNING THE LEGAL REGIME AND POLICY OF SHIP REGISTRATION**
[1]XHELILAJ ERMAL, [2]KSENOFON KRISAFI
[1]University "Ismail Qemali" Vlore, Albania, [2]European University of Tirana, Albania............. 323

# SECTION I
## NAVIGATION AND MARITIME TRANSPORT

# CATHODIC PROTECTION BY SACRIFICIAL ANODES OR IMPRESSED CURRENT, COMPARATIVE ANALYSIS

[1]ACOMI NICOLETA, [2]ACOMI OVIDIU

[1]*Constanta Maritime University,* [2]*GSP Offshore, Romania*

**ABSTRACT**

Cathodic protection represents a widely spread method for controlling the corrosion of metallic structures in contact with various environments containing enough ions to conduct electricity such as soils and seawater. The principle of cathodic protection consists in controlling the corrosion rate of a metallic structure by reducing its corrosion potential, bringing the metal closer to an immune state. This could be achieved by two main ways: using sacrificial anode or using an impressed current. The main difference between the two methods is that the impressed current cathodic protection uses an external power source with inert anodes while the sacrificial anodes cathodic protection uses the naturally occurring electrochemical potential difference between different metallic elements to provide protection.

The paper's aim is to realize a comparative analysis of these methods with regard to their benefits, features and also to the economic point of view. Another aspect presented is the way how the cathodic protection system differs for the commercial ships to the special purpose vessels - Floating Production Storage and Offloading which, regardless of their shape that still looks like a ship, have special requirements regarding the corrosion protection.

**Keywords:** *cathodic protection, sacrificial anodes, impressed current.*

## 1. INTRODUCTION

Investigations into a series of marine casualties have revealed that about 40% of them have resulted from structural failures, and corrosion deterioration is found to be the single largest factor leading to such failures [3]. These studies have stressed the need for a more active attention towards preservation and maintenance of the metal and have led to major changes in the approach towards mitigation of corrosion. The International Maritime Organization (IMO) has made its first recommendation in 1993, by issuing the Guidelines on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers, which specified the positive reporting of the condition of structural members in corrosion prone areas [8].

The Regulatory Environment generally prescribes adherence or compliance to the following norms:

1. Bulk ship failures in the late 80's lead the International Association of Classification Societies (IACS) to create the Enhanced Survey Program for the hull structure. The ESP mandated that all ballast tanks had to be coated with a "hard" coating and that the condition of the coating while the ship is in service must be "reasonable".

2. A short while after that, the International Maritime Organization (IMO) created recommendation in an attempt to bring the standard of work on new construction stage in line with what IACS would later require when the ships are in service.

3. In 2002 the IACS ESP was tightened again and the present requirements on coating condition in ballast tanks on tanker ships are quite stringent, and discussions of incorporating cargo tanks under the regime started.

In order to combat corrosion deterioration of hull structure, the fight should ideally begin from the building stage.

The conventional methods of protection the ship against corrosion should be used along with the regulatory requirements from the building stage.

Corrosion control in marine environment can be achieved by different methods: coatings, cathodic protection, materials selection, chemical inhibitors, and environmental change. Coating the metal is used in order to interpose a corrosion resistant coating between metal and environment. The action of protective coatings is often more complex than simply providing a barrier between metal and environment. In order to confer cathodic protection, paints may contain a corrosion inhibitor zinc coating on iron or steel, but, even that, all coatings are subjected to degradation over their service lifetime. The corrosion inhibitors are used in areas where the electrolyte solution is of a known and controllable quantity. On ships, this occurs in onboard equipment (boilers, tanks, pipes) but not on the hull.

Taking into account that the merchant ships are made of iron or steel and the sea water represents their environment, it is hard to believe that we could act on the two methods: material selection and environmental change.

The method that provides protection of the ships' hull against corrosion is the cathodic protection. The principle of cathodic protection consists in connecting an external anode to the material to be protected from corrosion. Therefore, all area of the metal surface becomes cathodic and will not corrode.

The cathodic protection of the ship can be achieved by different ways. The external anode may be a sacrificial anode or it may be an impressed current anode where the current is impressed from external direct current (DC) source. The next section presents the way how these act:

- Impressed current cathodic protection (ICCP); and

- Sacrificial (or galvanic) anode cathodic protection (SACP).

## 2. DESCRIPTION OF THE METHODS

### *2.1 Sacrificial anode cathodic protection*

The sacrificial anode technique uses the natural potential difference that exists between the structure and a second metal in the same environment to provide the driving voltage. No power source is employed. Moreover, the dissolution of the second metal, that is, the sacrificial anode, provides the source of electrons for cathodic polarization of the structure.

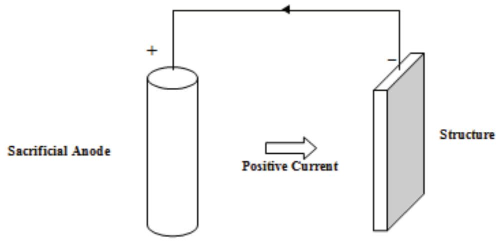



Figure 1 The use of a sacrificial anode for CP

Sacrificial anodes are coupled to the structure to be protected and the conventional current flows from the anode to the structure as long as the anode is more "active" than the structure. As the current flows, all the corrosion occurs on the anode which "sacrifices" itself in order to offer protection from corrosion to the structure.

The lower potential material becomes the anode and corrodes preferentially.

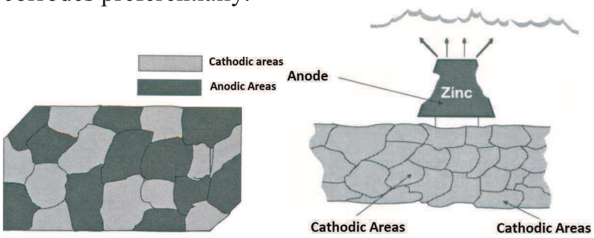



Figure 2 Anodic and cathodic areas in steel (a) before/ (b) after installing sacrificial anodes [6]

Figure 3 Sacrificial anodes on the ship's hull [1]

### *2.2 Impressed current cathodic protection*

Impressed current anodes are having longer life than sacrificial anodes in cathodic protection due to their negligible consumption rate, durability and strength. These impressed current anodes are also known as dimensionally stable (DSA) or insoluble anodes.

Using the impressed-current technique, the driving voltage for the protective current comes from a DC power source. The power source must be able to deliver DC and examples are transformer rectifier units, solar generating units or thermoelectric generators.

The circuit comprises the power source, an auxiliary or impressed current electrode, the corrosive solution, and the structure to be protected. The power source drives a positive current from the impressed current electrode through the corrosive solution and onto the structure. The structure is thereby cathodically polarized (its potential is lowered), and the positive current returns through the circuit to the power supply. Thus, to achieve cathodic protection, the impressed current electrode and the structure must be in both electrolytic and electronic contact. The figure below illustrates the use of an external power supply to provide the cathodic polarization of the structure.

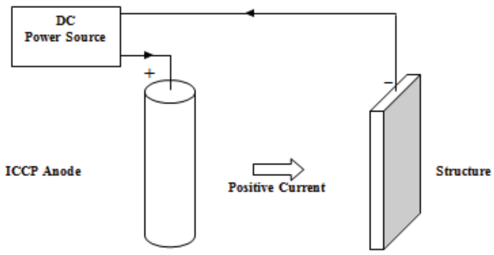



Figure 4 The use of an external power supply to provide CP

The ICCP system converts the ship's AC supply into a controlled low voltage DC output, which is then delivered onto the metal surface by long life anodes attached to, but insulated from the hull structure. Various factors affect the amount of current required, therefore to ensure the correct level of protection is accurately controlled it is necessary to measure the potential of the steel against a known and reliable reference cell. This potential is monitored by reference electrodes mounted on the underwater hull surface.

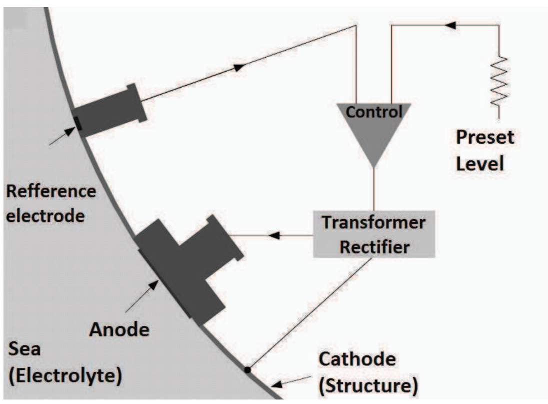



Figure 5 The role of the reference electrode

The number of electrodes and their locations is carefully selected in conjunction with the anode configuration and hull geometry. Solid state circuitry within an automatic control unit compares the reference potential against a desired and pre-set optimum. Any difference between these will induce a resultant error signal, which is electronically conditioned to provide suitable regulation of the DC power supply to the anodes.

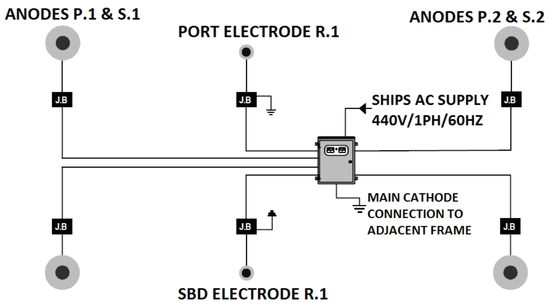



Figure 6 The ICCP system

An ICCP system can comprise of more than one anode fitted on Aft, Forward, Port, Starboard of the vessel, depending on the size and type of the vessel.

Figure 7 The anode in ICCP system [1]

The anodes used within impressed current cathodic protection systems are titanium coated with mixed metal oxide or platinum, silicon iron, graphite and magnetite.

## 3. COMPARATIVE ANALYSIS OF THE TWO TYPES OF CP

The first criteria that usually comes into our mind when we talk about comparison of the two products, in this paper two types of CP, is the cost criteria. The authors identify the most important quality parameters for these types of cathodic protection based on efficiency, features, lifetime benefits, installation, operation and maintenance.

### *3.1. The CP for a commercial ship*

The shipping industry is comfortable with ICCP (impressed current cathodic protection) systems for the hull. This reasoning is well justified when one considers the operation and function of a tanker, for example. Impressed current systems offer a number of advantages for these vessels, presented in the following table.

Table 1 The quality parameters

| No. | Quality parameter | SACP | ICCP |
|---|---|---|---|
| 1 | Free of Power source | Yes | No |
| 2 | Protect a wide range of structures | No | Yes |
| 3 | Simple to install | Yes | No |
| 4 | Small number of anodes required | No | Yes |
| 5 | Easy operation and maintenance | Yes | No |
| 6 | Controllable effects of CP | No | Yes |
| 7 | Effects of incorrect connection | No | Yes |
| 8 | Small resistance anodes contrary to the water flow | No | Yes |
| 9 | Adjusting when changing conditions | No | Yes |
| 10 | Easy to monitor of the anodes | No | Yes |
| 11 | Reduced cost to maintain | No | Yes |
| 12 | Long Lifetime | No | Yes |
| 13 | Cost for persons' special training | No | Yes |

The anodes in ICCP are either inert or have low consumption rates and can be surrounded by carbonaceous backfill to increase efficiency and decrease costs.

Thus, while the impressed-current anode may be more noble or more base than the protected structure, because the power source forces it to act as an anode, the sacrificial anode must be spontaneously anodic to the structure, that is, be more negative in the galvanic series for the given environment.

### *3.2. CP for an FPSO*

FPSO's (Floating Production Storage and Offloading) generally fall into two categories; new build vessels and conversions. There is no doubt however in either case that the end result still looks like a ship (Fig.8). When considering cathodic protection strategy however, design concerns have little to do with classifying the asset by appearance. Rather operability and longevity (for the intended life cycle) are the chief concerns.

FPSO structures present some interesting cathodic protection challenges. Are they ships or floating production platforms? Is impressed current cathodic protection the way to go? How do we handle protecting the ballast tanks? What about the mooring systems?

Figure 8 Floating Production Storage and Offshore [2]

The operation and function of an FPSO varies significantly from an ocean-going tanker in the following areas:

1. It is moored in one offshore location for protracted periods of time.
2. Regular dry-docking is not possible.
3. There are a number of appurtenances, risers, umbilical, mooring lines and turret structures that may be in close proximity to the hull.

These differences should be considered when developing a long term cathodic protection strategy. Certain implications of these differences might prove to make the use of sacrificial anode systems more attractive to many cathodic protection designers.

Related to the costs involved by the two systems of cathodic protection there were various studies to see if the ICCP is a cost effective method. Two main factors are important in this analysis: current requirement and water depth. Large current requirement/deep water both generally lend themselves to using ICCP. These factors are inter-dependent to a large degree but not always. For example, impressed current is attractive in Alaska area because of high current requirements and difficulties associated with the installation of galvanic anodes, regardless of relatively shallow water depth. Similarly a very large, shallow-water template type structure may have a very high current requirement because of the vast steel area. On the opposite side, a very deep structure such as a tension leg platform will have a very low subsea current requirement due to its design and the extensive use of subsea coatings - impressed current would probably not be a good retrofit option.

As a general rule of thumb impressed current systems begin to look quite attractive when current requirements exceed 400 - 500 Amperes and/or when water depth exceeds 200 feet [2].

## 5. CONCLUSIONS

From this comparative analysis results that a system based on impressed current is more complicated and more expensive to install than the systems with sacrificial anodes. The ICCP has the advantages that anodes material is nobler than the ship's steel and have a very low corrosion rate per year and it protects all the ship evenly. It should be also noticed that adding sacrificial anodes in the SACP, on the ship's hull would increase the consumption of fuel, which is not the case for the ICCP.

A particular advantage of an ICCP is that the voltage is automatically adjusted on the basis of the readings taken, to keep a certain difference of potential which changes based on the condition of the coating, the environmental changes or operational conditions, and thus the level of cathodic protection can be permanently optimized.

## 7. REFERENCES


[1] Anderson, C., *Protection against corrosion*, University of Newcastle upon Tyne, Lecture Notes, (http://www.ncl.ac.uk/marine/assets/docs/NclUni_Lect1_1103.pdf). 2003

[2] Britton, J., *Cathodic Protection Surveys Of Offshore Platforms - A New Approach*, Corrosion, San Diego, CA. National Association Of Corrosion Engineers, 2010

[3] Mathiazhagan, A., *Corrosion management for effective mitigation of corrosion in ships*, the 3rd International Conference in Information and Financial Engineering, IACSIT Press, Singapore, 2011

[4] Roberge, Pierre R., *Handbook of Corrosion Engineering*, ISBN 0-07-076516-2, 2000

[5] Oil Companies International Marine Forum, *Factors influencing accelerated corrosion of cargo oil tanks*, 1997

[6] The National Institute of Technology, Inspection of corrosion. Protective coatings, Norway, 2008

[7] Det Norske Veritas, *Corrosion Protection of ships*, recommended practice, 2000

[8] International Maritime Organization, *Guidelines on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers*, Resolution A.744(18), 1993

# STEPS TOWARDS THE ENERGY EFFICIENT SHIP

[1]ACOMI NICOLETA, [2]ACOMI OVIDIU

[1]*Constanta Maritime University,* [2]*GSP Offshore Constanta, Romania*

**ABSTRACT**

It is well known that air pollution is a serious and actual problem that affects our society. The maritime transport is responsible for a part of that pollution, approximately for 10% of the greenhouse gases emissions of the transport sector. In order to reduce greenhouse gas emission from international shipping, the Marine Environment Protection Committee (MEPC) from the International Maritime Organization developed technical and operational measures, helping to improve in the same time the fuel efficiency too. The measures have been reviewed by the Committee in a number of sessions and the results were the concepts of Energy Efficiency Design Index (EEDI), Energy Efficiency Operational Index (EEOI) and Ship Energy Efficiency Management Plan (SEEMP). They have also elaborated a model course comprising the main factors that should be well known and adjusted for an energy efficient ship.

The aims of this study are to offer an overview of the proposed measures, to emphasize their technical implications and also the operational requirements that have been set in maritime field regarding the marine environment.

**Keywords:** *energy efficient ship, greenhouse gas, marine pollution.*

## 1. INTRODUCTION

In the early 90' the United Nations recognized that the climate is a shared resource which can be affected by emissions of carbon dioxide and other greenhouse gasses (GHG). The United Nations Framework Convention on Climate Change (UNFCCC) was signed in 1992 in Rio de Janeiro, entered into force in 1994, and in March 2013 had 195 Parties [2]. Under the Convention, parties gather and share information, launch national strategies for addressing GHG and cooperate for the adaptation to climate change.

International shipping is the most environmentally-friendly and energy efficient mode of mass transport and only a modest contributor to the total volume of atmospheric emissions while moving a considerable part of world trade (90%). The emissions of $CO_2$ from shipping compared with global total emissions are presented in the Figure 1.

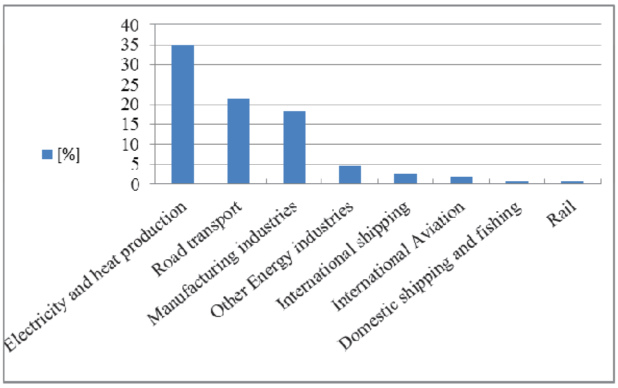



Figure 1 The compared analysis of the emissions of $CO_2$

Nevertheless, a global approach for further improvements in energy efficiency and emission reduction is needed as sea transport is predicted to continue growing significantly in line with world trade.

The International Maritime Organization (IMO), as the UN's Specialized Agency responsible for the global regulation of all facets pertaining to international shipping, has a key role in ensuring that the environment is not polluted by ships – as summed up in IMO's mission statement: Safe, Secure and Efficient Shipping on Clean Oceans.

The International Maritime Organisation (IMO), as the main regulatory body for shipping has, in recent years, devoted significant time and effort in order to regulate shipping energy efficiency and thereby control the marine GHG emissions. For this purpose, IMO has developed a number of technical and operational measures that include:

- Energy Efficiency Design Index (EEDI);
- Energy Efficiency Operational Index (EEOI);
- Ship Energy Efficiency Management Plan (SEEMP).

## 2. TECHNICAL AND OPERATIONAL ENERGY EFFICIENCY MEASURES FOR SHIPS

All the measures, technical and operational, are united in the same purpose: to ensure that the EEDI, EEOI and SEEMP deliver environmental effectiveness by generating, through enhanced energy efficiency measures, significant reductions in GHG emissions from international shipping.

Numerous stakeholders such as policy-makers, ship owners, naval architects, class societies, are contributing to this endeavour, providing technical and other input to the debate, leading to the development of an instrument that is eminently suited for its intended purpose.

In October 2011 IMO completed a study to estimate the $CO_2$ emission reductions resulting from the adoption of mandatory technical and operational energy efficiency measures.

### *2.1 Energy efficiency design index*

Shipping is permanently engaged in efforts to optimize fuel consumption, e.g., through the development of more efficient engines and propulsion systems, optimized hull designs and larger ships, and thereby achieve a noteworthy reduction in fuel consumption and resulting CO2 emissions on a capacity basis (tonne-mile). Although ships are the most fuel efficient mode of mass transport, the Second IMO GHG Study 2009 [3], identified a significant potential for further improvements in energy efficiency mainly by the use of already existing technologies. Additional improvements in hull, engine and propeller designs, together with reduction in operational speed, may lead to considerable reductions as illustrated in Table 1.

Table 1 Potential reductions of $CO_2$ emissions [3]

| Design | Saving of $CO_2$/tonne-mile |
|---|---|
| Concept, speed and capability | 2% to 50% |
| Hull and superstructure | 2% to 20% |
| Power and propulsion systems | 5% to 15% |
| Low-carbon fuels | 5% to 15% |
| Renewable energy | 1% to 10% |
| Exhaust gas $CO_2$ reduction | 0% |

It is already being used to enable a comparison to be made of the energy efficiency of individual ships with similar ships of the same size that could have undertaken the same transport work (i.e. moved the same cargo).

The Energy Efficiency Design Index for new ships creates a strong incentive for further improvements in ships' fuel consumption. The purpose of IMO's EEDI is:

- to require a minimum energy efficiency level for new ships;
- to stimulate continued technical development of all the components influencing the fuel efficiency of a ship;
- to separate the technical and design based measures from the operational and commercial measures (they will/may be addressed in other instruments); and
- to enable a comparison of the energy efficiency of individual ships to similar ships of the same size which could have undertaken the same transport work (move the same cargo).

As long as the required energy efficiency level is attained, ship designers and builders would be free to use the most cost-efficient solutions for the ship to comply with the regulations. The reduction level in the first phase is set to 10% and will be tightened every five years to keep pace with technological developments of new efficiency and reduction measures. IMO has set reduction rates up to 2025 from when a 30% reduction is mandated for most ship types calculated from a reference line representing the average efficiency for ships built between 1999 and 2009.

The EEDI provides a specific figure for an individual ship design, expressed in grams of CO2 per ship's capacity-mile (a smaller EEDI value means a more energy efficient ship design) and calculated by the following formula based on the technical design parameters for a given ship:

$$EEDI = \frac{CO_2 emission}{transport\_work} \tag{1}$$

The $CO_2$ emission represents total $CO_2$ emission from combustion of fuel, including propulsion and auxiliary engines and boilers, taking into account the carbon content of the fuels in question. The measures for EEDI reduction comprise the following technologies:

- optimising hull dimensions
- lightweight construction
- hull coating
- contra-rotating propeller
- engine efficiency improvement
- waste heat recovery
- gas fuelled
- hybrid electric power and propulsion concepts
- wind power
- solar power

If shaft generators or innovative mechanical or electrical energy efficient technologies are incorporated on board a ship, these effects are deducted from the total $CO_2$ emission. The energy saved by the use of wind or solar energy will also is deducted from the total $CO_2$ emissions, based on actual efficiency of the systems.

*2.2 IMO's ship energy efficiency management plan*

The purpose of the SEEMP is to establish a mechanism for a company and/or a ship to improve the energy efficiency of ship operations. Preferably, the ship-specific SEEMP is linked to a broader corporate energy management policy for the company that owns, operates or controls the ship. It should be recognized that the international fleet of merchant vessels comprises of a wide range of ship types and sizes that differ significantly in their design and purpose, and that ships operate under a broad variety of different conditions.

The amendments to MARPOL Annex VI require that all international ships over 400 gross tonnage retain on-board a Ship Energy Efficiency Management Plan (SEEMP). Guidance for the development of a SEEMP is contained in IMO circular MEPC.1/Circ.683 [4].

The SEEMP provides an approach for monitoring ship and fleet efficiency performance over time and forces the responsible persons and entities to consider new technologies and practices when seeking to optimize the performance of the ship. The related energy efficiency measures refer to:

- engine tuning and monitoring
- hull condition
- propeller condition
- reduced auxiliary power
- trim/draft
- voyage execution
- weather routeing

The Second IMO GHG Study 2009 [3] indicates that a 20% reduction on a tonne-mile basis by mainly operational measures is possible and would be cost-effective even with the current fuel prices, and the SEEMP will assist the shipping industry in achieving this potential.

*2.3 The energy efficiency operational indicator*

Improvements in energy efficiency are possible by operational measures, such as fleet management, voyage optimization and energy management, with 10 to 50% reductions of $CO_2$ emissions (on a capacity mile basis) estimated through the combined use of these measures. Saving energy at the operational stage is presently addressed by the SEEMP and the EEOI can be used as a monitoring tool and to establish benchmarks for different ship segments of the world fleet categorized by ship type and size.

The EEOI enables continued monitoring of individual ships in operation and thereby the results of any changes made to the ship or its operation. The effect of retrofitting a new and more efficient propeller would be reflected in the EEOI value and the emissions reduction could be quantified. The effect on emissions by changes in operations, such as introduction of just in time planning or a sophisticated weather routing system will also be shown in the EEOI value.

The energy efficiency of a ship should be monitored quantitatively. This should be done by an established method, preferably by an international standard. The EEOI developed by the Organization is one of the internationally established tools to obtain a quantitative indicator of energy efficiency of a ship and/or fleet in operation, and can be used for this purpose. Therefore, EEOI could be considered as the primary monitoring tool, although other quantitative measures also may be appropriate.

If used, the EEOI should be calculated in accordance with the guidelines developed by the IMO [4]. If deemed appropriate, a Rolling Average Index of the EEOI values may be calculated to monitor energy efficiency of the ship over time.

The EEOI provides a specific figure for each voyage. The unit of EEOI depends on the measurement of cargo carried or the transport work done, e.g., tonnes $CO_2$/(tonnes/nautical miles), tonnes $CO_2$/(TEU/nautical miles) or tonnes $CO_2$/(person/nautical miles), etc. The EEOI is calculated by the following formula, in which a smaller EEOI value means a more energy efficient ship:

$$EEOI = \frac{actual\_CO_2\_emission}{performed\_transport\_work} \tag{2}$$

The EEOI for a voyage is calculated as follows:

$$EEOI = \frac{\sum_j FC_j \times C_{FJ}}{m_{c\arg o} \times D} \tag{3}$$

For a number of voyages or voyage legs, the indicator is expressed as presented below:

$$Average\_EEOI = \frac{\sum_i \sum_j FC_{ij} \times C_{Fj}}{\sum_i m_{c\arg o,i} \times D_i} \tag{4}$$

Where:
- $j$ is the fuel type;
- $i$ is the voyage number;
- $FC_{ij}$ is the mass of consumed fuel $j$ at voyage $i$;
- $CF_j$ is the fuel mass to $CO_2$ mass conversion factor for fuel $j$;
- $m_{cargo}$ is cargo carried (tonnes) or work done (number of TEU or passengers) or gross tonnes for passenger ships; and
- $D$ is the distance in nautical miles corresponding to the cargo carried or work done.

The actual $CO_2$ emission represents total $CO_2$ emission from combustion of fuel on board a ship during each voyage, which is calculated by multiplying total fuel consumption for each type of fuel (distillate fuel, refined fuel or LNG, etc.) with the carbon to $CO_2$ conversion factor for the fuel(s) in question (fixed value for each type of fuel).

The performed transport work is calculated by multiplying mass of cargo (tonnes, number of TEU/cars, or number of passengers) with the distance in nautical miles corresponding to the transport work done.

## 3. ENERGY EFFICIENT SHIP OPERATION MODEL COURSE

During the sixty session of the Marine Environment Protection Committee, it was noted that, to assist in achieving the visions and goals set out in resolution on the "Human Element Vision, Principles and Goals for the Organization" [5], and the principles and aims of resolution on the "Need for capacity-building for development and implementation of new and amendments to existing, instruments" [6], the IMO Secretariat had engaged the World Maritime University (WMU) to develop a draft model course on energy efficient operation of ships.

A draft Model Course was submitted to the sixty-second session as document MEPC 62/inf.39 [7]. It was developed on the elements comprising the SEEMP as well as on the "Guidance for the development of a SEEMP" [4]. This draft model course provides general background on the climate change issue and IMO's related work and aims at building the different operational and technical tools into a manageable course programme, which will promulgate best practice throughout all sectors of the industry. The Course will help create benchmarks against which operators can assess their own performance.

The Committee agreed that the draft model course was an excellent start to provide a structured training course but that it required additional work to identify the relevant parts and information, such as key practical operational efficiency measures, which are pertinent to the ship's deck and engineering officers. The Marine Environment Protection Committee also considered important that consideration be given to integration of the SEEMP into the on board safety management system. In light of the improvements necessary to the

Model Course, the Committee invited interested delegations to provide practical information and examples on the efficient operation of ships to the Secretariat. The comments received from the validation group were the following [8]:

1. The draft Model Course with 5-days duration is too long compared with a similar course prepared by classification societies, which is only two days;
2. Considering that ship management both on board and on shore are the target participants of the course, EEDI and EEOI should be thoroughly discussed and actual calculation is a must; and
3. Impact of speed to fuel consumption cannot fully be appreciated using the full mission engine-room simulator. It is better to complement the simulator exercise using actual fuel consumption of existing vessel type data at various speeds to be calculated by the participants.

Taking into account the above comments from the validation group, the Secretariat adjusted the draft Model Course by adding some paragraphs in the relevant sections. The final Model Course Energy Efficient Operation of Ships first published in December 2011 was updated by IMO Marine Environment Division in February 2013 to adjust the course, taking into account comments from validation group for model courses under the STCW convention [8].

## 5. CONCLUSIONS

The EEDI establishes a minimum energy efficiency requirement for new ships depending on ship type and size and is a robust mechanism that may be used to increase the energy efficiency of ships stepwise to keep pace with technical developments for many decades to come. The EEDI is a non-prescriptive mechanism that leaves the choice of what technologies to use in a ship design to the stakeholders as long as the required energy efficiency level is attained enabling the most cost-efficient solutions to be used.

In order to evaluate the operational performance of their fleet, the ship-owners have in EEOI an instrument for measuring ships' energy efficiency at each voyage or over a certain period of time. Its use is voluntary and because the EEOI can also provide useful information on a ship's performance with regard to fuel efficiency, it is recommended to be applied.

With regard to the IMO model courses their purpose was to assist training providers and their teaching staff in organizing and introducing new training courses, or in enhancing, updating or supplementing existing training material, so that the quality and effectiveness of the training courses may thereby be improved.

## 6. REFERENCES

[1] IMO - Agenda item 9(a) - Emissions from fuel used for international aviation and maritime transport, *Technical and operational measures to improve the energy efficiency of international shipping and assessment of their effect on future emissions*, November 2011

[2] MEPC 59/24/Add.1, ANNEX 19, *Guidance for the development of a ship energy efficiency management plan (SEEMP),* 2012

[3] MEPC 59/INF.10, *Second IMO GHG Study*, 2009

[4] MEPC.1/Circ.683, Guidance for the Development of a Ship Energy Efficiency Management Plan, 2009

[5] MEPC 60, Resolution A.947(23) on the "*Human Element Vision, Principles and Goals for the Organization*", 2003

[6] MEPC 60, Resolution A.998(25) on the "*Need for capacity-building for development and implementation of new and amendments to existing, instruments*", 2003

[7] MEPC 62/INF.39, Draft model course for energy efficient operation ships, 2011

[8] MEPC 65/INF.17, IMO model course on energy-efficient operation of ships, 2013

# THE INFLUENCE OF LIQUID FREE SURFACE ON SHIP STABILITY

[1]ANDREI CRISTIAN, [2]LAMBA MARINEL-DANUT, [3]HANZU-PAZARA RADU

*[1,2,3] Constanta Maritime University, Romania*

**ABSTRACT**

Safety is the most commonly discussed feature of maritime transport and the stability is one of the most critical features of seagoing ships. In nowadays, the assessment and calculation of ship's intact stability is based on stability criteria where the righting lever curve should be corrected for the effect of free surfaces of liquids in tanks. This method, consider only the static attitude towards the sloshing phenomenon and do not take into consideration the dynamic attitude and his influence. The paper examines the effect of fluid free surfaces in slack tanks on ship's transverse stability and presents considerations on the influence of tank filling level, by analysing the heeling moment caused by sloshing generated by a liquid with free surface and has the purpose of demonstrating the liquid free surface dynamics influence on ship's stability.

**Keywords:** *liquid, free surface effect, safety, sloshing, stability, heeling moment, .*

## 1. INTRODUCTION

Ship stability is one of the most critical features of seagoing ships related to her safety because is influencing its overall sea keeping performance.

Ship stability is a field of many researches leading to the increase in understanding of the safety qualifying factors and remains a crucial factor determining sea keeping of ships. Stability against capsizing and excessive heeling is one of the most fundamental requirements considered by naval architects when designing cargo vessels and by their operators in the course of sailing and cargo handling [1]. The stability of a vessel belongs to operational characteristics enabling cost effective and safe operation [1].

The influence of moving liquid in partly filled tanks is one of the problems related to ship stability and its overall performance. The ballast tanks are the main group of tanks on board ships, which are usually used also in partly filled condition. According to their purpose, the ballast tanks can be classified as follows:

- Trimming tanks (fore and after peak tanks) which are very often used in partly filled condition due to the need of adjusting the trimming of ship and in this situations free surface of liquids appear.
- Stability tanks, used for improving ship's stability during cargo operations due to rising of ship's vertical centre of gravity. A very important feature of these tanks is the fact that the breadth is very large (the breadth can equals half breadth of the ship or even full ship's breadth) and therefore its generate large free surface of liquids.
- List control tanks, are usually located on the sides and are often used in partly filled condition to adjust the list of the ship.
- Strength control tanks, utilized to adjust the longitudinal weight distribution.

The importance of ballast tanks is significant and their total weight in relation with ships types is shown in figure 1.

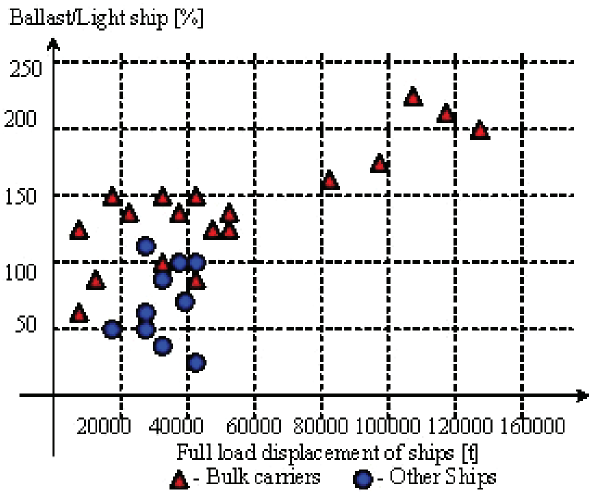



Figure 1. Correlation between lightship weight and ballast water weight

A very important aspect that is revealed from the figure 1, is that the total weight of ballast water on board vessel may be equal or even more than the lightship weight among ships other than bulk carriers and can be twice the lightship in case of bulk carriers. If only part of these tanks are partly filled in the same time, will creates free surfaces and the phenomenon of moving liquids in tanks which will have a great negative influence over ship stability.

The strong interaction between the liquid oscillation with free surface and the ship motion is a difficult issue when the analysis of the dynamic response of ship has to be made. However, this field of research is very important, due to the problems generated by this matter, for certain situations like tanker ships (due to sloshing induced loads over the side walls of the cargo tanks), damage survivability analysis or small ships with water shipped on deck.

Stability characteristics of ships with free surfaces, especially with regard to capsizing, have been deeply studied, involving static, dynamic and hydrodynamic approaches depending on the model used for description the motion of the liquid inside the compartment. The static model, treats the liquid as moving of free surface in connection with ship inclination, which reveals that the oscillation of liquid is calculated and added to the righting moment of a ship as a correction for free surface effect. The dynamic models, analyses the roll motion of the ship with free surface liquids by a set of two coupled differential equations. This approach allows the assessment in terms of natural frequencies of oscillation, corresponding to the square root of eigenvalues of the coupled equations. The hydrodynamic model was mainly used for solving the sloshing problem.

Depending on the physical characteristics of the liquid, on the geometry of the compartment and on the external excitation sloshing loads can be assessed in different ways [2].

In sloshing problems, an important role in the reduction of the speed of propagation of surface waves and smoothing of high frequency waves is played by the liquid viscosity.

In resonance conditions, a train of traveling waves inside the compartment, in many cases resulting in a hydraulic jump, depending on the magnitude of the external excitation. Thus, the large standing waves superposed by hydraulic jump develop a sloshing induced moment whilst the fast waves can induce impact loads on the sides of the compartment with the possible result of structural damage. In this respect, it is important to note that the problem of sloshing of liquids inside the compartments on board ship connected with the roll motion of ship is an important factor when the safety of ship is analysed.

## 2. SLOSHING AND THE INFLUENCE ON HEELING MOMENT

Liquid slosh within a compartment (tank) exposed to motions is known to be quite complex, particularly under the influence on multiple-axis excitations, as encountered in ships.

When the ship motions contain energy in the vicinity of the highest natural period for the fluid motion inside the tank, a partly filled tank will experience violent liquid motion.

The nonlinear movements, accompanied by oscillatory motions, of liquids inside partially filled tanks generate the sloshing phenomenon.

This liquid movement generates dynamic loads on the tank structure and thus becomes a problem of relative importance in the design of marine structures in general and an especially important problem in some particular cases [3].

The sloshing is more severe as the larger tanks size is and less internal structures obstructing the flow in the tank are present. This fact is related to [12]:

- Larger tanks size lead to increase the highest natural sloshing period and hence higher sea states and larger ship motions will excite the severe sloshing.
- Internal structures dampen the fluid motions.

The problem of sloshing phenomenon has been investigated in the last 50 years, through many methods like mechanical models by adjusting terms in the harmonic equation of motion [4], [5], by potential flow problem with the sophisticated treatment of the free surface boundary conditions [3] or by nonlinear shallow water equations [6] with the use of different techniques [7].

The hydrodynamic loads occurred inside a compartment are classified as: dynamic loads (are loads with dominant time variations on the time scale of the sloshing period) and impact loads (may only last 0.01 to 0.001 seconds).

The static heeling moment due to liquid in a partly filled tank can be divided in two components as follows:

- moment of liquid’s weight without any changes of shape during ship heeling;
- moment of liquid such as a “frozen liquid” or compared with a solid [4].

In the same way can be assessed the total dynamic heeling moment due to sloshing of liquid inside the tank: one component is the moment due to dynamic action of “frozen” liquid at zero angle of heel and other component is due to liquid sloshing inside the tank.

Thus, the total moment of heeling (static and dynamic) may be expresses by the relations:

$$M_S = M_{fls} + M_{ft} \quad (1)$$

$$M_D = M_{fld} + M_{ff} \quad ......2)$$

where:

$M_S$ - total static moment due to liquid in a tank with free surface ,

$M_{fls}$ - static heeling moment due to the weight of liquid considered “frozen”,

$M_{ft}$ - static heeling moment of fluid transfer for each angle of heel,

$M_D$ - total dynamic moment due to sloshing of liquid in tank,

$M_{fld}$ - dynamic heeling moment due to weight of liquid considered “frozen”,

$M_{ff}$ - free floating component of the dynamic moment due to sloshing of liquid in tank.

<u>*Low fill depth case*</u>

In the situation of a small amount of liquid in the tank (when the liquid fill is small in comparison with the tank depth), the velocity vector of a fluid particle is almost parallel to the tank bottom. Thus, the component of the velocity which is perpendicular to the tank bottom can be neglected and thereafter the particle velocity is independent of the vertical coordinate. At the low fill depth, the transient effects are important, and the interface of wet and dry domains develops along the tank bottom.

When the movement of the fluid is restricted in the plan of tank’s breadth and depth, the liquid is sloshing freely between the tanks sides as a response to the ship’s rolling motion.

When the fluid is moved to one side and the tank bottom becomes partially dry, the natural tank period and the ship’s rolling period closely match. This is the situation of resonance when a hydraulic jump if formed and travels back and forth between the tank walls and the energy of the fluid particles crossing the jump is not conserved.

*Deep fill depth case*

In the situation of tanks filled with large amounts of liquid, the period of the main excitation due to the rolling motions and the greatest natural period do not closely match, because the former is much greater than the later. Thus, the liquid free surface remains essentially flat but it may be oblique.

In the deep fill depth case, can be applied the multimodal method to a domain assumed with a small opening which is based on the fact that the small variation of the domain does not change the eigenmodes significantly [Faltinsen & Timokha, 2009].

For the relative slow motions of the ship, only the gravitational force is expected to play an important role. If the volume of the liquid inside the tank remains constant during the roll motions, then the position of the liquid free surface can be described by only one parameter, the transversal surface slope.

From the Lagrange equation can be derived the equation of motion of the liquid free surface as

$$\ddot{\psi} = \frac{g}{\partial \dot{y} / \partial \psi} \sin(\varphi + \psi) \cdot \cos\psi \cdot \cos\beta \qquad (3)$$

where, $\dot{y}$ is the position of the centre of gravity of the liquid in the tank's breadth direction and $\beta$ is the pitch angle.

During ship motions in seaway, the ship's resistance to the effect of external heeling moments will decrease due to the increasing intensity of liquid cross-flow from side to side of the compartment.

The sloshing phenomenon is a very big problem in tanker ships, because if the tanker ship is partly filled, sloshing of cargo from one side to other side occurs and could cause the damage of the structure or even capsizing. This is the result of the fact that when the acceleration of the ship is too high or when the external excitation frequency is closed to the frequency of the liquid cargo in the tank, violent oscillations of the liquid may occur [10].

The design improvement is to separate the tanker into several smaller areas (cargo tanks) or to install additional plates inside the cargo tanks. These plates contribute to lower the amplitude of the liquid's oscillations and thus to reduce the impact forces on the structure. Both practices are used today in tanker ship construction.

Sloshing is also of concern for shuttle tankers and Floating Production Storage and Offloading units. The severity of sloshing is related to possible filling level restrictions for ships that are carried fluid products such as FPSOs, shuttle tankers, oil tankers or gas carriers. Of course the bulk carriers are exposed to such dangerous phenomenon since ballast exchanges are required outside the port and lead to possibilities of slamming damages, with particular concern for the hatch covers.

The modelling of ship motion coupled with liquid sloshing is a complex problem which has to be solved in order to increase the safety of tanker ships [11].

## 3. SSESSMENT OF FREE SURFACES ON BOARD SHIPS

Nowadays, on board ships, assessment of ship's stability is based on the stability criteria published by International Maritime Organization through Resolution A749(18) or Intact Stability Code 2008, known as IS Code 2008. According to above mentioned recommendations, the initial calculated metacentric height should be corrected for the free surface effect of liquid for any partly filled tanks up to the level of 98% from its volume.

As stated in the IS Code, the correction for free surface effect may be done by any of the accepted methods:

- Based on the moment of inertia of tank's horizontal projection,
- Based on the actual moment of fluid transfer calculated for each angle of heel.

In the first method, which is very common, the correction for free surface of liquid is ascertained by the a formula

$$\delta GM = \frac{i \cdot \rho_{lt}}{\Delta} \qquad (4)$$

where, $i$ is the moment of inertia of tank's horizontal projection the tank is in upright condition (without any angle of inclination), $\rho_{lt}$ is the density of the liquid contained in the partly filled tank and $\Delta$ is the ship's displacement.

The above formula is based on the assumption that the liquid surface is always same as the waterline, i.e. straight, and depends only on the ship's angle of inclination, as presented in Figure 2.

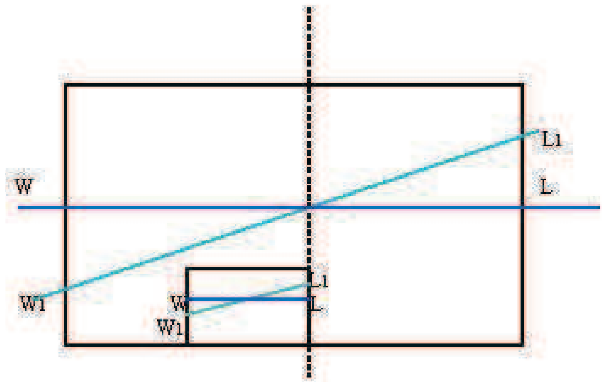



Figure 2. Same condition of waterline and liquid's free surface in partly filled tank

Due to wide stability margins provided, the correction given by the eq. (4) is safer than the correction based on the moment of fluid transfer for each angle of heel. However, in the situations where particular conditions are met, like:

- the tank has a rectangular form with wall-sides;
- the tank is low filled (the liquid surface is less than the tank's bottom / roof surface);
- the angle of ship's heel is small enough as $tg\varphi \approx \sin\varphi$.

both methods of assessment the free surface correction create almost the same results.

There is a limited range of heel angles, which are highly dependent on the tanks height to breadth ratio, for which the free surface correction, calculated with any recommended method, ensuring equal values. However, despite the limitations, the formula from eq.(1) is commonly used worldwide. Due to significant values of the free surface corrections, noted on board of various types and sized of ships, the determination of proper free surface effect is of great importance for the correct assessment of ship's stability.

## 4. HE EFFECT OF FREE SURFACES ON VESSEL STATIC STABILITY

The most common relation which determines the free surface moment of a liquid in an upright tank is

$$FSM = I \cdot \rho_{lt} \quad (5);$$

where, $I$ is the transverse second moment of area of tank waterplane and $\rho_{lt}$ is the density of the fluid in the tank.

The eq.(5) reveals the that volume of fluid in the tank is not influencing the free surface moment. However, in reality FSM is influenced by the volume of the liquid in the tank this fact being reflected by value of the FSM for different levels of fluid in the tank.

The shape of the tank has a major influence on FSM value, as the transverse second moment of inertia is fully dependent especially on the tank breadth.

The presence of a free surface liquid on board acts as a mechanism that shifts the natural roll period of the ship depending on the geometry of the tank, its own position on respect to the centre of mass of the ship and on the liquid depth [9].

For the study of a free surface fluid moving we considered a tank with rectangular cross-section filled with liquid up to half of its total height. The tank is then heeled to an angle φ. The area of the immersed and emerged wedges are calculated as

$$S = \frac{b^2 \cdot \tan\varphi}{8} \quad (6)$$

The centre of gravity of the fluid, upon heeling the tank, can be found by taking moments about the initial position of the tank's center of gravity as follows:

$$y_g = \frac{b^2 \tan\varphi}{6h}$$

and

$$z_g = \frac{b^2 \tan^2\varphi}{12h}. \quad (7)$$

As the fluid centre of gravity shifted to heeled part, this led to shifting of vessel's centre of gravity which is influencing the reduction of righting lever. The reduction of righting lever, can be calculated from the horizontal shift of the tank centre of gravity with the relation

$$\delta GZ = \delta y_g \cdot \frac{V_t \cdot \rho_{lt}}{V_s \cdot \rho_{sw}} \quad (8)$$

The free surface moment can be also calculated, as in the most commonly way of approaching, by considering that the shifting of tank's centre of gravity is equal with, is producing, a virtual rise of the vessel's center of gravity and can be calculated by the relation

$$\delta GZ = \frac{FSM}{V_s \delta_{sw}} \cdot \sin\varphi \quad (9)$$

then, the relation for free surface moment became,

$$FSM = \frac{\delta y_g \cdot V_t \cdot \delta_{lt}}{\sin\varphi}. \quad (10)$$

If the horizontal shift of the tank center of gravity is calculated as

$$\delta y_g = \frac{b^2 \tan\varphi}{6h}\cos\varphi + \frac{b^2 \tan^2\varphi}{12h}\sin\varphi, \quad (11)$$

then, the final form of free surface moment is

$$FSM = \frac{V_t \cdot \delta_{lt} \cdot b^2}{6 \cdot h}\left(1 + \frac{\tan^2\varphi}{2}\right). \quad (12)$$

The eq. (12) is valid for the moderate heel angles in the range of

$$0 \le \varphi \le \tan^{-1}\left(\frac{h}{b}\right) \quad (13)$$

If the heel angle is increased in the range of

$$\tan^{-1}\left(\frac{h}{b}\right) \le \varphi \le -\tan^{-1}\left(\frac{h}{b}\right) \quad (14)$$

then, the free surface moment is given by the relation

$$FSM = V_t \cdot \rho_{lt} \left[ \frac{h}{4} + \frac{b}{4\tan\varphi} - \frac{h^2}{6b\tan\varphi}\left(1 + \frac{1}{2\tan^2\varphi}\right) \right] \qquad (15)$$

From the eq. 912) and (15) it is noted the importance and the influence of the heel angle of ship on free surface moment.

It is also important to be mentioned that the eq. (13) and (15) are valid only in the case of prismatic tanks with rectangular cross section and half filled with liquid. Of course similar equations could be derived for other shapes of compartments but we believe that is a complicate approach and however will be possible only by a computer model where the actual position of the liquid inside the compartments, taking into consideration the heel and trim of the ship, is easy to be computed.

## 5. HE INFLUENCE OF LIQUID DYNAMICS ON SHIP STABILITY

When on board vessel a compartment partly filled with a liquid, which generates free surface, is engaged in roll motions (during ship's rolling), at lower depths of the liquid it will be developed resonance frequencies with high wave amplitudes. In this respect, it is formed a strongly non-linear phenomenon, called hydraulic jump, which moves periodically between the sides of the compartment.

If it is considered a rectangular compartment with length (l), breadth (b), filled with liquid, of density ρ, up to a certain level h, the natural frequency of the surface waves inside the compartment, during rolling, will be

$$\omega_{lw} = \sqrt{k \cdot g \cdot \tanh(kh)} \qquad (13)$$

where, k is the wave number, calculated as a function of wave length which in this situation is twice the breadth of the compartment.

When the motion of a ship, with liquids in compartments, is examined in seaway, two problems are to be approached:

- The liquid oscillations in compartments (sloshing problem), which is key problem, and the solving solution is based by using the method of liquid motion velocity for description of liquid volume oscillations. In this approach, the solution is presented in a analytical form, it considers the ship with the liquid on board as a whole.
- Solving the combined equations of ship and liquid oscillations during motion of ship in seaway, which is connected with numerical integrating of the equations of hydrodynamics. This method is more convenient for calculate the free surface in any moment of time and the impact loads within the compartments.

If the compartment that contains the liquid is limited to angular oscillations, the free surface of the liquid will develop a heeling moment which consists in three components as follows:

$$M_{th} = M_s + M_m + M_v \qquad (14)$$

where,

- $M_s$ - is the component caused by the shifting of liquid centre of gravity in the same direction with ship inclination due to liquid cross-flow. It is in connection with the compartment angle of inclination and results in a form of free surface plane rotation relatively to the compartment sides.
- $M_m$ - is the component caused by the liquid mass of inertia, manifested in the additional shift of its centre of gravity;
- $M_v$ - is the component related with the angle velocity, explained by the loss of liquid volume motion energy due to friction forces.

By using an increment for a metacentric height, the influence of liquids with free surface on ship stability may be taken into consideration within the limits of linear approximation and the restoring moment can be presented in the form of

$$M(\phi) = \rho \cdot V(GM_0 - \delta GM) \cdot \phi \qquad (15)$$

where, stability reduction factor due to free surface effect can be determined from the relation

$$\delta GM(\omega) = \delta GM_l(1 + \frac{z_l \cdot \omega^2}{g}) \cdot \Omega_l(\omega)\cos\xi_l(\omega)$$

where: $z_l$ is the distance between liquid mass centre and ship's centre of gravity, $\Omega_l(\omega)$ is the amplitude-frequency characteristic, $\xi_l(\omega)$ is the phase-frequency characteristic and $\delta GM_l$ is the correction for free surface applied to metacentric height.

During motion in a seaway, the intensity of liquid cross-flow from side to side of the compartment, is increased by the liquid sloshing and thus will lead to decreasing of ship's resistance to the effect of external heeling moments. This decrease will be more pronounced in case of ships in damaged condition with flooded high positioned decks or platforms.

## 6. CONCLUSIONS

An essential element of ship stability assessment is the movements of liquids inside partly filled tanks which however, presently is based only on a static approach with the use of free surface corrections. A more reliable assessment of ship stability is the dynamic approach towards liquid sloshing phenomenon. As being a complex approach, the studied phenomenon depends on a various important variables and thus cannot be considered only with the use of some simple formulas as in the situation of static approach. A dynamic approach of sloshing phenomenon looks to be close to reality as it enables more reliable assessment of ship stability. As the phenomenon of sloshing depends on a list of various and essential variables, it cannot be characterized only with the use of simple formulas like in the case of the static approach.

It was demonstrated that the free surface moment is far to be a constant value as the vessel's heel angle is modified. For this reason, it is recommended that the assessment of ship's intact stability at large angles of inclination should take into account the effects of free surfaces in tanks by modelling the actual position of the fluid in tank rather than approximating this effect from the tank free surface in the upright condition.

In the future addressing problem of partly filed tanks with influence on ship stability it is very important to be established when the sloshing has the maximum effect in respect with the level of the liquid, in order to be avoided. Moreover, the interaction between roll, sway and liquid motion it is important to be studied having in view the effects that the sway motion of the ship can cause the sloshing of liquids in compartments or tanks on board ships.

## 7. REFERENCES

[1] *Final Report and Recommendations to the 22nd ITTC,* The Specialist Committee on Stability, Trondheim, Osaka, Heraklion, St.John's, Launceston 1996-1999.

[2] ARMERIO V., - *A Critical Review about Analytical and Numerical methods Applied in the Analysis of Sloshing Loads in Compartments*, Report No 81, Institute of Naval Architecture, University of Trieste, Italy, 1991.

[3] TVEITES P., OSTVOLD T.K., PASTOOR L.W. & SELE H.O., *A sloshing design load procedure for membrane LNG tankers*. Proceedings of the 9th Symposium on Practical Design of Ships and other Floating Structures, Luebeck-Travemuende, Germany, 2004

[4] GRAHAM E.W. & RODRIGUEZ A.M., *The characteristics of fuel motion which affects airplane dynamics*. Journal of Applied Mechanics, 1952, 381-388.

[5] LEWISON G.R.G, *Optimum design of passive roll stabiliser tanks*. RINA Transactions and Annual report 1976, pp.31-45.

[6] STOKER J.J., *Water waves. Pure and applied mathematics*, Vol IV, Interscience, New York, 1957

[7] LEE T., ZHOU Z & CAO Y., *Numerical simulations of hydraulic jumps in water sloshing and water impacting.* Journal of Fluid Engineering 124, 22.215-226, 2002.

[8] *Code on Intact Stability for all types of ships covered by IMO instruments*. Resolution A.749(18). IMO, 1995

[9] ARMENIO V., CARDO A., LA ROCCA M. & MELE P. *Numerical Prediction of Roll Motion of a Ship with Liquids on Board in Regular Waves from Different Directions*, Fifth International Conference on Stability of Ships and Ocean Vehicles, Florida, November 1994.

[10] DONGMIN L., *Three dimensional liquid sloshing in a tank with bafflers*, Ocean Engineering no.36, pp 202-212, 2009.

[11] MI-AN X., PENGZHI L., *Numerical study of ring baffle effects on reducing violent liquid sloshing*, Computer & Fluids no.52, 2011.

[12] FALTINSEN M., Sloshing, Department of Marine Hydrodynamics Norwegian University of Science and Technology, Trondheim, Norway.

# ENHANCING MANAGEMENT CAPACITY OF THE MARITIME INDUSTRY PERSONNEL

[1]ARSENIE PAULICA, [2]HANZU-PAZARA RADU, [3]BOYAN MEDNIKAROV, [4]KALIN KALINOV

*[1,2]Constanta Maritime University, [3,4]"N. Vaptsarov" Naval Academy Varna, Bulgaria*

**ABSTRACT**

Safety was and still is the most important aspect of activities onboard ships. In time, due to development of new threats against sea transport, security becomes the same importance with safety. Achieving of the present standards regarding ship, personnel, passengers and environment safety and security can be realized through a specific training. Taking in consideration actual requirements related to maritime transport safety and security, in particular at management level, Constanta Maritime University, in cooperation with Varna Naval Academy, have decided to initiate and develop a Master degree programme dedicated to training in these matters. This project is possible with the support of International Association of Maritime University (IAMU) and The Nippon Foundation in Japan. In the present paper is intended to present the objectives and goals of the project entitled "MAREM – Enhancing management capacity of the maritime industry personnel".

**Keywords:** *Safety, security, cooperation, master degree programme, IAMU research project*

## 1. INTRODUCTION

Today, the safety and security of life at sea, protection of the marine environment and over 90% of the world's trade depends on the professionalism and competence of seafarers. The IMO's International Convention on Standard of Training, Certification and Watchkeeping for Seafarers (STCW), with all amendments made, is the only one internationally-agreed Convention to address the issue of minimum standards of competence for seafarers, and, in the same time, to provide effective mechanisms for enforcement of its provisions.

Safety on board ships has come a long way in reducing accidents, but there is still a lot of scope to improve safety. Most of the accidents at sea are due to human error, which can be reduced by proper training and motivation. Accidents mainly happen due to lack of management, taking shortcuts, complacency, attitudes, etc. The responsibilities to avoid incidents based on safety and security flow from the top management levels, from the shore establishment to onboard management officers, especially to the Master, to each and every individual onboard.

The dynamic nature of the regulatory environment for security in the international trade and maritime transport requires that personnel involved have to maintain an active awareness of new or evolving requirements that may apply to their vessels and operations. This means being able to integrate the latest requirements into their existing security plans, to achieve the desired level of compliance with the letter and intent of the new regulations. In this way, is required that personnel with duties on ship security to maintain an awareness of changes or additions to the expanding universe of domestic and international regulations that may have an impact on their ability to maintain a secure operating environment.

## 2. THE "MAREM" PROJECT

The complexity of modern maritime transport and the increasing risks related to safety and security lead to a significant challenge to maritime education. The growth of international maritime trade, combined with the increased threats on maritime safety and security, lead to the necessity of better trained personnel onboard ships, able to manage these new situations and satisfy the highest levels of safety and security requirements on seas.

In line with this, the overall objective of the "MAREM" project is:

A) To develop a novel approaches for maritime academic safety and security programs that meet the requirements of modern maritime industry. The idea is to achieve the objective by establishing a Master degree program in Maritime transportation safety and security. Taking into account, on one hand, that maritime transportation is international by nature, and on the other, that the International Association of Maritime Universities (IAMU) goal is to develop a comprehensive Maritime Education System for following generations, the initial Master degree program is to be established in cooperation between two maritime universities - Constanta Maritime University (Romania) and "N. Vaptsarov" Naval Academy (Bulgaria).

Therefore, the project objectives are:

B) To establish an international cooperation in the area of modern maritime education. The cooperation between maritime institutions is not completed by the involvement of two universities. The project relies on academic participation of a wide variety of representatives from the maritime community: maritime industry representatives, involved authorities, Black Sea maritime universities, members of the International Association of Maritime Universities.

In this context and taking into account the International Association of Maritime Universities (IAMU) goal for preparing and developing standardized

Undergraduate Curricula and an International Certification System for Competency, the following two additional projects objectives are valid:

C) To establish a common understanding on the priorities of modern maritime education and a basis for common standards for maritime competency of the management personnel;

D) To enhance the cooperation and communication between maritime universities and maritime industry in the area of advanced maritime education and training.

## 3. ACTUAL CONSIDERATIONS ABOUT MARITIME SAFETY

The maritime safety has main objectives the reduction and elimination of accidents which involve injuries to ship' personnel and damage to property and the environment. These objectives can be reached through strong principles about safety. Accidents are the last step in a chain of deficiencies. To avoid accidents is necessary to eliminate previous deficiencies. Elimination of these deficiencies is made through safety policies applied in different activity sectors onboard ship, like safety of navigation or safety of ship operations.

In the maritime field, safety has to be seen as a culture and to be applied in all activities. From this point of view, safety is of interest of all management level officers, because improving of it saves lives and as well as money. When makes references to safety culture, experts commonly describe it as the values and practices that management and personnel share to ensure that risks are minimised and mitigated to the greatest degree possible. In a way, can be said always safety is the first priority. With a true safety culture, every crew member thinks about safety, and new ways of improving it. The cause of practically every unsafe incident can be traced to some form of human or organisational error. If people think about safety continuously, many accidents simply will not happen because virtually all so called "accidents" are in fact preventable.

For the analysis of maritime safety levels, International Maritime Organisation use concepts like Human Element Analysing Process and Formal Safety Assessment. The Human Element Analysing Process is a practical and non-scientific checklist to assist regulators in ensuring that all the human element aspects related to the ship and its equipment, and the master and his crew, have been taken into consideration.

Formal Safety Assessment is a structured and systematic methodology, aimed at enhancing maritime safety, including protection of life, health, the marine environment and property, by using risk and cost/benefit assessment. This concepts can be used as a tool to help in the evaluation of new regulations for maritime safety and protection of marine environment or making a comparison between existing and possibly improved regulations, with a view to achieving a balance between the various technical and operational issues, including the human element, and between maritime safety or protection of marine environment and costs.

An important step for increasing safety was done with the ISM Code implementation. The ISM Code brings policies and procedures used for a more valuable safety in all ship operations. In this spirit, a proper implementation of the ISM Code should result in a safety culture onboard ship. With all of these, can be a difference between complying with the letter of the ISM Code and fulfilling its spirit, the conscious practice of an attitude to safety in which all accidents are seen as preventable, and everything reasonably possible is done to ensure that accidents are actually prevented.

The achievement of a total safety culture goes beyond compliance with the ISM Code since it can provide a means of maximising the benefits and cost savings. As seafarers, may be compelled to follow certain procedures, but, as people, cannot be compelled to believe in these procedures or to think about the safety implications of everything that they are doing.

In order to maintain the required levels of safety, seafarers in charge with these matters, need to address all activities undertaken in the operation of the ship together with possible situations that may arise which would affect the safety of the ship or its operation. These activities and situations will involve varying degrees of hazard to the ship, its personnel and the environment. Careful assessment of these hazards, and the probability of their occurrence, will determine the severity of the risks involved.

In the actual context of maritime activities, professional skills related to maritime safety are, but not limited to:

- maintain a safe navigational, engineering and radio watches and a general surveillance of the ship;
- manoeuvre the ship in safety conditions;
- manage the safety functions of the ship during all operations;
- perform appropriate operations for the prevention of damage to the marine environment;
- maintain the safety arrangements and the cleanliness of all accessible spaces to minimize the risk of fire;
- ensure a safe carriage of cargo during transit;
- inspect and maintain, as appropriate, the structural integrity of the ship;
- operate the main propulsion and auxiliary machinery and maintain them in a safe condition to enable the ship to overcome the foreseeable perils of the voyage.

For certain categories of vessel, such as tankers, are laid down special training provisions, required for this type of vessel. For this categories of vessel there are particular mandatory minimum requirements concerning the training and qualifications of seafarers serving on board these specific categories of vessel. Related to safety, following matters have to be considered by seafarers, especially by those at management level:

- to provide safe practices in operation and a safe working environment;
- to establish safeguards against all identified risks;
- to maintain a continuous improvement of safety management skills, including preparing for emergencies related to safety and environmental protection.

## 4. BEST PRACTICES IN MARITIME SECURITY

Last years has seen a significant number of security regulations promulgated that are applicable to the maritime industry. Many of these share common imperatives, such as developing and maintaining current security plans and ensuring that appropriate training are provided. Some are specific to certain sectors of the maritime community and were developed to address deficiencies in the preventive security measures established mainly by ISPS Code.

All of this begs the questions of exactly who is responsible for what regulations as they apply to a specific port or vessel and how to effectively integrate these changes into the existing security structures and training curricula.

It is essential that security programs to maintain an active awareness of changes in the security regulations that pertain to their operations so that the training requirements and curriculum for the onboard personnel with designated security duties may be tailored to address both the letter and intent of the requirements. Training programs that focus solely on “checking the box” compliance for meeting the letter of the requirements, without addressing the accompanying practical components needed to achieve functional compliance, may not survive a due diligence evaluation by the agencies responsible for oversight and enforcement.

The specialised training regarding ship security is developed according to requirements stated by the International Ship and Port Facility Security Code (ISPS Code), which is a comprehensive set of measures to enhance the security of ships and port facilities, developed in response to the perceived threats to ships and port facilities. In essence, the ISPS Code takes the approach that ensuring the security of ships and port facilities is a risk management activity and that, to determine what security measures are appropriate, an assessment of the risks must be made in each particular case. The Code intent to provide a standardised, consistent framework for evaluating risk, enabling responsible entities to offset changes in threat with changes in vulnerability for ships and port facilities through determination of appropriate security levels and corresponding security measures.

The Code framework for ship security includes requirements like ship security plan, ship security officer, company security officers and certain onboard equipment. In addition, the following requirements are included: monitoring and controlling access, monitoring the activities of people and cargo, ensuring of availability of security communications.

Taking all of these in consideration, a person in charge with security onboard vessels have to comply with following requirements in order to protect the ship and the crew:

- to establish a framework to detect security threats and take preventive measures against security incidents affecting the ship;
- to establish roles and responsibilities for ensuring security;
- to ensure the early and efficient collection and exchange of security-related information;
- to provide a methodology for security assessments so as to have in place plans and procedures to react to changing security levels;
- to ensure confidence that adequate and proportionate maritime security measures are in place.

## 5. CHALLENGES FOR TRAINING IN MARITIME SAFETY AND SECURITY

Taking account the latest considerations about maritime safety and security, the maritime education and training have to be an active part of the maritime industry. This participation need to be made through specialised trainings, especially in these areas of interest where is most necessary. Safety and security needs in the maritime activities are in a continuous changing. New requirements are issued by international and national organisations in order to cover as much as possible all dangerous situations which can be met during ship’s operation. The compliance with these requirements is reached through an adequate training.

An adequate training is based on competencies. Through competencies are reached the necessary level of knowledge in any field of activity. Maritime safety and security is one of the activities where is required a specific level of knowledge and understanding, to be able to react and minimize any possible threat on safety or security of the ship.

Related to maritime safety, the following abilities are considered as necessary to be created following to a specialised training program:

- to have knowledge of the general dangers involved in shipboard operations;
- to understand the role of the safety policies;
- to understand the importance of identifying general hazards and spreading safety awareness;
- to carry out a risk assessment procedure;
- to be able to carry out accident investigation;
- to be able to handle stress and fatigue and to understand its implications to dangerous situations and accidents;
- to be able to apply the Formal Safety Assessment methodology;
- to understand the technological progress for safety reasons;
- to know the difference between monitoring diagnostics, management and control systems;
- to be able to deal with matters involving vessel safety systems;
- to be able to deal with matters involving public safety control;
- to understand the technological progress in navigation technology;
- to be able to apply the rules of the safe navigation;
- to be able to exchange general information on safety equipment carried by ships.

For maritime security training, the following abilities have to be considered:

- to be familiarized with matters related to maritime transport;
- to be able to understand the current threats against maritime vessels;
- to be able to identify the risk factors which can lead to dangerous situations for ship;
- to know and understand responsibilities related to security matters;
- to be able to apply the relevant security policies;
- to conduct ship security and associated risk assessment;
- to be able to implement effective search mechanisms and security controls;
- to be able to identify, recognize and response to different security threats;
- to be able to take actions for ship security;
- to deal with stowaways and piracy;
- to be able to identify weapons and improvised explosives devices;
- to know the capabilities and limitations of security equipment and systems.

## 6. MASTER DEGREE PROGRAMME ON MARITIME SAFETY AND SECURITY

As one of the main objective of the project, the master degree programme is developed starting from identified considerations, visions and trends in the field of maritime safety and security. The approach of these subjects will be done at a management level manner, considering practical experience and knowledge already acquired by the trainees during their previous activity on ships.

Considering these aspects and the European and international requirements for master degree training, present master programme is organised on three semesters of 15th weeks, with 1350 study hours, lecturers and applications. In the same time, at the end of this programme, a graduate will collect a number of 120 ECTS.

As structure, every semester have four courses, except the last one, dedicated mainly to final paper preparation. First semester is intended to cover subjects regarding maritime safety matters, when the second semester is more focused on security matters.

At the end of the master degree programme, the trainees will have a complete knowledge about identification of safety problems and security threats and will be able to successfully apply solutions to minimize or eliminate completely these problems.

## 7. MANAGEMENT OF SECURITY THREATS

The first course developed as part of the future master programme, was "Management of security threats". This course was created and generated by project team members from Varna Naval Academy.

This course aims to prepare new recruits for a life at sea, to give them profound knowledge and enough practical exercises considering: genesis, types and current Maritime Security Threats, methods of conducting through the analysis of the risk for the Maritime Security, the basis of the management's risks for the Maritime Security. It also aims to give a lot of examples about opposing against Maritime Security.

The expected objects of this course must be accomplished through the realization of the main tasks:

First - those who successfully complete this course will claim knowledge about:

- Current problems of the Maritime Security and basis of Strategy for Maritime Security Management;
- Legal regulation of Maritime Security – International, Allied, Regional and National regulations;
- Special features of the European requirement for Maritime Security – Directive 65 – Regulations 725;
- Politics about Maritime Security – Global, Regional, National;
- Current Maritime Security Threats – Typology and Nature;
- Definition, frames, factors for the beginning of the terrorism, piracy and armed robbery, stowaways, organized crime, internal sabotage, inter-state hostilities;
- Methods for valuation the risk of a critical marine unit's security;
- Fundamentals of Scenario Approach in Maritime Security;
- Organization and qualities of the main parts of the National System of Maritime Security;
- Bases of the security assessment of a critical marine unit;
- Intelligence and Maritime Forces and their Role in Maritime Security;
- Mitigation Strategies for Enhance Maritime Security;
- Maritime security equipment;
- Maritime security responsibilities and authorities;
- Bases of the security of a critical marine unit;
- Maritime Security Administration;
- Ship and Port Security Contingency Planning;
- Organization of the tuition of opposing against Maritime Security Threats;
- Methods for conducting tuition and trainings considering the Maritime Security;
- The meaning of the computers in the Maritime Security trainings.

Second - those who successfully complete this course will be able to:

- Defining the frames of analysis of each threat against the Maritime Security – historical, geographical, legal;
- Identification of potential main points of the Maritime Security Threats;
- Revealing the connection of actual Maritime Security Threats;
- Making analysis of Maritime Security Threats;
- Making valuation of the situation in the Mediterranean-Black sea region
- Prognosticating the development of the main Maritime Security Threats in the Mediterranean-

Black sea region;
- Extraction of useful lessons from past Maritime Security Threats;
- Fulfillment of the main steps of the methods of security assessment of a critical marine unit;
- Application of Scenario Approach in Maritime Security Threats;
- Applications of Scenario Approach in Maritime Security Vulnerabilities;
- Orientation in the mission, functions, tasks and the organization of a National Maritime Search and Rescue Coordinative Center;
- Using of the main Maritime Security Equipment;
- Putting the main points from the different plans of security into practice;
- Organizing the interaction between the National Institutions with responsibilities of the Maritime Security;
- Reacting in different situations of Maritime Security.

After the successful completion of the course of education the recruits could:
- Work as an expert in National Governmental or Non-Governmental organizations, connected to the and the Maritime Security and Safety.
- Work as an expert in International, European and Regional structures, connected to the Maritime Security and Safety.
- Work as an expert analyzing the risk in recognized organization for Maritime Security.
- Work as an officer or expert of Security in the National Maritime and Port Administration.
- Work as an officer or expert of Security in the Ship Company.
- Raise his qualification as an officer from Naval Forces in the Naval Coordination and guidance of shipping as a tool of Maritime Security.

The teaching programme satisfies completely the demands of the National Standards for preparation of different officials, considering the questions of the Maritime Security. After taking the necessary exams in the National Maritime Administration, the student could be certificated as an Officer of the Security of the Company, port facility equipment, or if the officer is a certificated seafarer as an Officer of the Security of a ship for International Sailing considering the ISPS Code and the Manila Supplements of the STCW Code. An additional advantage for the trainees, successfully taken the course, is the knowledge about ATP-2 vol II, given them effective knowledge for their interaction with the Naval Forces.

## 8. SAFETY BASED SHIP DESIGN

Second course scheduled was “Safety based ship design”, created by lecturers from Constanta Maritime University, members of project teams.

Safety based ship design aims at a systematic integration of safety risk analysis in the design process with prevention and reduction of risk to life, property and environment, embedded as a design objective, alongside standard design objective such as speed, cargo capacity, passenger capacity, and turnaround times. This implies the adoption of a methodology that links safety risk prevention/reduction measures to ship performance and cost by using relevant tools to address ship design and operation. This can be considered a radical shift from the current treatment of safety, as a design constraint imposed by rules and regulations. The present concept offers freedom to the designer to choose and identify optimal solutions to meet safety targets. For safety based ship design to be realized, safety must be treated as a life cycle issue, which in turn implies focus on risk-based operation and need for a safety-based regulatory framework.

Safety based ship design is expected to satisfy the international maritime industry need to deliver ever more innovative and competitive transport solutions to their customers as well as a wider societal need for increasingly safer transport. Is expected this concept to deliver the foundation for the maritime sector to sustain world-leadership on safety-critical and knowledge-intensive ships, maritime services, products, equipment and related software.

Having successfully completed the course, the student will be able to demonstrate knowledge and understanding of:
- Tools and methodologies used in ship design process
- Statutory and regulatory requirements in ship design
- Needs to integrate safe design and operation within the ship design process
- Safety assessment methodology and risk acceptance criteria in ship design
- Concept of reliability based design in ship building
- Design principles and criteria
- High-level approval process for novel and risk and safety based design
- Operation of safety based designed ships
- Role of safety based ship design in collision and grounding
- Ship damage stability and survivability
- Safety based design for fire, explosion and evacuation in these situations

Having successfully completed the course, the student will be able to:
- Apply design tools and synthesise safety information
- Apply the methodology and tools used in the ship design process
- Interpret and apply statutory regulations and classification rules
- Estimate suitable dimensions according with the safety requirements, carry out checks on ship capacity, mass balance and compliance with statutory regulations, including assessment of ship economic viability
- Ensuring the arrangement meets the requirements for layout, capacities, choice of deck equipment and machinery, safety and statutory regulations

## 9. CONCLUSIONS

From the beginning, the maritime transport was the most profitable way for goods carrying, and the safety and security of this have to be treated as an important part. Problems related to ship safety and security affect the entire personnel, but, main responsibility for these are at management level.

To avoid problems generated by the missings of ship safety or security systems, need to exist specialized training for those in charge with these aspects. This was one of the reasons for designing and realization of the master degree programme in maritime safety and security.

At graduation, trainees will be able to understand risks and threats for ship safety and security and will be able to manage in a right manner these situations to protect ship, personnel, passengers and the enviroment.

## 10. ACKNOWLEDGMENTS

The materials and data in this publication have been obtained through the support of the International Association of Maritime Universities (IAMU) and The Nippon Foundation in Japan.

## 11. REFERENCES

[1] Austin, M., Samadzadeh, M., *An Objective Method to Measure the Effectiveness of a Risk Management System*, In proceedings from 19th International Conference on Systems Engineering, pp. 508-511, 2008

[2] Besse, P., Boisson, P., McGregor, J., *What classification rules for the future and what future for classification,* RINA Conference on Developments in Classification & International Regulations, 24-25 January 2007. London, UK., 2007

[3] Ditlevsen, O., *Decision Modeling and Acceptance Criteria. Structural Safety*, Vol. 25, No. 2-4, 139-163, 2003

[4] Guedes Soares, C., Das, P. K., *Analysis and Design of Marine Structures*. Leiden: CRC Press, 2009

[5] European Training Manual for Maritime Security Personnel/ISPS Code, Project team Nico J. Bezemer, Frans Mahn, Fredrik Cornell, Johan Ohlsson and Marc Wille, CoESS Working Committee Maritime Security,CoESS 2008

[6] Fisher, Robert J., Edward Halibozek, and Gion Green, *Introduction to security*, Amsterdam, Elsevier, 2008

[7] ICC, *Piracy and Armed Robbery against Ships*, 2011 Annual Report, January 2012

[8] International Chamber of Shipping. (2001, November). *Guidance for Shipowners, Ship Operators and Masters on the Protection of Ships from Terrorism and Sabotage*, London

[9] IMO Resolution A.867 (20) *Combating unsafe practices associated with trafficking of transport of migrants by sea*, November 1997

[10] IMO Resolution A.871 (20) *Guidelines on the Allocation of Responsibilities to Seek the Successful Resolution of Stowaway Cases*, November 1997

[11] IMO *Manila Amendments to the annex to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (STCW), STCW/CONF.2/33

[12] Papanikolaou, A. (Ed.), *Risk-Based Ship Design*, Springer Publishing, Berlin, 2009

[13] Touchot, Arthur, *Piracy: Operation Ocean Shield.*,The National Strategy Forum Review. Winter/Spring 2012 Volume 21, Issue 1-2

[14] UNO on Drugs and Crime (UNODS). *The Globalization of Crime,* A transnational Organized Crime Threat Assessment, Vienna, 2010

[15] EMSA Official site www.emsa.europa.eu

[16] IMO Official Site www.imo.org

[17] NATO Shipping Center www.shipping.nato.int

[18]OECD Maritime Transport Committee www.oecd.org

[19] UN Official site www.un.org

# EXTREME WEATHER CONDITIONS DUE TO EX-TROPICAL CYCLONE OSWALD

BOSTINA ALINA-LUCIA

*Constanta Maritime University, Romania*

**ABSTRACT**

In January 2013, ex-Tropical Cyclone Oswald and associated monsoon trough passed over parts of Queensland and New South Wales, Australia over a number of days, causing widespread impact including severe storms, flooding, and tornadoes. Coastal regions of Queensland were the most impacted with Mundubbera and Bundaberg in the Wide Bay-Burnett hit severely. In the wake of Oswald, torrential rain and record breaking winds, tidal surges, and even tornados rushed over the East Coast. In many places the rainfall total for January set new records. Across the affected region, damage from severe weather and flooding amounted to at least 2.5 billion$

**Keywords:** *ex-tropical cyclone, Queensland, hazard, flooding, damages, storm surges r.*

## 1. INTRODUCTION

The cyclone Oswald had formed in the Gulf of Carpentaria just north of Australia. It was degraded to an ex-tropical storm when making landfall on Queensland's coast on January 22. Slowed down by a low pressure system, the storm hugged south-east Queensland for days before moving further south towards New South Wales.

This event is a meteorological hazard for the area where it occurs. There are situations in which tropical cyclones occurs predictable and known limitations, and cases in which such phenomena translates into material losses and even victims.

During cyclones, many treacherous acts of nature can occur. Some of which include high wind speeds, heavy, on-going rain, flooding, and even miniature tornadoes. Sadly, cyclone Oswald possessed all of these attributes which plagued the east coast of Australia and caused a terrific amount of damage to the cities, streets, and neighborhoods.

The terminology of hazard analysis is often used inconsistently. In common language "hazard," "vulnerability," and " risk" are often used almost interchangeably.

These terms, however, all have dist inct meanings: *Hazard* refers to the occurrence of the actual event that threatens human development .

*Vulnerability* refers to the susceptibility of human development to harmful impacts of that hazard.

*Risk* refers to the likelihood of suffering harm from the hazard in question.

**Definitions:**

A **hazard** is any agent that is reasonably likely to cause harm or damage to humans or the environment with sufficient exposure or dose.

**Risk** is the probability that exposure to a hazard will lead to a negative consequence, or more simply, Risk = Hazard x Dose (Exposure).

A hazard poses no risk if there is not exposure to that hazard.

## 2. CYCLONE – A HAZARDOUS PHENOMENON

A cyclone is a violent storm characterized by high winds rotating about a calm center of low atmospheric pressure that can produce winds in excess of 200 km/h which can cause extensive damage and result in death or injury caused by flooding, buildings collapsing or flying debris into dangerous missiles.

Cyclones can also bring flooding rains, which cause further damage to property, and increase the risk of drowning.

Many cyclones also bring about storm surge, which is a rapid rise in sea level that moves inland very quickly. Storm surge can damage buildings and cut off evacuation routes and be the cause of injuries and sometimes death.

While most deaths from cyclones occur as a result of drowning, many lives have been lost due to collapsing buildings or flying debris which can become lethal in high winds.

## 3. CYCLONE IN QUEENSLAND, NORTH EASTERN-AUSTRALIA

Tropical cyclones typically form close to the equator in the southwest Pacific Ocean. It is from the warm equatorial waters that cyclones derive their energy. Most cyclones play out their whole life in the tropics. Sometimes though, a few cyclones migrate out of the tropics into the mid-latitudes, close to New Zealand. As they move south into cooler waters generally, their central core cools causing the cyclone to weaken. Some cyclones can re-intensify to become mid-latitude "ex-tropical cyclones".

Queensland is vulnerable to many natural and man-made hazards*. **Every year between November and April, the coastal regions of Queensland are at risk of being hit by cyclones***.

The risk of storm surge is the most dangerous hazard associated with cyclones and can cause flooding of low-lying coastal areas. Most cyclone-related deaths are from drowning in a storm surge or flood.

Storm surges happen when the high winds of a cyclone whip up the sea, generating a massive movement of seawater inland that can last several hours. They are at least 50 kilometres wide and can be up to several metres high. Storm surges can swamp coastal areas. Low offshore islands may be completely inundated. The damage is worse when a storm surge coincides with high tide or river flooding. The combination of storm surge and normal ocean tide is known as "storm tide".

Queensland's weather systems are changeable and unpredictable.

## 4. CASE OF OSWALD EX-TROPICAL CYCLONE, QUEENSLAND, AUSTRALIA, JANUARY 2013

The low pressure system that was tropical cyclone Oswald is continuing to wreak havoc across the state, five days after it made landfall on Cape York Peninsula.

NASA's Aqua satellite passed over Oswald's remnants on January 25 at 14.58 UTC (9:58 a.m. ES/U.S.) as it hugged the southeastern coast of Queensland, dumping heavy rainfall.

Ex-tropical cyclone Oswald doesn't know when to stop causing problems for Queensland, Australia, and teamed up with a low pressure area, it continues to bring heavy rainfall. NASA's Aqua satellite passed over the remnants and saw Oswald hugging the southeastern Queensland coast.

On Saturday, January 26 at 4 a.m. Queensland local time (or 3 p.m. EST/U.S. on Jan. 25) ex-Tropical Cyclone Oswald was located over land in Queensland, Australia, about 55 nautical miles (63 miles/ 102 km) northeast of Emerald and 85 nautical miles (97.8 miles/ 157.4 km) west northwest of Rock Hampton. Oswald and a trough of low pressure are bringing heavy rainfall to eastern Queensland. The trough, an elongated area of low pressure, stretches from the southern Gulf of Carpentaria to ex-Tropical Cyclone Oswald and over to the southern Capricornia coast. Ex-Tropical Cyclone Oswald and the trough are expected to continue moving southwards over the next few days.

Residents have expected gusty winds, rough seas, heavy rainfall, and possible flash flooding.

There were gale warnings in effect over many areas, including: St. Lawrence to Burnett Head; Burnett Heads to Double Island Point, including Hervey Bay; Double Island Point to Point Danger, including Moreton Bay; and Bowen to St. Lawrence.

According to the Australian Bureau of Meteorology (ABM), on January 25 at 2 p.m. EST, the heaviest rainfall was occurring over the southern Capricornia district. ABM noted that rainfall in excess of 27.5 inches (700 mm) in less than 2 days, leading to rapid river and stream rises in the area.

The extreme weather system across eastern Australia is caused by the remnants of Tropical Cyclone Oswald which began in the Gulf of Carpentaria near northern Australia.

Three people have died in Queensland as the remnants of Tropical Cyclone Oswald continue to wreak havoc in eastern Australia.

Three people have died in Queensland as the remnants of Tropical Cyclone Oswald continue to wreak havoc in eastern Australia.

More than one meter of rain has fallen in the state in a twenty-four hour period.

People living in Sydney have been warned to expect torrential downpours as the ex-tropical cyclone moves slowly down the New South Wales coast.

The state capital, Brisbane, has been hit hard: around 200,000 houses are without electricity and many roads are closed.

In the Queensland city of Bundaberg, 300 kilometers north of Brisbane, 1200 properties have been flooded and helicopters have been used to rescue 18 people from their rooftops.

In the small beach town of Mooloolaba, Queensland, weather conditions have churned sea water producing foam on the land.

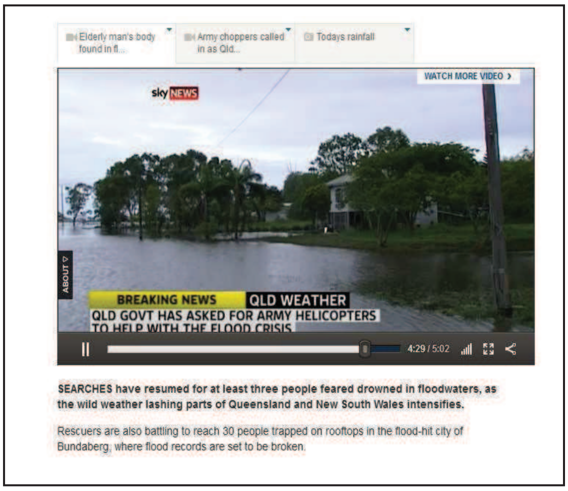



Fig.1 Queensland Weather in Media

On January 27, the Australian Bureau of Meteorology Brisbane issued a High Seas Weather Warning announcing storm force warning for north-eastern area. Ex- tropical Cyclone Oswald has 994 mb (hPa).The forecast tell about NW to NE winds 34 to 45 knots. Wind reaching 45 to 50 knots within area bounded by 26.5S 153E to 26.5S 155E to 28S 155E to 153E, easing below 45 knots after 00.00 UTC in 28 January. Also are predicted scattered squalls with gusts to 65 knots, very rough to high seas and moderate to heavy N to NW swells.

All ships in area are requested to send weather reports every three hours using normal channels.

On January 28, for people in the Southeast Coast and parts of the Wide Bay and Burnett and darling Downs and Granite Belt Forecast Districts has issued a Severe Weather Warning.

At this time, the system of low pressure was moving east southeast at about 10 km/h and was expected to move into New South Wales later.

This warning is for damaging wind gust in excess of 90 km/h that still occurring in central and southern parts of Southeast Coast district. And locally destructive wind gust in excess of 125 km/h are also possible, chiefly in coastal and elevated areas south of Brisbane. Wind gusts of 90 km/h have been recorded in coastal areas around

Moreton Bay. Rainfall has eased throughout the area. Heavy rainfall which may lead to flash flooding is no longer expected. Flood Warnings remain current for various rivers and streams in these districts. Water levels on the morning`s high tide are likely to exceed the highest tide of the year about coastal and island location of Burnett Heads to the New South Wales border. The sea level is likely to rise above the normal tide and the exposed beaches will experience damaging waves and flooding of some low lying areas close the shoreline. Also, there are dangerous surf conditions, with significant beach erosion, that continue along the coast from Double Island Point to the New South Wales, including northern parts of Moreton Bay.

The same day, January 28, Australian Government Bureau of Meteorology issued Coastal Waters Wind Warning. At 4 a.m. EST, Ex-Tropical Cyclone Oswald was located over land about 108 nautical miles west northwest of Brisbane and was moving east southeast at 6 knots and is expected to move across the New South Wales border, later.

For area Burnett Heads to Double Island Point, including Hervey Bay is announced Gale Warning, N to NE winds 34 to 40 knots, easing to 25 to 33 knots by around sunrise and scattered squalls with gusts to 55 knots. Also, seas 5 meters, with a 4.5 m E to NE swell. Waves and swell breaking dangerously inshore.

In Double Island Point to Point Danger, including Moreton Bay there was Storm Force Wind Warning.

NW to NE winds 40 to 45 knots, reaching 45 to 50 knots at times. Winds decreasing to 34 to 40 knots during the afternoon. Scattered squalls to 65 knots.

Seas 4 to 5 meters, reaching 6.5 m south of Noosa. Waves and swell breaking dangerously inshore.

In the following figure (2) is an overview of the weather in the Gold Coast, for data 28th and 29th January, near the end of the range of expression of ex-tropical cyclone Oswald.

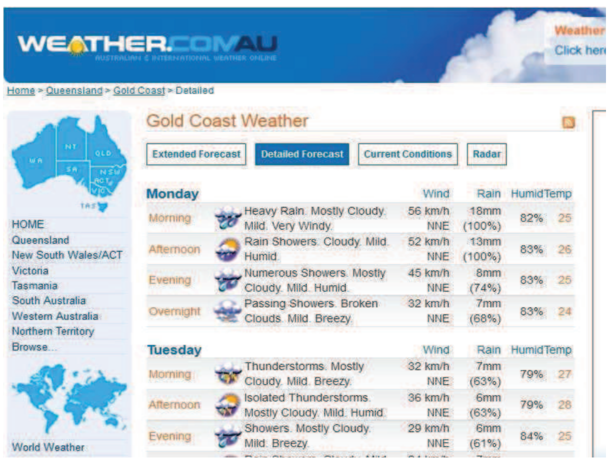



Fig.2 Gold Coast Weather -Detailed Forecast

In Figure 3, the map shows the distribution of isotherms in the upper layer of water in the period analyzed in this paper.

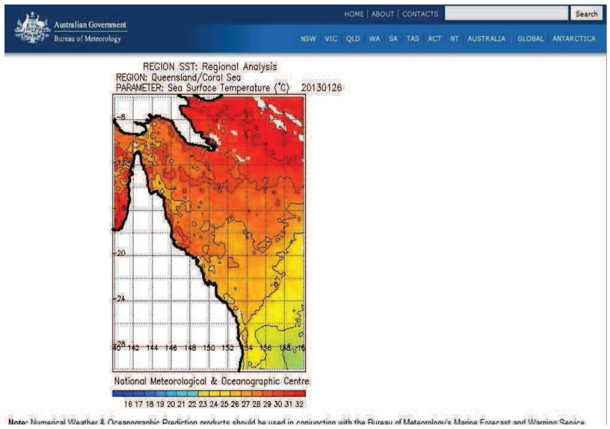



Fig. 3 Gold Coast – Water Temperature

## 6. AREAS AFFECTED BY CYCLONE OSWALD AND CONSEQENCES

Areas affected by cyclone Oswald and conseqences: Brisbane, Sunshine Coast, Gympie, Bundaberg, Gladstone, Sydney and Northern part of New South Wales.

**Gladstone:** 900 homes evacuated with Boyne Island and Tannum Sands both experienced unprecedented flooding. Homes flooded up to their ceilings at Baffle Creek.

**Bundaberg**: body of elderly man pulled from water at Burrum Heads. Burnett River breaks its banks, up to 100 homes and businesses flooded with fears up to 200 others could be inundated, disaster declaration covers most low-lying suburbs. Region hit by six tornadoes.

**Gympie:** man missing in floodwaters after trying to cross Widgee Creek. People rescued from roofs in Widgee and Sexton, authorities searched for a woman who was last seen driving into floodwaters.

**Sunshine Coast**: storm surges, 125 km/h winds and torrential rain, about 26500 homes without power, evacuation centers set up at Nambour, Noosa and Caloundra.

**Brisbane**: up to 3600 properties was inundated, cyclonic winds and torrential rain, about 19000 homes without power, winds of 125 km/h, equivalent to a strong category one cyclone.

**New South Wales:** An estimated 41000 people were temporarily isolated by flooding in New South Wales. In the Tweed Valley the Tweed River peaked at 3.3 meters on the 28 January, the highest level recorded in 30 years. In Grafton the Clarence River peaked a new record height of 8.1 meters. Records for the river height in Grafton go back to 1839.The city's levee was credited with preventing more severe flooding. Despite that, around 1500 people who lived closed to the Clarence River were asked to evacuate on the night of 28 January. Maclean was spared flooding from the Clarence River due to the town's levee. The Clarence Valley was not as fortunate with many properties cut-off and without power. The area was officially declared a disaster zone, as was the Tweed Shire.

## 7. CONCLUSIONS

Many areas of the world are vulnerable to a lot of natural and man-made hazards.

Queensland`s weather systems are changeable and unpredictable. The risk of storm surge is the most dangerous hazard associated with cyclones and can cause flooding of low-lying coastal areas. Most cyclone-related deaths are from drowning in a storm surge or flood.

The entire state Queensland and especially the Gold Coast have suffered greatly due the consequences of Oswald cyclone. Social life, all types of transport, many economic activities, especially tourism have felt the effects of the period of manifestation of cyclonic activity. In addition to material losses and expenses incurred for the restoration of affected areas, many losses were due to disruption of the tourist season, which peak during that time. Such phenomena show unexpected ways represents a hazard for the area, the area is at risk of cyclones in various points during the year.

## 8. REFERENCES

[1] Alina Boştină, ,,Tropical cyclone - a really hazardous phenomenon`` - Analele Universității Maritime Constanța 2009

[2] Jamie Walker & Rosanne Barrett, "Flood disaster engulfs two states". The Australian (News Limited) 2013

[3] Queensland Regional Office (February 2013)- Tropical Cyclone Oswald. Australian Bureau of Meteorology.

[4] ***,,Major losses at Mundubbera", *The Chronicle* (Toowoomba Newspapers), 28 January2013

[5] www.weather.com.au

[6] http://www.bom.gov.au/cyclone/history/eastern.shtml

[7] http://www.disaster.qld.gov.au

[8] www.emergency.qld.gov.au/emq

# MODELATION OF THE OSCILLATORY MOTIONS OF THE SHIP FOR THE MEDITERRANEAN SEA NAVIGATION CONDITIONS, USING THE OCTOPUS SOFTWARE

[1]CHITU MIHAELA-GRETI, [2]MANEA EMIL, [3]BORMAMBET MELAT

[1,3] *Ovidius University of Constanta,* [2] *Over Seas Manager Ship Repairs & Conversions Projects, Constanta Shipyard, Greece Representative Office, Romania*

**ABSTRACT**

The paper presents a complex study about oscillatory motions of a ship for offshore industry in the Mediterranean Sea conditions of navigation. Geometrical, constructive and hydrodynamic particularities of these special vessels make interesting and also necessary – for safety of the navigation and operation of the ship – this study for the ships movements, considered as a rigid body with six degree of freedom. The study provides information regarding RAO (Response Amplitude Operator) operator of the ship for the displacement of gravity centre of the ship, related with the incident wave systems in the Mediterranean Sea, interpreted by the Jonswap energy spectrum, and other several conclusions. For the study, are used features offered by OCTOPUS as a tool for modelling and simulation – software that allows the study of the computerized behaviour of the ship on the waves in the real sailing conditions. Program library was used for both the vessel itself and navigation modelling environment (for regular waves as well for the irregular waves which was modelled using Jonswap energy spectrum).

**Keywords:** *roll, pitch and heave motion; wave energy spectrum; RAO.*

## 1. INTRODUCTION

Knowing the behaviour of the ship hull in large seal, description of the complex process of interaction between it and the fluid moving through, the analysis and prediction of marine phenomena with random events are incentives for the development of theoretical and experimental studies towards establishing practical solutions aimed at reduce, even eliminate the limitations and unintended consequences.

The main objective of the ship design architect is to satisfy operational requirements imposed by the owner and ensuring adequate water qualities sailing class falling. No doubt, the priority lies with safety of the ship, cargo and personnel carried on board. From this perspective, the study of the general motions of the ship as free rigid, navigation under real sea, it is an essential component of constructive, technical, economical and safety criteria, since the early stage of design.

Among the issues that concern the study of naval architects and engineers, the general motions of the ship, it is noted with regard to:

a) deterioration or loss of buoyancy, which can lead to sinking ship (if not ensure a leak) as a consequence of flooding the bridge at the entrance of a board or extremities below the wave;

b) loss of transverse stability, which can lead to the overthrow of the ship, caused by: a dangerous inclination of the ship on the side, determined by turning, in terms of a high degree of agitation of the sea; rough roll oscillations caused by wave action at resonance;

c) worsening of the ship government caused by: decrease maneuverability under unfavorable hydro-dynamic wave action on the rudder; loss of the road stability trough the drift phenomenon, by the adverse action caused by wind and sea currents when, for various reasons, the steering system cannot operate;

d) reduction of the march qualities due: worsening propulsion system operation throughout driveline (propellers is out of the water and revolves empty, and to reinforce the water are overworked and causing shock in the system); ship speed reduction due to the increase drag and malfunctioning thruster in heavy sea conditions; reduce the autonomy of the ship by increasing energy consumption;

e) loss of line to perform oscillations, in the strong impact of the hull and waves, resulting: seasickness appearance (accompanied by discomfort to passengers and crew on board); vibrations due to appearance of the slamming (hitting bow wave) whipping (hitting stern wave) and slams (repeated shocks) effects, under the unfavorable impact of waves; worsening functioning of the board facilities and ancillary systems, subject to dynamic actions of the water craft on deck;

f) worsening of the elastic-plastic behavior of the hull resistance due: general and additional local loads; general weakening of the resistance by fatigue.

Given the complexity of the problem, the random orientation factors involved, required advanced programming languages and specialized software. These high-performance programs are designed for the numerical calculations and graphs in science engineering and naval architecture also. They allow numerical analysis, matrix calculation, signal processing and graphics representations in a simple way, excluding the need for traditional programming prior.

## 2. THEORETICAL CONSIDERATIONS

In 1950, the Society of Naval Architects and Marine Engineers (SNAME) are imposed the symbols and definitions for the linear and angular coordinates of the ship motions also for the forces and moments which actions on the ship during the navigation on the real sea. All this are summarized in the Table 1.

Table 1. SNAME symbols and notations for the general motions of the ship

| TRANSLATIONS | | | |
|---|---|---|---|
| **Type of motion** | **Linear coordinates [m]** | **Linear velocities [m/s]** | **Forces [kN]** |
| Longitudinal translation SURGE | $x$ | $u = \dot{x} = \frac{dx}{dt}$ | $X$ |
| Transversal translation SWAY | $y$ | $v = \dot{y} = \frac{dy}{dt}$ | $Y$ |
| Vertical translation HEAVE | $z$ | $u = \dot{x} = \frac{dx}{dt}$ | $Z$ |
| **ROTATIONS** | | | |
| **Type of motion** | **Angular coordinates [rad]** | **Angular velocities [rad/s]** | **Moments [kNm]** |
| Rotation around the longitudinal axe ROLL | $\varphi$ | $p = \dot{\varphi} = \frac{d\varphi}{dt}$ | $K$ |
| Rotation around the transversal axe PITCH | $\theta$ | $q = \dot{\theta} = \frac{d\theta}{dt}$ | $M$ |
| Rotation around the vertical axe YAW | $\psi$ | $r = \dot{\psi} = \frac{d\psi}{dt}$ | $N$ |

Therefore, the general equations of motion of the ship, considered as rigid with six degrees of freedom, can be written using vectors:

$$\begin{cases} \eta = [\eta_1^T \quad \eta_2^T] & \eta_1 = [x \quad y \quad z]^T & \eta_2 = [\varphi \quad \theta \quad \psi]^T \\ \nu = [\nu_1^T \quad \nu_2^T] & \nu_1 = [u \quad v \quad w]^T & \nu_2 = [p \quad q \quad r]^T \\ \tau = [\tau_1^T \quad \tau_2^T] & \tau_1 = [X \quad Y \quad Z]^T & \tau_2 = [K \quad M \quad N]^T \end{cases} \quad (1)$$

where:

$\eta$ is the position vector of any point on the ship, expressed in relation to the fixed reference system, with the coordinates: $\eta_1$, vector of the linear coordinates which is characteristic for the translational movement; $\eta_2$, vector of the angular coordinates which is characteristic for the rotational movement;

$\nu$ is the velocity vector of any point on the ship, expressed in relation to the fixed reference system, with the coordinates: $\nu_1$, vector of the linear velocities, which is characteristic for the translational movement; $\nu_2$, vector of the angular velocities which is characteristic for the rotational movement;

$\tau$ is the vector of forces and moments acting on the vessel at the point considered, expressed in relation to the fixed reference system, with the coordinates: $\tau_1$, vector of forces; $\tau_2$, vector of moments.

In the study of general movements of the ship, considered as a free rigid, it is used two reference systems:

The mobile reference system. Noted $GX_GY_GZ_G$, is integral with the ship, originating in the center of gravity, G, of it. Axes – longitudinal, $GX_G$, positive toward the bow, transverse, $GY_G$, positive to starboard; vertical $GZ_G$, positive to ship's keel - are central axes of inertia of the ship mass.

The fixed reference system. Noted $OX_OY_OZ_O$, is considered inertial, with the origin, $O$, in the plane of the free surface of the calm water (without waves). The axes have the directions and senses same with the mobile reference system, for the rest position of the ship.

Ship deviation from the equilibrium position, at a time, $t$ , lead to changes in the relative position of the two co-ordinate systems. The position and orientation of any point on the ship, at the time, t, with respect to the fixed reference system can be specified by six independent coordinates: three are linear and described translational movements; three are angular and described rotational movements.

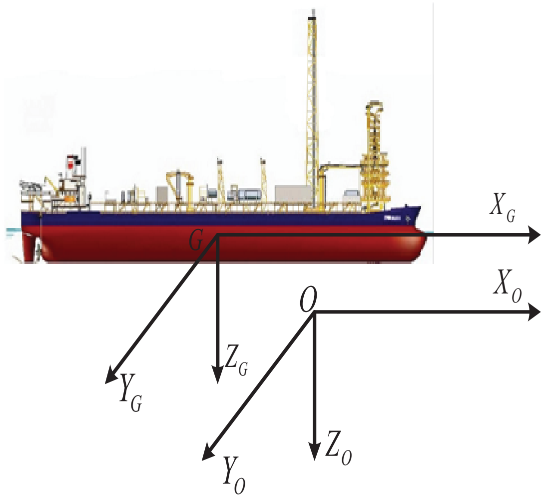



Figure 1 Reference systems

In agreement with the notation established in Newtonian mechanics [6], translational and rotational motions of a free rigid are given by the relations:

$$F_p = m(\dot{v}_p + \omega \times v_p + \dot{\omega} \times r_{pG} + \omega \times (\omega \times r_{pG})) \quad (2)$$

$$M_p = I_p \dot{\omega} + \omega \times (I_p \omega) + m r_{pG} \times (\dot{v}_p + \omega \times v_p) \quad (3)$$

The general equation of motion of the ship, in a vector form, referred to the moving reference system, takes the form:

$$M\dot{\nu}_r + C(\nu_r)\nu_r + D(\nu_r)\nu_r + g(\eta) = \tau_M + \tau \quad (4)$$

where

$\nu_r = \nu - \nu_c$

- relative velocity vector;

$\dot{\nu}_r$

- relative acceleration vector;

$\nu = [\nu_1^T \quad \nu_1^T]^T = [u \quad v \quad w \quad p \quad q \quad r]^T$

- overall velocity vector of the ship;

$\nu_c = [\nu_{1c}^T \quad \nu_{2c}^T]^T = [u_c \quad v_c \quad w_c \quad 0 \quad 0 \quad 0]^T$

- overall velocity vector of marine currents;

$\eta = [\eta_1^T \quad \eta_2^T]^T = [x \quad y \quad z \quad \varphi \quad \theta \quad \psi]$

- position vector of an arbitrary point belonging to the vessel.

$g(\eta)$

- generalized vector of restored forces and moments;

$\tau$

- generalized vector of the disruptive forces and moments due to operations control and manoeuvre executed with the propulsion and steering systems;

$\tau_M$

- generalized vector of the disruptive forces and moments generated by the currents and waves on the wetted surface of the hull respectively by the action of the wind on the sail area of the vessel;

$M$

- the matrix of the ship mass inertia and additional water masses;

$C(\nu_r)$

- complementary matrix for the ship motions and additional water masses;

$D(\nu_r)$

- the damping matrix determined by the dynamic action of the water on the ship surface caused by the moving of the vessel.

The general equation of motion of the ship, in a vector form, referred to the fixed reference system, takes the form:

$$M_\eta(\eta)\ddot{\eta} + C_\eta(\nu_r,\eta)\dot{\eta} + D_\eta(\nu_r,\eta)\dot{\eta} + g_\eta(\eta) = \tau_{M\eta}(\eta) + \tau_\eta(\eta) \quad (5)$$

In writing equation took into account the transformation matrix, $J(\eta)$, which allows to establish the relationship between the position vectors, $\eta$ and velocities, $\nu_r$, so:

$$\begin{cases} \dot{\eta} = J(\eta)\nu_r \\ \ddot{\eta} = J(\eta)\dot{\nu}_r + \dot{J}(\eta)\nu_r \end{cases} \quad (6)$$

$$\begin{cases} \nu_r = J^{-1}(\eta)\dot{\eta} \\ \dot{\nu}_r = J^{-1}(\eta)[\ddot{\eta} - \dot{J}(\eta)J^{-1}(\eta)\dot{\eta}] \end{cases} \quad (7)$$

where the notation has been made:

$$\{\bullet(\bullet(M_\downarrow\eta(\eta) = J^\uparrow(-T)(\eta)MJ^\uparrow(-1)(\eta)@C_\downarrow\eta(\nu_\downarrow r,\eta) = \\ = J^\uparrow(-T)(\eta)[C(\nu_\downarrow r) - MJ^\uparrow(-1)(\eta)J(\eta)]J^\uparrow(-1)(\eta)\ )@\bullet(D_\downarrow\eta(\nu_\downarrow r,\eta) = \\ = J^\uparrow(-T)(\eta)D(\nu_\downarrow r)J^\uparrow(-1)(\eta)@g_\downarrow\eta(\eta) = \\ = J^\uparrow(-T)(\eta)g(\eta)\ )@\bullet(\tau_\downarrow M\eta(\eta) = J^\uparrow(-T)(\eta) \quad (8)$$

In developing this theoretical support, a significant contribution has brought Prof. T. Fossen, in his book "*Guidance and Control of Ocean Vehicles*" [4], contribution which involved:

- independent analysis of the various phenomena and changes due to external disturbances, insisting on the ways of coupling the motions of translation and rotation;
- use superposition principle in assessing the irregular and random behavior of the navigation environment;
- application of modern analytical mechanics to determine the inertia matrices and complementary;
- reasoned explanation of the additional mass concept and theoretical process of the related phenomena; adaptation and improvement " strip theory " for use in resolving the issues raised by the determination of hydrodynamic coefficients involved in the equation of motion of the ship.

## 3. CASE STUDY

The case study has the following relevant parameters:

a) OCTOPUS software

OCTOPUS-OFFICE 6 "BASIC" is used to calculate the transfer functions of ship responses in waves (absolute and relative motions, velocities, accelerations, hull girder loads and linear combinations of responses). The program has a built-in geometry modeller to prepare 2D- and 3D-models as input for the hydrodynamic calculations (2D-strip theory or a 3D-diffraction database can be used). Nonlinear sea state dependent transfer functions are solved by means of stochastic linearization. The program features extensive possibilities for graphical and textual reporting and presentation, including export functions to MS Word and Excel [8].

b) geometrical and constructive particularities for the ship [5]

For the case study was chosen a FPSO vessel type. A floating production, storage and offloading (FPSO) unit is a floating vessel used by the offshore oil and gas industry for the processing of hydrocarbons and for storage of oil. An FPSO vessel is designed to receive hydrocarbons produced from nearby platforms or subsea template, process them, and store oil until it can be offloaded onto a tanker or, less frequently, transported through a pipeline. FPSOs are preferred in frontier offshore regions as they are easy to install, and do not require a local pipeline infrastructure to export oil.

The ship has a hull with bulbous in bow and aft in mirror; the construction of rudder post adequate of making a semi suspended rudder with weld caisson, semicompensed, with hydrodynamic profile, done in middle plane (having the shim area of surface $S_p = A_R = 36{,}4\ \text{m}^2$); principal dimensions are: length $L = 200{,}31$ m, width $B_x = 38$ m, draught $T = 8$ m; displacement deadweight 43476 dwt; dynamic mechanical particularities: service speed $v = 15$ knots; chain of propulsion is made by propeller with 4 fixed blades, dispose in the middle plane (having the diameter $D = 6{,}533$ m, pitch ratio $P/D = 0{,}721$ and disk ratio $A_E/A_0 = 0{,}64$ at speed $n = 127$ rot/min), an axial line with speed reducer and one medium speed engine 6L52/55A, in four time, reversible, with supercharge and direct injection, having nominal power $P = 6100$ Hp and rpm $n = 127$ .

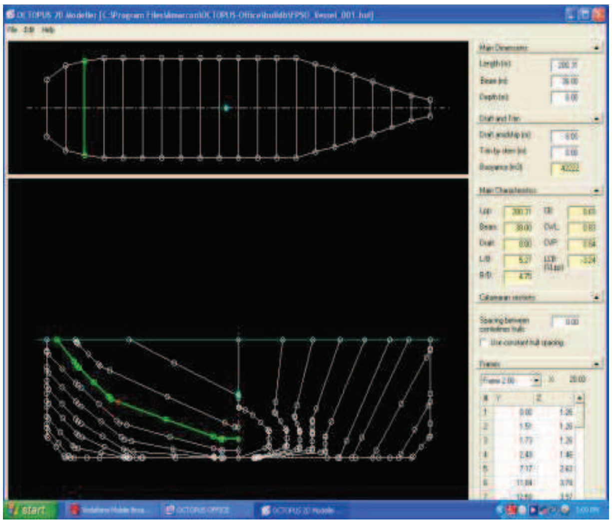


Figure 2 The body line of the ship

c) the navigation environment

In assessing the degree of agitation and irregularity of the sea, particularly interested in the statistical analysis of the elements "visible" or "apparent" wave like apparent height or apparent period, and the components of "invisible" such as operator RAO (response amplitude), the average height of the waves, their frequency or percentage achieving the repeatability of these heights average in total number of time intervals considered.

Thus, in international practice, use the following indicators, essential for assessing the intensity of the various schemes of agitation of the sea [2]: wave height with 3% insurance, $\tilde{h}_{3\%}$; significant height, $\tilde{h}_{1/3}$; average wave period, $\tilde{T}_m$; energy spectra for two-dimensional (plane) waves, $S(\omega)$, respectively for three-dimensional (spatial) waves, $S(\omega,\varphi)$.

The Mediterranean Sea is characterized by waves with height $\tilde{h} = 3$ m, length $\tilde{\lambda} = 74$ m apparent velocity $c = 11{,}5$ m/s. In describing the degree of agitation of the sea, the JONSWAP wave spectrum was chosen.

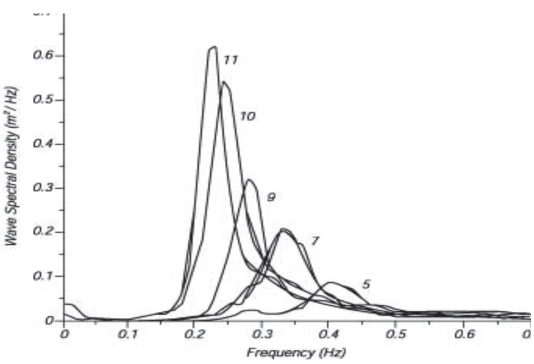



Figure 3 The average JONSWAP wave spectrum

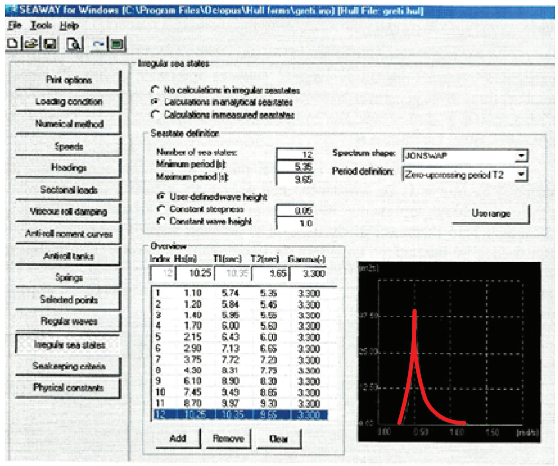


Figure 4 The JONSWAP wave spectrum approximated by OCTOPUS software

Irregular surface navigation environment resulted in superposition of 12 regular-type cosine waves with significant heights between 1.10 and 10.25 m, respectively, zero crossing periods between 5.35 and 9.65 sec.

Testing program was made for the ship service speed of 15 knots. The angle of incidence of ship waves was elected to the value of 45 deg.

The results are shown follow.

## 4. RESULTS

OCTOPUS [8] provided results are much more extensive and complex than can be presented in this paper, and refer to:

- input (selected by the user for the hull and navigation environment);
- geometrical characteristics approximated by conformal two-dimensional hull transforming Lewis;
- fit to the contour exactly;
- two-dimensional hydrodynamic coefficients values;
- values of the coefficients involved in the equations of motion and values of disturbed forces and moments on the regular waves for the six degrees of freedom;
- RAO spectra for the center of gravity of the ship, consequence response to the incident wave spectrum system (regular and irregular);
- numerical spectra on the position, speed and acceleration corresponding of the center of gravity of the ship, consequence response to the incident wave spectrum system (regular and irregular);
- significant height values, their periods and zero crossing periods for the center of gravity of the ship;
- response spectra numerical values of forces and moments acting on the ship, in the selected section, consequence response to the incident wave spectrum system (regular and irregular).

They have been provided by the program in the form of numerical spectra were performed by the authors and plotted using Excel.

Further, examples will be presented graphically on its application to the study of ship motion, for the center of gravity of the vessel and the selected section, through the response spectra on the disturbance caused by waves (regular and irregular).

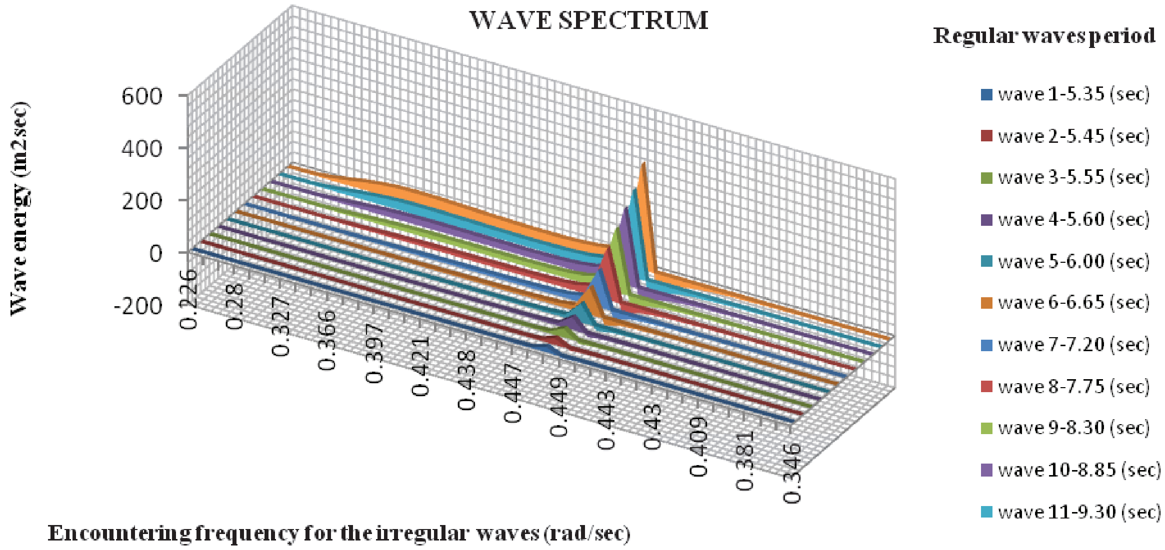



Figure 5 Wave spectrum interpreted by the JONSWAP energy spectrum

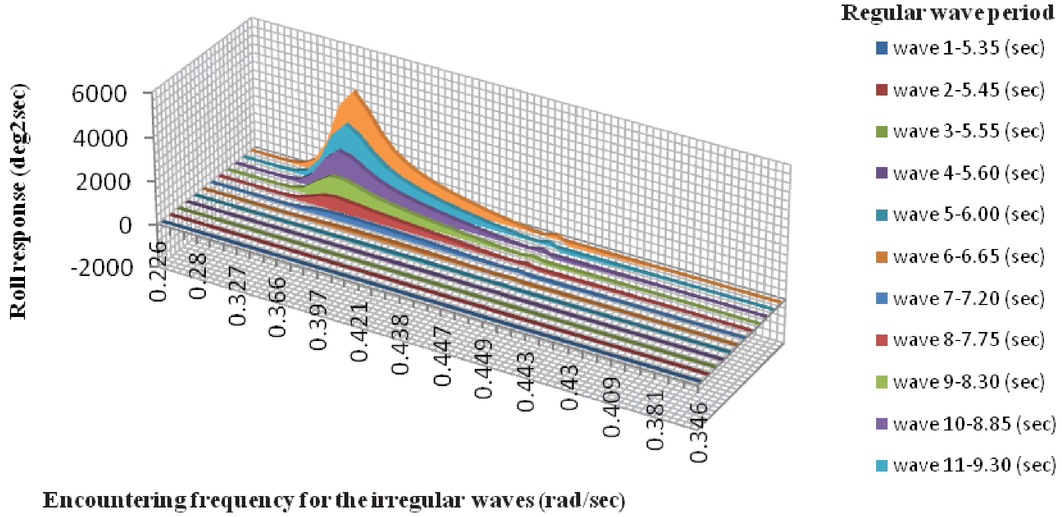



Figure 6 RAO spectrum for Roll motion (center of gravity)

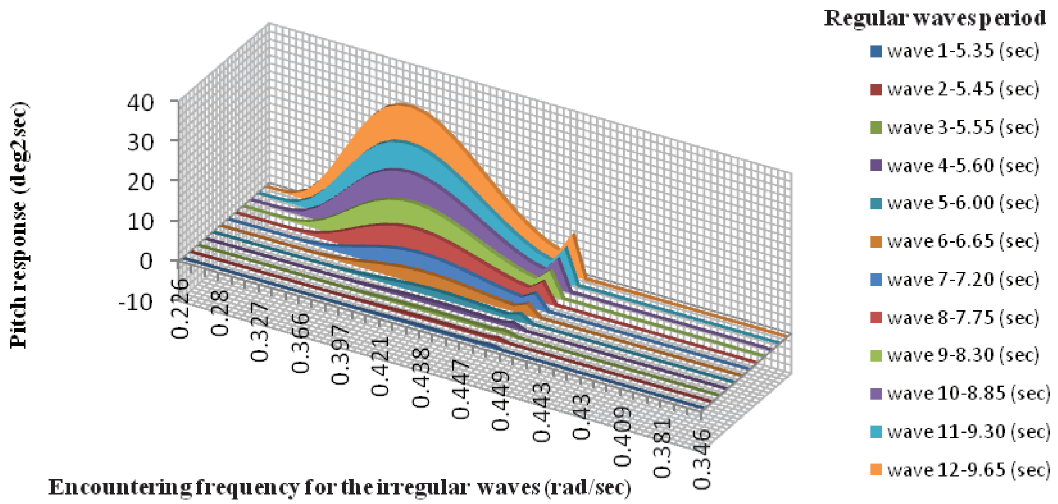



Figure 7 RAO spectrum for Pitch motion (center of gravity)

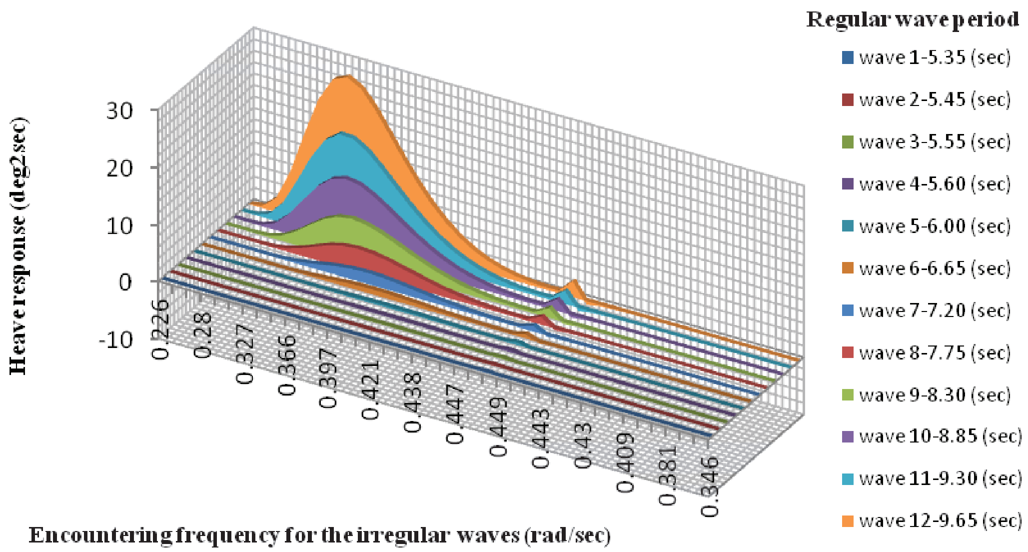



Figure 8 RAO spectrum for Heave motion (center of gravity)

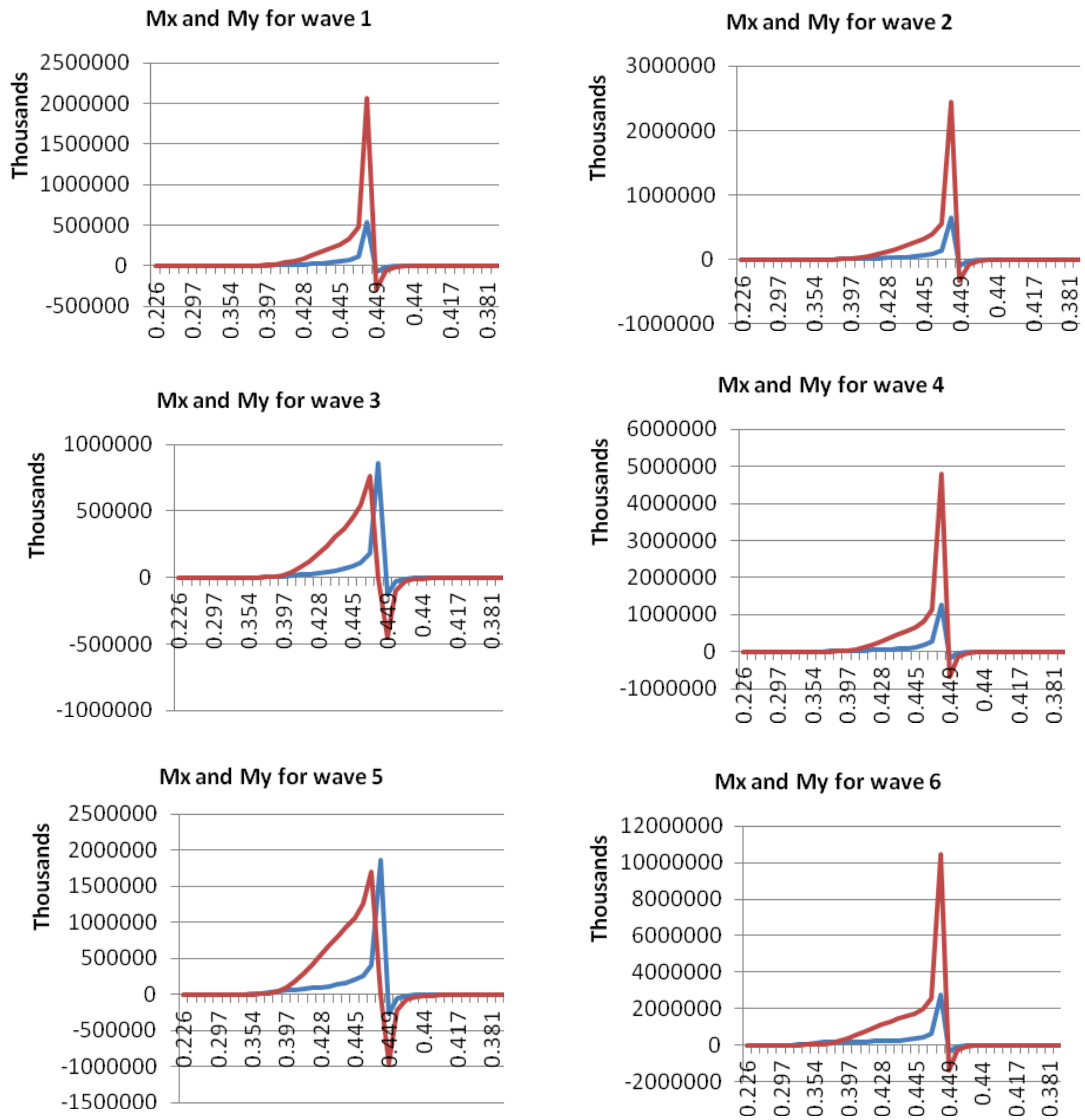



Figure 9 RAO spectrum moments Mx and My in regular waves 1 to 6

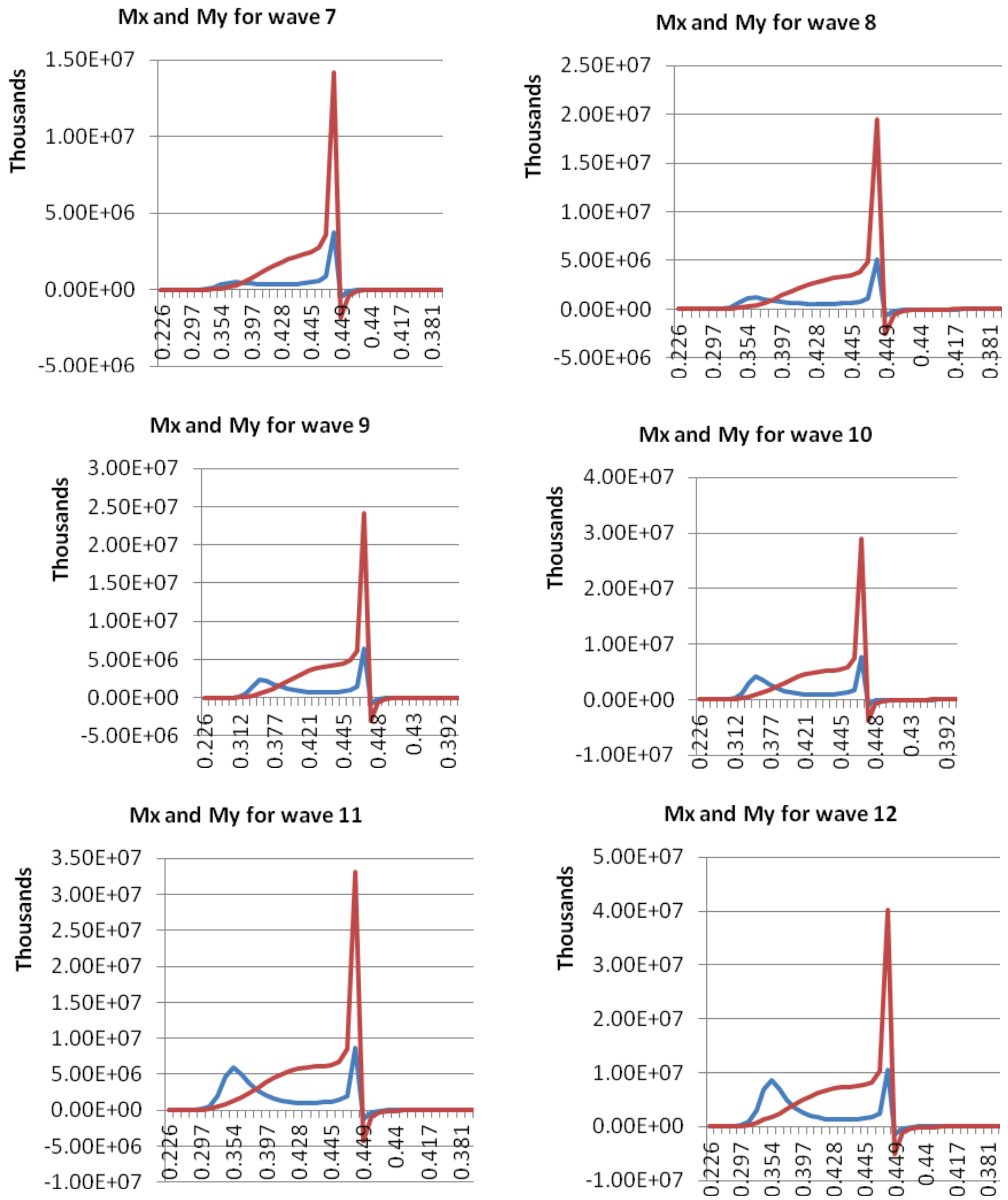



Figure 10 RAO spectrum moments Mx and My in regular waves 7 to 12

## 5. CONCLUSIONS

Description of the process of interaction between hull (known complex technical system) and real sea (deterministic or random) respective the behaviour of navigating condition induce on the ship, is one of the difficult problems of Ship Mechanics.

Various theoretical solutions proposed and published by researchers interested in the fields consist in developing physically based mathematical models, seeking the most accurate description of the problem addressed, responding to the practical needs of the shipbuilder and crew.

A permanent goal is the validation of theoretical models with practical tests in large sea (on the prototype), hydrodynamic laboratory experiments (on the models) and computerized numerical simulations.

In the case study to highlight the features and performance program OCTOPUS, considered general and complete movement of a ship-type FPSO in Mediterranean sailing conditions. In this context, this paper contributes, in part, to solve problems related to the study of vessel behaviour in real sea, connection purpose is the highlighting the represented by numerical simulation performance.

Finally, the results provided by the program illustrate, in advance, the ship behaviour, as free rigid body in the real sea. OCTOPUS contains several utility programs exclusively naval, conducted by AMARCON (Advanced Maritime Consulting) in Netherlands.

Includes routines for specific areas of interest, allowing the study of the behaviour witnessed ship on the waves.

Authors may be contacted for further refinements.

Correspondence address: mgchitu@gmail.com

## 7. REFERENCES

[1] CHIȚU, M.G., *Contributions to the Ship Oscillations on the Waves*, Ph.D. thesis, Politehnica University of Bucharest, 2003

[2] DOMNIŞORU, L., *Ship Dynamics. Oscillations and Vibrations of the Ship Hull*, Editura Tehnică, Bucharest, 2001

[3] EDWARD, V.L., *Principles of Naval Architecture*, Vol. 1, 2, 3, New jersey, SNAME, 1988, 1989

[4] FOSSEN, T., *Guidance and Control of Ocean Vehicles*, John Wiley&Sons, University of Trondhaim, Norway, 1994

[5] MAIER, V., *Ship Mechanics and Construction*, Vol. 1, 2, 3, Editura Tehnică, Bucharest, 1985, 1987, 1989

[6] VOINEA. R., *Introduction to Solid Mechanics with Engineering Applications*, Editura Academiei, Bucharest, 1989

[7] Volker, B., *Practical Ship Hydrodynamics*, Oxford, Great Britain, 2000

[8] ***, *OCTOPUS Office 6 User Manual*, Amarcon BV, 2010

# STANDARD MARITIME VOCABULARY PHRASES

[1] GHETU PAULA CLAUDIA, [2] RUSEI ALEXANDRU-FLORIN

[1]*Liceul Panait Cerna Brăila,* [2]*Constanta Maritime University, Romania*

**ABSTRACT**

The choice of English language training is critical: as the majority of seafarers now work in mixed nationality crews, effective English language training should focus on developing spoken fluency; understanding English spoken with a range of international accents.

**Keywords:** *SMCP, IMO, STCW, IHO*

## 1. INTRODUCTION

So what is communication? If it is so important, how do we ensure that when one person talks to another, that the other person listens and understands? How do we know if the message (or sign) has not only been heard (or read) but also understood? What can be done to limit the opportunities for mistakes and to enhance the effectiveness of communications?

It is a self-evident fact that people speaking different languages can generally not converse at all and even people speaking their own language can misinterpret spoken messages.

And the reason these messages become garbled is probably because we probably have too many ways of passing ideas one to another especially in maritime communication where do we have a multinational and multicultural crew.

## 2. THE EFFECTIVE COMMUNICATION AT SEA

The ability to properly convey information by word of mouth and /or by written communication is important not only to the safety of ships' crews, visitors and passagers, but also to the wellbeing of crews. It would seem that the standard of English of some seafarers is so bad that they have difficulty communicating not only between themselves but also with agencies outside the ship. The aim of IMO Standard Marine Communication Phrases (SMCP) is to get round the problem of language barriers at sea and avoid those misunderstandings which can cause accidents. The key to improved verbal communication is in the recruitment of seafarers who have an understanding of the English language; in education, in the art of effective communication and in the corect use of the English language in the maritime environment; and in a programme of regular testing in their knowledge of the English language.

### *2.1 Phrases and expressions used onboard- IMO regulations*

Investigations into the human factor regarding disasters at sea, which focused on communication behaviour, revealed that one third of accidents happen primarily due to insufficient command of Maritime English. In VTS (Vessel Traffic Service) controled areas communicatively relevant factors contribute up to 40% of collisions involving the human element. Most of them caused by failures in the radio communication even in routine conversations, but some also true face-to-face communications deficiencies. More than 86% of all SOLAS (Safety Of Life At Sea) vessels are presentely called with multilingual personnel who, for diverse reasons, are frequently unable to render the Maritime English skills required, risking and even causing damage to lives, property and the environment. This eventually made IMO re-consider how to minimize Maritime English communication problems. In 2001, IMO adopted the SMCP and via STCW95 (Standards of Training, Certification and Watchkeeping for Seafarers) they become a mandatory part of the education of officers at all white-listed training institutions.

The phrases provide a sort of Srvival Kit; they include all essential safety-related communicative events where spoken English is required. Being trained in the use of the SMCP, officers will definely encounter less communication difficulties managing safety-related situations, performing navigational duties, and organising or supervising cargo operations.

### *2.2. Variety of phrases used onboard*

The IMO SMCP builds on a basic knowledge of English and has been drafted in a simplified version of maritime English. It includes phrases for use in routine situations such as berthing as well as standard phrases and responses for use in emergency situations.

They aim to explain:

- external communication phrases – ship to ship & ship to shore communication,
- onboard communication phrases – communication within the ship.

Standard Wheel Orders:

The art of steering a ship can be gained by practice. The ship's head, rudder and steering wheel all turn the same way, that is, to turn the ship to starboard one must turn the wheel to starboard. The angle of turn given to the rudder is shown in degrees on the helm indicator situated forward of the wheel. All orders received by the helmsman are to be repeated twice; once when the order is received and again when the order has been carried out. This is to ensure that the helmsman has both understood and carried out the orders correctly.

Here are some standard wheel orders taken from the Standard Marine Communication Phrases (SMCP) list:

Table 1. Standard wheel orders

| Order | Meaning |
|---|---|
| Midships | Rudder to be held in the fore and aft position |
| Port five | 5 of port rudder to be held. |
| Port twenty-five | 25 of port rudder to be held. |
| Hard-a-port | Rudder to be held fully over to port. |

When the officer of the watch requires a course to be steered by compass, the direction in which he wants the wheel turned should be stated followed by each numeral being said separately, including zero. It been said in 3 digits to avoid misunderstanding like 15 (fifteen) instead of 50 (fifty).

Table 2. Steering

| Order | Course to be steered |
|---|---|
| "Port, steer one eight two" | 182° |
| "Starboard, steer zero eight two" | 082° |
| "Port, steer three zero five" | 305° |

Standard Engine Orders

Any engine order given should be repeated by the person operating the bridge telegraph/s and the officers of the watch should ensure that the order is carried out correctly and right away.

Listed below are some standard engine orders from the SCMP manual.

Table 3. Standard engine orders

| Order | Meaning |
|---|---|
| Full ahead | Maximum manoeuvring engine revolutions for ahead propulsion. |
| Half ahead | Revolutions as indicated in ship's orders. |
| Stop engine/s | No engine revolutions |
| Slow astern | Revolutions as indicated in ship's orders. |

The 1978 STCW Convention was the first to establish basic requirements on training, certification and watchkeeping for seafarers on an international level. Previously the standards of training, certification and watchkeeping of officers and ratings were established by individual governments, usually without reference to practices in other countries. As a result standards and procedures varied widely, even though shipping is extremely international of nature.

This SMCP vocabulary addresses to phrases and it's aim is to structure communication onboard namely instead of "please steer 3 degrees to starboard" the order will be "3 degrees to port". This SMCP vocabulary structure phrases to be standardized, and everyone could understand.

What has not yet made this SMCP vocabulary, not established common rules for printing navigating documents, not established common rules for chart plotting.

The first concern of SMCP vocabulary was to standardize communication onboard.

## 3. STANDARDIZATION OF TERMS USED AND WORK PRACTICES ON THE CHART

Navigation is the process of position finding as well as planning, recording and controlling the movement of a craft or vehicle from one place to another.

Due to differences in grading chart plotting were created uniform standards to chart plotting and the navigation log, which are important documents in the event of incidents are used in processes and plotting style of the chart and points name must be similar.

So were further developed technical standards for chart plotting. This international Standard contains terms, abbreviations and graphical symbols, which are to be used in maritime navigation on board ships.

### *3.1 Special units in maritime navigation*

- Units of length:

The nautical mile is not an SI-unit. This definition was adopted by the First Hydrographic Conference in 1929. Symbol M used in Charts according to the "Chart Specifications of the IHO" came into force at the XIIth International Hydrographic Conference 1982 in Monaco.
Nautical mile =NM (in charts: M) 1NM = 1852m
One-tenth of a nautical mile*,* is called cable, cable length = cbl

- Unit of velocity and speed is calld knot, knots=kn 1kn=1NM/h

Units of angle are degrees and minutes. In maritime navigation, angles should be specified in degrees, minutes and decimals of minutes.
(example: write 17˚40,25' not 17˚40'15").

### *3.2 Directions used in maritime navigation*

- North directions are horizontal reference directions used in navigation such as:

- true north = TN(Northerly direction of the meridian)
- magnetic north = MN (Northerly direction of the horizontal component of the earth's magnetic field
- compass north = CN (Northerly direction of the needle or zero-index of a magnetic compass)
- gyro north = GyN (Northerly direction indicated by the gyro-compass)

- Dead ahead direction is the direction ahead of the ship's fore-and-aft line.
- Course (CSE) and heading (HDG) directions are angles, measured in the horizontal plane from one of the reference directions, counted clockwise from 000˚ through<360˚, written as three-digit numbers.In radar navigation, the abbreviations CRS for course and HDG for heading are preferred.

- true course =TC=T CRS ( the direction, in which the ship is intended to be steered
- course to steer = CTS(line of the ship, expressed in angular units from true north (000˚)

- true heading=TH=T HDG(actual direction in which the longitudinal axis of the ship is pointed)
- course over ground=COG(direction of the ship's movement relative to the earth, measured on board the ship, expressed in angular units from true north.

- Track the term "track" is used as the path of voyage over the ground(ground track) or through the water(water track) as plotted in the chart, expressed in angular units from true north(000˚) clockwise through<360˚ or as the path of radar-targets on a plan position indicator. Types of track:

- water track=WAT TRK(actual path of the shp's movement through the water)
- ground track = GND TRK (actual path of the shp's movement relative to the earth)

*3.3 Position and lines*

- leeway angle (angular difference between the course through water and course to steer (CTW-TC)
- drift angle(angular difference between the course of advance or course over ground and course through water (COA-CTW or COG-CTW)
- dead reckoning position=DR (calculated position of a vessel obtained by adding to the last fix the ship's true course and own speed)

For example in romanian marine vocabulary we do not have the notion of dead reckoning.

- corrected dead reckoning position = Drcor (calculated position of a vessel obtained by adding to the last fix the ship's course and speed through water)
- estimated position = EP (most probable position of a vessel obtained by adding to the last fix the ship's course and speed of advance, considering all estimated influences, including current

⨁ last fix

1. leeway angle
2. drift angle
3. own shp's velocity
4. intended water track
5. intended ground track
6. leeway vector
7. drift vector

DR dead reckoning position
$DR_{cor}$ corrected dead reckoning position
EP estimated position

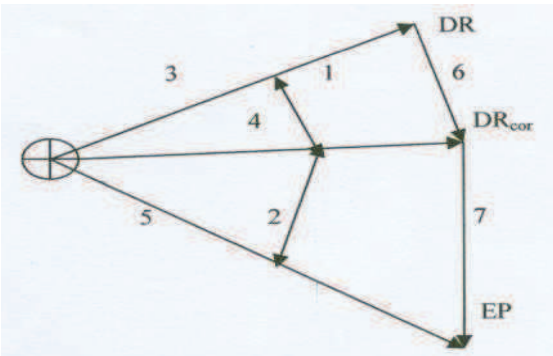



Figura1. Leeway and drift triangle

*3.4 Waypoint navigation*

Waypoints are sets of coordinates that identify a point in physical space. Coordinates used can vary depending on the application. For maritime navigation these coordinates include longitude and latitude. Although the term *waypoint* has only come into common use in recent years, the equivalent of a waypoint in all but name has existed for as long as human beings have navigated.

Some terms used in waypoint navigation:

- port or point of departure=the port or point where voyage begins
- destination=DEST(the geographic point to which a craft is navigating. It may be the next waypoint along a route of waypoints or the final destination of a voyage)
- waypoint=WPT(point on a route)
- waypoint distance(distance to a waypoint)

*3.5 Units of time used in maritime navigation*

- estimated time of arrival=ETA(the predicted time of reaching a destination or waypoint)
- time to go=TTG(the predicted duration to reach a destination or waypoint from the present position)
- estimated time of departure=ETD(the predicted time of leaving a port or waypoint)

## 4. HARMONIZATION CONTENT OF NAUTICAL PUBLICATIONS

This standard manages to create a common technical language of how is made navigation not only the maritime communication. But we conclude that the producers of books, charts and nautical documents are more and although they have common elements still have elements that separate them, make them be different.

The best buoy sistem IALA developed by IHO still however, failed to unify the international system of buoy because of the practices and refusals of states, and appears in 2 areas: area A and area B with theyr own rules.

*4.1 The International Hydrographic Organization (IHO)*

The International Hydrographic Organization (IHO) is the inter-governmental organisationrepresenting the hydrographic community. It enjoys observer status at the United Nationswhere it is the recognised competent authority on hydrographic surveying and nautical charting. When referring to hydrography and nautical charting in Conventions and similar Instruments, it is the IHO standards and specifications that are normally used. The principal work undertaken by the IHO is to bring about a close and permanent association between national hydrographic offices, to further the exchange of nautical charts and documents between hydrographic officers of member governments. To extend and facilitate the application of oceanographic knowledge for the benefit of navigators. Most IHO publications, including the standards, guidelines and associated documents such as the International Hydrographic Review, International Hydrographic Bulletin, the Hydrographic Dictionary and the Year book are available to the general public free from the IHO website.

*4.2 IHO publications*

- Bathymetric Publications:

- General Bathymetric Chart of the Oceans (GEBCO)
- Standardization of Undersea Feature Names (Guidelines, Proposal Form Terminology)
-The History of GEBCO

- **Periodical Publications:**

- IHO Yearbook (30 April March 2013)
- IHO Annual Report

- Standards and Specifications:

- Guidance for the Preparation and Maintenance of International Chart Schemes and Catalogue of International (INT) Charts; Last update: mars 29, 2013
- Standardization of List of Lights and Fog Signals, June 2004 (Corrections to June 2006)
- Hydrographic Dictionary
- Standardization of Mariners' Routeing Guides, April 2010 Items recommended as USEFUL for a Mariners' Routeing Guide concern subjects of importance to safe navigation in a particular geographic area on which information would be helpful to the mariner and its collection in a single document (the MRG) would facilitate its use.
- IHO Data Protection Scheme (April 2012)

- Draft Publications Awaiting Approval by Member States

- IHO Chart Specifications: Topography (closing date 14 Apr 2013)

- Draft Publications for discussion (not for Approval and Password protected):

- Manual on Technical Aspects of the UN Convention on the Law of the Sea.
- Standardization of Undersea Feature Names

In 1986 the North Sea Hydrographic Commission completed a study on the consequences of the development of Electronic Chart Display and Information Systems (ECDIS) for Hydrographic Offices (HOs). It was then decided to establish an International Hydrographic Organization (IHO) Committee on ECDIS As several manufacturers were now developing these systems, it was of immediate importance to all concerned (Hydrographic Offices, mariners, national shipping authorities, and manufacturers) to have at least a first draft of the IHO and International Maritime Organization (IMO) guidance for both the Electronic Navigation Chart (ENC) and its display systems.

A first draft of the specifications was presented to IHO Member State Hydrographers in May 1987 at the 13th International Hydrographic Conference in Monaco. This draft was also widely distributed to National Shipping Authorities, mariner associations and manufacturers, for comment.

In November 1988, the COE established the Colours & Symbols Maintenance Working Group (CSMWG) to develop specifications and guidelines for chart symbol and colour definition for evaluation by hydrographic offices, ECDIS users, and manufacturers.

*4.3 The last publications*

"REGULATIONS OF THE IHO FOR INTERNATIONAL (INT) CHARTS AND CHART SPECIFICATIONS OF THE IHO": Edition 4.3.0 – August 2012

It includes:

• Part A: 'Regulations of the IHO for International (INT) Charts'

• Part B: 'Chart Specifications of the IHO for Medium- and Large-scale National and International (INT) Charts'

• Part C: 'Chart Specifications of the IHO for Small-Scale International (INT) Charts'

„GUIDANCE FOR THE PREPARATION AND MAINTENANCE OF (INT) CHART SCHEMES, AND CATALOGUE OF (INT) CHARTS"

Last update: mars 29, 2013

Part A "Guidance for the Preparation and Maintenance of INT Chart schemes" is maintainted by the IHO Chart Specifications and Paper Chart Working Group (CSPCWG)

S-11 Part A

Part B "Catalogue of INT Charts" is maintained by the IHB in liaison with all regional INT chart coordinators

## 5. CONCLUSION

Effective communications are an essential ingredient to safe and efficient ship operations.

Communication can be achieved in many ways but the prime method for operational communications is through speech. And when in an operational situation such as berthing a ship or fighting a fire, it is vitally important that those involved can communicate effectively. The international community has chosen the English language as the medium for that communication and IMO has developed a standard vocabulary and the training tools to deliver it. We all now look to the teachers of maritime English to instil in young maritime students the appropriate skills and knowledge to ensure that failures of communications are no longer cited as a contributory cause of maritime accidents.

## 6. REFERENCES

[1] Winbow, A., *The importance of effective communication*, International Seminar on Maritime English, Maritime Faculty, Istanbul Technical University, Istanbul, Turkey, 20 to 22 March 2002

[2] *** *IMO's Standard Marine Communication Phrases* (SMCP), adopted by the IMO 22nd Assembly in November 2001 as resolution A.918(22)

[3] *** ISO 19018: 2004 Standard, *Ship and marine technology – Terms, abbreviations, graphical symbols and concepts on navigation*

[4] *** *Regulations for International (INT) Charts and Chart Specifications of the IHO*, August 2012,

INTERNATIONAL HYDROGRAPHIC BUREAU, *www.iho.int*

[5] *** *Standardization of List of Lights and Fog Signals*, June 2004, INTERNATIONAL HYDROGRAPHIC BUREAU, *www.iho.int*

[6] *** *Standardization of Undersea Feature Names*, Bathymetric Publication No. 6, 4th Edition, November 2008, English/French Version, INTERNATIONAL HYDROGRAPHIC BUREAU, *www.iho.int*

# ANALYSIS OF THE OPERATING REGIMES OF POWER PLANTS FOR DIFFERENT SITUATIONS NAVAL NAVIGATION

LUPCHIAN MARIANA

*"Dunarea de Jos" University of Galati, Romania*

**ABSTRACT**

This paper presents an analysis of exploitation parameters for naval propulsion plant at different operating regimes. The resistance of progress is calculated in two situations the navigation (ballast and full load). For regimes analyzed is determined propeller efficiency.

**Keywords:** *energetic plant, the ship, deadweight, ballas, full load*

## 1. INTRODUCTION

The current marine engines with compression ignition regimes operate on variables of power and speed which entail the changing parameters indicate, effective, that characterize the operating mode of the engine.

The functioning regimes for naval propulsion plants are determined by the mechanic characteristics of the internal combustion engine, functioning, power transmission and the ship.[6]

The operation of the vessel must take into consideration the parameters for which it was designed and built, thus satisfying all the aspects the technical and economical competitiveness included.[4]

This paper presents a calculation method to determine optimum operating conditions of power plants installations with internal combustion engines used on ships. Need to find the optimal order size to ensure optimal operating regimes.

## 2. CASE STUDY

The tanker is equipped with a single propeller, the propulsion of the vessel being provided by a diesel engine, MAN B & W with 6-cylinder. Engine power: 9480 [kW], 127 [rpm]; deadweight in the sea water is 37000 tdw.[2]

The ship is equipped with three Diesel generators each with many 6 cylinder in-line power of 960 kW, speed 900 (rpm).

The manufacturer is running a trial race at full load, ship ballast water is high, the draft of 10.50 [m].

The crew consists of 31 persons.

The vessel is equipped with a single propeller.

The propulsion factors were estimated. The results obtained are very close to basin results of trials to. Propulsion of the ship is provided by a fixed pitch propeller that allows modification propulsion performance by adjusting a single parameter function: speed propeller.

With resistance to progress was calculated power required to motor flange, considering yields of propulsion, propeller shafts, bearing in mind that some yields depend on ship speed.

Resistance of progress was graphically represented according to speed and load.

The resistance to progress is one of the most important qualities for navigation, which depends on the power of the propulsion system.

For propulsion plant study appears the need for a method of estimating the required propulsion power.

Table 1. The resistance to progress of the ship

| No. | v [Nd] | $R_{tb}$ [kN] (ballast) | $R_t$ [kN] (full load) |
|---|---|---|---|
| 1. | 11,00 | 253,260 | 326,150 |
| 2. | 12,00 | 310,990 | 390,400 |
| 3. | 13,00 | 380,850 | 463,870 |
| 4. | 13,57 | 430,000 | 504,186 |
| 5. | 14,00 | 466,380 | 541,370 |
| 6. | 14,87 | 560,000 | 619.075 |
| 7. | 15,00 | 573,420 | 636,780 |
| 8. | 15,38 | 637,000 | 677,525 |
| 9. | 16,00 | 696,440 | 753,360 |

Rtb [kN]- the resistance of progress (ballast);
Rt [kN]- the resistance of progress (full load);
v[Nd] - ship's speed.

Method used for determining the ship's the resistance to progress is G.GJ.Mennen and J.Holtrop.[5]

Engine power is determined operating conditions analyzed (ship loaded) the diagram engine load supplied by the manufacturer.

The independent variables for a naval propulsion plant with internal combustion engine, with an imposed structure, induce the exploitation regimes for this naval propulsion plant, determined by the functional characteristics of internal combustion engines, power transmission characteristics, the consumer's characteristics.[5]

he manufacturer is running a trial race at full load, the sh

Changing a parameter influences many other factors lead to changes in other parameters. It is impossible to change a dimension or parameter no significant effects on several dependent variables.

Naval power plant performance are determined by the performance of each part of the system and the connections between them.

Its elements must achieve energy fuel processing, transmission, processing and consuming it with maximum economy.

In figure 1 is represented the resistance to progress of the ship for navigation the two situations analyzed.

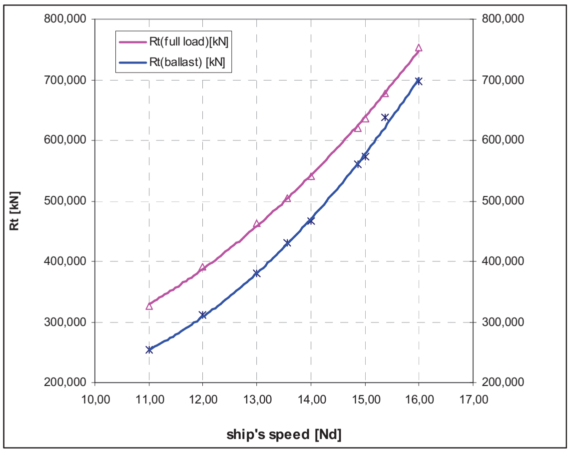



Figure 1. The resistance to progress of the ship

Marine engine operation is automated and controlled by a computer system that adjusts the parameters to achieve optimal performance in all situations.

It can be said that a ship is more effective during the voyage as the ship is higher compared to residence time of the ship.

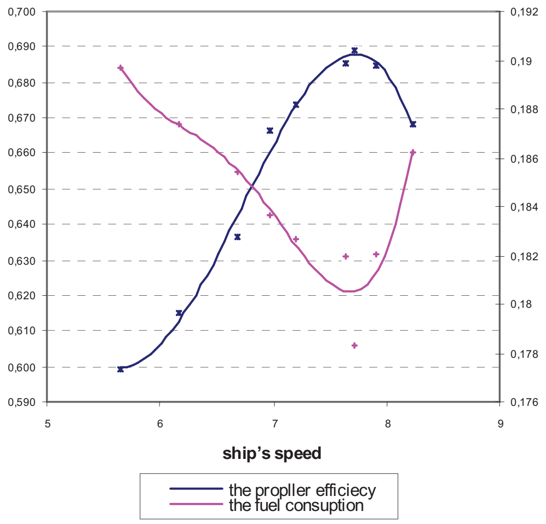



Figure 2. The resistance to progress of the ship

Figure 2 presents the propeller efficiency and fuel consumption depending on vessel speed.

For a propeller with constant characteristics the speed variation is make by changing the propeller speed.

Operation of the vessel must take into consideration the parameters for which it was designed and built thus satisfying all the aspects technically.

Fuel efficiency is dependent on several parameters of a vehicle including engine parameters, aerodynamic, weight and rolling resistance.

## 3. RESULTS OBTAINED

The vessel must operate at the parameters for which it was designed and constructed, satisfy all aspects of competitiveness the technical and economical.

Maximum efficiency was obtained from the system with vessel speed v = 15 Nd, where fuel consumption minimum. The resistance to progress of the ship is Rt = 636,780 [kN](full load) and $Rt_b$=573,420 [kN] (for ballast).

The functioning regimes for naval propulsion plant are determined by the mechanic characteristics of internal combustion engine, functioning, power transmission and the ship: thermic regime, exterior adjustment parameters of the engine, technical state of internal combustion engines.

In the case of the energetic plant with internal combustion engines, which dispose of automatization systems, their functionality is assured by two essential elements: their structure and the program of implementing the functioning regimes.

## 4. REFERENCES

[1] MC Programme Engine Selection Guide MAN B&W Diesel A/S Two- stroke Engines 2nd Edition February 1992.

[2] Engine SelectionGuide Two-Stroke MC/MC-C Engines, 5th Edition February 2000.

[3] MC Programme Engine Selection Guide MAN B&W Diesel A/S Two- stroke Engines 2nd Edition February 1992.

[4] Stan, L., Memet, F., Buzbuchi, N. Combustion simulation for naval diesel engine, Proceedings of the 3rd International Conference on Maritime and Naval Science and Engineering

[5] Caraghiulea Mariana (Lupchian Mariana), Formulating thermoeconomic optimization problems for the energetic plant with internal combustion engines applied on ship, METIME, Galati, 2007.

[6] Lupchian Mariana, Determination of optimum operating regime for a naval power plant based on minimum fuel consumption, Modern Technologies, Quality and Innovation - New face of TMCR, 24-26 May 2012, Sinaia.

# THE GENERALIZATION OF THE QUADRANTAL ZENITH ANGLE COUNTING RULE

[1]LUPU SERGIU, [2]POCORA ANDREI, [3]LUPU ELENA-CARMEN

[1,2]*Mircea cel Batran Naval Academy, Constanta,* [3]*OvidiusUniversity of Constanta, Romania*

**ABSTRACT**

Calculating the azimuth of a star can be achieved by using spherical trigonometry formulas „sin$Z_C$”, „ctg$Z_S$” or with A.B.C. tables using D.H-90 tables or Norrie’s Nautical Tables. The quadrantal zenith angle counting rule can be achieved only for the positive heights of a star. In this paper the authors developed the generalized quadrantal zenith angle counting rule for the cases in which the heights are negative.

**Keywords:** *spherical triangle, azimuth, cotangent formula, quadrantal zenith angle.*

## 1. INTRODUCTION

The spherical triangle of position arises through the intersection of three great circles:

- the observer’s celestial meridian;
- the vertical circle of the star;
- the hour circle of the star.

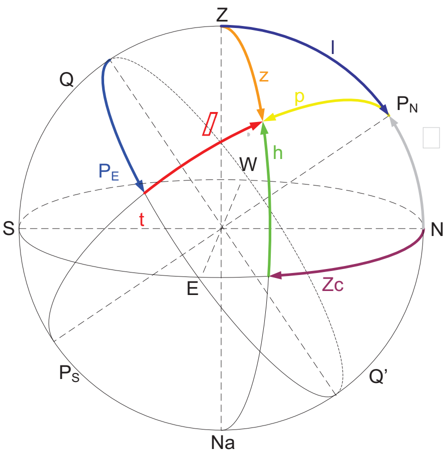



Figure 1. The celestial sphere

The elements of a spherical triangle are:

- the triangle’s peaks;
- the triangle’s sides;
- the triangle’s angles.

The peaks of spherical triangle are:

- the zenith (Z);
- the high celestial pole NP (SP);
- the star A.

Spherical triangle’s sides are great arcs resulted by combining horizontal and equatorial coordinates at the intersection of the three great circles:

- the colatitude $\ell = 90° - \varphi$ ;
- the zenith distance $z = 90° - h$ ;
- the polar distance $p = 90° - \delta$ ;

Spherical triangle’s peaks are as follows:

- the zenith angle (Z);
- the pole angle (P);
- the parallactic angle A.

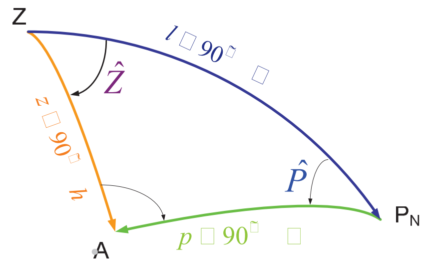



Figure 2. The spherical triangle

Calculation of the azimuth of a star can be achieved through three methods:

1. using cot $Z_S$ formula;
2. using the A.B.C. tables;
3. using sin $Z_C$ formula.

## 2. THE CALCULATION OF AZIMUTH (Az) ACCORDING TO LATITUDE (φ), DECLINATION (δ) AND THE POLE ANGLE (P) USING “cot. $Z_S$” FORMULA.

The deduction of formula.

The four consecutive elements formula is applied in the spherical triangle of position:

“The cotangent of the edge angle multiplied by the sine of the mean angle is equal to the product of the side edge cotangent through the sine of the mean side, minus the product of the middle elements cosine [1-8].

The consecutive elements are:

- the zenith angle Z;
- the colatitude $\ell = 90° - \varphi$;
- the pole angle P;
- the polar distance $p = 90° - \delta$.

Thus:

$$\cot Zs = \tan\delta \cdot \cos\varphi \cdot \operatorname{cosec}\hat{P} - \sin\varphi \cdot \cot\hat{P} \qquad (1)$$

The formula can be solved using logarithms, as follows:

$$m = \tan\delta \cdot \cos\varphi \cdot \operatorname{cosec}\hat{P} \qquad n = -\sin\varphi \cdot \cot\hat{P}$$

$$\cot Zs = m + n \qquad (2)$$

The rule of the signs:

m>0 if φ and δ have the same name (sign);

n>0 if P>90°;

m<0 if φ and δ have different names (signs);

n<0 if P<90°;

If cot $Z_S > 0$, then $Z_S$ = the calculated value cot $Z_S$ <0, then $Z_S$ = 180° - the calculated value.

The obtained zenith angle $Z_s$ is a semicircular zenith angle counted from the high pole vertical, to East or West according to the pole angle P.

## 3. THE CALCULATION OF AZIMUTH (Az) USING "A.B.C." TABLES: METHOD OF PREPARATION AND USE (T-40 – D.H.-90 OR NORIE'S NAUTICAL TABLES)

The table if founded using the following formula (1). This is inconvenient for logarithmic calculation therefore it was transformed by dividing with cos φ and multiplying by 10, thus:

$$10\cdot\cot Zs\cdot\sec\varphi = 10\cdot\tan\delta\cdot\cos ec\hat{P} - 10\tan\varphi\cdot\cot\hat{P} \quad (3)$$

The following notations take place :

A = 10 tan δ cosec P

B = -10 cot P tan φ

C = 10 cot Z sec φ

C = A + B

## 4. THE CALCULATION OF AZIMUTH (Az) ACCORDING TO HEIGHT (h), DECLINATION (δ) AND POLE ANGLE (P) USING THE FORMULA "sin $Z_C$"

The deduction of the formula.

The law of sines is applied in the spherical triangle of position:

"the ratio between the angle sines and opposite sides sines are equal".

$$\frac{\sin Z_C}{\sin p} = \frac{\sin\hat{P}}{\sin z} \Rightarrow \frac{\sin Z_C}{\sin(90^\circ - \delta)} = \frac{\sin\hat{P}}{\sin(90^\circ - h)} \quad (4)$$

$$\frac{\sin Z_C}{\sin\delta} = \frac{\sin\hat{P}}{\cosh} \Rightarrow \sin Z_C = \sec h\cdot\cos\delta\cdot\sin\hat{P} \quad (5)$$

The setting of the horizon quadrant is made based on the position of the star from the first vertical and the hemisphere in which the star in positioned.

In order to determine the origin of counting, N or S, of the obtained quadrantal zenith angle, is proceeded as:

**I. δ and φ have the same sign (name)**

- if δ > φ the counting of $Z_C$ starts from the high pole vertical;
- if δ < φ the counting of $Z_C$ is as follows:
  - if h < $h_I$ the counting starts from the high pole vertical; (Table -39 DH-90)
  - if h > $h_I$ the counting starts from the low pole vertical; (Table -39 DH-90)

**II. δ and φ have different signs (names)**

The counting of $Z_C$ starts from the low pole vertical.

The counting to E or W is made according to the pole angle $P_{E/W}$.

The 39th table from D.H.-90 [9], contains the heights of a star in the first vertical. During daytime movement the star intersects the first vertical twice, but it can only be observed the passing of those stars whose declination is smaller than the site's latitude and have the same sign as it (if the declination has the opposite sign than the latitude, than the star will pass beneath the horizon). If the stars declination is bigger than the site's latitude, than the star will not intersect at all the first vertical and it will bear away from the site's meridian at a certain angle named elongation.

The table if founded using the following formula

$$\sinh_I = \frac{\sin\delta}{\sin\varphi} \quad (6)$$

Input arguments in the use of the table are the observer's latitude and the stars declination.

## 5. THE GENERALIZATION OF THE QUADRANTAL ZENITH ANGLE COUNTING RULE

The quadrantal zenith angle counting rule can be applied only if the height of the star is positive. If the star's declination is of opposite sign with the site's latitude the counting rule does not fully comply.

The generalized zenith angle counting rule, where the star's declination is of opposite sign to the site's latitude:

**II. δ and φ of opposite signs (names)**

- if δ < (90º-φ) (the colatitude) the counting of $Z_C$ is as follows:
  - if h > 0 from the low pole vertical;
  - if h < 0 $Z_C$ is counted as follows:
    - if |he| < $h_I$ from the low pole vertical; (Table -39 DH-90)
    - if |he| > $h_I$ from the high pole vertical; (Table -39 DH-90)
- if δ > (90º-φ) (the colatitude), the star's height is negative then $Z_C$ is counted as follows:
  - if |he| < $h_I$ from the low pole vertical; (Table -39 DH-90)
  - if |he| > $h_I$ from the high pole vertical; (Table -39 DH-90)

The counting to E or W is made according to the pole angle $P_{E/W}$.

## 6. NUMERICAL APPLICATIONS

Case 1.

Declination δ < (90º-φ) (the colatitude),

Altitude h > 0

Table 1. The azimuth values for case 1

| Initial data | sinh | cot $Z_S$ | sin$Z_C$ |
|---|---|---|---|
| φ = 40º00'.0N<br>δ = S10º00'.0<br>$\hat{P}_E$ = 070º00'.0 | he = 08º25'.1 | $Z_S$ = S69º.3E<br>Az = 110º.7 | $Z_C$ =SE69º.3<br>Az = 110º.7 |

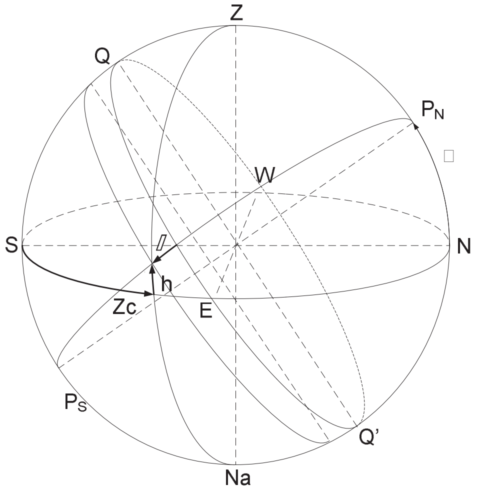



Figure 3. The star representation for case 1

Case 2.
Declination $\delta < (90^o\text{-}\varphi)$ (the colatitude),
Altitude $h < 0$,
$|he| < h_I$ from T-39 DH-90 $h_I = 15^o._7$

Table 2. The azimuth values for case 2

| Initial data | sinh | cot $Z_S$ | sin$Z_C$ |
|---|---|---|---|
| $\varphi = 40^o00'._0N$ | he = $-14^o02'._5$ | $Z_S$ = S88º.6E Az = 091º.4 | $Z_C$ =SE88º.6 Az = 091º.4 |
| $\delta = S10^o00'._0$ | | | |
| $\hat{P}_E = 100^o00'._0$ | | | |

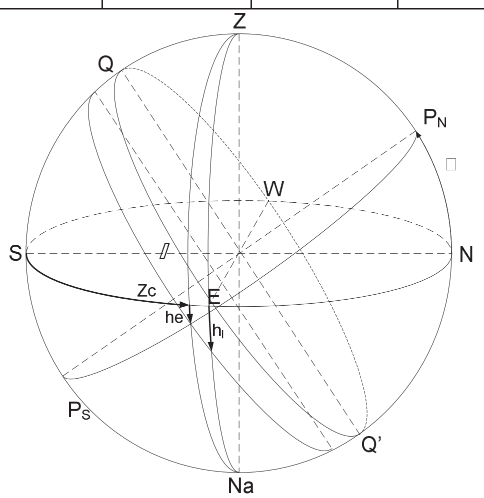



Figure 4. The star representation for case 2

Case 3.
Declination $\delta < (90^o\text{-}\varphi)$ (the colatitude),
Altitude $h < 0$,
$|he| > h_I$ from T-39 DH-90 $h_I = 15^o._7$

Table 3. The azimuth values for case 3

| Initial data | sinh | cot $Z_S$ | sin$Z_C$ |
|---|---|---|---|
| $\varphi = 40^o00'._0N$ | he = $-29^o15'._8$ | $Z_S$ = N77º.9E Az = 077º.9 | $Z_C$ =SE77º.8 Az = 102º.2 |
| $\delta = S10^o00'._0$ | | | |
| $\hat{P}_E = 120^o00'._0$ | | | |

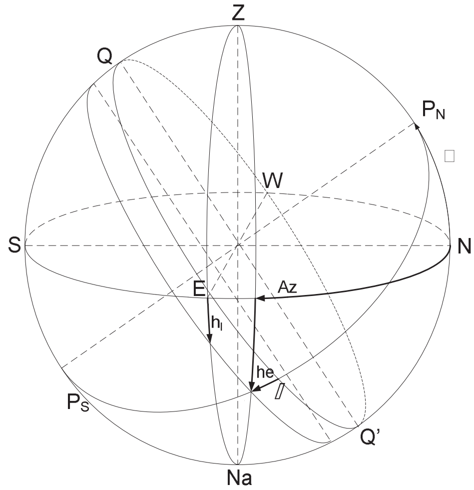



Figure 5. The star representation for case 3

Case 4.
Declination $\delta > (90^o\text{-}\varphi)$ (the colatitude),
Altitude $h < 0$
$|he| < h_I$ from T-39 DH-90 $h_I = 69^o._9$

Table 4. The azimuth values for case 4

| Initial data | sinh | cot $Z_S$ | sin$Z_C$ |
|---|---|---|---|
| $\varphi = 50^o00'._0N$ | he = $-23^o28'._4$ | $Z_S$ = S45º.4E Az = 134º.6 | $Z_C$ =SE45º.4 Az = 134º.6 |
| $\delta = S46^o00'._0$ | | | |
| $\hat{P}_E = 070^o00'._0$ | | | |

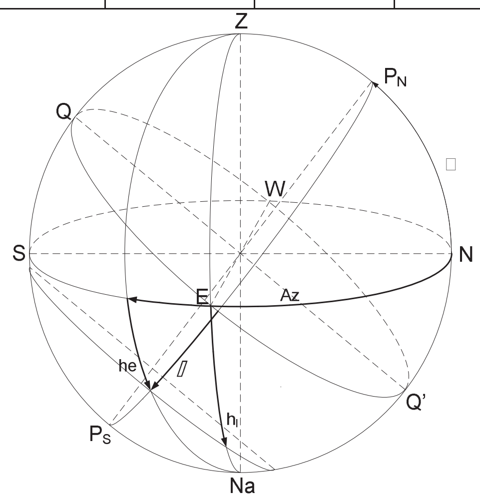



Figure 6. The star representation for case 4

Case 5.
Declination $\delta > (90^o\text{-}\varphi)$ (the colatitude),
Altitude $h < 0$
$|he| > h_I$ from T-39 DH-90 $h_I = 69^o._9$

Table 5. The azimuth values for case 5

| Initial data | sinh | cot $Z_S$ | sin$Z_C$ |
|---|---|---|---|
| $\varphi = 50^o00'._0N$ | he = $-76^o04'._8$ | $Z_S$ = N81º.0E Az = 081º.0 | $Z_C$ =SE81º.0 Az = 099º.0 |
| $\delta = S46^o00'._0$ | | | |
| $\hat{P}_E = 160^o00'._0$ | | | |

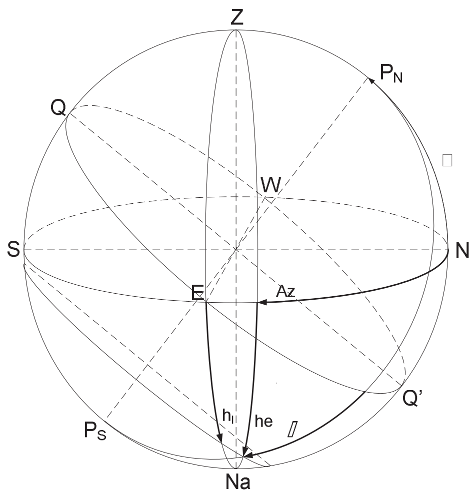



Figure 7. The star representation for case 5

## 7. CONCLUSIONS

The quadrantal zenith angle counting rule is no longer valid for cases 3 and 5. In these cases other values are obtained due to the low pole counting rule, in our case from the south celestial pole. For these cases, the quadrantal zenith angle rule proposed by the authors solves the problem of determining the star's azimuth.

Thus, the generalization of quadrantal zenith angle counting rule, both for positive and negative estimated heights, was achieved.

## 8. REFERENCES

[1] BALABAN, Gh., *Tratat de navigație maritimă*, Editura Leda, Constanța, 1996.
[2] BLANCE A.G. *Norie's Nautical Tables*, University Press, Cambridge, 1977
[3] BOŞNEAGU R. "*Navigație astronomică*", Ed. Hidrografică, 2012
[4] CHIRIȚĂ, M., *Astronomie nautică*, Editura Forțelor Armate, Bucureşti, 1958
[5] COJOCARU, S., „*Tratat de navigație maritimă – Metodele moderne ale navigație maritime*", Editura Ars Academica, Bucureşti, 2008
[6] INDRAJITH D. Wijayratne, Principles of geodesy – Course notes, Michigan Technological University Houghton, 2004
[7] IORDĂNOAIE F. *Astronomie şi navigație astronomică*, 2004
[8] PROSSINAGG C. *Curs de navigatie*, Tipografia Scoalei Navale, Constanta, 1933.
[9] * * *, *Table nautice DH-90*, Direcția Hidrografică Maritimă, Constanța, 1989

# SHIPS NEW BUILDINGS, REPAIRS & CONVERSIONS OUTLOOK 2009-2012. 2013 TRENDS

[1]MANEA EMIL, [2]CHIȚU MIHAELA-GRETI

[1]*Over Seas Manager Ship Repairs & Conversions Projects, Constanta Shipyard, Greece Representative Office*
[2]*Ovidius University of Constanta, Romania*

**ABSTRACT**

Shipbuilding is known as one of the competitive markets in the world.

Shipbuilding is the sector worst affected by the financial and economic crisis, the current global crisis hitting severely this industry. It can have the most painful impact on many shipbuilding countries of the world due to the biggest overcapacity of shipyards ever seen and far greater supply of fleet than required by the market. Analysis shows that world shipbuilding order book is shrinking fast because of decreasing of new orders and cancellations.

The global competitive position of the European industry is under severe pressure due to the difficult market environment. European industry has to advance in superior products regarding ship safety, efficiency and marine environment protection as well as in innovative processes intended to increase production productivity.

**Keywords:** *international seaborne trade, freight rates, shipbuilders market, ship repairs & conversions market.*

## 1. INTRODUCTION

The year 2008 marked a major turning point in the history of the world economy and trade. Growth in the world economy slowed abruptly in the last part of 2008, with deeping of the global financial crisis.

Growth in developing economies and countries with economies in transition has turned out to be less resilient than expected.

After 2009 when merchandise trade (imports and exports) in developed countries at a rate higher than the world their recoveries in 2010 – 2012 there are not as per expectations. By the middle of 2008, things took a turn of worse, as the global financial crisis began to affect demand.

Trade volumes in the bulk cargo and liners sectors, sustained dramatic declines, which continued for the remainder of the year 2008 and well furthermore coming period of 2009 – 2012.

Freight rates in 2011 and 2012 were often at unprofitable levels for ship owners. Substantial freight-rate reductions were reported within the dry bulk, liquid bulk and containerized cargo segments. Vessels oversupply continued to be a driving factor behind reductions in freight rates. Ship operators attempted to make savings through greater economies of scale by investing in large capacity ships in the tanker and dry bulk market segment.

Global new buildings contracting remain difficult and uncertain due in particularly to the significant size of the ships supply and the impact of the demand/supply mismatch on shipping markets. Ship owners have a problem of low utilization rate. Second hand prices for ships are more volatile than new buildings market, being “market” driven and ships as assets value are much less 2012 than 2008.

Up to 2015 ships that are above 20 years will be demolished. Mandatory regulations (as: Ballast Water Treatment; Energy efficiency Design Index) are affecting the shipping market where tankers have sluggish demand but a smaller order book and bulkers have stronger demand but big order book.

The immediate outlook for the world’s ship repairers is currently an interesting one based on the main trading routes, areas existing ships repair capacities and facilities, ship owners repair ships pressure and existing shipyards competition.

## 2. DEVELOPMENTS IN INTERNATIONAL SEABORNE TRADE

The world economy is highly dependent of shipping which meets approximately 85% of the global demand of transport. The world economy generates the basic demand for seaborne trade. Developments in particular commodities and changes in the distance over which cargo is transported, are key players in modifying the economics of world trade for the shipping market. We live in a global society which is supported by a global economy and that economy simply cannot function if it were not for ships and the shipping industry.

The international shipping industry can be divided into closely related shipping markets, each trading in a different commodity:

a. The freight market consists of ship-owners, charterers and brokers. They use contractual arrangements. Ship-owners contract to carry cargo for an agreed price per ton while the charter market hires out ships for a certain period. A charter is legally agreed upon in a charter-party in which the terms of the deal are clearly set out;

b. The sale and purchase market. Second-hand ships are traded between ship-owners. The administrative procedures used are roughly the same as in the real-estate business, using a standard contract. Trading ships is an important source of revenue for ship-owners, as the prices are very volatile. The second hand value of ships depends on freight rates, age, inflation and expectations;

c. The demolition market. Ships are sold for scrap. The transactions happen between ship-owners and demolition merchants, often with speculators acting as intermediaries;

d. The new building market deals with transactions between ship-owners and shipbuilders. Contract negotiation can be very complex and extend beyond price. They also cover ship specifications, delivery date, stage payments and finance. The prices on the new building market are very volatile and sometimes follow the prices on the sale and purchase market;

e. The ship repair and conversion market. Ship repair is a highly competitive industry, with yards all over the world competing for work. New yards are entering the market and the international tendering process, with bargain prices being offered in the yards of the former Soviet Union and Eastern Europe, China and Vietnam in the Far East. Traditional big repair bases like Rotterdam, Hamburg, Singapore and Japan have to face this new competition.

These markets are linked by cash flow and push the market traders in the direction they want.

## 3. WORLD SEABORNE 2008-2012

The year 2008 marked a major turning point in the history of the world economy and trade. Growth in the world economy slowed abruptly in the last part of 2008, with the deeping of the global financial crisis. Growth in developing economies and countries with economies in transition has turned out to be less resilient than expected.

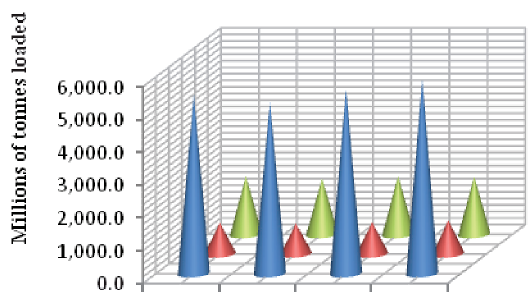
In tandem with the economical downturn and reduced trade, growth in international seaborne trade decelerated in 2008 expanding by 3.6 per cent compared with 4.5 per cent in 2007.

The volume of international seaborne trade in 2008 was estimated at 8.17 billion tons. Reflecting a sharp decline in demand for consumption goods , as well a fall in industrial production in major economies and reduced energy demands, the deceleration in seaborne volumes affected all shipping sectors.

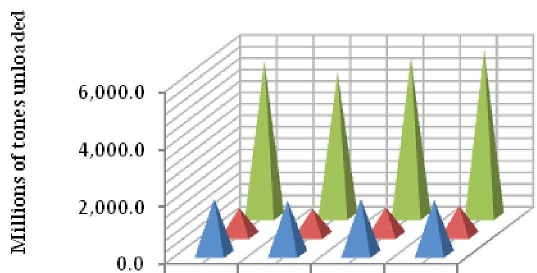
The year 2009 witnessed the worst global recession in over 7 decades and the sharpest decline in the volume of global merchandise trade, international seaborne trade volumes contracted by 4.5 per cent in 2009. While no shipping segment was spared, minor dry bulks and containerized trades suffered the most severe contractions. This reflected the weak consumer confidence which depressed the retail sector and low level of capital investment, as well as slowdown in the real estate and housing sectors. In contrast iron ore and coal trade volumes held strong on the backs of China's robust import demand driven, in particular by China's large stimulus package.

The world economic situation has brightened in 2010. However, multiple risks threaten to undermine the prospects of a sustained recovery and a stable world economy- including sovereign debt problems in many developed regions, and fiscal austerity. These risks were further magnified by the extraordinary shocks that have occurred in 2011, which have included natural disasters and political unrest, as well as rising and volatile energy and commodity prices. Given that for shipping, all stands and falls with worldwide macroeconomic conditions, the developments in world seaborne trade volumes mirrored the performance of the wider economy. After contracting in 2009, international shipping experienced an upswing in demand in 2010, and recorded a positive turnover in seaborne trade segments. However the outlook remains fragile, as seaborne trade is subject to the same uncertainties and shocks that face the world economy.

In tandem with the world economy and global merchandise trade, international seaborne shipments continued to grow in 2011, albeit at a slower rate than in 2010. Fuelled by strong growth in container and dry bulk trades, world seaborne trade grow 4 per cent in 2011, taking the total volume of goods loaded worldwide to 8.7 billion tons. In addition to the sovereign debt crisis in Europe and other difficulties facing advanced economies, a number of factors have weighted down on global growth. These include heightened global financial risks, political and social unrest in North Africa and Western Asia, natural disasters in Japan and Thailand which have disrupted regional and global supply chains, rising oil prices and volatility, the impact of austerity measures introduced in many countries and fading of the stimulus effect of 2010, and growing geopolitical tensions. Many of these factors remain relevant in 2012.




| | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| Dry cargo | 5,487.2 | 5,216.4 | 5,637.5 | 5,951.9 |
| Petroleum product & gas | 957.0 | 931.1 | 983.8 | 1,033.5 |
| Crude | 1,785.2 | 1,710.5 | 1,787.7 | 1,762.4 |




| | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| Dry cargo | 1,942.3 | 1,874.1 | 1,933.2 | 1,907.0 |
| Petroleum product & gas | 957.0 | 931.1 | 983.8 | 1,033.5 |
| Crude | 5,409.2 | 5,036.6 | 5,531.4 | 5,823.7 |

Figure 1 World goods loaded (left) and unloaded (right) during the 2008-2012 period

## 4. WORLD FLEET 2009 – 2012

At the beginning of 2009 the world fleet reached 1.19 billion deadweight tons, a year-on – year growth of 6.7 per cent compared to January 2008. The growth was the result of vessel orders placed before the financial crisis, when the industry still expecting continuing high grow rates in demand. By the beginning of 2010, the world merchant fleet reached 1.276 million deadweight tons, an increase of 84 million dwt over 2009.The year of 2010 saw an increase of 8.6 per cent growth in the world fleet. Deliveries amounted to 11.7 per cent of the existing fleet; the previous peak had been in 1974, when deliveries amounted to approximately 11 per cent of the existing fleet. The world merchant fleet reached almost 1.4 billion deadweight tons in January 2011, an increase of 120 million dwt over 2010. The world fleet continued to expand during 2011, reaching more than 1,5 billion deadweight tons in January 2012, an increase of over 37 per cent since 2008.

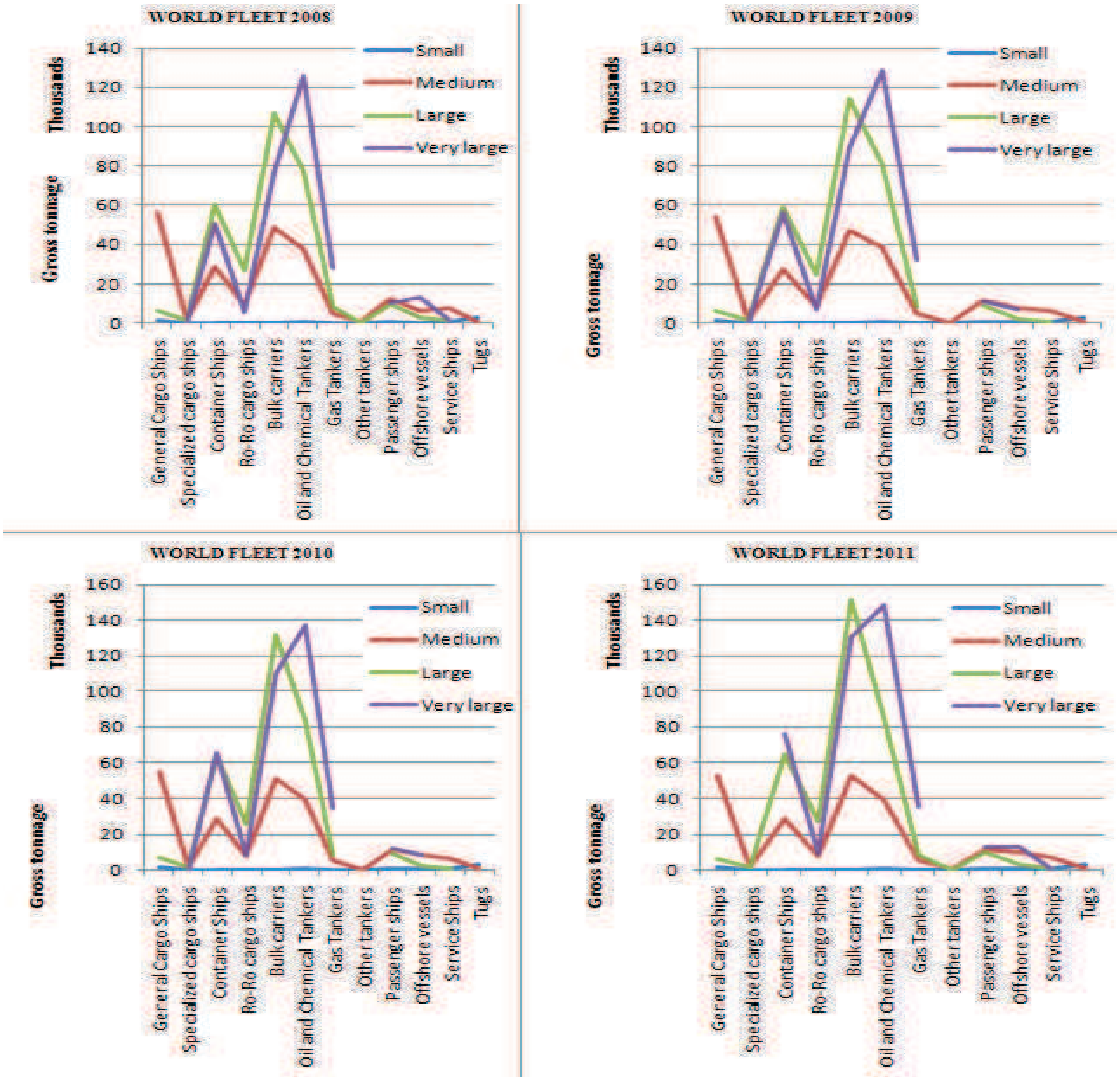



Figure 2 World fleet gross tonnage during the 2009-2011 period

## 5. FREIGHTS

As the world's shipping capacities continues to increase even during the economic downturn, the industry find itself confronted with a surge of oversupply and tumbling charter freight rates. Even the economic crisis, the new tonnage that entered on the market would have led to an oversupply of tonnage and a decline in vessel's prices. In 2009 as a consequence of falling demand and increased supply, freight rates have fallen from their 2008 heights. Freight rates in 2010 perform better than 2009. However tanker freight rates in general still remained depressed, in the dry bulk sector performed well for the first half of the year but lost from the end of May to mid July 2010 when Baltic Exchange Dry Indez declined about two thirds. Container freight rates in 2010 witnessed a major transformation brought about by a boost in exports and measures, the result could be seen in the New ConTex Index, which tripled in value from early 2010 to mid 2011. Freight rates in 2011 and in the beginning 2012 were often at unprofitable levels for ship owners. Substantial freight reductions were reported within dry bulk, liquid bulk and containerized cargo segments. Vessel oversupply continued to be a driving factor behind reductions in freight rates. Ships operators attempted to make savings through greater economies of scale by investing in large capacity ships in the tanker and dry bulk market sector.

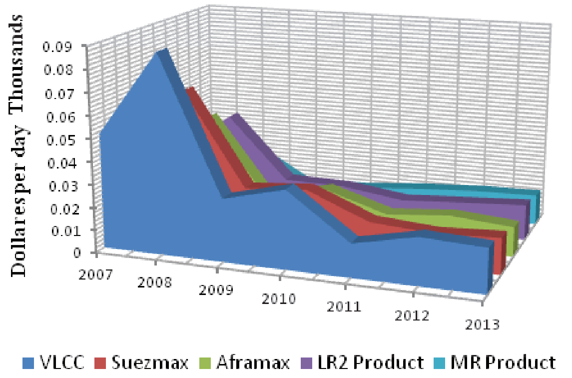



Figure 3 Tanker freights 2007-2013

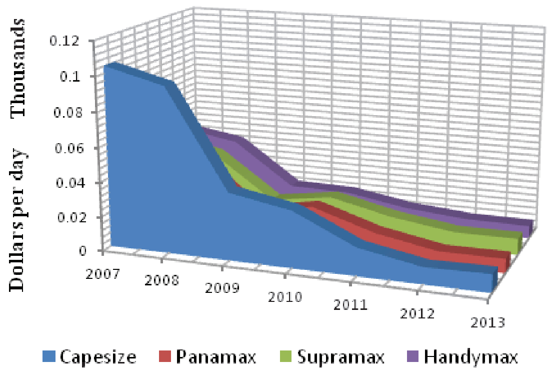
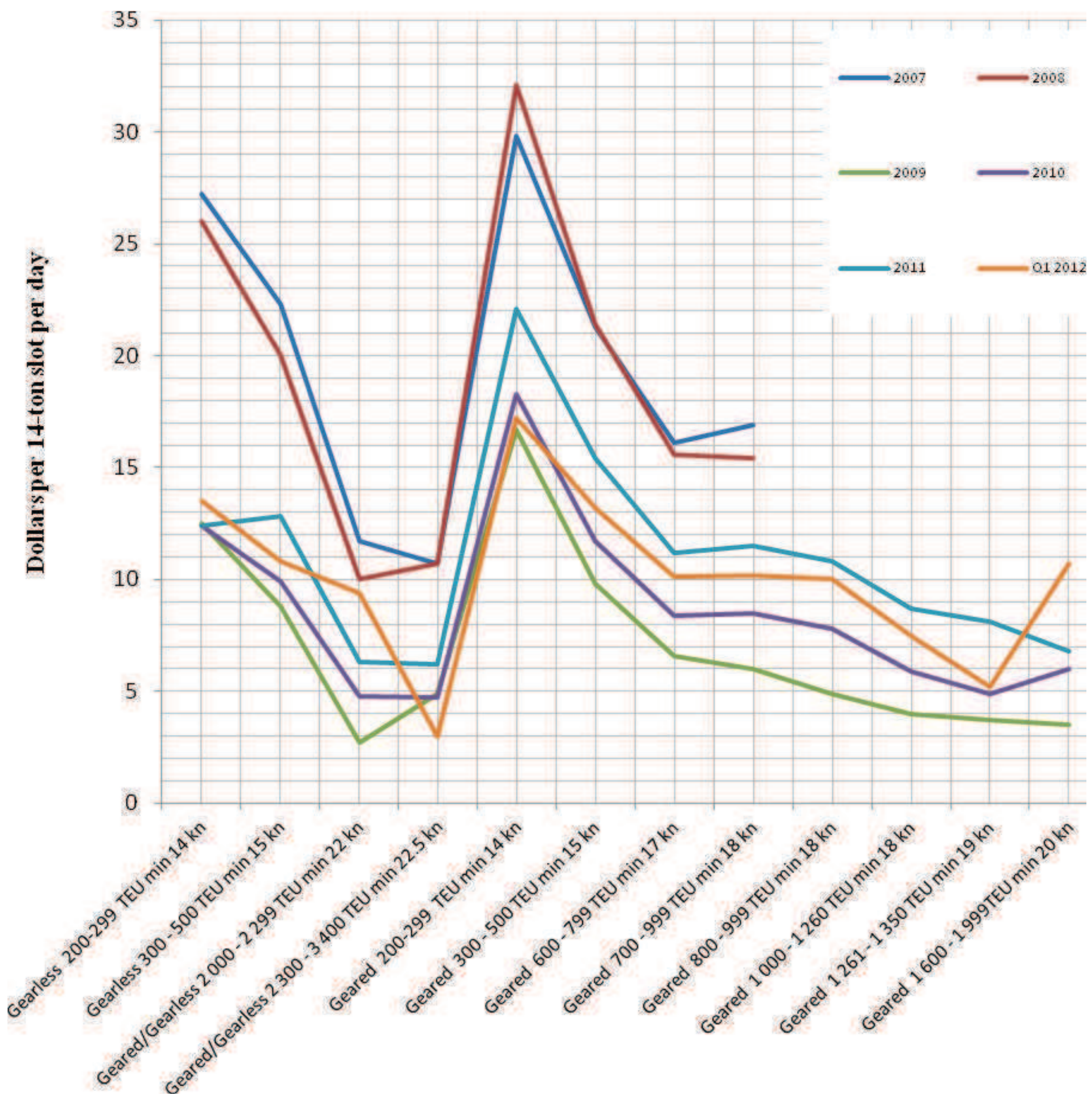



Figure 4 Bulk carrier freights 2007-2013




Fgiure. 5 Container freights 2007-2013

## 6. DEMOLITIONS

Prices for scrap metal in 2009 remain low compared to early 2008, and many owners have preferred to hold on and lay off their ships, hoping for better times to come. The resulting oversupply of new buildings tonnage in 2009 than led to an over 300 per cent surge in demolitions of older tonnage. In January 2011 have been registered approximately 30 million dwt from demolitions and other withdrawals from the market.

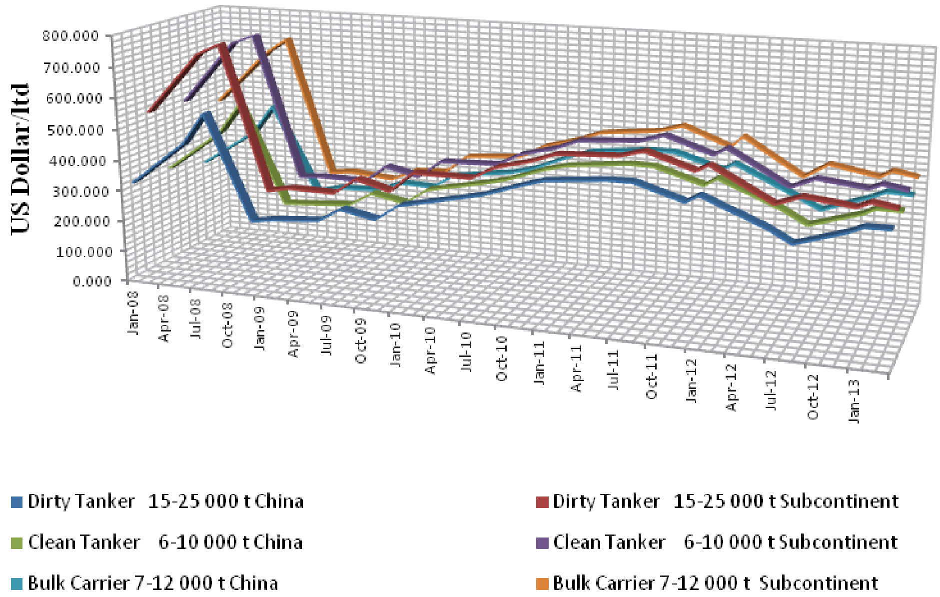



Figure 6 Demolition prices 2008-2013

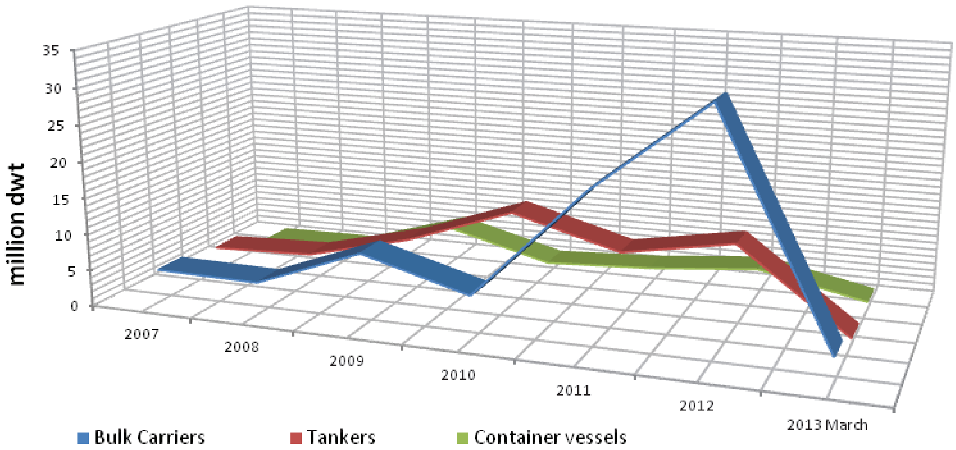



Figure 7 Demolition, in million dwt, 2007-Q1 2013

## 7. SECOND HAND MARKET

In 2008 price for second hand tonnage fluctuated more than prices for new buildings. Between 2001 – 2007 prices for 5-years-old dry bulk carriers had surged more than six fold, reaching levels that were in fact significantly higher than the corresponding new building. In the economic downturn, a 5-years-old dry bulk carrier of 170,000 dwt was 47 per cent cheaper than a new building and a 5-years-old 300,000 dwt tanker cost 27 per cent less than the corresponding new building. Between the end of 2007 and the end of 2008, second hand prices for tankers went down with 15 – 20 per cent and second hand prices for dry bulk carriers went down between 67 – 71 per cent.

In 2009 on account of overcapacity prices for second-hand ships continued to fall in 2009 more dramatic. Average prices for 10-years-old dry bulk vessel decreased by between 46 – 61 per cent, 10-years-old container ships were between 47-69 per cent cheaper in 2009 than 2008 and oil tanker prices declined by between 38 – 42 per cent. On average second-hand vessel prices were 50 per cent more volatile than new building prices because our market-driven whereas new building prices are driven by the cost of ships building.

In 2010 the result were mixed. The large oil tankers held their value, while small tankers and specialized product tankers declined in value. In the dry bulk sector, the price of medium size Panamax vessels decreased, while the price of smaller and larger vessels increased.

The price of all size of second hand container ships also raise in value during 2010 as trade volumes recovered.

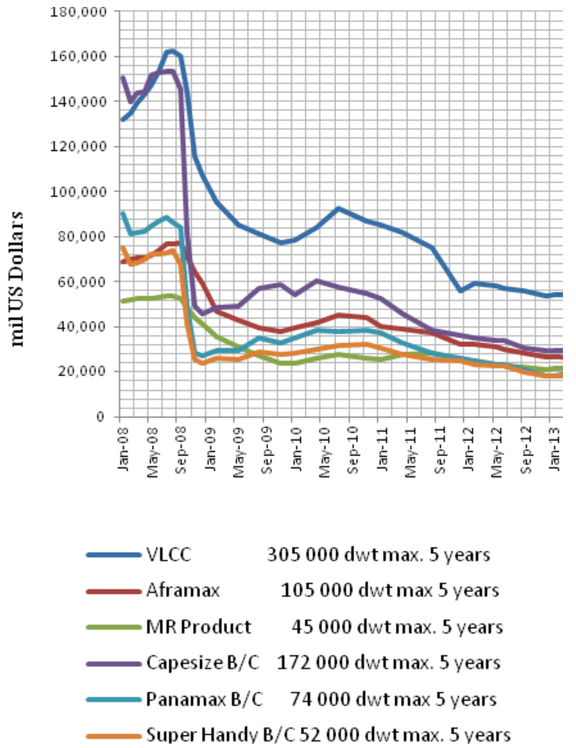



Figure 8 Second hand vessels prices 2009-2013

## 8. SHIPYARDS NEW BUILDING MARKET

In 2008 although new orders for practically come to stand still, vessels continued to be constructed in line with orders prior to the economic crisis, especially in the dry bulk segment. In fact new buildings activities reached the highest level ever recorded in terms of deadweights tons , with deliveries totaling 82.3 million dwt. Deliveries of oil tankers reached a historical record of 437 units of 10,000 dwt and above meaning abt. 33.7 million dwt. There were 335 dry bulker carriers with a combined tonnage of 28.9 million dwt. Others vessel types delivered- including car carriers, container ships, LNG tankers and general cargo ships reached 2,207 units with a combined tonnage of 19.7 million dwt.

In 2009 numerous orders at the world's shipyards have been cancelled. Ship builders have been spending more time on renegotiating existing contracts than on receiving new enquires on orders. Although new orders for most vessel types have been practically come to a standstill, vessels continued to be delivered by the world's shipyards, especially in the dry bulk segment. 2009 become a new record in new deliveries of 117 million dwt. New buildings grew by 42 per cent over 2008 because of ships ordered prior to the downturn in demand.

The price of new buildings in 2010 was lower for all vessels type reflecting market views that the capacity of the world fleet is sufficient to meet world trade in the short term.

In the world order book has counted a reduction by one third in 2011. Still largely responding to orders placed prior the economic crisis, the ship builders are reluctant to cancel or postpone deliveries.

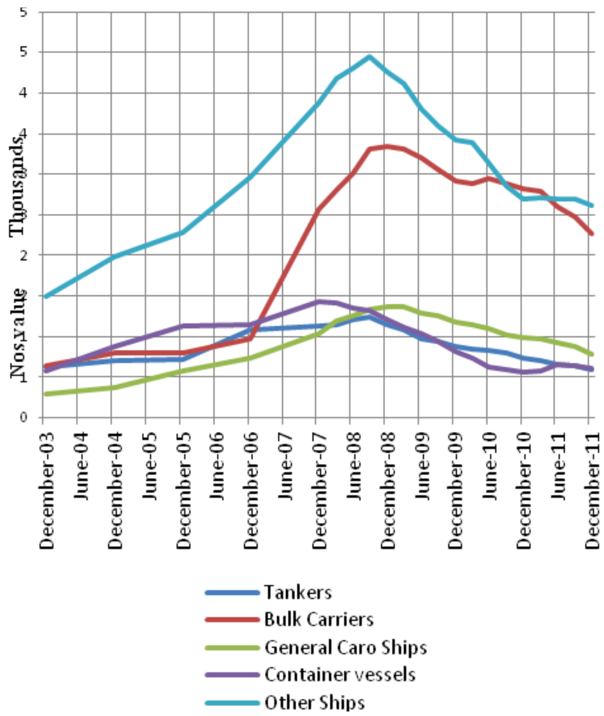



Figure 9 New building ships on order from December 2003 until November 2011

## 9. SHIPYARDS REPAIR & CONVERSION MARKET

Ship maintenance, repair and conversion represent a special business segment, in many aspects from the ship new building industry. Ship conversion is closer to new building yards activities in time of scales for each job; however, a refit requires a totally different approach in having the flexibility to constantly accommodate changes in work plan, according to the satisfaction of the client. Besides, ship maintenance and repair is typically a short term activity; so, most of the time, the ship is dry-docked and stays in dock on average between 10 to 12 days. Finally, the sector has the characteristic of a service industry with the aim to assure safe shipping and maritime operations and clean seas.

The fleet requires a regular inspection and maintenance of equipment and machinery. Ships are also generally by scheduled periodic repairs for which Classification Society and other Statutory Bodies have formulated guidelines for periodic survey such as : Special Hull and Machinery survey every 5 years, Dry-Dockings at 2 ½ years, and Hull and Machinery annual survey every year.

The world fleet growth increasing the demand in the ship repair industry taking into consideration the increased complexity of the modern ships requiring more regular maintenance.

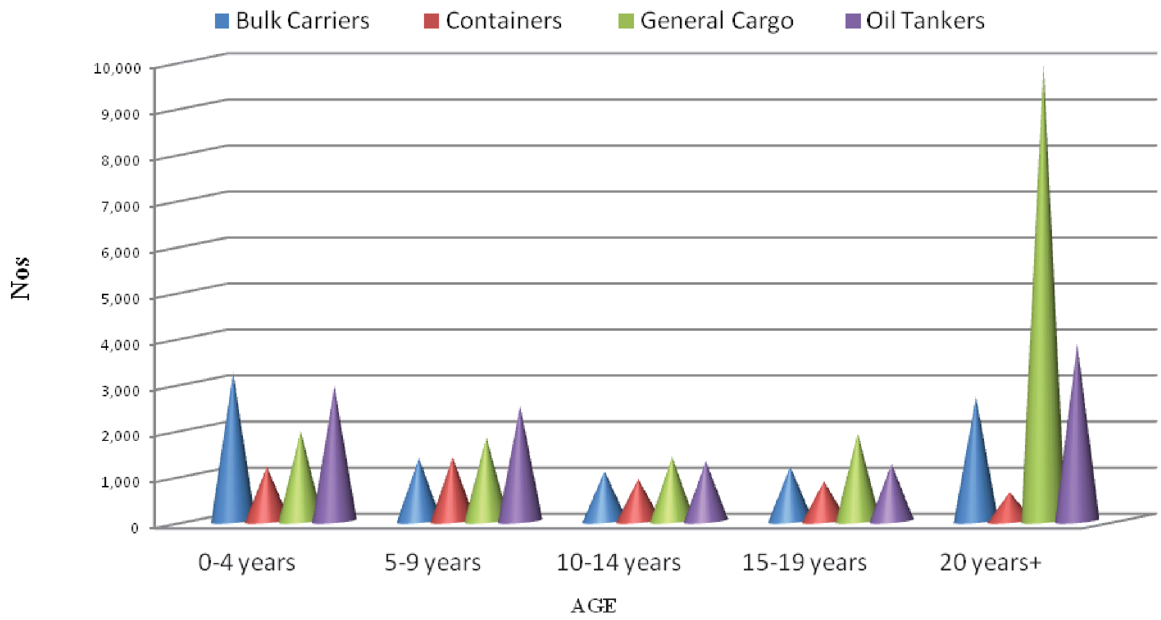



Figure 10 World fleet age in accord with the no. of ships

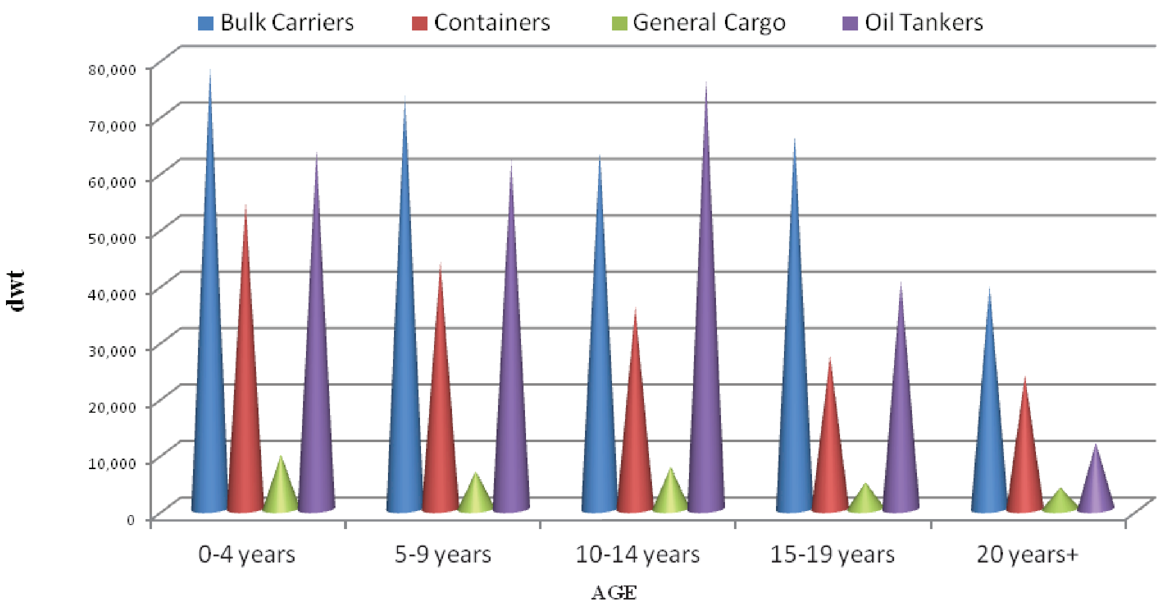



Figure 11 World fleet age in accord with the no. of ships respectively dwt

## 10. CONCLUSIONS

Global shipbuilding industry has been going through a downturn for the last four years. The downturn has been felt more in the commercial shipbuilding industry where demand tends to be driven by fixed asset investments and growth in global trade. Global commercial ship orders were down 48% Yoyo in the first nine months of 2012 and order backlog fell to half of the level in first half of 2008. At this point all lead sector indicators such as freight rates, ship prices, used ship transactions, and used ship prices suggest that commercial shipbuilding demand is unlikely to recover much in 2013 as the sector continues to suffer from oversupply, a weak financing market, and low freight rates.

Some shipbuilding industry segments are in a robust condition and show promising growth perspective; examples are supply vessels and installations for the of-shore industry (oil, gas and off shore wind energy) and marine dredgers. In relation to innovation, shipyards take a position in the role of system integrator, combining innovations from third parties/marine equipment suppliers in an integrated ship design and construction, and are a driving force behind new ships designed and innovations in response to market demands and in view of enhanced efficiency. A promising area is the "greening" of shipping through the reduction of emissions from ships and improvement of their energy efficiency.

The fleet requires a regular inspection and maintenance of equipment and machinery. Ships are also generally by scheduled periodic repairs for which Classification Society and other Statutory Bodies have formulated guidelines for periodic survey such as: Special Hull and Machinery survey every 5 years, Dry-Dockings at 2 ½ years, and Hull and Machinery annual survey every year.

The world fleet growth increasing the demand in the ship repair industry taking into consideration the increased complexity of the modern ships requiring more regular maintenance.

## 11. REFERENCES

[1] *** *The Platou Market Reports* 2010, 2011, 2012, 2013;

[2] *** Institute of Shipping Economics and Logistics – *Shipping Statistics and Market Review* 2012;

[3] *** *Equasis Statistics* – The World Fleet Reports 2008, 2009, 2010, 2011, 2012;

[4] *** *United Nations Conference on Trade and Development* – Review of Maritime Transport Reports 2009, 2010, 2011, 2012, 2013.

# IMPROVED THE MARITIME ONLINE TEACHING BY USING THE KNOWLEDGE MANAGEMENT CONCEPT

[1]RAICU ALEXANDRA, [2]RAICU GABRIEL, [3]LAMBA DANUT

[1,2,3]*Constanta Maritime University, Romania*

**ABSTRACT**

Many activity fields including maritime area involve the concept of Knowledge Management. These programs are typically tied to organizational objectives such as improved performance, competitive advantage, innovation, developmental processes, lessons learnt transfer and the general development of collaborative practices. The paper present the applied online teaching system used by our university, designed to offer easy access to information for teachers and students, but also available for former students, now officers onboard ships, in order to be able to update latest information's about technical development in maritime field necessary in their duty activities. The international work to improve maritime education and training has identified lack of access to quality learning material and tutors in many countries. It is assumed that increased use of information and communication technologies will be one major component for future quality improvement of maritime education and training.

**Keywords:** *Knowledge Management, Maritime Education Training, Technology, Economic performance.*

## 1. INTRODUCTION

Knowledge Management comprises a range of practices used by organizations to identify, create, represent, distribute and enable adoption of what it knows, and how it knows it. Knowledge Management is frequently linked and related to what has become known as the learning organization, lifelong learning and continuous improvement.

Knowledge Management may be distinguished from Organizational Learning by a greater focus on the management of knowledge as an asset and the development and cultivation of the channels through which knowledge, information and signal flow.

The goal of Knowledge Management is to improve the creation, dissemination, and exploitation of knowledge for the purpose of building competitive advantage. The international work to improve maritime education and training has identified lack of access to quality learning material and tutors in many countries. It is assumed that increased use of information and communication technologies will be one major component for future quality improvement of maritime education and training.

## 2. THE KNOWLEDGE MANAGEMENT SYSTEMS

Knowledge Management is a multi-faceted initiative involving a degree of cultural change for the organization. The background for the crucial importance of learning is that the combination of globalization, information technology and deregulation of formerly protected markets leads to more intense competition and to more rapid transformation and change, as you can see in figure 1.

Knowledge Management is an approach that helps address these challenges and the potential benefits of knowledge management for IT support and self-service are well known. However, the steps that need to be taken are not self-evident: Support organizations are often unsure how to organize a KM initiative because the decision to embrace knowledge management is predicated on answering a number of vital questions: What kinds of processes are needed to create content? How should roles and responsibilities be assigned? How should content be structured?

To effectively resolve incidents and help end-users remain productive, analysts must quickly diagnose IT incidents and problems and provide solutions to address customers' needs. Unfortunately, unless knowledge management is a formalized process within support, the know-how of support personnel is often underutilized.

Davenport and Prusak stated: *"Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knower. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms."*

King defined three criteria that are essential to the successful implementation of KM within an organization: focus, relevance and timeliness. To achieve all three requires a system that enables inputs, outputs and communication to be related to specific goals and to specific users who will act upon the knowledge in a timely and cost effective manner.

The practice of knowledge management has evolved to address this challenge. Generally speaking, knowledge management is a set of practices designed to collect, organize, structure and distribute knowledge for ongoing use and training and for enrichment of the corporate culture.

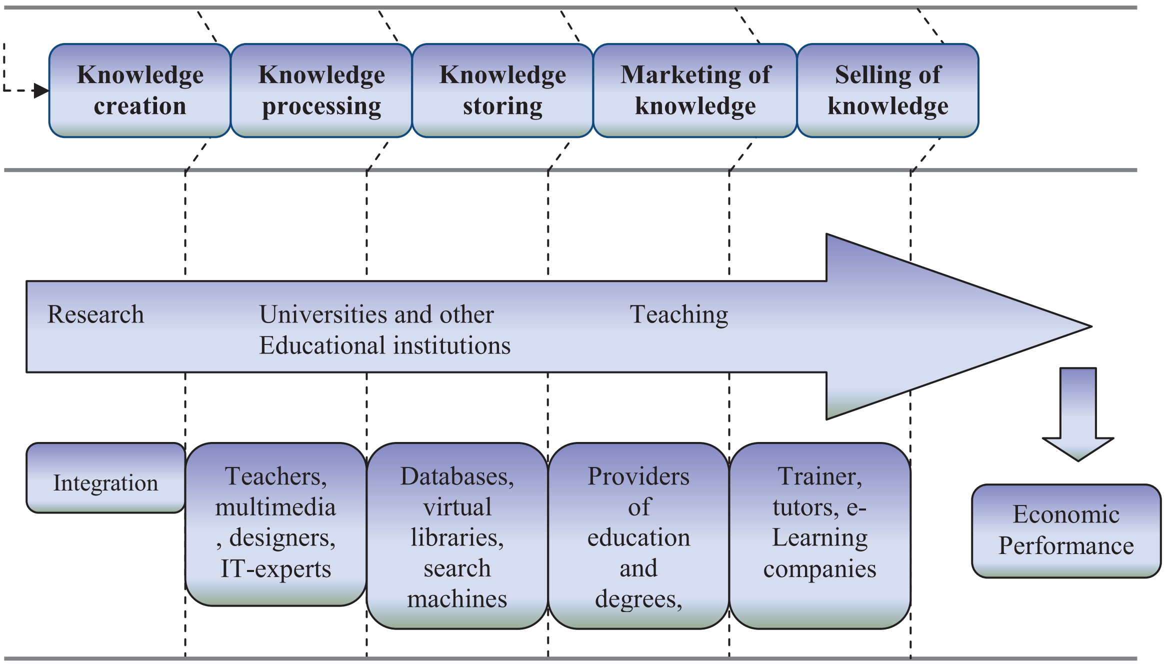



Figure 1 Synoptically view regarding Knowledge Management

## 3. THE LIFELONG LEARNING PRINCIPLES

Lifelong learning is used for combining formal, informal and non-formal education and training, with a reconsideration of professional recognition and quality assurance processes. It is the process of acquiring and expanding knowledge, skills and dispositions throughout the life to foster well-being.

The philosophy of education system is now changing globally and rapidly towards a continuous learning process. The change in the education system opens up the opportunity of part-time higher education in vocational and non-vocational streams.

In October 2006 the European Commission published a Communication entitled *"Adult learning: It is never too late to learn"*. This document suggests lifelong learning to be the core of the ambitious Lisbon 2010 process, in which the whole of the European Union should become a learning area. In December 2007, the European Parliament's Committee on Culture and Education published a *"Report on Adult learning: It is never too late to learn"*, which recognized the Commission Communication and a number of related recommendations and resolutions, and which urged member states to establish a long life learning culture.

Corroborating the European Commission policy with the population ageing of European countries, the role of lifelong learning and the educational system position near this situation must be an important one.

The principal providers of the long life learning in this moment, all over the world, are the universities and associate graduate institutions. At this level there are possibilities to create and develop material, as courses and practical applications, for graduates of the same or inferior level.

Putting together the social and economic conditions, economical being prior, and the opportunities creates by the online teaching procedures the development possibilities of this lifelong learning concept increase considerable.

To provide the necessary knowledge for a specified activity domain is most important to have your own trained persons, as lecturers, as institution. Taking account the differences between this kind of learning and the formal learning is obviously request to institution to have persons in charge with necessary skills for this. In this idea, the previous step in creation of the learning curricula is the process of train the trainers to be qualified for this activity.

## 4. KNOWLEDGE MANAGEMENT IN MARITIME EDUCATION AND TRAINING AREA

Every European Maritime University must have a department which aims to provide practice-oriented technological information management and application-oriented research for making use of information systems in the field of naval and mechanical engineering.

Appling knowledge management in maritime universities is important because:

- The purpose of knowledge management is to harness, develop and direct the expertise of the organization and to apply it effectively to achieve strategic objectives;
- Knowledge management is purpose is also to encourage learning and innovation as sources of competitive advantage;
- Knowledge management permits vision and gap analysis, identifies new sources of technology and ideas;
- Knowledge management explores creativity, innovation and idea mapping.

The Information Age demands increased focus on the management of information in institutions. Capturing and distributing intelligence, knowledge, leadership, collaboration, and group decision-making have become vital to institutional innovation and sustaining competitive advantage. Accordingly, increasing numbers of software applications and tools are now available to foster these objectives and support new kinds of management decision making by individuals and groups.

The main project objective is to coordinate the development of a maritime flexible learning system. The new and modern techniques are the flexible learning courses, the production of learning demonstrators and testing of those by maritime students and officers.

## 5. KNOWLEDGE MANAGEMENT SYSTEM IN CONSTANTA MARITIME UNIVERSITY

In Constanta Maritime University, applying knowledge management is important and we apply it effectively to achieve strategic objectives. We intend to encourage learning and innovation as sources of competitive advantage, to permit vision and gap analysis, identifies new sources of technology and ideas. Through Knowledge Management in our university we explore creativity and innovation.

You can see the practical CMU approach: http://campus.e-shipping.ro, figure 2. We use Moodle as Knowledge Management System; through will have an explicit Knowledge Management objective of some type such as collaboration, sharing good practice. Moodle is a Course Management System (CMS), also known as a Learning Management System (LMS) or a Virtual Learning Environment (VLE). It is a free web application that educators can use to create effective online learning sites.

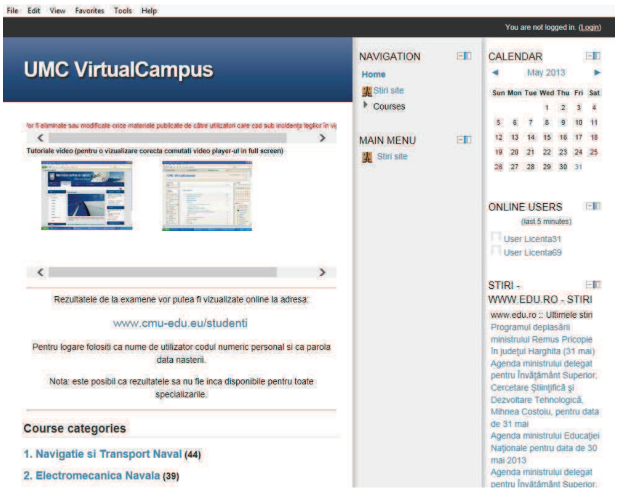



Figure 2 Constanta Maritime University Virtual Campus

Constanta Maritime University has begun E-learning in 2001, when first test distant learning was introduced. In 2004, massive investments in IT tool were made and one year later the first official CMU e-learning Campus was inaugurated.

Since 2007, in the CMU was developed a Web based IMO Tanker Courses under the EU project for distant simulation and tutorial systems on board. The new campus has the main project objective to co-ordinate the development of a maritime flexible learning system. Also, CMS ILIAS as KMS are developed to support and enhance knowledge-intensive processes, tasks or projects of e.g., creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, transfer, distribution, retention, maintenance, refinement, revision, evolution, accessing, retrieval and last but not least the application of knowledge, also called the knowledge life cycle. You can see the practical approach: http://training.e-shipping.ro, in figure 3.

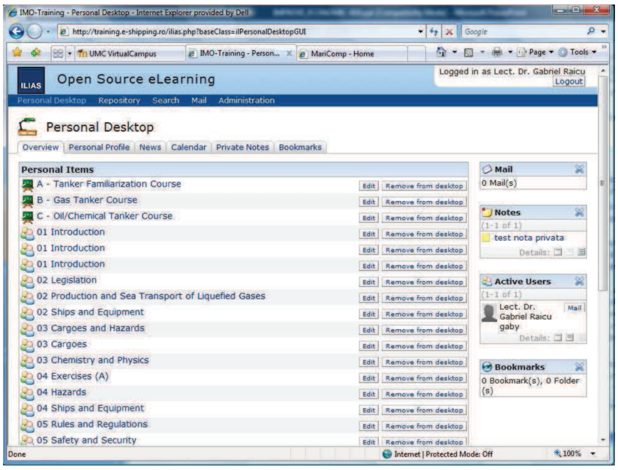



Figure 3 Web based IMO Tanker Courses

A Learning Management System (LMS) is a set of software tools designed to manage user learning interventions. LMS go far beyond conventional training records management and reporting and the value added for it is the extensive range of complementary functionality they offer. Via internet and LMS the participants have access to the internal tests of different topics and the students can enrol themselves directly on the website.

The term KMS can be associated to Open Source Software, and Open Standards, Open Protocols and Open Knowledge licenses, initiatives and policies and when we refer to the further evolution, we can talk about another EU project developed in CMU: MariComp. The partner groups in this project consist of six MET-institutions from different countries: Denmark, The Netherlands, Estonia, Ireland, Romania and Norway. Furthermore, advice was given by an educational university in Denmark and a Nordic marine engineers' federation. One of the objectives of this EU project was to develop a European virtual learning space for maritime educational institutions and to develop, test and evaluate a pilot e-learning course for maritime lecturers.

The LMS course intend to be a European virtual learning space for maritime lecturers in view of knowledge-sharing in continuous and informal ways as well as collegiate supervision at maritime educational institutions.

The importance of this platform is that European maritime lecturers with expert knowledge have better opportunities of developing their competencies and creating an international network of colleagues within the same maritime discipline. For the platform where lecturers inside and outside the partnership can seek and share knowledge we used CMS Dokeos. In the figure 4, you can see the MariTrainer Wiki based on Dokeos & DekiWiki under MARICOMP Leonardo da Vinci Project. The practical CMU approach: http://maricomp-web.eu.

Figure 4 MariTrainer Wiki

The MariTrainer Wiki is a new and modern technique and flexible learning courses, the production of learning demonstrators and testing of those by maritime students and officers.

The MariTrainer Wiki allowed us to gain access to a greater range of teaching and learning materials and methods, made us more prepared to enhance our skills, helped us to encourage a greater European dimension in the work of our organizations and met our continuing professional development needs. We intend to continue the cooperation with the other maritime faculties: improvement of the courses, new tests, and international participation on the courses.

Other EU project developed in Constanta Maritime University was Maritime Education Platform (http://mep.stc-r.nl).

The main idea of this project was to produce and share high quality educational material. This was done by developing a virtual learning space and by organising seminars. Each partner developed a high standard and up to date e-learning course on a certain subject. This course was available for the other partners by means of a virtual learning space. Moreover the seminars aim to give opportunity to share and discuss within the group of partners to the content. Subsequently the course was improved by the author. Summarized, the project provided improvement of quality of maritime educational material, cooperation between maritime educational institutions, an innovative virtual learning space filled with high quality e-learning courses.

The concrete aims of the project was:

- To collaborate by working together in a project and meeting each other during seminars, from both concerned and interested parties;
- To share the knowledge by developing up to data web based learning material that is presented, discussed and improved during seminars;
- To develop a virtual learning space called MEP;
- To improve the level of maritime education for lecturers in the EU; and
- To contribute in bringing the maritime profession on a higher and more equal level, more known and more attractive in the EU.

The learning system requests trainers and lecturers capable to offer the necessary learning materials for the process. Constanta Maritime University starts programs dedicated to the lifelong learning, based on a series of online courses and in parallel to improve its capacities for this, training lecturers to be able to offer in the future the requested knowledge and information's for people's involved in the maritime industry.

LMSs are based on a variety of development platforms, from Java EE based architectures to Microsoft.NET, and usually employ the use of a robust database back-end.

## 6. CONCLUSIONS

Technology and knowledge are now the key factors of production. Knowledge and expertise can be transported instantaneously around the world, and any advantage gained by one company can be eliminated by competitive improvements overnight. We are now an information society in a knowledge economy where knowledge management is essential.

Use of the newest techniques as online and distant learning, combined with traditional forms of training, or based on these, seems to represent the optimum solution for better and high quality learning system inside of the lifelong learning concept.

A key element of knowledge management is to enhancing the learning capacity. One way to do so is to build a learning organization based on KMS principles. Since the introduction of computer based training in some shipping companies since a decade, the use of internet has increased tremendously.

## 7. REFERENCES


[1] NIȚĂ A, RAICU G., *Improve maritime education training through online teaching*, Proc. Journal of Marine Technology and Environment, ISSSN: 1844-6116, vol.III, 2009

[2] RAICU G., NIȚĂ A., *Knowledge Management in the context of Maritime Education*, Maritime Transport 09 Conference, Barcelona, ISBN 978-84-7653-891-3, Universitat Politecnica de Catalunya, Departament de Ciencia i Enginyeria Nautiques, 2009

[3] BELL D. K., & JACKSON, L. A. *Knowledge management: Understanding theory and developing strategy. Competitiveness Review,* 11(1), 1-11, 2001

[4] DAVENPORT, T., & PRUSAK, L. *Working Knowledge: How Organizations Manage What They Know Magazine*. Cambridge, MA: Harvard Business School Press, 1998

# AN ASPECT REGARDING THE NAVAL HISTORY OF THE HELLENISTIC WORLD: THE FLEETS OF AGATHOCLES

[1]STAICU GEANINA, [2]NEDU DECEBAL

[1,2]*University "Dunarea de Jos" of Galati, Romania*

**ABSTRACT**

The naval military history of the Hellenistic World constantly brings to light famous characters like Demetrius Poliorcetes and Ptolemy I Soter or the Carthaginian fleets that sailed towards Sicily to fight against the Greeks on the island. As regards Agathocles, modern researches concentrate mainly on his political achievements and his terrestrial military campaigns. This study aims at evaluating the part played by the Syracusan fleet in the wars that Agathocles waged against Carthage and in the military operations in the Southern regions of Italy. The presence of the Syracusan warships is attested in the operations that took place in 310 B.C., 307 B.C. or 306 B.C., in the context of Agathocles' expansion in the Italic area and in organizing the war against Carthage, in 289 B.C.

**Keywords:** *Agathocles, Aspis, Bruttium, Carthage, Croton, Hipponium, Hippo Acra, North Africa, Syracuse, Utica.*

## 1. INTRODUCTION

An overview of Agathocles' life reveals him as a contradictory character. The most important ancient literary sources which offer information on his government are the writings of Diodorus and Justin. The analysis of these sources resulted in the monographies signed by R. Schubert and H. Tillyard or the modern analyses published in *The Cambridge Ancient History* [1]. Most modern studies dealing with the Syracusan leader focus on his political accomplishments and his terrestrial military operations. His fleet, although present in the wars he waged in Sicily, in the North of Africa and the South of Italy, was sporadically and briefly mentioned.

Immediately after he took over Syracuse, in 316 BC, Agathocles tried to gain popularity through a series of measures. He made promises to people to cancel their debts, to redistribute the lands and to create new workplaces through the extension of the fleet and the construction of new buildings in Syracuse. After he reinforced his control over Syracuse, Agathocles started an expansionist and aggresive policy mainly relying on the mercenary army and, in some moments, on the war fleet.

## 2. SHIPS AND FLEETS IN THE HELLENISTIC AGE

The standard warship in the classical Greek period (the 5th century BC) was the trireme, which derives its name from its three rows of oars on each side of the vessel. In the 4th century BC and the 3rd century BC, the warships underwent several modifications and their denominations also changed. In this period, there can be found penteres (quinqueremes), quadriremes, hepteres and even octeres [2].

Although the ships suffered technical modifications, they did not result in different rows of oars, hence the numerical reference rests on the number of oarsmen. It is possible that in a quadrireme, the crew to have pulled at two rows of oars with two men per oar. In the case of a pentere, the crew were pulling either at two rows of oars, with two or three men per oar, or at three rows of oars with two men at the upper levels and one at the lower level. As the number of the persons pulling at the oars increased, the oars were elongated and the width of the ship was also extended. This evolution led to the building of impressive ships, which were used by the Hellenistic rulers during their state visits and diplomatic missions. They probably tried to impress with the size of the ships carrying them or they wanted to show their wealth, since the cost of such vessel was very high [3].

The most frequently used technique in the sea battles was the ramming of the enemy ship. For this reason, the warships in the 4th – 3rd century BC were equipped with a spur. This device was used to pierce the body of the enemy ship, using a manoeuvre that required both speed and precision. In case the spur did not succeed in breaking the body of the enemy ship, but the two ships were close enough to one another, a hook was used to immobilize the enemy vessel, allowing the soldiers to pass from one deck to another. This procedure gave results especially in the narrow spaces, within the harbours or gulfs [4].

## 3. THE FLEET OF AGATHOCLES DURING THE AFRICAN CAMPAIGN

The African war waged by Agathocles between 310-306 BC represented the ideal moment for using the Syracusan ships, because he decided to sail towards the shore of the North Africa. The previous military actions had dried the resources but the tyrant took drastic measures to recruit an efficient army to oppose the Carthaginian forces. The organization of the African expedition needed financial resources which determined Agathocles to seize people's money and to impose new taxes [5]. With this aim in mind, he borrowed all the funds owed by the wealthy orphans, assuring them that he was going to take better care of the money than their legal tutors and that he was going to give it back to them when they would reach the age of maturity. At the same time, Agathocles borrowed money from merchants, took hold of the temple hoards and deprived women of their jewels [6].

He thus succeeded to prepare 60 ships and 13,500 soldiers, especially mercenaries, for his African expedition, in 310 BC. Then he waited for the right time to break the blockade set by the Carthaginians on the Syracusan harbour. The decisive moment came when a merchant fleet carrying cereals diverted the attention of the Carthaginian ships and allowed Agathocles' fleet to leave the harbour [7].

After six days of sailing in the Mediterranean Sea, the tyrant's army moored safely near Latomiae, at about 110 kms from Carthage [8]. As regards the attack against Carthage, Agathocles would have diminished his forces if he had left a unit to secure the defence of the fleet. In these conditions, the tyrant did something meant to have a psychological effect on his people. He set the ships on fire, telling his soldiers that it was meant as an offering to the godesses Demeter and Kore, the divine protectors of Syracuse, in order to thank them for the success of the journey [9].

The ritual firing of the ships put an end to the "adventure" of the fleet that carried the expeditionary troops of the tyrant towards Africa. Unfortunatelly, the literary tradition accounts only about the number of the ships, without recording any technical details about their building or the number of oarsmen. Therefore, the hypothetical reconstructions should be cautiously taken into account. Agathocles could not have used transport ships to sail with his troops to Africa because they could be handled very slowly. In order to avoid the Carthaginian blockade in the harbour of Syracuse, speed was the essential factor the tyrant should have considered. In these circumstances, the most plausible scenario would have been to build fast warships in the Syracusan shipyards. The 13,500 men would probably have turned from soldiers to oarsmen during the six days of travelling towards the North African shore. Thus, Agathocles succeeded in placing a fast fleet in the waters of the Mediterranean Sea, capable of transporting the fighting troops towards the African continent in the shortest possible time and without a useless freight. An incident that took place in the same year, 310 BC, brings an additional argument in favour of the Syracusan tyrant using battleships. The Carthaginians gathered the spurs from the ships Agathocles set on fire and sent them to Syracuse, as a token of defeating his army in Africa [10]. This device, as shown above, was a main feature of the warships in the Hellenistic period.

Following 310 BC, when Agathocles succeeded in creating a powerful military base on the African territory, the year 307 BC was marked by military operations on two fronts. In Sicily, the tyrant's lieutenants continued to protect Syracuse against the enemies and in the North Africa he extended his operations in the territory at the West of Carthage. In this area, the first important city that surrendered to Agathocles' troops was Utica. The Syracusan leader left a garrison there and then he went to Hippo Acra, which owned the largest natural harbour in the region. After he conquered the city, Agathocles built a shipyard in the harbour that was supposed to provide him with a fleet [11]. Somewhere between 310 BC and 307 BC, he installed another naval base at Aspis [12].

The naval installations built by Agathocles in 310-307 BC proved their utility during the future events. After the occupation of the Carthaginian western territories and the consolidation of his authority in the conquered regions, the tyrant decided to leave the African war under the command of his son Archagathus and to come back to Sicily, in order to suppress the democratic riot started by Xenodicus. With the vessels probably built in the shipyards from Aspis and Hippo Acra (boats and 50 warships), Agathocles left Africa in 307 BC and sailed towards Sicily with a detachment of 2,000 soldiers [13]. Though, one year later, in 306 BC, the tyrant did not have enough ships to evacuate his troops from North Africa and tried to leave the African territory only with a small group of people, made up of his son Heracleides and other trustful persons [14]. The reasons for the lack of ships in 306 BC are not mentioned in the literary tradition, but we can suppose that Agathocles suffered some naval losses during his presence in Sicily, in the previous year. This hypothesis can be true if we take into account the fact that in 307 BC the tyrant had only 17 ships and he could break the Carthaginian blockade in the harbour of Syracuse only after he was helped by 18 Etruscan vessels [15].

The events that took place in 307 BC show that Agathocles, a capable general in land fights, also understood the important part a fleet could play in the war against Carthage. Three years earlier, the tyrant succeeded in building two light ships with 30 oarsmen and sent them to Syracuse with the mission to announce his victory in the battle from Tunis [16]. In 307 BC, the conquering of the maritime cities Utica and Hippo Acra most probably indicates Agathocles' intention to set a permanent communication line with Sicily and to cut off the Carthage maritime ways of supply. On long term, with a powerful and numerous fleet, the tyrant could also thought of setting a naval blockade on Carthage [17].

Analyzing the evolution of the conflict between Syracuse and Carthage from 312-306 BC, Agathocles seems to have understood the importance of a military fleet in a war. His naval activity had been limited in 310 BC due to the lack of proper economical resources but, in 307 BC, following the conquering of some naval bases on the shore of North Africa, the tyrant tought of reinforcing the Syracusan naval power.

## 4. THE FLEET OF AGATHOCLES DURING THE MILITARY OPERATIONS FROM SOUTHERN ITALY

Shortly after the war against Carthage which ended in 306 BC, Agathocles proclaimed himself king, following the example of the generals of Alexander the Great [18]. His new position had to be consolidated through an active and expansionist external policy and Agathocles directed his actions towards Italy, where he carried out military operations from 304 BC to 295 BC. The extension of his control over the Southern area of the peninsula could not have been done without naval support, be it only for the transport of the troops beyond the Messina Strait.

Diodorus' references are useful in order to reconstruct the role of the fleet in Agathocles' operations in Italy [19]. The historian from Sicily mentions the presence of the Syracusan ruler in the Italian waters in 304 BC, when he plundered the Lipare Islands [20]. Then, for 300 BC, the same author records the repress of a Ligurian and Etruscan riot started in Agathocles' army in the South of peninsula, incident that was followed by a conflict with the Bruttians, who defeated the king's army [21]. In 295 BC, Agathocles occupied the city of Croton, ruled by the tyrant Menedemus, and made alliances with the Iapygians and Peucetians [22]. Later on, he deployed a big military campaign in Bruttium that ended with the occupation of the city of Hipponium [23].

During all these actions, Agathocles certainly needed ships, to transport his troops and to attack the Greeks cities on the Southern shore of Italy. His last Italic expedition is significant for the naval potential of Syracuse at the beginning of the 3rd century BC, because Agathocles had enough ships to carry more than 30,000 soldiers to the South of Italy. A little earlier, around 300 BC, Agathocles' military fleet was powerful enough to protect Corcyra against Cassander and to set the Macedonian ships on fire [24].

At Hipponium, according to the information recorded by Strabo, the Syracusan king set a harbour base, that was probably meant for the future operations in the Italian area and for the gathering of the necessary timber for the ships, which could be taken from the forests of Bruttium [25]. Moreover, in 295 BC, he concluded alliances with the Iapygians and Peucetians, offering them ships for piracy actions in the Adriatic Sea, in order to receive a part of the prize in exchange [26].

Beyond the political factor, some economical objectives could be related to the military interventions in the Southern regions of Italy. After the occupation of the cities of Croton and Hipponium, Agathocles could control the naval traffic along the Southern coast of the peninsula and his allies in the Apulia area ensured the surveillance over the commercial naval transports between Greece and Italy [27].

## 5. CONCLUSIONS

The idea of revenge against Carthage after the defeat in the 312-306 BC war did not leave Agathocles' mind until his death. The land troops and an impressive fleet of 200 ships were prepared in 289 BC for a new confrontation, but the king died in the same year without fulfilling his plans against Carthage. According to Diodorus of Sicily, he intended to block the Carthaginian cereal imports from Sicily and Sardinia and to invade again the North African territory [28].

Seen from a political and economical point of view, Agathocles' vision on the power balance in the Mediterranean Sea was a correct one. Though, only with a powerful land army, Syracuse was an important Sicilian power. Yet, the fleet was the one that could make his ambition of turning Syracuse into a Mediterranean power come true.

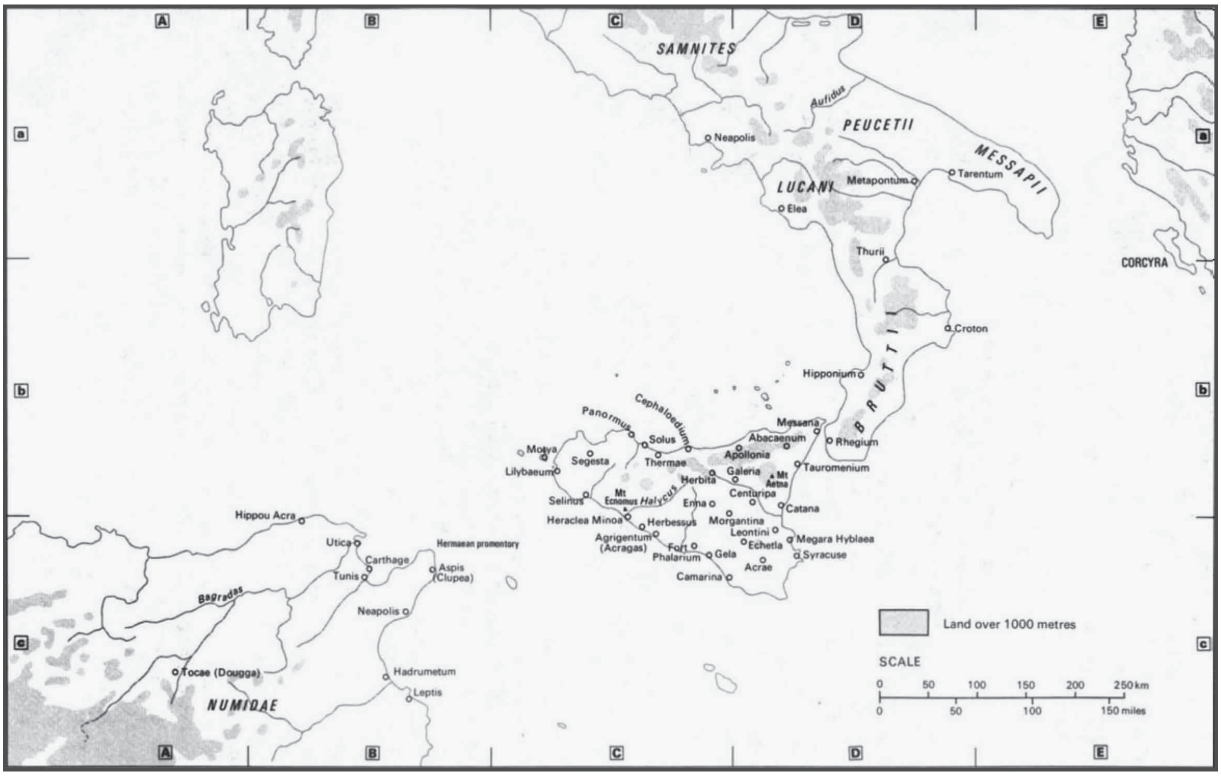



Figure 1. South Italy, Sicily and North Africa
K. Meister, *Agathocles*, in F. Walbank, A. Astin, M. Frederiksen, R. Ogilvie (eds.),
*The Cambridge Ancient History* VII.1, Cambridge 1984, p. 386 (map 6)

## 6. REFERENCES


[1] R. SCHUBERT, *Geschichte des Agathokles*, Breslau 1887; H. TILLYARD, *Agathocles*, Cambridge 1908; M. CARY, *Agathocles*, in S. COOK, F. ADCOCK, M. CHARLESWORTH (eds.), *The Cambridge Ancient History* VII, Cambridge 1927; K. MEISTER, *Agathocles*, in F. WALBANK, A. ASTIN, M. FREDERIKSEN, R. OGILVIE (eds.), *The Cambridge Ancient History* VII.1, Cambridge 1984.
[2] PH. DE SOUZA, *Naval Forces*, in PH. SABIN, H. VAN WEES, M. WHITBY (eds.), *The Cambridge History of Greek and Roman Warfare* I – *Greece, the Hellenistic World and the Rise of Rome*, Cambridge 2007, p. 357.
[3] *Ibidem*.
[4] Idem, *Naval Battle and Sieges*, in PH. SABIN, H. VAN WEES, M. WHITBY (eds.), *The Cambridge History of Greek and Roman Warfare* I – *Greece, the Hellenistic World and the Rise of Rome*, Cambridge 2007, p. 434-437.
[5] M. CARY, *op. cit.*, p. 625; ST. GSELL, *Histoire ancienne de l'Afrique du Nord* III – *Histoire militaire de Carthage*, Paris 1928, p. 22; K. MEISTER, *op. cit.*, p. 394.
[6] DIODORUS OF SICILY, *Library of History* 20.4.5-6 (Loeb Classical Library); H. TILLYARD, *op. cit.*, p. 89; ST. GSELL, *op. cit.*, p. 22; K. MEISTER, *op. cit.*, p. 394.
[7] DIODORUS OF SICILY, *Library of History* 20.5.3-5; H. TILLYARD, *op. cit.*, p. 91; M. CARY, *op. cit.*, p. 625; ST. GSELL, *op. cit.*, p. 23-24; K. MEISTER, *op. cit.*, p. 394.
[8] DIODORUS OF SICILY, *Library of History* 20.6.3; JUSTIN, *Abrégé des Histoires Philippiques de Trogue Pompée* 22.5.1-2 (Garnier); K. MEISTER, *op. cit.*, p. 394.
[9] DIODORUS OF SICILY, *Library of History* 20.7.1-5; JUSTIN, *Abrégé des Histoires Philippiques de Trogue Pompée* 22.6.4; H. TILLYARD, *op. cit.*, p. 106; ST. GSELL, *op. cit*., p. 28-29; K. MEISTER, *op. cit.*, p. 394-395.
[10] DIODORUS OF SICILY, *Library of History* 20.15.1-3; ST. GSELL, *op. cit.*, p. 34.
[11] DIODORUS OF SICILY, *Library of History* 20.54.2-20.55.3; APPIAN, *Libyké* 16.110 (Loeb Classical Library); H. TILLYARD, *op. cit.*, p. 155-157; M. CARY, *op. cit.*, p. 629; ST. GSELL, *op. cit.*, p. 47-48; K. MEISTER, *op. cit.*, p. 398; D. MUSTI, *La Grecia Classica*, Roma / Bari 2003, p. 554.
[12] STRABO, *Geography* 17.3.6 (Loeb Classical Library); ST. GSELL, *op. cit.*, p. 48; K. MEISTER, *op. cit.*, p. 398.
[13] DIODORUS OF SICILY, *Library of History* 20.55.5; JUSTIN, *Abrégé des Histoires Philippiques de Trogue Pompée* 22.8.1-3; H. TILLYARD, *op. cit.*, p. 158; D. MUSTI, *op. cit.*, p. 554.
[14] DIODORUS OF SICILY, *Library of History* 20.68.1-4; H. TILLYARD, *op. cit.*, p. 177, n. 3.
[15] DIODORUS OF SICILY, *Library of History* 20.61.6-7; H. TILLYARD, *op. cit.*, p. 167-168.
[16] DIODORUS OF SICILY, *Library of History* 20.16.3-4.
[17] H. TILLYARD, *op. cit.*, p. 167-158; K. MEISTER, *op. cit.*, p. 398.
[18] K. MEISTER, *op. cit.*, p. 405.
[19] H. TILLYARD, *op. cit.*, p. 203-205, 210-218; K. MEISTER, *op. cit.*, p. 406-407; R. VATTUONE, *Linee della politica di Agatocle in Magna Grecia*, in Rivista storica dell'antichità 17-18, 1987-1988, p. 55-72; D. MUSTI, *op. cit.*, p. 556-558.
[20] DIODORUS OF SICILY, *Library of History* 20.101.1-2.
[21] DIODORUS OF SICILY, *Library of History* 21.3.
[22] DIODORUS OF SICILY, *Library of History* 21.4.
[23] DIODORUS OF SICILY, *Library of History* 21.8.
[24] DIODORUS OF SICILY, *Library of History* 21.2.1-3; H. TILLYARD, *op. cit.*, p. 210-212.
[25] STRABO, *Geography* 6.1.5; H. TILLYARD, *op. cit.*, p. 218.
[26] DIODORUS OF SICILY, *Library of History* 21.4.
[27] G. MARASCO, *Agatocle e la politica siracusana agli inizi del III secolo A.C.*, in Prometheus 10, 1984, p. 107.
[28] DIODORUS OF SICILY, *Library of History* 21.16.1.

# SECTION II
## MECHANICAL ENGINEERING AND ENVIRONMENT

# THE CONTRIBUTION OF MAINTENANCE ACTIVITIES TO THE OPERATIONAL STATUS OF A TECHNICAL EQUIPMENT

[1]BUS CAMELIA-GABRIELA, [2]CARLAN MILTIADE, [3]BOCANETE PAUL

[1]*Ministry of Transport,* [2] *S.C. Formenerg S.A,* [3]*Maritime University of Constanta, Romania*

**ABSTRACT**

The service period of a technical equipment is greatly influenced by a multitude of maintenance activities:
**-**interventions that take place at scheduled time-intervals, having the purpose to reduce the effect of atrition on the structure of the functional modules that form the technical entity;
**-**solving the „out of service" situations occurred as a consequence of the impairment of the operational conditions caused by the deviations from the recommended exploitation conditions (disregarding the exploitation conditions, unsuitable profesionalism of human resource, distructive natural phenomena). Anticipated determination of the remedial intervention moments can be achieved by observing the time behaviour of that specific installation, a defining element in the substantiation of a preemptive-remedial maintenance schedule for the „in service" technical equipment or for those to be brought to service. This paper considers analyzing the evolution of the contribution of maintenance activities on the operational status of an equipment, activity that is undertaken by a group of experts, whose opinions – marks, estimations- , are given in a non-numerical manner, using an arbitrarily proposed, hierarchical scale.

**Keywords:** *Fuzzy hierarchical scale, Semantics, Level, Step, Regression equation, Regression coefficients, Correlation factor.*

## 1. INTRODUCTION

The evaluations of experts appertain to a liniar scale, having a certain number of levels, that have a corresponding in the levels of the scale numerically defined within the [0;1] interval and which represents the eficiency (contribution) of maintenance actions. A linear scale in characterized by the step, $\Delta\alpha$**,** constant. In the followings, a linear scale shall be used. The scale has a number of seven levels and it is called a septenary scale [1], [2], [3]. The deffining elements of this scale are given in table 1, and in figure 1 represented the plot of this scale.

Table 1

| $n_i$ | $n_k$ | Semantics | Simbol | Level $\alpha_K$ | Step $\Delta\alpha_K$ |
|---|---|---|---|---|---|
| 1 | 0 | Unsatisfactory | N | 0 | 0 |
| 2 | 1 | Almost unsatisfactory | AN | 0,167 | 0,167 |
| 3 | 2 | Little unsatisfactory | PS | 0,333 | 0,167 |
| 4 | 3 | Satisfactory | S | 0,5 | 0,167 |
| 5 | 4 | Good | B | 0,667 | 0,167 |
| 6 | 5 | Almost very good | AFB | 0,833 | 0,167 |
| 7 | 6 | Very good | FB | 1 | 0,167 |

The level of the scale reprezents the number associated to the respective evaluation; it is deduced using:

$$\alpha_k = \frac{n_k}{n^{\max}}, \quad (1)$$

and the step is obtained as a difference between two consecutive levels:

$$\Delta\alpha_k = \alpha_k - \alpha_{k-1} \quad (2)$$

where:
$n_k$ represents the index of the levels:

$$n_k \in [0;6] \in N \quad (3)$$

$n^{\max}$ expresses the position of the highest level.
Figure 1 presents the plot of the linear septenary scale:

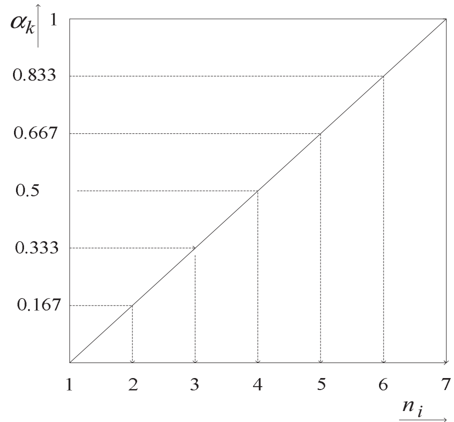



Figure 1. The plot of the linear septenary scale

In the case when the experts prefer a more precise scale is composed out of two parabolic segments that have a sigmoidal convex-concave shape [1] (S letter shape). For technical applications, the septenary scale is to be preferred compared to those scales, because the last ones have a more difficult to comprehend semantics. The contribution of maintenance to a technical system presents a slow-ascending temporal evolution, records a maximum at a certain moment, and after that shape of the plot becomes rapidly descending, with a null asimptotically trend – figure 2.

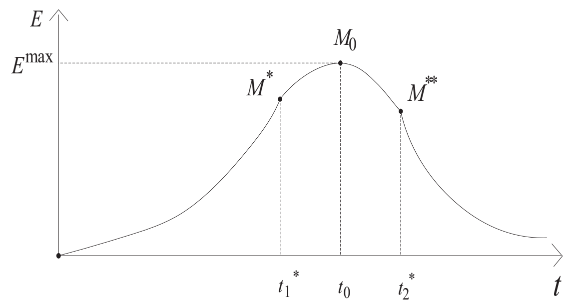



Figure 2 . The temporal evolution of the contribution of maintenance actions on the operational status of a technical system, $M_0$ - the optimun point, $M^*, M^{**}$ flex points of the plot.

Indeed, because the equipment is new, the need for maintenance actions is insignificat, or even unnecessary; as the time passes the maintenance actions are needed more and more, the repairs prove their usefullness and the eficiency becomes maximal.
On the other hand, the attrition and the reliability, affecting more significantly the operational potential of the installation, demand more expensive and more frequently maintenance actions and that have an injustifiable, technically or economically, contribution on the operational status. Therefore, this is the moment when the technical entity is to be decommissioned.
Figure 3 presents the temporal evolotions of the following quantities:

E - the contribution of maintenance;
U - the attrition;
R - the reliability.

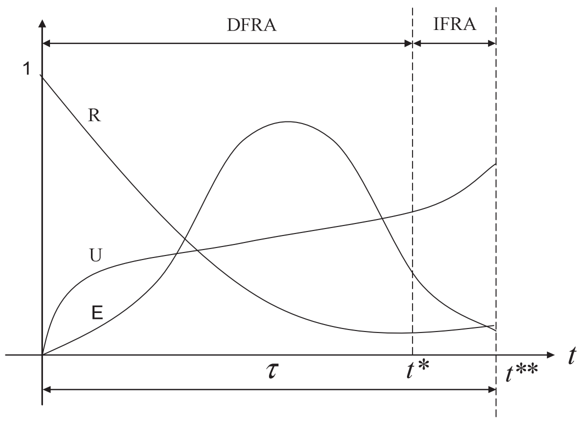



Figure 3. Temporal evolution of quantities: E, R, U

Where:

$t^*$ is the moment when the attrition increases with an accelerated rythm;

$t^{**}$ expresses the moment of the decommissioning of the installation;

$\tau$ represents the life time of a technical system.

The notations DFRA and IFRA [4] correspond to the evolution of attrition over the lifetime course of technical equipment:

DFRA - Decreasing Failure Rate Average;
IFRA –Increasing Failure Rate Average.

Based on the phenomenological evolution of the function,

$$E = f(t) \tag{4}$$

the following expression for the eficiency of the maintenance actions contribution on the operational status of the techical equipment is introduced:

$$E = Kt^m e^{-nt} \tag{5}$$

Where:

$t$ represents the time-interval at the end of which the operational status of the installation is assest by the group of experts;

$K, m, n$ - the regression coeficient of which values are obtained on statistical basis, using „the least squares method" [5].

According to the optimum criterion,

$$\frac{d}{dt}(E) = 0 \tag{6}$$

the optimal time (of maximum efficiency):

$$\frac{d}{dt}(E) = \Delta\left(\frac{m}{t} - n\right)\ln E = 0$$

$$t_0 = \frac{m}{n} \tag{7}$$

Also, the moments of the flex points are obtained:

$$\frac{d^2}{dt^2}(E) = 0 \tag{8}$$

$$t_1^* = \frac{m - \sqrt{m}}{n}, \; t_2^* = \frac{m + \sqrt{m}}{n} \tag{9}$$

The maximum value of the efficiency is deduced:

$$E^{max} = \Delta\left(\frac{m}{n \cdot e}\right)^m \tag{10}$$

## 2. CASE STUDY

It is considered a technical equipment, subject to an analisys regardind the contribution of maintenance actions on its operational status. During the time-interval [1;15] years a group of experts $(e_j)_n$ have recorded their assesments.

The evolution during the course of the time-interval (15; 28) years has been forecasted in table 2.

Table 2

| $i$ | $t_i$ | $E_i$ | $t_i^2$ | $\ln t_i$ | $\ln E_i$ | $\ln^2 t_i$ | $t_i \cdot \ln t_i$ | $\ln t_i \cdot \ln E_i$ | $t_i \cdot \ln E_i$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 0,167 | 25 | 1,60944 | - 1,78976 | 2,59030 | 8,04720 | - 2,88051 | - 8,94880 |
| 2 | 11 | 0,5 | 121 | 2,39790 | - 0,69315 | 5,74992 | 26,37690 | - 1,66210 | - 7,62465 |
| 3 | 15 | 0,833 | 225 | 2,70805 | - 0,18272 | 7,33353 | 40,62075 | - 0,49481 | - 2,74080 |
| 4 | 25 | 0,667 | 625 | 3,21887 | - 0,40496 | 10,36112 | 80,47175 | - 1,30351 | - 10,12400 |
| 5 | 28 | 0,333 | 784 | 3,33220 | - 1,09961 | 11,10356 | 93,30160 | - 3,66418 | - 30,78908 |
| $\sum_i$ | 84 | * | 1780 | 13,26646 | - 4,17020 | 37,13843 | 248,81820 | - 10,00505 | - 60,22733 |

The system of equations is obtained:

$$\begin{cases} 5{,}00000 \ln A + 13{,}26646\, m - 84{,}00000\, n = -4{,}17020 \\ 13{,}26646 \ln A + 37{,}13843\, m - 248{,}81820\, n = -10{,}00505 \\ 84{,}00000 \ln A + 248{,}81820\, m - 1780{,}00000\, n = -60{,}22733 \end{cases}$$

The values of the regression coefficients are calculated: $m = 3{,}85$; $n = 0{,}247$; $A = 0{,}001$.
Hence, the regression equation is:

$$E = 0{,}001 t^{3{,}85} e^{-0{,}247 t} \qquad (11)$$

According to (7), (9), (10) the following parameters are determined:

- optimum moment,
  $t_0 = 15{,}6$ years
- the moments of plot flex points,
  $$\begin{cases} t_1^* = 7{,}6 \text{ ani;} \\ t_2^* = 23{,}6 \text{ ani.} \end{cases}$$
- the maximum contribution (efficiency) of maintenance $E^{\max} = 0{,}832$.

This values appertains to the following scale interval: $0{,}85 \in [0{,}833;\ 1]$, which corresponds to the semantic interval: $E^{\max} \in$ ( Almost very good; Very good ) , or $E^{\max} \in$ the level of the scale, $E^{\max} = 0{,}832 \cong \alpha = 0{,}833$, error; $\varepsilon = 0{,}12\%$ - figure 4.

## 3. CORRELATION FACTOR

Also called Pearson coefficient [6], it is a measure of the intensity of the link between the two variables, $E_i$ and $\tilde{E}_i$ (the last one is obtained out of the regression equation). The $\tilde{E}_i$ values represent ordinate of points that belong to the curve function and determined based on the regression equation. Table 3 presents the calculation algorithm for correlation factor, $\eta$.

Table 3

| $i$ | $E_i$ | $\overline{E}$ | $\tilde{E}_i$ | $E_i - \overline{E}$ | $E_i - \tilde{E}_i$ | $(E_i - \overline{E})^2$ | $(E_i - \tilde{E}_i)^2$ |
|---|---|---|---|---|---|---|---|
| 1 | 0,167 | 0,5 | 0,143 | - 0,333 | +0,024 | 0,110889 | 0,000576 |
| 2 | 0,5 | | 0,675 | 0 | - 0,175 | 0 | 0,030625 |
| 3 | 0,833 | | 0,832 | +0,333 | +0,001 | 0,110889 | 0,000001 |
| 4 | 0,667 | | 0,502 | +0,167 | +0,165 | 0,027889 | 0,027225 |
| 5 | 0,333 | | 0,370 | - 0,167 | - 0,0370 | 0,027889 | 0,001369 |
| $\sum_i$ | 2,5 | * | * | * | * | 0,277556 | 0,059796 |

The value of the correlation factor is to be determined using:

$$\eta = \sqrt{1 - \frac{\sum_i \left(E_i - \tilde{E}_i\right)^2}{\sum_i \left(E_i - \overline{E}\right)^2}} \qquad (12)$$

According to the calculation data, it can be deduced that:

$\eta = 0{,}886$ .

This high level of the link intensity between $E_i$, $\tilde{E}_i$ variables, confirm a strong correlation.

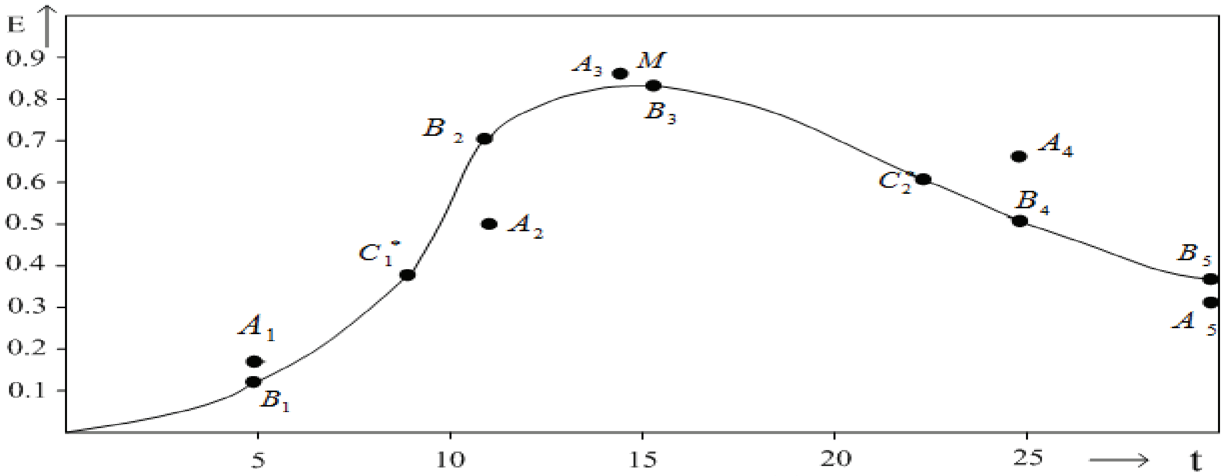



Figure 4. The plot of the $E = f(t_i)$

Legend :

$A_i$ - points deffined by calculus data;

$B_i$ - points belonging to the function plot;

$C_1^*, C_2^*$ - flex points;

$M\left(t_0, E^{\max}\right)$ - optimum points.

## 4. CONCLUSIONS

The anticipation, over a long period of time, of the moments when maintenance actions must be undertaken, is an important factor regarding when building the supplies of materials, spare parts or components necessary for the functional retrieval of installations.

The assesments regarding the temporal behaviour the installations, corroborated with technical prescriptions made by the beneficiary, replenished with the warranties issued by the supplying companies are a very important informational segment for the substantiation of the optimal strategy regarding the maintenance activity.

## 5. REFERENCES

[1] CÂRLAN M., "*Un indicator al calității lucrărilor de mentenanță*"( *An indicator of the quality of maintenance*). Rev. Producerea, Transportul şi Distribuția energiei electrice şi termice, Bucureşti 1997.

[2] CÂRLAN M., "*Probleme de optimum în ingineria sistemelor tehnice*" (*Optimunm problems in technical systems engineering*). Editura Academiei Române, Bucureşti, 1994.

[3] CÂRLAN M., BENDEA C., "*Aportul calității mentenanței asupra diferenței medii de temperatură la un aparat de transfer de căldură*" (*Quality maintenance contribution on average temperature difference in a heat transfer device*). Rev. Tehnologiile Energiei, Bucure□ti, 2009.

[4] CĂTUNEANU V. M., MIHALACHE A., "*Bazele teoretice ale fiabilității*" (*Theoretical fundamentals of reliability*). Editura Academiei Române, Bucureşti,1983.

[5] Salvadori M.G., Baron M.L., "*Metode numerice în tehnică*" (*Numerical methods in technical*). Traducere din lb. engleză. Editura Tehnică, Bucureşti, 1972.

[6] Baron T., Biji E., Tövissi L., Wagner P., Isaic-Maniu Al., Korca M., Porojan D. "*Statistica teoretică şi economică*" (*Statistics and economic theory*). Editura Didactică şi Pedagogică, Bucureşti, 1996.

# AN THE ASSESMENT OF THE MEAN OF OPERATIONAL TIME-INTERVALS FOR A TECHNICAL EQUIPMENT DESCRIBED BY A WEIBULL TEMPORAL EVOLUTION

[1]BUS CAMELIA GABRIELA, [2]BOCANETE PAUL, [3]COSTEA MARIUS AUREL, [4]CARLAN MILTIADE

*[1]Ministry of Transport, [2]Maritime University of Constanta, [3]The University of South- East Europe Lumina, Romania, [4]S.C. Formenerg S.A., Romania*

## ABSTRACT

The mean of the operational time-intervals, MTBF (Mean Time Between Failures) is one of the most important parameters in „The theory concerning the reliability of systems". It is a quantity described by the opposite value of the failure intensity of a retrievable system and it indicates the mean time-interval between two consecutive failure situations of a one entity. The assesment of this quantity, when assuming the case of a Weibull distribution, is different compared to the exponential model version. This paper analyzes a „case study" where two technical equipments – water heaters – have a different time evolution: one of them is described by an exponential distribution of the operational time-intervals whereas the other is described by a Weibull operational behaviour.

**Keywords:** *Normal distribution assesment test, Weibull distribution assesment test, Calculation quantile, Test quantile, Likelihood threshold, Standard deviation, Variation coefficient.*

## 1. INTRODUCTION

It is considered the temporal evolution of one entity. According to figure 1, it is ascertainable that, during a certain time-interval, the technical equipment has recorded a certain number of failure situations. The mean of operational time-intervals is defined by the arithmetical average of operational time-intervals.

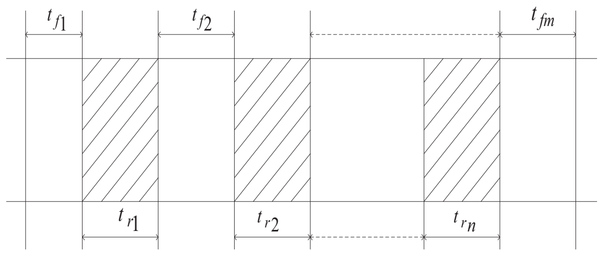



Figure 1 Time-evolution of a retrievable system

In figure 1, $t_{f_i}$, $t_{r_j}$, $i=\overline{1;n}$, $j=\overline{1;m}$ are the time-intervals when the system is operational or out of service. The mean of operational time-intervals, respectively, the mean time to repair (MTR), are presented in [1], [3], [4], [5], [6], [9]:

$$MTBF = \frac{\sum_i t_{fi}}{n}, \quad i = 1;n \tag{1}$$

$$MTR = \frac{\sum_i t_{rj}}{m}, \quad j = 1;m \tag{2}$$

These two equations are used only when the distribution function of time-intervals is exponential: *m,n* represent the number of time-intervals when the system is operational (*m*), respectively, out of service (*n*). The assement of these quantities is preceded by the process of revising the behaviour of the system: if the proposed assumption does not confirm the exponential character of the operational time-intervals , the Weibull version is validated, or any other type of distribution, each model determining a certain calculation process.

## 2. CASE STUDY

This paper sets a goal in analyzing the operational evolution of two thermal transmission devices, parts of a naval instalation endowment, during the course of four years (1461 days). The duty cycle of heat-exchanging devices requires simultaneous operational status, in most cases, of both technical equipments.

The ship also has a third heater, able to automatically absorb the flows of the other heaters in overload situations, in both heat-exchanging devices go out of service. The time-evolutions of the two equipments are described in table 1.

According to (1) and (2), the values of the two parameters, MTBF and MTR, are deduced obtained based on the informations presented in table 1, as follows:

a. – for heater $H_1$:

MTBF= 159 days between two consecutive failures;

MTR=4 days between two consecutive operational conditions.

b. – for heater $H_2$:

MTBF= 204 days between two consecutive failures;

MTR=5.5 days between two consecutive operational conditions.

These are the values of MTBF and MTR quantities, when considering that the service behaviour of each equipment is of exponential nature.

Table 2 presents the calculus elements necessary in order to establish the exponential character of the operational time-intervals.

Table 1

| Heat exchanger number one | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $i$ | 1 | - | 2 | - | 3 | - | 4 | - | 5 | - | 6 | - | 7 | - | 8 | - | 9 | $\sum_i$ |
| $t_i$ | 226 | - | 203 | - | 109 | - | 276 | - | 204 | - | 218 | - | 60 | - | 75 | - | 60 | 1431 |
| $j$ | - | 1 | - | 2 | - | 3 | - | 4 | - | 5 | - | 6 | - | 7 | - | 8 | - | $\sum_j$ |
| $t_j$ | - | 4 | - | 3 | - | 5 | - | 3 | - | 5 | - | 3 | - | 2 | - | 5 | - | 30 |
| Heat exchanger number two | | | | | | | | | | | | | | | | | | |
| $i$ | 1 | - | 2 | - | 3 | - | 4 | - | 5 | - | 6 | - | 7 | $\sum_i$ | | | | |
| $t_i$ | 258 | - | 196 | - | 249 | - | 158 | - | 202 | - | 113 | - | 252 | 1428 | | | | |
| $j$ | - | 1 | - | 2 | - | 3 | - | 4 | - | 5 | - | 6 | - | $\sum_j$ | | | | |
| $t_j$ | - | 6 | - | 5 | - | 8 | - | 5 | - | 5 | - | 4 | - | 33 | | | | |

Table 2

| Heater number one | | | | |
|---|---|---|---|---|
| $i$ | $t_i$ | $\bar{t}$ | $t_i - \bar{t}$ | $(t_i - \bar{t})^2$ |
| 1 | 226 | 159 | + 67 | 4489 |
| 2 | 203 | 159 | + 44 | 1936 |
| 3 | 109 | 159 | - 50 | 2500 |
| 4 | 276 | 159 | + 117 | 13689 |
| 5 | 204 | 159 | + 45 | 2025 |
| 6 | 218 | 159 | + 59 | 3481 |
| 7 | 60 | 159 | - 99 | 9801 |
| 8 | 75 | 159 | - 84 | 7056 |
| 9 | 60 | 159 | - 99 | 9801 |
| $\sum_i$ | 1431 | * | * | 54778 |
| Heater number two | | | | |
| 1 | 258 | 204 | - 54 | 2916 |
| 2 | 196 | 204 | - 8 | 64 |
| 3 | 249 | 204 | + 45 | 2025 |
| 4 | 158 | 204 | - 46 | 2116 |
| 5 | 202 | 204 | - 2 | 4 |
| 6 | 113 | 204 | - 91 | 8281 |
| 7 | 252 | 204 | + 48 | 2304 |
| $\sum_i$ | 1428 | * | * | 17704 |

In order to asses the exponential nature of the operational time-intervals given in table 1 and table 2, the **Hann** – **Shapiro-Wilk** [7] model is used. According to this model, the distribution checks out to be of exponential nature if the double inequality is fulfilled [11]:

$$W_{n;p}^{\inf} < W_0 < W_{n;p}^{\sup} \qquad (3)$$

where:

$W_{n;p}^{\inf}, W_{n;p}^{\sup}$ are the quantiles of the test, the lower/upper limits presented in table 3;

$n$ - the number of the operational time-intervals;

$P$ – likelihood threshold; for this table, the value $P$=0.95 is considered;

$W_0$ – calculated quantile – relation (4):

Table 3

| $n$ | $P = 0{,}95$ | |
|---|---|---|
| | $W^{\inf}$ | $W^{\sup}$ |
| 7 | 0,025 | 0,260 |
| 8 | 0,025 | 0,230 |
| 9 | 0,025 | 0,205 |
| 10 | 0,025 | 0,184 |
| 11 | 0,025 | 0,166 |
| 12 | 0,025 | 0,153 |
| 13 | 0,025 | 0,140 |
| 14 | 0,024 | 0,128 |
| 15 | 0.024 | 0,119 |
| 16 | 0.023 | 0,113 |
| 17 | 0.023 | 0,107 |
| 18 | 0.022 | 0,101 |
| 19 | 0.022 | 0,096 |
| 20 | 0.021 | 0,090 |
| 21 | 0.020 | 0,085 |
| 22 | 0,020 | 0,080 |
| 23 | 0,019 | 0,075 |
| 24 | 0,019 | 0,069 |
| 25 | 0,018 | 0,065 |
| 26 | 0,018 | 0,062 |
| 27 | 0,017 | 0,058 |
| 28 | 0,017 | 0,056 |
| 29 | 0,016 | 0,054 |
| 30 | 0,016 | 0,053 |

$$W_0 = \frac{\sum_i \left(t_i - \bar{t}\right)^2}{\left(\sum_i t_i\right)^2} \quad (4)$$

After calculating quintiles presented in table 3 test we optain:

- for heater $H_1$ :

$$W_0 = 0{,}0267$$

According to the restrain (3):

$$W^{\inf}_{n=9;P=0{,}95} = 0{,}025 < W_0 = 0{,}0267 < W^{\sup}_{n=9;P=0{,}95} = 0{,}205$$

The imposed condition beeing fulfilled, this validates the assumption of a normal distribution for the operational time-intervals of the time evolution of heater $H_1$. Hence, the values of MTBF and MTR quantities, previously deduced, are corect.

- for heater $H_2$ the following quantile is obtained:

$$W_0 = 0{,}0087$$

It can be noticed that the imposed validation conditions are not fulfilled: the quantile does not pertain to the range ($W^{\inf}$ ; $W^{\sup}$), for heater $H_2$.
Consequently, it is put to proof if the repartition of operational time-intervals determines a Weibull hypothesis.

According to the model MANN-SINGPURWALLA-GUPTA [11], prescripted for these types of cases, table 4 is built:

Table 4

| $i$ | $t_i$ | $t_{i+1} - t_i$ | $\Delta E(Z_i)$ | $l_i$ |
|---|---|---|---|---|
| 1 | 113 | 45 | 1,079055 | 41,703157 |
| 2 | 158 | 38 | 0,591587 | 64,234001 |
| 3 | 196 | 6 | 0,442789 | 13,550472 |
| 4 | 202 | 47 | 0,387289 | 121,356403 |
| 5 | 249 | 3 | 0,387714 | 7,737662 |
| 6 | 252 | 6 | 0,480648 | 12,483148 |
| 7 | 258 | - | - | - |
| $\sum_i$ | * | * | * | 261,064843 |

where:
-the values of time-intervals are registerd in a descending order;
-the statistical quantity $\Delta E(Z_i)$ is drawn out form table 5.

For the analyzed case, the significant sample is the one corresponding to values $t_i$ , $n$=7;
-quantity $l_i$ from table 4 is determined using (5):

$$l_i = \frac{t_{i+1} - t_i}{\Delta E(Z_i)} \quad (5)$$

Table 5

| $n$ | $i$ | $\Delta E(Z_i)$ | $S^*$ |
|---|---|---|---|
| 5 | 1 | 1,115718 | |
| | 2 | 0,645384 | |
| | 3 | 0,532445 | 0,95 |
| | 4 | 0,583273 | 0,77 |
| | 5 | - | 0,86 |
| 6 | 1 | 1,093929 | |
| | 2 | 0,612330 | |
| | 3 | 0,474330 | 0,95 |
| | 4 | 0,442920 | 0,76 |
| | 5 | 0,522759 | 0,86 |
| | 6 | - | 0,73 |
| 7 | 1 | 1,079055 | |
| | 2 | 0,591587 | |
| | 3 | 0,442789 | 0,95 |
| | 4 | 0,387289 | 0,77 |
| | 5 | 0,387714 | 0,86 |
| | 6 | 0,480648 | 0,74 |
| | 7 | - | 0,80 |

The following statistics is calculated:

$$S^c = \frac{\sum_{\left[\frac{n}{2}\right]+1}^{n-1} l_i}{\sum_{1}^{n-1} l_i} \quad (6)$$

(Parenthesis $\left[\frac{n}{2}\right]$ is the full part of the fraction. Hence $\left[\frac{7}{2}\right] = [3{,}5] = 3$ ). It follows that the numerator of relationships (6) is obtained adding the values of quantity $l_i$ , starting with line $i$=4. It is obtained that: $S^c = \frac{141{,}577213}{261{,}064843} \Rightarrow S^* = 0{,}542$. The Weibull hypothesis is accepted if the inequality is fulfilled:

$$S^c < S^* \quad (7)$$

$S^*$ is the quantile of the test. For $n$=7 and a likelihood threshold, P=0,95, the test quantile is $S^* \in$ {0,95; 0,77; 0,86; 0,74; 0,80}, and the calculated value os inferiour to any $S^*$ values belonging to the previous period.
A Weibull repartition hypothesis is confirmed for the operational time-intervals of heater two.
The Weibull repartition function is expressed as follows:

$$F = e^{\left(\frac{\gamma - t}{\eta}\right)^k} \quad (8)$$

where $\gamma$ is the position parameter $\eta$ is the variance parameter and $k$ is the shape parameter. The specialized literature, refering to the signification of these quantities, states: $\gamma$ - the minimum time-interval until a failure of a certain entity is recorded; $\eta$ emphasizes the characteristic operational time-interval; $\beta$ reflects the intensity of the attrition process [2], [8] . Usually, $\gamma$ is considered to be null. Consequently, the reduced form of the repartition function is:

$$F = 1 - \exp\left(\frac{t}{\eta}\right)^k \qquad (8')$$

The reliability of an equipment having a Weibull behaviour, is:

$$R = -\exp\left(\frac{t}{\eta}\right)^k \qquad (9)$$

In order to determine the values of the parameters of Weibull distribution, the method of the moments will be used, method proposed by K.Pearson [7]. To this end, the following phases are covered:

- the mean square deviation is calculated, σ:

$$\sigma = \sqrt{\frac{(t_i - \bar{t})^2}{n}} \qquad (10)$$

- the variation coefficient is calculated, $CV$:

$$CV = \frac{\sigma}{\bar{t}} \qquad (11)$$

-from table 6, for this value of the variation coefficient, the following quantities are considered: $g_\beta$, $V_\beta$, β - obtained through interpolation: $g_\beta$=0,2253; $V_\beta$ =0,9193; $\beta$ =4,622. The quantity $MTBF_W$ is deduced – the mean of the operational time-intervals according to the Weibull version: $MTBF_W = \theta \cdot \Gamma\left(\frac{1}{\beta}+1\right)$ where:

$$\theta = \frac{\tau}{g_\beta} \qquad (12)$$

$$\Gamma = \left(\frac{1}{\beta}+1\right) = V_\beta \qquad (13)$$

and the quantities $g_\beta$,$V_\beta$ are drawn from table 6, according to $CV$ quantity.

It is obtained $\theta$ = 223 days (relation (12)). It is deduced that $MTBF_W$ = 223 · 0,9139 → $MTBF_W \cong$ 204 days; the $\bar{t} = MTBF_W$ relation checks out.

Knowing the quantities $MTBF_e$ and $MTBF_W$, the maintenance frequency is obtained [10], for the two heaters during one year $T_{an}$ = 365 days:

- heater $H_1$: $f(MTBF_e) = \frac{T_{an}}{MTBF_e}$,

$f(MTBF_e) = \frac{365}{159} \Rightarrow f(MTBF_e) \cong 2{,}3$: two corective actions and two preventive inspections per year.

- heater $H_2$: $f(MTBF_W) = \frac{T_{an}}{MTBF_W}$,
- $f(MTBF_W) = \frac{365}{204} \Rightarrow f(MTBF_W) \cong 2$ corective actions per year.

Table 6

| $k_\beta$ | $V_\beta$ | $g_\beta$ | $CV$ |
|---|---|---|---|
| 0,900 | 1,0520 | 1.1719 | 1,1130 |
| 1,000 | 1,0000 | 1,0000 | 1,0000 |
| 1,100 | 0,9649 | 0,8783 | 0,9102 |
| - | - | - | - |
| - | - | - | - |
| - | - | - | - |
| 1,500 | 0,9927 | 0,6129 | 0,6703 |
| - | - | - | - |
| - | - | - | - |
| - | - | - | - |
| 4,000 | 0,9064 | 0,2543 | 0,2805 |
| 4,500 | 0,9126 | 0,2301 | 0,2521 |
| 5,000 | 0,9182 | 0,2103 | 0,2291 |

## 3. CONCLUSIONS

For the same equipment, the *MTBF* parameters have a smaller value when using Weibull hypothesis compared to the exponential version.

The Mean of Operational Time-Intervals depinds of the shape parameter, β, the one that indicates the attrition status of the technical equipment.

In the hypothesis of an exponential distribution, this parameter is equal to the unit value, which implies a constant attrition level, during the entire course of the equipment service time.

The *MTBF* quantity is also a criterion when scheduling maintenance operations- relation (1).

## 4. REFERENCES

[1] BARON T. (coordinating), ISAIC-MANIU Al., TÖVISSI L., NICULESCU D., BARON C., ANTONESCU V., ROMAN I.,"*Calitate şi fiabilitate. Manual practic* " (Quality and reliability. Practice Manual). Editura Tehnică, Bucureşti,1998.

[2] CĂTUNEANU V. M., MIHALACHE A., "*Bazele teoretice ale fiabilităţii*" (*Theoretical fundamentals of reliability*). Editura Academiei Române, Bucureşti,1983.

[3] CÂRLAN M., "*Probleme de optimum în ingineria sistemelor tehnice*" (*Optimunm problems in technical systems engineering*). Editura Academiei Române, Bucureşti, 1994.

[4] POLLARD A., RIVOIRE C., "*Fiabilité et statistiques prévisionnelles. Méthode de Weibull*"(). Ėd. Eyrolles Paris –V , Ėd.D'organisation, Paris VII, 1971.

[5] NIŢU V., IONESCU C.D.,"*Fiabilitate în energetică*" (*The reliability in the energetic*). Editura Didactică şi Pedagogică, Bucureşti, 1980.

[6] FELEA I., "*Ingineria fiabilităţii în Electroenergetică*" (*Reliability Engineering in Electroenergetics*).Editura Didactică şi Pedagogică, Bucureşti, 1980.

[7] ISAIC-MANIU Al., VODĂ V. Gh., "*Fiabilitatea şansă şi risc*" (*Reliability chance and risk).* Editura Tehnică, Bucureşti, 1986.

[8] IVAS D., MUNTEANU F., VOINEA E., NEMEŞ C.,"*Ingineria fiabilităţii sistemelor complexe*"(*Reliability*

*engineering complex systems*). Editura Perfect, Bucureşti, 2001.
[9] PEYRET B-G., "*La fiabilité industrielle ses bases Mathématiques*". Ėd. Eyrolles Paris –V, 1969.
[10] LYONNET P., "*La maintenance. Mathématiques et méthodes*". Ėd. Technique & Documentation, Paris , 1992.
[11] VODĂ V. Gh., "*Controlul durabilităţii produselor industriale*" (*The durability test of industrial products*). Editura Tehnică, Bucureşti,1981.

# THE MAINTENANCE TEAM STATISTICAL AND CYBERNETICAL ANALYSIS

[1]BUS CAMELIA GABRIELA , [2]COSTEA MARIUS AUREL , [3]BOCĂNETE PAUL, [4]CÂRLAN MILTIADE

[1]*Ministry of Transport,* [2]*The University of South- East Europe Lumina, Romania,* [3]*Maritime University of Constanța,* [4]*S.C. Formenerg S.A.*

**ABSTRACT**

The paper present an approach of structuring the work group - the team- in order to perform maintenance activities. Optimum selection of staff requires the decisional factor to conduct a thorough analysis concerning: professional training of team members, efficient use of work time, achievment of full congruence between the work complexity and the skills of workers, diminishment of time interval allotted to tecnical support when the features of work activities exceed the operational potential of the group, avoidance of wasting human resources that have higher qualifications compared to the profile of the activity and also achieving a sinergistic performance level concerning work cooperation of executing group.

**Keywords:** *Service factor, Regression equation, Correlation ratio, Degrees of freedom, Quantile, Markov chain, Carson-Laplace transform, Transfer function, Reverse transform.*

## 1. INTRODUCTION

Service factor, $G_0$, of a group is a quantity defined by the relation [1]:

$$G_0 = \frac{\overline{M_e}}{M} \cdot 100 \quad [\%] \qquad (1)$$

where

$\overline{M_e}$ is the average number of members of the directly productive staff (assesed by the work process analyst);
$M$ - the number of members of staff available to the group.

Concerning the average number of actually executing staff, this results from the equation

$$\overline{M_e} = \frac{\sum_j Me_j}{m}, \quad j = \overline{1;m} \qquad (2)$$

$Me_j$ is the number of executing staff members observed by the analyst during the *m* moment of time intervals (days, weeks), belonging to a sufficiently cogent time interval, chosen with the purpose of obtaining pieces of information characterized by a high degree of likelihood.
In order to determine (identify) the moments for data recordings, techniques of the Monte Carlo simulation method [2], [3] will be used.
Relation (2) is meaningfull only if the skill level of executing staff , and also workplace logistics, during the time when data recording takes place, meet the demands imposed by project execution.
Determining a relation like $G_0 = f(M)$ imposes the subsequent restriction (phenomenological restrictions):

$$\begin{cases} \lim\limits_{M=0} G_0 = 0 \\ \lim\limits_{M \to \infty} G_0 = 0 \end{cases} \qquad (3)$$

and the regression equation that meets this set of restrictions is considered to be like [4]:

$$G_0 = A \cdot e^{-cM}\left(1 - e^{-M}\right) \qquad (4)$$

where $A$, $c$ are the regression coefficients of the function.
Is noticeable that the proposed regression relation meets the set of restrictions (3) and has an extremum point whose abscissa gives the personal optimum number, $M_0$:

$$\frac{dG_0}{dM} = 0 \;\Rightarrow M_0 \Rightarrow G_0^{\max} \qquad (5)$$

where:

$$M_0 = \ln \frac{c+1}{c} \qquad (6)$$

The plot of $G_0 = f(M)$ function is given in figure 1:

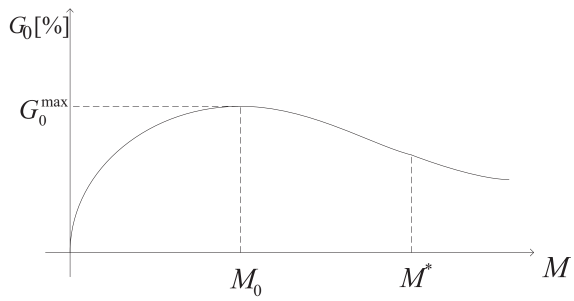



Figure 1 Plot of $G_0 = f(M)$ function

where $G_0^{\max}$ is the maximum level of service factor.
According to the least squares method [4], the following relation is obtained:

$$S = \sum_i \left( G_{0i} - \tilde{G}_{0i} \right)^2 \Rightarrow \text{minimum} \quad (7)$$

where: $S$ is the sum of the squares of the deviances; $G_{0i}$ - noticed values of the service factor of the $M_i$ executing staff members and $\tilde{G}_{0i}$ is the values of the service factor belonging to the regression equation. Linearizing relation (4) and taking in consideration the conditions imposed by this method:

$$\begin{cases} \frac{\partial S}{\delta A} = 0 \\ \frac{\delta S}{\partial c} = 0 \end{cases} \quad (8)$$

the Gauss equation system is obtained:

$$\begin{cases} n \ln A - c\sum_i M_i = \sum_i \ln G_{0i} + \sum_i \ln\left(1 - e^{-M_i}\right) \\ \ln A \sum_i M_i - c \sum_i M_i^2 = \sum_i M_i \ln G_{0i} + \sum_i M_i \ln\left(1 - e^{-M_i}\right) \end{cases} \quad 9)$$

Primary data $\left(M_i, G_{0i}\right)$, $i = \overline{1;n}$, of the $n$ volume statistical sample will be determined according to one of the Monte Carlo simulation method procedures as follows:

-the $r$ ratio is calculated:

$$r = \frac{n}{\theta} \quad (10)$$

where $\theta$ is a certain time interval measured using time units (days, weeks, etc.);

-the $N^*$ natural number is inferred; $N^*$ consists of five digits of the fractional part of $\left\{\frac{n}{\theta}\right\}$ ratio ;

-from table 2 of random number, extract from the statistics of Rand Corporation american company, $n$ numers are kept, $N \leq N^*$, belonging to one (some) certain column(s); the position of these $N$ indicate the moment when the analyst, accompanied by the person in charge of that particular job, project, can assess the service factor of the $M$ members of the work group. Therefore, according to the rank (position) of this number, the moment for assessing the $G_{0i}$ service factor is identified.

The degree of proximity of values $G_{0i}$, $\tilde{G}_{0i}$ is defined by the quantity, correlation ratio [5]:

$$\eta = \sqrt{1 - \frac{\sum_i \left( G_{0i} - \tilde{G}_{0i} \right)^2}{\sum_i \left( G_{0i} - \bar{G}_0 \right)^2}} \quad (11)$$

$\bar{G}_0$ is the average level of the service factor.

Table 1 gives the values of this quantity for different scenarios:

Table 1

| $\eta$ | Correlation meaning |
|---|---|
| $0 \leq \eta < 0{,}2$ | insignificant correlation |
| $0{,}2 \leq \eta < 0{,}5$ | low correlation |
| $0{,}5 \leq \eta < 0{,}75$ | medium correlation |
| $0{,}75 \leq \eta < 0{,}95$ | high correlation |
| $0{,}95 \leq \eta \leq 1$ | deterministical correlation |

A probabilistical analysis of the structure of the work group (the team), variable in different moments of data recording process can identify a possible trend of defectiv staff allocation. This is the case when an oversizement of the effectively executing work group is noticed. This situation can be highlighted if- according to Markov chain theory [6], applied to the temporal evolution of couples $(M_i, G_{0i})$, an „entropic degradation trend" is proven. Obviously, in a situation like this one, the Shannon entropy [7] has an ascending trend. The deciding factor, when noting this situation, has to resize the team with an optimum number of staff members, according to those previously shown.

The maintenance team, defined in this „case study", is a cybernetic system, whose adjustment mechanis is, obviously, the deciding factor.

## 2. CASE STUDY

THE OPTIMUM SIZING (STRUCTURING) OF A MAINTENANCE TEAM. Solving this problem involves undergoing a statistical route presented in in the followings. Determining data recording moments. Let there be $n = 16$ weeks belonging to a time interval $\theta = 80$ consecutive weeks.

According to (10) yields: $r = \frac{16}{80} \Rightarrow r = 0{,}20000$, therefore, $N \in [00000;20000]$.

The moments (weeks) for the random selection of couples $(G_{0i}, M_i)$, are to be identified based on table 2, columns 4 and 5. The highlighted numbers –from this table- are associated to the order (succession) of data registration. Registered elements $(G_{0i}, M_i)$ are given in table 3:

Table 3

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $M_i$ | 6 | 5 | 5 | 4 | 6 | 6 | 4 | 4 |
| $G_{0i}$ | 75 | 70 | 80 | 65 | 75 | 75 | 70 | 70 |
| $M_i$ | 8 | 5 | 4 | 6 | 5 | 8 | 8 | 8 |
| $G_{0i}$ | 75 | 75 | 75 | 75 | 75 | 65 | 75 | 70 |

The statistical sample can be a useful reference to define the regression equation (relationship (4)) that is representative. Taking in consideration the relative small amount of registered data, their representativeness is to be accepted only if a Poisson distribution hypothesis is validates [8], [9]. Table 4 given the calculation procedure for $\chi^2$ quantity, this beeing, according to Pearson method, the criterion for confirming the reprezentativeness of samples, only if the following condition is met: $\chi_c^2 \leq \chi_{\upsilon;P}^2$ (12)

where: $\chi_c^2$ is the calculated quantile; $\chi_\upsilon^2$ - test quantile; $\upsilon$ - the number of degrees of freedom is held in the table 6 [10], $\chi_\upsilon^2$ ;

$$\upsilon = n - (\gamma + 1) \tag{13}$$

Table 2

| | | | | | | |
|---|---|---|---|---|---|---|
| 38631 | 90045 | 69696 | 48572 | *05917* | 51905 | 10052 |
| 37984 | 77892 | 89766 | 86489 | 46619 | 50263 | 91136 |
| 84260 | 19693 | 36701 | 43233 | 62719 | 53117 | 71153 |
| 49095 | 84746 | 22018 | *19014* | 76781 | 61086 | 90216 |
| 77707 | 54317 | 48862 | 53823 | 52905 | 70654 | 68212 |
| | | | | | | |
| 01951 | 72166 | 52682 | 97598 | *11955* | 73018 | 23528 |
| 31794 | 86423 | 58037 | 36065 | 32190 | 31367 | 96007 |
| 03652 | 80824 | 33407 | 40837 | 97749 | 18364 | 72666 |
| 55159 | 62184 | 86208 | *09764* | 20244 | 88388 | 98675 |
| 44999 | 36785 | 65035 | 65933 | 77378 | 92339 | 96454 |
| | | | | | | |
| 60144 | 65591 | 09774 | *16216* | 63561 | 59751 | 78771 |
| 86031 | 83148 | 34970 | 30892 | 53489 | 44999 | 18021 |
| 27311 | 61586 | 28576 | 43092 | 69971 | 44220 | 80410 |
| 92335 | 55299 | 27161 | 64486 | 71307 | 85883 | 69610 |
| 81142 | 44271 | 36433 | 31726 | 74879 | 89348 | 76886 |
| | | | | | | |
| 55921 | 82774 | 62745 | 48338 | 88348 | 61211 | 88074 |
| 87613 | 94627 | 63622 | *08110* | *16611* | 88599 | 02890 |
| 36897 | 17215 | 73339 | 69856 | 43622 | 22567 | 11518 |
| 37618 | 94851 | 63020 | 65348 | 55857 | 91742 | 79508 |
| 70630 | 37136 | 50922 | 83387 | *15014* | 51838 | 81760 |
| | | | | | | |
| 01629 | 72184 | 33853 | 95144 | 67943 | 19345 | 93469 |
| 78555 | 97442 | 78809 | 40575 | 79714 | 06201 | 34576 |
| 85974 | 68067 | 78814 | 40103 | 70759 | 92129 | 46716 |
| 84157 | 23241 | 49332 | 23646 | *09390* | 13032 | 51569 |
| 80335 | 58090 | 85871 | *07205* | 31749 | 40571 | 51755 |
| | | | | | | |
| 45538 | 41435 | 61103 | 32428 | 94042 | 39971 | 63678 |
| 84904 | 50163 | 22625 | *07845* | 71308 | 00859 | 87984 |
| 23149 | 07370 | 65065 | *06580* | 46285 | 07884 | 83928 |
| 23023 | 83242 | 89938 | 40510 | 27252 | 55565 | 64714 |
| 81645 | 60479 | 71035 | 99380 | 59759 | 42161 | 93440 |
| | | | | | | |
| 78156 | 07871 | 20369 | 53947 | *08534* | 39433 | 57216 |
| 46255 | 80541 | 42903 | 37366 | 21164 | 97516 | 66181 |
| 44260 | 90570 | 01632 | 21002 | 24413 | 04671 | 05665 |
| 34660 | 22510 | 71558 | 78228 | 42304 | 77197 | 79168 |
| 59480 | 88092 | 00441 | 96016 | 76091 | 51823 | 94442 |
| | | | | | | |
| 25479 | 77684 | 88439 | 35112 | 26052 | 57112 | 91653 |
| 76297 | 15290 | 84688 | 74002 | *09467* | 41111 | 19194 |
| 59327 | 44422 | 53372 | 27823 | 25417 | 27150 | 21750 |
| 47284 | 05578 | 88774 | *15293* | 50740 | 07932 | 87633 |
| 26886 | 70002 | 96643 | 36008 | *02239* | 93563 | 66429 |

Table 4

| $k$ | 1 | 2 | 3 | 4 | $\sum_k$ |
|---|---|---|---|---|---|
| $G_{0k}$ | 65 | 70 | 75 | 80 | * |
| $f_k$ | 2 | 4 | 9 | 1 | 16 |
| $N$ | 16 | | | | |
| $f_k G_{0k}$ | 130 | 280 | 675 | 80 | 1165 |
| $\bar{G}_{0k}$ | 73 | | | | |
| $G_{0k} - \bar{G}_0$ | -8 | -3 | +2 | +7 | * |
| $(G_{0k} - \bar{G}_0)^2$ | 64 | 9 | 4 | 49 | * |
| $f_k (G_{0_k} - \bar{G}_0)^2$ | 128 | 36 | 36 | 49 | 249 |
| $\sigma$ | 4 | | | | * |
| $X_k$ | -2 | -0,75 | +0,5 | +1,75 | * |
| $\phi(X_k)$ | 0,023 | 0,204 | 0,464 | 0,309 | * |
| $p_k$ | 0,023 | 0,204 | 0,464 | 0,309 | 1,000 |
| $Np_k$ | 0,368 | 3,264 | 7,424 | 4,944 | * |
| $f_k - Np_k$ | 1,632 | 0,736 | 1,576 | -3,944 | * |
| $(f_k - Np_k)^2$ | 2,663 | 0,542 | 2,484 | 15,555 | * |
| $\frac{(f_k - Np_k)^2}{Np_k}$ | 7,236 | 0,166 | 0,335 | 3,146 | 10,883 |

$n$ - with the known signification, and $\gamma$ expresses the number of estimated parameters: $\gamma = 2$ ( the average value $\bar{G}_0$ and the $\sigma$ deviance):

$$\overline{G_0} = \frac{\sum_k f_k \cdot G_{0k}}{N} \tag{14}$$

$$\sigma = \sqrt{\frac{\sum_k f_k \left( G_{0k} - \bar{G}_0 \right)^2}{N}} \quad 15)$$

$$N = \sum_k f_k \tag{16}$$

and $P$ expresses the likelihood level of statistical samples representativeness:

$$P = 1 - \alpha \tag{17}$$

$\alpha$ is the risk factor(coefficient);

$$X_k = \frac{G_{0k} - \bar{G}_0}{\sigma} \tag{18}$$

$$p_k = \phi(X_k) - \phi(X_k - 1) \tag{19}$$

in the last $p_k^*$ value, the followings are inferred:

$$p_k^* = 1 - \sum_{k-1} p_k \qquad (20)$$

$\phi(X_k)$ is Gauss – Laplace function, whose values are obtained from table 4.

The calculated quantile of the test, $\chi_c^2$ is deduced according to:

$$\chi_c^2 = \sum_k \frac{(f_k - N \cdot p_k)^2}{N \cdot p_k} \qquad (21)$$

The hypothesis of Poisson repartition, according to (12), is validated:

$$\chi_c^2 = 10{,}883 < \chi^2_{P=0{,}95;\upsilon=16-(2+1)} = 22{,}4$$

Quantile value test $\chi^2_{p,\upsilon}$ is extracted from table 6. Hence, the representativeness of data belonging to the statistical sample is confirmed.

Table 5

| $\chi$ | $\phi(\chi)$ | $\chi$ | $\phi(\chi)$ | $\chi$ | $\phi(\chi)$ |
|---|---|---|---|---|---|
| 1 | 2 | 1 | 2 | 1 | 2 |
| -2,9 | 0,0019 | -0,9 | 0,1841 | 1,1 | 0,8643 |
| -2,8 | 0,0026 | -0,8 | 0,2119 | 1,2 | 0,8849 |
| -2,7 | 0,0035 | -0,7 | 0,2420 | 1,3 | 0,9032 |
| -2,6 | 0,0047 | -0,6 | 0,2743 | 1,4 | 0,9192 |
| -2,5 | 0,0062 | -0,5 | 0,3085 | 1,5 | 0,9332 |
| -2,4 | 0,0082 | -0,4 | 0,3446 | 1,6 | 0,9452 |
| -2,3 | 0,0107 | -0,3 | 0,3821 | 1,7 | 0,9554 |
| -2,2 | 0,0139 | -0,2 | 0,4207 | 1,8 | 0,9641 |
| -2,1 | 0,0179 | -0,1 | 0,4602 | 1,9 | 0,9713 |
| -2,0 | 0,0228 | 0 | 0,5000 | 2,0 | 0,9772 |
| -1,9 | 0,0288 | 0,1 | 0,5398 | 2,1 | 0,9821 |
| -1,8 | 0,0359 | 0,2 | 0,5793 | 2,2 | 0,9861 |
| -1,7 | 0,0446 | 0,3 | 0,6179 | 2,3 | 0,9893 |
| -1,6 | 0,0548 | 0,4 | 0,6554 | 2,4 | 0,9918 |
| -1,5 | 0,0668 | 0,5 | 0,6915 | 2,5 | 0,9938 |
| -1,4 | 0,0808 | 0,6 | 0,7257 | 2,6 | 0,9953 |
| -1,3 | 0,0968 | 0,7 | 0,7580 | 2,7 | 0,9965 |
| -1,2 | 0,1151 | 0,8 | 0,7881 | 2,8 | 0,9974 |
| -1,1 | 0,1357 | 0,9 | 0,8159 | 2,9 | 0,9981 |
| -1,0 | 0,1587 | 1,0 | 0,8413 | | |

In figure 2, the plot of the Poisson repartition function is given: $f(G_{0k}) = \varphi(G_{0k})$.

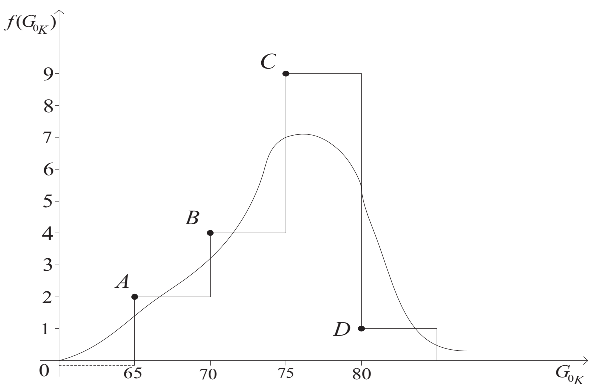



Figure 2 The plot of function $f(G_{0k}) = \varphi(G_{0k})$:

$f(G_{0k})$ represents the frequency of different values of the service factor.

This discrete type function is defined only in A,B,C and D points. The continous shape shows the placement trend of these points.

Table 6

| P \ N | 0,80 | 0,90 | 0,95 | 0,98 | 0,99 | 0,995 | 0,998 | 0,999 |
|---|---|---|---|---|---|---|---|---|
| 4 | 5,99 | 7,78 | 9,49 | 11,67 | 13,28 | 14,9 | 16,9 | 18,5 |
| 5 | 7,29 | 9,24 | 11,07 | 13,39 | 15,09 | 16,3 | 18,9 | 20,5 |
| 6 | 8,56 | 10,64 | 12,59 | 15,03 | 16,8 | 18,6 | 20,7 | 22,5 |
| 7 | 9,80 | 12,02 | 14,07 | 16,6 | 18,5 | 20,3 | 22,6 | 24,3 |
| 8 | 11,03 | 13,36 | 15,51 | 18,2 | 20,1 | 21,9 | 24,3 | 26,1 |
| 9 | 12,24 | 14,68 | 16,9 | 19,7 | 21,7 | 23,6 | 26,1 | 27,9 |
| 10 | 13,44 | 15,99 | 18,3 | 21,2 | 23,2 | 25,2 | 27,7 | 29,6 |
| 11 | 14,63 | 17,3 | 19,7 | 22,6 | 24,7 | 26,8 | 29,4 | 31,3 |
| 12 | 15,8 | 18,5 | 21,0 | 24,1 | 26,2 | 28,3 | 31,0 | 32,9 |
| 13 | 17,0 | 19,8 | 22,4 | 25,5 | 27,7 | 29,8 | 32,5 | 34,5 |
| 14 | 18,2 | 21,1 | 23,7 | 26,9 | 29,1 | 31,3 | 34,0 | 36,1 |
| 15 | 19,3 | 22,3 | 25,0 | 28,3 | 30,6 | 32,7 | 35,6 | 37,7 |
| 16 | 20,5 | 23,5 | 26,3 | 29,6 | 32,0 | 34,2 | 37,1 | 39,3 |
| 17 | 21,6 | 24,8 | 27,6 | 31,0 | 33,4 | 35,7 | 38,6 | 40,8 |
| 18 | 22,8 | 26,0 | 28,9 | 32,3 | 34,8 | 37,2 | 40,1 | 42,3 |
| 19 | 23,9 | 27,2 | 30,1 | 33,7 | 36,2 | 38,6 | 41,6 | 43,8 |
| 20 | 25,0 | 28,4 | 31,4 | 35,0 | 37,6 | 40,0 | 43,1 | 45,3 |
| 22 | 27,3 | 30,8 | 33,9 | 37,7 | 40,3 | 42,7 | 45,9 | 48,3 |
| 24 | 29,6 | 33,2 | 36,4 | 40,3 | 43,0 | 45,5 | 48,7 | 51,2 |
| 26 | 31,8 | 35,6 | 38,9 | 42,9 | 45,6 | 48,2 | 51,5 | 54,1 |
| 28 | 34,0 | 37,9 | 41,3 | 45,4 | 48,3 | 51,0 | 54,3 | 56,9 |
| 30 | 36,3 | 40,3 | 43,8 | 48,0 | 50,9 | 53,7 | 57,1 | 59,7 |

Figure 3 presents the plot of $G_0 = f(M)$ function, built based on $(M_i, G_{0i})$, $i = \overline{1;16}$ data couples:

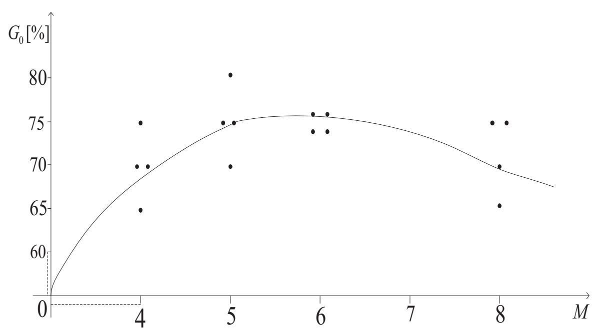



Figure 3 The plot of funcției $G_0 = f(M)$

The calculation process of the regression coefficients– relation (4) and equations system (9) – is synthesized in table 7.

Hence: $A = 74{,}3$; $c = 0{,}002543$; $M_0 \in [5;6]$ executing staff members; $G_0^{\max} = 75\%$.

Table 7

| $i$ | $M_i$ | $G_{0i}$ | $M_i^2$ | $1-e^{-M_i}$ | $\ln(1-e^{-M_i})$ | $M_i \ln(1-e^{-M_i})$ | $\ln G_{0i}$ | $M_i \ln G_{0i}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 75 | 36 | 0,99752 | -0,00248 | -0,01488 | 4,31749 | 25,90494 |
| 2 | 5 | 70 | 25 | 0,99326 | -0,00676 | -0,03380 | 4,24849 | 21,24245 |
| 3 | 5 | 80 | 25 | 0,99326 | -0,00676 | -0,03380 | 4,38203 | 21,91015 |
| 4 | 4 | 65 | 16 | 0,98168 | -0,01849 | -0,07396 | 4,17439 | 16,69756 |
| 5 | 6 | 75 | 36 | 0,99752 | -0,00248 | -0,01488 | 4,31749 | 25,90494 |
| 6 | 6 | 75 | 36 | 0,99752 | -0,00248 | -0,01488 | 4,31749 | 25,90494 |
| 7 | 4 | 70 | 16 | 0,98168 | -0,01849 | -0,07396 | 4,24849 | 16,99396 |
| 8 | 4 | 70 | 16 | 0,98168 | -0,01849 | -0,07396 | 4,24849 | 16,99396 |
| 9 | 8 | 75 | 64 | 0,99966 | -0,00034 | -0,00272 | 4,31749 | 34,53992 |
| 10 | 5 | 75 | 25 | 0,99326 | -0,00676 | -0,03380 | 4,31749 | 21,58745 |
| 11 | 4 | 75 | 16 | 0,98168 | -0,01849 | -0,07396 | 4,31749 | 17,26996 |
| 12 | 6 | 75 | 36 | 0,99752 | -0,00248 | -0,01488 | 4,31749 | 25,90494 |
| 13 | 5 | 75 | 25 | 0,99326 | -0,00676 | -0,03380 | 4,31749 | 21,58745 |
| 14 | 8 | 65 | 64 | 0,99966 | -0,00034 | -0,00272 | 4,17439 | 33,39512 |
| 15 | 8 | 75 | 64 | 0,99966 | -0,00034 | -0,00272 | 4,31749 | 34,53992 |
| 16 | 8 | 70 | 64 | 0,99966 | -0,00034 | -0,00272 | 4,24849 | 33,98792 |
| $\sum_i$ | 92 | * | 564 | * | -0,11228 | -0,50144 | 68,58218 | 394,36558 |

The link (correlation ) between the average values of the service factor specific to a certain number of staff members, $\bar{G}_{0l}$ and $\tilde{G}_{0l}$ values, belonging to the regression function is highlighted by the Pearson correlation ratio, quantity obtained according to the calculus presented in table 8:

Table 8

| $l$ | $M_l$ | $\bar{G}_{0l}$ | $\bar{G}_0$ | $\bar{G}_{0l}-\bar{G}_0$ | $\tilde{G}_{0l}$ | $\bar{G}_{0l}-\tilde{G}_{0l}$ | $(\bar{G}_{0l}-\bar{G}_0)^2$ | $(\bar{G}_{0l}-\tilde{G}_{0l})^2$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 4 | 70 | 73 | -3 | 71 | -1 | 9 | 1 |
| 2 | 5 | 75 | | +2 | 73 | +2 | 4 | 4 |
| 3 | 6 | 75 | | +2 | 73 | +2 | 4 | 4 |
| 4 | 8 | 71 | | -2 | 72 | -1 | 4 | 1 |
| $\sum_k$ | * | * | * | * | * | * | 21 | 10 |

In this table, the average service factor associated to the same number of staff members $\bar{G}_{0l}$ , is obtained using the relation:

$$\bar{G}_{0l} = \frac{\sum_l G_0(M_l)}{q} \tag{22}$$

$q$ is the number of service factor values for the same number of staff members ( $q = 4$ for any $M_k$ value).

The correlation ratio is obtained – relation (11):

$$\eta = \sqrt{1-\frac{10}{21}} \Rightarrow \eta \cong 0,724$$

According to table 1 a medium intensity correlation is obtained – obvious consequence of the relatively small size of the statistical sample. From a systemical point of view, the maintenance team has a temporal evolution,defined by the four states–variable number of executing staff members: $M \in [4;5;6;8]$ executing staff members. Thus , according to the succession of $M_i$ values from din table 7, the transition graph is presented in figure 4:

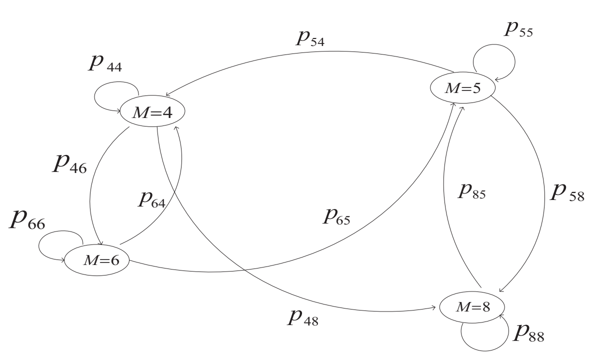



Figure 4 Staff members number transition graph

Using Markov chaines theory , „state probabilities ” in stabilized conditions can be determined [6]:

- $p_4^*$ : for the staff, $M = 4$ executing team member;
- $p_5^*$ : for the staff, $M = 5$ executing team member;
- $p_6^*$ : for the staff, $M = 6$ executing team member;
- $p_8^*$ : for the staff, $M = 8$ executing team member.

The probabilities concerning using a certain number of members in a team, $M \in [4;5;6;8]$ are equal; there are four years since each executing staff is called, therefore the frequency $f(M_k) = 4$.

It is obtained that

$$p(M_k) = \frac{f(M_k)}{n} \tag{23}$$

$p(M_k) = \frac{4}{16} \Rightarrow \quad p(M_k) = 0{,}25$, value associated to each executing staff, inferred based on the statistical protocol – column 2- from table 7.

Depending on the succession of work groups, (table 7, column 2) and the graph of transitions from figure 3, the transition probabilities matrix (stochastic matrix) [M] is obtained:

$$[M] = \begin{bmatrix} l_{44} & l_{45} & l_{46} & l_{48} \\ l_{54} & l_{55} & l_{56} & l_{58} \\ l_{64} & l_{65} & l_{66} & l_{68} \\ l_{84} & l_{85} & l_{86} & l_{88} \end{bmatrix}$$

The „ dynamic matrix" $[D]$ results:

$$[D] = [M] - [I] \tag{24}$$

$[I]$ is the „unit matrix":

$$[I] = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{25}$$

The dynamic matrix is obtained:

$$[D] = \begin{bmatrix} p_{44}-1 & p_{45} & p_{46} & p_{48} \\ p_{54} & p_{55}-1 & p_{56} & p_{58} \\ p_{64} & p_{65} & p_{66}-1 & p_{68} \\ p_{84} & p_{85} & p_{86} & p_{88}-1 \end{bmatrix}$$

The linear equation system (S) is obtained:

$$(S): \begin{cases} (p_{44}-1)p_4^* + p_5^4 \cdot p_5^* + p_{64} \cdot p_6^* + p_{84} \cdot p_8^* = 0 \\ p_{54} \cdot p_4^* + (p_{55}-1)p_5^* + p_{56} \cdot p_6^* + p_{58} \cdot p_8^* = 0 \\ p_{64} \cdot p_4^* + p_{65} \cdot p_5^* + (p_{66}-1)p_6^* + p_{68} \cdot p_8^* = 0 \\ p_{84} \cdot p_4^* + p_{85} \cdot p_5^* + p_{86} \cdot p_6^* + (p_{88}-1)p_8^* = 0 \\ p_4^* + p_5^* + p_6^* + p_8^* = 1 \end{cases}$$

The values of transition probabilities $p_{gh}, g, h = 4;5;6;8$ are deduced according to the successions of staff repartition, extracted from table 7, column 2; the calculation process of these transition probabilities is given in table 9. In this table $f_{gh}$ is the frequency of the $gh$ transition, $p_{gh}$ is the probability of this transition. The transition probabilities are obtained through this process, and the „state probabilities in stabilized conditions" $p_4^*$, $p_5^*$, $p_6^*$, $p_8^*$ are obtained solving the equations system. The $f_{gh}$ probabilities are calculated according to the relation:

$$p_{gh} = \frac{f_{gh}}{\sum_g f_{gh}} \tag{26}$$

Based on this data , the following linear system of five equations and four variable is obtained:

$$(S): \begin{cases} -0{,}75 p_4^* + 0{,}5 p_5^* + 0{,}25 p_6^* = 0 \\ -0{,}75 p_5^* + 0{,}5 p_6^* + 0{,}333 p_8^* = 0 \\ 0{,}5 p_4^* - 0{,}75 p_6^* = 0 \\ 0{,}25 p_4^* + 0{,}25 p_5^* - 0{,}333 p_8^* = 0 \\ p_4^* + p_5^* + p_6^* + p_8^* = 1 \end{cases}$$

In order to solve this system, one variable is substituted from the last equation of $(S^*)$ system and replaced in one of the any other three equations.

The obtained values are: $p_4^* = 0{,}22339$; $p_5^* = 0{,}04478$; $p_6^* = 0{,}14925$; $p_8^* = 0{,}58258$.

Compared to the equal levels: $p_4 = p_5 = p_6 = p_8 = 0{,}25$ of the initial state, an increasing trend is set for the probability of oversizing the work group, 8 executing staff members, but which does not belog to the optimum number of executing staff members: $M_k \in [6;7]$.

Therefore, it is necessary to determine the optimum number of maintenance team staff members. If contrary, a disorganisation trend of staff repartition will be noticed. This undesired situation is evidenced by the enthropy evolution from the initial repartition situation to the stabilized state.

Table 10 presents the level of enthropy for both situations: $H_k^0, H_k^*$.

The determination of this quantity is performed according to a Shannon meaning:

$$H^0 = -\frac{1}{\ln 2}\left[p_M^0 \ln p_M^0 + \left(1 - p_M^0\right)\ln\left(1 - p_M^0\right)\right] \tag{27}$$

$$H^* = -\frac{1}{\ln 2}\left[p_M^* \ln p_M^* + \left(1 - p_M^*\right)\ln\left(1 - p_M^*\right)\right] \tag{27'}$$

In initial scenario, for the team repartition probability with a different number of staff members, but with the same frequency $\left(f(M_k) = 0{,}25\right)$, the enthropy has the same value for any number of staff members, $M_k \in [4;8]$:

$$H^0 = -1{,}442695[0{,}25(-1{,}38629) + 0{,}75(-0{,}28768)]$$

$$H^0 = 0{,}8113 \text{ bit.}$$

Table 9

| State | | M=4 | | M=5 | | M=6 | | M=8 | |
|---|---|---|---|---|---|---|---|---|---|
| | | $f_{4h}$ | $p_{4h}$ | $f_{5h}$ | $p_{5h}$ | $f_{6h}$ | $p_{6h}$ | $f_{8h}$ | $p_{8h}$ |
| M=4 | Followed by | 1 | 0,25 | 0 | 0 | 2 | 0,50 | 1 | 0,25 |
| M=5 | | 2 | 0,50 | 1 | 0,25 | 0 | 0 | 1 | 0,25 |
| M=6 | | 1 | 0,25 | 2 | 0,50 | 1 | 0,25 | 0 | 0 |
| M=8 | | 0 | 0 | 1 | 0,333 | 0 | 0 | 2 | 0,667 |

In stabilized regim (permanent), the enthropy diminishes for for the staff repartition $M_k \in [4;5;6]$, but increases if the ascending trend is kept for the increasement of the number of effective executing staff members upt to the level $M = 8$ .
Table 10 highlights this situation:

Table 10

| $M_k$ | Moment 0 | | Moment * | | Deviance |
|---|---|---|---|---|---|
| | $p^0(M_k)$ | $H^0(M_k)$ -bit | $p^*(M_k)$ | $H^*(M_k)$ -bit | |
| 4 | 0,25 | 0,8113 | 0,2233 9 | 0,76630 9 | 55% diminishment |
| 5 | 0,25 | 0,8113 | 0,0447 8 | 0,26379 | 67,5% diminishment |
| 6 | 0,25 | 0,8113 | 0,1492 5 | 0,60797 | 25,1% diminishment |
| 8 | 0,25 | 0,8113 | 0,5825 8 | 0,98026 | 21% diminishment |

Therefore, the increasement trend for the number of staff members determines a chaos situation, determining a service factor with an obvious recrudescence perspective.

The optimum functionning regim for the maintenance team, as a cybernetic system, is defined by its repartition with an optimum number of staff members ([4] – quote). In figure 5, a system like this is presented: the maintenance team. This analysis taked in consideration two quantities:

-input quantity defined by the number of staff members, $M$ ;

-the output quantity, considered as the service factor achieved by the members of the team; $G_0(M)$.

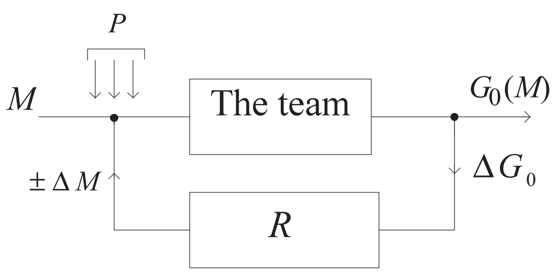



Figure 5 The maintenance team, a cybernetic system

In this figure, excepting the reminded input/output quantities $M$ şi $G_0(M)$. -, others intervene: $R$ - the adjustment factor of the system activity, deviances from the optimum regim: $\pm\Delta M \neq 0$ , whose effect is the diminishment of the service factor $(-\Delta G_0), P$ assemblage of disturbances that generate these deviances: inferior skills level compared to activity requirements, morally and physically worn out logistics, defective purveyance, poor ergonomic requirements, oversized staff (wasted human resource), etc.

Using the Carson – Laplace transform, the transfer function of the system is obtained, $\Delta M(S)$: the ration of $C - L$ transforms for the input/output quantities:

$$\Delta M(S) = \frac{L^{c-1} G_0(M)}{L^{c-1} M} \tag{28}$$

where

$$L^{c-1} G_0(M) = A L^{c-1} \left[ e^{-c} \left( 1 - e^{-M} \right) \right] \tag{29}$$

From table 11 we use:

$$L^{c-1} M = \frac{1}{S} \tag{30}$$

$$L^{c-1} A e^{-cM} \left( 1 - e^{-M} \right) = A \left[ \frac{S}{S+c} - \frac{S}{S+c+1} \right] \Rightarrow$$

$$L^{c-1} G_0(M) = A \left[ \frac{S}{(S+c)(S+c+1)} \right] \tag{31}$$

The C – L transform of the transform functions is obtained:

Table 11

| $f(M)$ | $\ell(S)$ |
|---|---|

| | |
|---|---|
| $M$ | $\frac{1}{S}$ |
| $e^{aM}$ | $\frac{S}{S+a}$ |
| $\frac{1-e^{-aM}}{a}$ | $\frac{1}{S+a}$ |
| $\frac{e^{-bM}-e^{-aM}}{a-b}$ | $\frac{S}{(S+a)(S+b)}$ |
| $\frac{ae^{-aM}-be^{-bM}}{a-b}$ | $\frac{S^2}{(S+a)(S+b)}$ |
| $Me^{-aM}$ | $\frac{S}{(S+a)^2}$ |
| $\frac{M^{n-1}e^{-aM}}{(n-1)!}$ | $\frac{S}{(S+a)^n}$ |
| $\frac{e^{-aM}-e^{-bM}}{M}$ | $S\log\frac{S+b}{S+a}$ |

$$\Delta M(S) = A\frac{\frac{S}{(S+c)(S+c+1)}}{\frac{1}{S}} \Rightarrow$$

or $\Delta M(S) = A\frac{S^2}{(S+c)(S+c+1)}$

In order to obtain a physical meaning of the analyzed process, the transfer function will be subject to another transform: the reverse C – L transform, known as the Mellin – Fourier transform, $L^{-1}\Delta M(S)$:

$$L^{-1}\Delta M(S) = \frac{ce^{-cM}-(c+1)e^{-(c+1)M}}{c-(c+1)} \quad (32)$$

For an optimum activity regim, the $\pm\Delta M$ quantity, the subject of the adjustment element, becomes null; therefore $L^{-1}E(S)=0$ :

$$(c+1)e^{-(c+1)M} = c\cdot e^{-cM}$$

or

$$\frac{c+1}{c} = e^M \Rightarrow M_{optim} = \ln\frac{c+1}{c} \cong \ln\frac{1}{c} = -\ln c$$

The optimum operational regim of the team involves an optimum number of staff members; the same relation of the effectively executing staff is achieved, determined according to the condition (5). Table 11 is an extract from the [10] quoted work.

## 3. CONCLUSIONS

Optimum sizing of a maintenance team an important factor concerning using the qualified staff at a performance level. The optimum number of effectively executing staff members is not neccessary a figure; - it is recommended to be seen as an optimum interval, limited by a cardinal (the number of elements of an assemblage): maximum 3.

Because an optimum like this does not require an inflexible sizing – a certain number of staff members – positive outcomes are noticed due to the fact that the deciding factor has a natural trenf of using a larger number of members in a team. A problem resolution like this generates certain advantages, for example, achieving redundancy concerning the skills level of the team, but it is also possible to generate bad consequences: wasting human resources.

The examination of the representativeness of the statistical sample is a first priority operation. Expected likelihood results can be obtained only when using high likelihood pieces of data, drawn from a sufficiently conclusive volum.

The correlation ratio, between the assumptions and the results obtained through the statistical analysis, should offer to the decisional factor the moral effect of an action concentrated with work and passion, for the wellgeing of that particular technical entity.

## 4. REFERENCES

[1] MĂCRIŞ A., GHEORGHE A., "*Optimizări în ingineria energetică*" (*Optimization in energetic engineering*). Editura Academiei Române, Bucureşti, 1994.

[2] CULMANN G., "*Recherche opérationnelle*". Ėd. Eyrolles Paris, 1970.

[3] STARR M. K., "*Conducerea producţiei. Sisteme şi sinteze*"( *Production management. Systems and synthesis*). Editura Tehnică, Bucureşti 1979.

[4] CÂRLAN M., "*Probleme de optimum în ingineria sistemelor tehnice*" (*Optimunm problems in technical systems engineering*). Editura Academiei Române, Bucureşti, 1994.

[5] BARON T., BIJI E., TÖVISSI L., WAGNER P.,., ISAIC-MANIU Al., KORKA M., POROJAN D., "*Statistică teoretică şi economică* " (*Theoretical statistics and economic*). Editura Didactică şi Pedagogică, Bucureşti,1996.

[6] LYONNET P., "*La maintenance*". Ėd. Technique & Documentation. Paris, 1992.

[7] CONSTANTINESCU P., "*Modelarea unitară a genezei şi dezvoltării sistemelor*" (*Genesis and development of unified modeling systems*). Editura Tehnică, Bucureşti, 1983.

[8] CIUCU G., CRAIU V., ŞTEFĂNESCU A., "*Statistică matematică şi cercetări operaţionale*" (*Mathematical statistics and operational research*). Editura Didactică şi Pedagogică, Bucureşti.

[9] RUMIŞISKI I.Z., "*Prelucrarea matematică a datelor experimentale*" (*Mathematical processing of the experimental data*). Editura Tehnică, Bucureşti, 1974.

[10] KAUFMANN A., "*Metode şi modele ale cercetării operaţionale*" (*Methods and models of operational research*). Traducere din limba franceză. Editura Ştiinţifică, Bucureşti , 1968.

# SEISMIC LOADS NUMERIC CALCULATION FOR A NUCLEAR CLASS 2 PIPING SYSTEM

[1]CALIMANESCU IOAN, [2]STAN LIVIU-CONSTANTIN

[1,2]*Constanta Maritime University, Romania*

**ABSTRACT**

Due to its location, seismic activity is common in Romania and earthquake engineering is a well known subject. Earthquake risks maps have been constructed to predict the ground acceleration in different parts of the country. All structures, including pipeline systems, are designed according to a particular design code. In particular for NPP of Cernavoda, the ASME Sect.III design code (App. N) may be used in structural earthquake design. Significant increased cost is involved in the design, making and installation of structures where seismic loading is taken into account. In particular, the supports for piping systems are made bigger and stiffer to withstand the loading.

Therefore, it is of utmost importance to have a simple standard procedure for seismic design/verification of piping systems. The focus here is on the seismic loads calculation for a Nuclear Class 2 piping system. The proposed FE model was developed inside the Piping Module of ANSYS, with 197 elements and 214 nodes, the pipe runs and the valve were modeled using Pipe 16 element type, the elbows with Pipe 18 Element type and the Snubbers and Spring hangers with Combin 14. The computed model showed good results and behaviour as far as the static loads are concerned but failed to pass the Seismic response analysis.

**Keywords:** *Finite Elements, Nuclear Class 2, Piping System, Spectrum Analysis.*

## 1. INTRODUCTION

Due to its location, seismic activity is common in Romania and earthquake engineering is a well known subject. Earthquake risks maps have been constructed to predict the ground acceleration in different parts of the country. The seismicity of Romania is clustered in several epicentral zones: Vrancea, Făgăras-Câmpulung, Banat, Crisana, Maramures and Southern Dobruja. Other epicentral zones of local importance can be found in Transylvania, in the area of Jibou and Târnava River, in northern and western part of Oltenia, in northern Moldavia and in the Wallachian Plain. The Vrancea seismogenic zone is the most important among these seismic zones, having in mind the energy, the extent of the macro seismic effects and the persistent and confined character of the earthquakes that occur in this area. Two belts of moderate and shallower seismicity are emphasized in the other regions of the country, one along the Southern Carpathians and the eastern edge of the Pannonian Basin, the other along the Eastern Carpathians that extends towards SE on the Peceneaga–Camena line. For instance predicted ground acceleration as 0.1 g is generally thought to be enough to cause damage to weak construction.

All structures, including pipeline systems, are designed according to a particular design code. In particular for NPP of Cernavoda, the ASME Sect.III design code (App. N) may be used in structural earthquake design. Significant increased cost is involved in the design, making and installation of structures where seismic loading is taken into account. In particular, the supports for piping systems are made bigger and stiffer to withstand the loading.

Therefore, it is of utmost importance to have a simple standard procedure for seismic design/ verification of piping systems. The focus here is on the seismic loads calculation for a Nuclear Class 2 piping system.

## 2. SOME THEORETICAL CONSIDERATIONS

Many standards or guidelines are available to provide criteria for the design of mechanical (metal) systems and components to resist dynamic loads. The primary guidance for nuclear facilities is found in Appendix N (Dynamic Analysis Methods) [6] of the ASME B&PV Code, Section III. This guideline is defined as a Non-Mandatory Appendix to ASME Section III and at the present, it is primarily concerned with cyclic dynamic loads associated with earthquakes and fluid flow–induced vibration of structures contained within the cross-flow of fluids.

Earthquake or Other Building Filter-Cyclic Loads Cyclic loads are characterized as alternating loads or displacements that are applied to mechanical systems or components. These earthquake-associated loads are caused by the inertial response of a structure, system, or component (SSC) to the earth-quake-induced motion of the SSC supports or the foundations of the supports. The response of a system or component is highly dependent on the damping of the system. In addition, the system or component response depends on the closeness of the time-dependent forcing function frequency (which defines the input) to the dominant response frequency of the seismically loaded system or component.

If the system or component has a natural frequency closed to that of the applied forcing function, resonance can occur, resulting in large amplification of an equivalent static load applicable to the mechanical system or component. Such amplification could theoretically be as high as 100 times the peak cyclic-force level at low-damping and near-resonance (system or component frequency is very near the cyclic-load frequency). For real structures under seismic excitation, the amplification factor rarely exceeds 25.

*2.1 Basic Equations of Motion and Time-Dependent Loading Functions*

The basic equations of motion can be found in ref. [9] or other similar introductory texts on structural dynamics. Those equations involve the following parameters:

$$m\ddot{x} + c\dot{x} + kx = f(t) \quad (1)$$

where *m*-mass of the system or component; *k*-stiffness of the system or component; *c*-damping coefficient, due to energy absorption in the material and system; *f(t)*-dynamic forcing function; *x*-displacement of the system or component for a particular degree of freedom; $\dot{x} = \frac{dx}{dt}$ - velocity of the system or component for a particular degree of freedom; $\ddot{x} = \frac{d^2x}{dt^2}$ -acceleration of the system or component for a particular degree of freedom.

The actual formulation and method of solution of the general differential equation of motion depends considerably on the nature and location of the forcing function *f(t)*. For cyclic loads, the system or component is usually represented as a multi–degree-of-freedom system with multidirectional input in which the force applied to a given mass point is a function of that mass point's inertial properties in response to a base-input motion rather than an external force applied to the system or component. This type of loading lends itself to solution by the modal response spectrum method of analysis [9].

Associated with the solution of the basic equation of motion, ignoring damping and the forcing function, there are the following relationships:

$$\omega = \sqrt{\frac{k}{m}} \quad (2)$$

where *ω*-is the natural frequency of the system or component in radians/sec, and,

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \quad (3)$$

$f$ -natural frequency of the system or component in cycles/sec or Hz.

It has been found for cyclic (earthquake and vibratory) design loads in which the dynamic force is the result of inertial response to a base motion loading, the solution is expedited by variable substitution such as a modal equation of motion becomes:

$$\ddot{A}_i + 2\omega_i\beta_i\dot{A}_i + \omega_i^2 A_i = P_i\ddot{x}_s \quad (4)$$

$Ai$ -modal displacement (rotation) of mode *i* relative to the base; $\ddot{A}_i$ -modal acceleration (rotational) of mode *i* relative to the Base; $\dot{A}_i$ -modal velocity (rotational) of mode *i* relative to the base; $\beta_i$ -percent critical damping in the *i*th mode; $\ddot{x}_s$ -absolute translational (angular) acceleration of the base; *Pi*-modal participation factor of the *i*th mode:

$$P_i = \sum_{r-1}^{n}\left(\frac{m_r\Phi'_{ri}}{m_r\Phi_{ri}^2}\right) \quad (5)$$

Finally, the inertial force applied to the *r*th mass in the *i*th mode becomes:

$$f_{ri} = m_r a_{ri} = m_r\left(P_i S_{ai}\Phi_{ri}\right) \quad (6)$$

Where:
$a_{ri}$-inertia acceleration applied to the *r* mass in the *i*th mode; $m_r$-the *r*th mass; $P_i$-modal participation factor in the *i*th mode; $f_{ri}$-inertia force applied to the *r*th mass in the *i*th mode; $S_{ai}$-response spectra acceleration in the *i*th mode (damping is built into this parameter) response spectra are a plot of the maximum response of a series of SDOFs to the earthquake time-history input; $\Phi'_{ri}$ -modal displacement of the *r*th mass in the *i*th mode in the direction of the applied earthquake motion; $\Phi_{ri}$ -all modal displacements of the *r*th masses in the ith mode (are Eigen vectors); $\omega_i^2$ -are the Eigen-values solution of the modal equation of motion.

*2.2 Ground-Response Spectra*

Earthquake loads are generally taken as cyclic. Loads associated with this cyclic input can be generally solved by time-step integration of the equations of motion, but more often the simplified method of response spectrum modal analysis is used.

Historically, for nuclear power plant (NPP) design, three generic earthquake free-field–ground-surface time-histories have been used in addition to many site-specific time-histories of motion. Analyses have generally used response-spectra representations of these time-history motions.

Four sets of response-spectra-shape-amplification parameters for various damping values are shown in Fig. 1, for 5% damping. The Housner spectrum a weighted-average spectrum is based on four different earthquake-response time-histories. The Regulatory Guide 1.60 spectrum is a mean-plus-one standard deviation in the amplified region that reduces to a mean acceleration in the high frequency un-amplified region; it is based on 14 recorded earthquake time-histories. Both of these spectra have some degree of conservatism by defining damping at lower bound values and using weighted-average or mean-plus-one standard deviation spectral shapes. The spectral shape designated as NUREG/CR-0098 has recently become popular; it is generally considered a generic free-field–ground-surface median spectral shape and employs best-estimate damping values. It has been used excessively for verifying seismic design adequacy of existing plants and is generically recommended for the design of new NPPs, where the use of site-specific spectra has not been specified [12].

For completeness, the spectral shape contained in the International Building Code-applicable to the United States is also given in Fig. 1. In general, it can be expected that site-specific spectra can be developed either by deterministic and/or probabilistic means that can be used as earthquake input to a particular site, which will somewhat reduce the energy content of the generic spectra shown in Fig. 1.

The (2007) Appendix N, Tables N-1221(a & b)-1, presents inflection point values for the construction of response spectra based on the percent of critical damping. These values are illustrated in Table 1. When these data are plotted on a scale similar to Figure.1, a significant difference in the spectra is evident. The spectra in the current Appendix N uses a straight line interpolation between the spectral values on the log-log chart whereas the previous spectra were developed using a straight line on a chart with the period on a linear scale. This results in an added degree of conservatism in the new spectra.

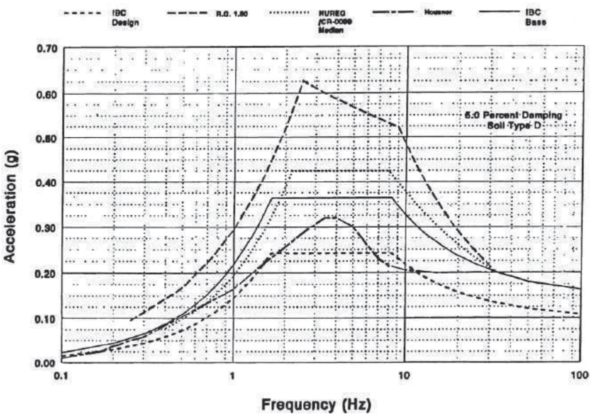



Figure 1 Generic earthquake-response spectral shape

Table 1 Appendix N horizontal response spectra values – in/sec

| Percent Critical Damping | | | | | |
|---|---|---|---|---|---|
| Frequency -Hz | 0.5 | 2 | 5 | 7 | 10 |
| 0.1 | 72.38 | 56.55 | 46.37 | 42.52 | 38.45 |
| 0.25 | 180.96 | 141.37 | 115.92 | 106.31 | 96.13 |
| 2.5 | 146.36 | 104.55 | 104.55 | 66.91 | 56.09 |
| 9 | 33.89 | 24.19 | 24.19 | 15.51 | 12.98 |
| 33 | 1.86 | 1.86 | 1.86 | 1.86 | 1.86 |

The introduction of floor response spectra (covered in the next section) resulted in higher loads being placed on equipment in upper stories of structures. The cost implications of these higher design loads have led many owners to call for the development of site-specific time histories and ground response spectra.

As stated in ASCE 7-02 [16]: "A site-specific study shall account for the regional seismicity and geology, the expected recurrence rates and maximum magnitudes of events on known faults and source zones, the location of the site with respect to these near source effects, if any, and the characteristics of subsurface site conditions." Generally, the uses of this site-specific data tend to be less conservative than the generic data that has been discussed.

For an existing NPP site, a 10-3/yr. to 10-5/yr. occurrence or exceedence probability is used for most safety-related SSCs in conjunction with the Regulatory Guide 1.60 shaped spectrum. A 10-4/yr. probability of exceedence is expected to be used in conjunction with the median NUREG/CR-0098 shaped spectra. The IBC spectrum is associated with a 4x10-4/yr. earthquake occurrence exceedence level; it is sometimes applied to safety-related items associated with radioactive material storage and processing at NPP sites rather than safety-related SSCs associated with nuclear reactor operation.

It is anticipated that any new zero period acceleration NPP safety related SSC will use a 10-5/yr. median probability of occurrence or exceedence with median damping and shaped spectra.

Alternatively, a 10-4/yr. median-plus-one standard deviation as defined in R.G 1.60 or mean zero period ground acceleration with the spectral shape as shown in Fig. 1 and the associated damping of R.G 1.61 [15] will be used.

### *2.3 Floor-Response Spectra*

The earthquake motion applicable to mechanical systems or components in the form of response spectrum or time-history acceleration are usually affected by the building structures through which they are transmitted. Such building structures tend to vibrate at their own dominant natural frequencies. Consequently, the near-random or white-noise earthquake ground motion introduced at the base of the building (primary) structure is made more sinusoidal, which gives a significantly higher response at a given percent critical damping to systems and components (secondary) near the dominant frequency of the building (primary) structure.

Most equipment will have negligible interaction effects on the primary structure-as in the case of equipment with relatively small mass and high frequency-and will only need to be included in the mass distribution of the primary system model. However, there are major equipment systems, such as a reactor coolant system or large pressure vessel, in which the stiffness, mass, and resulting frequency range should be considered for representation in the building model to account for possible dynamic-interaction effects.

For most architectural, mechanical, and electrical systems and components (secondary), a separate analysis of the secondary system may be performed using output from the building analysis. If building equipment interaction is significant, as defined in refs. [1] and [6], the equipment should be included in an integrated mathematical model of the structure. The representation of the equipment included in the building model should be adequate to consider major interaction effects, but it need not be as detailed as the mathematical model used in a separate analysis of the equipment.

When a coupled model is used additional concern, is that some of the stresses in the secondary system will be primary (inertia-induced) and some secondary (building static deformation–induced). Because the allowable stress limits in mechanical systems and components have different allowable stresses for primary and secondary stresses, it is important that a means be found to distinguish between these primary and secondary stress resultants. One such approach is to reanalyze the coupled model and set the secondary mass to near 0; the resulting stress in mechanical system or component should be secondary in nature. Another method is to record the maximum displacements in each mode and apply them to a model of the secondary systems, thereby determining the stress resultants in each mode. The model stresses, when combined on an SRSS basis, would yield the secondary stress component of the secondary system.

Systems and components (secondary) may be analyzed by combining the complete secondary model with the support structure (primary) model and applying the proper excitation to the base of the primary model. In this method, no separate equipment-decoupled support excitations need to be generated, as the equipment will be excited directly through the structure.

For equipment that is not analyzed as part of the building structural model, the response may be obtained by a separate analysis using floor-response spectra curves, time-history excitations at the point of the support(s), or other frequency- domain methods.

It should be noted that in dynamically coupled system, both stiffness and mass of both systems are represented, not just mass alone when generating primary-structure floor-response spectra applicable to the secondary system. Oftentimes significant coupling can result in higher loads in the primary system and lower loads in the secondary system than when they are analyzed considering no dynamic coupling. A secondary to primary effective mass ratio of as little as 0.1% can add the effect of 3% more damping [12].

However, the U.S. Nuclear Regulatory Commission (USNRC) has not permitted the use of the mass ratio effect in the generation of floor-response spectra, although it is included in the result of a coupled model analysis.

*2.4 Damping*

The phenomenon of energy loss called damping occurs because motions in a structural system will usually dissipate energy from the system. Damping as it relates to the equation of motion may be mathematically represented in many ways, including Coulomb and viscous damping [9] the latter being the one normally used in NPP design, as represented in equation (1). Total system or component damping is composed of many energy-absorption mechanisms-material damping, for instance, caused by internal friction with the material, as well as geometric damping (caused by the working of joints, connections, and associated small nonlinearities such as cracking in concrete) and impact damping (caused by gaps that open and close, thereby dissipating energy by local impact). Taken together, these various components of damping are structural damping as shown in Table 2.

Table 2-Structural percent critical modal damping

| ITEMS | DAMPING (% of critical damping) | | |
|---|---|---|---|
| | with stress levels<yield | | with stress levels ≥yield |
| | Old [Notes (1)–(2)] | New [Note (3)] | |
| (a) Structures: | | | |
| (1) Reinforced concrete structures: | 7.0 | 7.0 | 10.0 |
| (2) Welded steel structures: | 4.0 | 5.0 | 7.0 |
| (3) Bolted or riveted steel structures: | 7.0 | 7.0 | 10.0 |
| (4) Reinforced masonry walls: | 4.0 | 7.0 | 10.0 |
| (5) Unreinforced masonry walls: | — | 5.0 | 7.0 |
| (6) Steel structures with precast panels: | — | 7.0 | 7.0 |
| (b) Soil: For simplified soil-structure interaction analysis (SSI) radiation damping as a function of structural foundation geometry and material properties will not be limited but resultant composite modal damping should not exceed values in typical national standards (i.e., 15.0 percent). However, the use of higher values, if properly justified and determined, would be permitted. | | | |
| (c) Systems and Components: (except the following): | 3.0 | 5.0 | 5.0 |
| (1) Tank liquid sloshing: | 0.5 | 0.5 | 0.5 |
| (2) Cable Raceway: if at least one quarter full of loose cable | 7.0 | 10.0 | 15.0 |
| (3) HVAC Duct: | 7.0 | 7.0 | 7.0 |
| (4) Vertical pumps: (deep well and emersion) | 3.0 | 3.0 | 3.0 |
| (5) Instrument racks | 4.0 | 3.0 | 3.0 |

Notes: (1) Old damping values are based on the use of USNRC Regulatory Guide 1.61 (damping) and Regulatory Guide 1.60 (shaped spectra).
(2) Housner damping limited to 0.5% damping for piping.
(3) Based on the use of NUREG/CR-0098 shaped spectra.

In the (2007) version of Appendix N, a more compact table of damping values is presented, as illustrated in Table 3.

Two values for each component are listed. The smaller damping value is to be used for the OBE. A second, higher value is indicated for the SSE. This reflects the fact that a higher load in the SSE will result in higher deflections and some associated plastic deformation is permissible. Notably missing from Table 3 are any values associated with fluid sloshing. All of the existing codes and guidelines suggest a value of 0.5% for sloshing, whether for the OBE or the SSE.

Table 3 Appendix N damping values - % critical

| | Earthquake Magnitude | |
|---|---|---|
| Structure or Component | OBE | SSE |
| Equipment | 2 | 3 |
| Piping systems | 5 | 5 |
| Welded steel structures | 2 | 4 |
| Bolted steel structures | 4 | 7 |
| Prestressed concrete structures | 2 | 5 |
| Reinforced concrete structures | 4 | 7 |

## 3. NUMERICAL INVESTIGATION

In this section the FE Code used was ANSYS, Piping Module.

### *3.1 Problem Definition*

The reader is made aware that the model subjected to this investigation is not a real one and, for understandable reasons, it is a hypothetic one. On the other hand this is to demonstrate at the end of the investigation that a piping system which is behaving perfectly under static loads may show a very poor behavior being subjected to a seismic loading, scenario which in the real nuclear designing world is not acceptable.

Let's consider an insulated Nuclear Class 2 piping system, with 4 inch NPS for saturated steam, as in Fig.2:

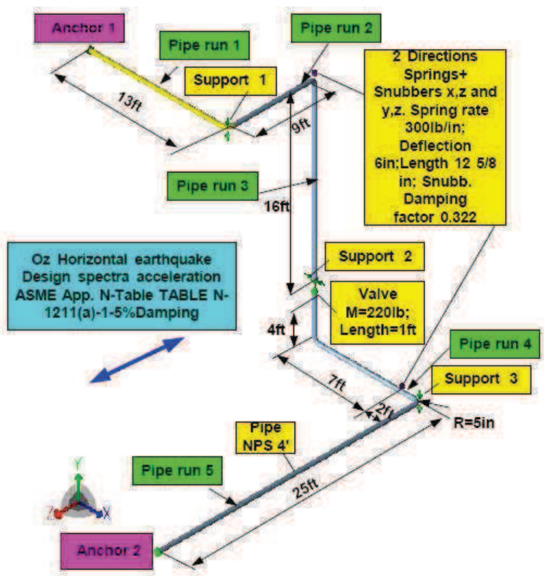



Figure 2 Piping System Model

Considering Oy as the vertical axis, the system is spanning between 2 anchors, containing 5 pipe runs, having 3 unidirectional supports (wrong design decision which will determine bad results for seismic behavior), 2 combined supports with snubber plus spring hangers acting in two directions and a valve with a 220 lb mass. The horizontal earthquake excitation component is acting on Oz axis.

The material and process data are:

Table 4 Materials and Process Data

| NPS | Sch(in) | T°C | P,Psig |
|---|---|---|---|
| 4 inch | 0.237 | 200(392F) | 100 |

| Material | Parameter | Value |
|---|---|---|
| Carbon Steel A106 Gr.B | Young Modulus E | 27.5 Mpsi |
| | Allowable stress $S_{al}$ | 14.4 Ksi |
| | Density $\rho_{Steel}$ | 0.283 lb/in$^3$ |
| | Thermal expansion coef. | 8e-6 |
| Insulation | Rock Wool Density $\rho_{Rock\ Wool}$ | 0.00343 lb/in$^3$ |
| Insulatiion Thickness | $t_{insul}$ | 2 in |
| Steam | Density $\rho_{Water}$ | 0.000268695 lb/in$^3$ |

### *3.2 Finite Elements Model*

The FE model was developed inside the Piping Module of ANSYS, with 197 elements and 214 nodes, the pipe runs and the valve were modeled using Pipe 16 element type, the elbows with Pipe 18 Element type and the Snubbers and Spring hangers with Combin 14.

The node numbering and locations are given below:

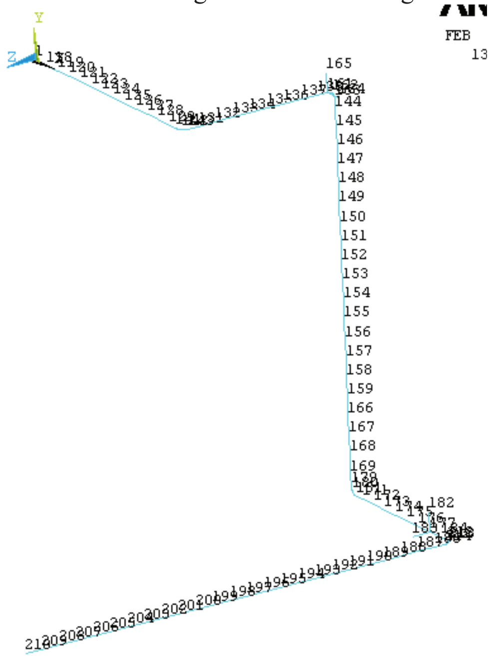



Figure 3 Nodes numbering

### *3.3 Static Analysis*

Firstly a static analysis was performed, the model being subjected only to the thermal expansion forces and the weight of the pipe/steam/insulation.

The displacements in inches are given in the figure:

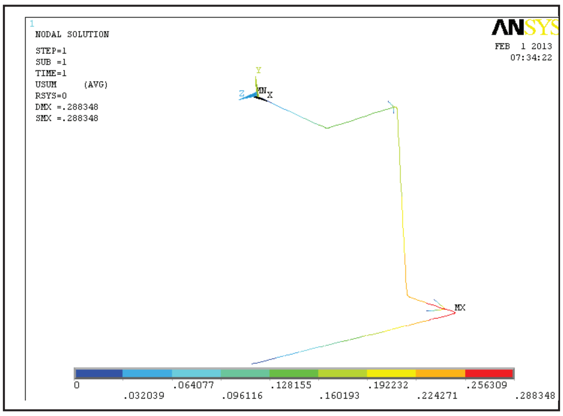



Figure 4 Displacements calculated for static analysis

It may be seen that the maximum displacements are calculated for the elbow between pipe runs 3 and 4 with a reasonable magnitude of 0.288in=7.31mm.

The reactions for the supports and anchors nodes are given below, the overall conclusion is that the system is not stressing the supports heavily.

```
PRINT REACTION SOLUTIONS PER NODE

  *****  POST1  TOTAL  REACTION  SOLUTION  LISTING
*****
LOAD STEP=      1  SUBSTEP=      1
   TIME=     1.0000        LOAD CASE=    0

  THE  FOLLOWING  X,Y,Z  SOLUTIONS  ARE  IN  GLOBAL
COORDINATES

    NODE       FX           FY           FZ
       1   13.249      -1.8774      -1.7769
       MX           MY           MZ
    -521.78      -827.12      -94.081
     NODE       FX           FY           FZ
     141                    -7.5617
     159    4.9823
     164   -5.4289      0.27150E-01-0.63081E-01
     165   0.28367E-01 -18.651      -0.21747
     182  -0.94653E-01  11.553       0.22798
     183  -0.60492      0.20780      75.087
     NODE       FX           FY           FZ
     210   -12.172     -0.21894E-01 -73.260
       MX           MY           MZ
    -1.8462       1772.5      -711.59
    NODE       FX           FY           FZ
     214                  16.397
```

Finally the Hoop pressure stress for code calculations and Moment stress at nodes I and J for code calculations were processed and are given below:

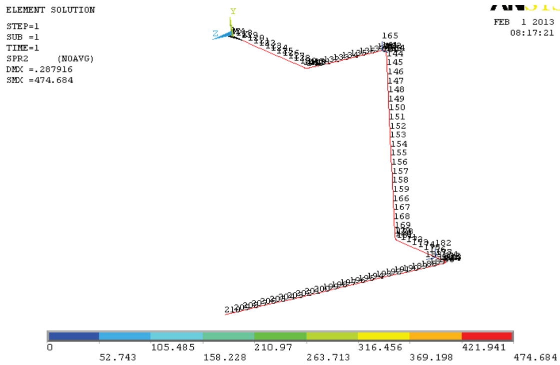



Figure 5a Hoop pressure stress

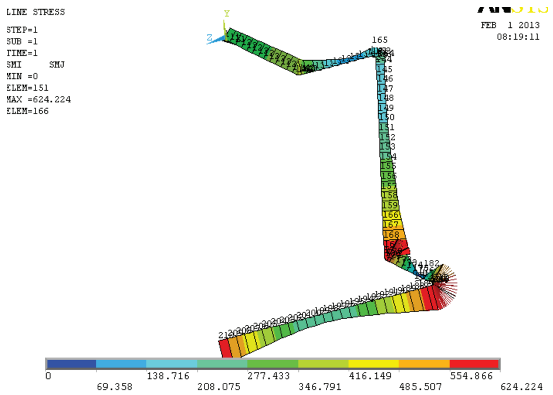



Figure 5b Moment stress at nodes I and J

The maximum Hoop pressure for code calculations are reaching a humble value of 474psi=3.28MPa, and the Moment stress 624psi=4.3MPa.

### *3.4 Modal Analysis*

The modal analysis of the system was targeting the calculation of the first 20 Mode shapes and eigen values. The mode extraction method employed was Subspace, the calculated natural frequencies are:

```
****  INDEX OF DATA SETS ON RESULTS FILE  *****
```

| SET | TIME/FREQ | LOAD STEP | SUBSTEP | CUMULATIVE |
|---|---|---|---|---|
| 1 | 0.12098 | 1 | 1 | 1 |
| 2 | 0.15504 | 1 | 1 | 2 |
| 3 | 0.20688 | 1 | 1 | 3 |
| 4 | 0.31067 | 1 | 1 | 4 |
| 5 | 0.40808 | 1 | 1 | 5 |
| 6 | 0.41819 | 1 | 1 | 6 |
| 7 | 0.59512 | 1 | 1 | 7 |
| 8 | 0.68124 | 1 | 1 | 8 |
| 9 | 1.1062 | 1 | 1 | 9 |
| 10 | 1.2692 | 1 | 1 | 10 |
| 11 | 1.3321 | 1 | 1 | 11 |
| 12 | 1.4623 | 1 | 1 | 12 |
| 13 | 1.5448 | 1 | 1 | 13 |
| 14 | 1.6776 | 1 | 1 | 14 |
| 15 | 2.1745 | 1 | 1 | 15 |
| 16 | 2.2625 | 1 | 1 | 16 |
| 17 | 2.4909 | 1 | 1 | 17 |
| 18 | 2.5451 | 1 | 1 | 18 |
| 19 | 2.6489 | 1 | 1 | 19 |
| 20 | 2.8418 | 1 | 1 | 20 |

It is a fact already that the first natural frequency is 0.12098 Hz and it is by now a very bad news for the designer; the system will become resonant for a very low value of the excitation.

For exemplification, the Mode 1 and Mode 20 are given in the following figures:

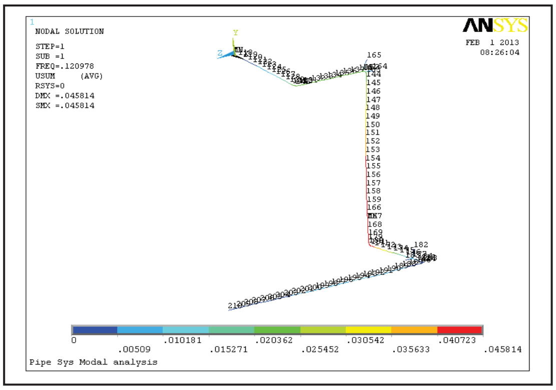



Figure 6 Mode 1

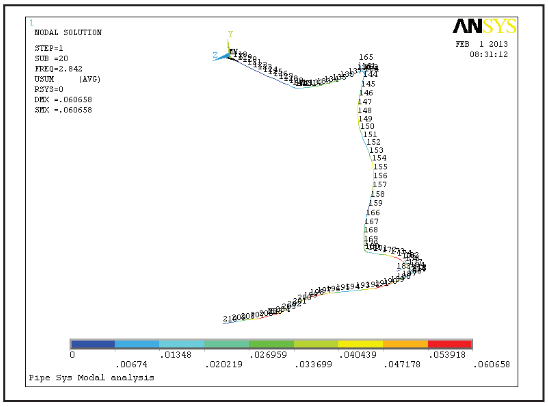



Figure 6 Mode 20

### 3.5 *Seismic Response Analysis*

Based on the Modal analysis the model advanced to calculate the Seismic response. The horizontal design response spectra relative values of spectrum amplification factors for control points used is given below:

| Frequency Hz | 0.1 | 2.5 | 9 | 33 |
|---|---|---|---|---|
| Acceleration in/s$^2$ | 19.3 | 1208.86 | 1008 | 386.22 |
| Percent of Critical Damping=5% - TABLE N-1230-1 | | | | |

Table 5 Values of spectrum amplification factors

The sum of the displacements calculated for the excitation above is shown in the figure 7:

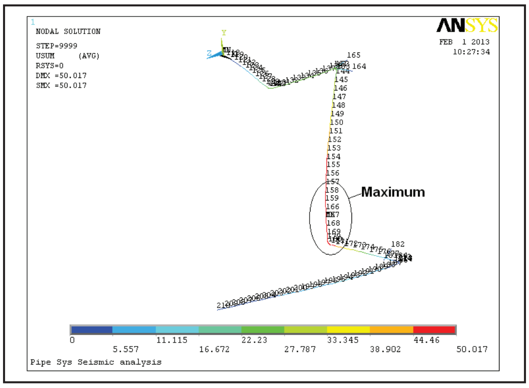



Figure 7 Sum of displacements

The maximum displacement is calculated for the Pipe run 3 in the region of the Valve location, as somehow has expected. What was not too much expected, it is its value of 50in=1270mm of the displacement under seismic loading, which in terms of structural engineering is a catastrophic situation.

The reactions forces for supports are given below:

```
*****  POST1  TOTAL  REACTION  SOLUTION  LISTING
*****

 CALCULATED LOAD CASE=      0

 THE FOLLOWING X,Y,Z SOLUTIONS ARE IN GLOBAL
COORDINATES

    NODE       FX          FY          FZ
       1    745.58      74.528      7232.1
               MX          MY          MZ
            36242.   0.76846E+06   3730.3
     NODE      FX          FY          FZ
    141                 1726.3
    159     2429.8
    164     988.08      0.0000      0.0000
    165     0.0000      1996.7      0.0000
    182     0.0000      535.80      0.0000
    183     0.0000      0.0000      2786.4
    210     3668.5      142.77      6122.4
               MX          MY          MZ
            13545.   0.35304E+06  37778.
    NODE       FX          FY          FZ
    214                 1431.6
```

Nodes 1 and 210 correspond to the Anchors which are experimenting staggering loading moments My=76.846E+04=868, 243 Nm which is far beyond any known material to tackle.

In order to have an idea upon the loads acting on the Pipe Runs 3 and 4 (Nodes 138…188) which are showed the biggest values, the below table is provided:

Table 6 Loads acting Pipe Runs 3 and 4

**Nodes 138-188**

```
RINT SUMMED NODAL LOADS

 ***** POST1 SUMMED TOTAL NODAL LOADS LISTING *****

 CALCULATED LOAD CASE=      0

 THE FOLLOWING X,Y,Z SOLUTIONS ARE IN GLOBAL COORDINATES
```

| NODE | FX | FY | FZ | MX | MY | MZ |
|---|---|---|---|---|---|---|
| 137 | 1774.4 | 3522.3 | 10212. | 0.35573E+06 | 0.50347E+06 | 1684.7 |
| 138 | 1822.1 | 3590.7 | 9899.7 | 0.39844E+06 | 0.48183E+06 | 1684.6 |
| 141 | 1491.0 | 1726.3 | 12755. | 72469. | 0.57484E+06 | 14850. |
| 142 | 1491.6 | 3307.0 | 12622. | 77311. | 0.61743E+06 | 3158.1 |
| 143 | 1494.6 | 3307.9 | 12486. | 89003. | 0.63055E+06 | 1685.0 |
| 144 | 61.556 | 203.70 | 9173.4 | 0.30915E+06 | 0.46943E+06 | 2762.3 |
| 145 | 26.195 | 109.60 | 8822.0 | 0.20071E+06 | 0.46943E+06 | 3318.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 146 | 17.801 | 52.523 | 8403.9 | 97241. | 0.46942E+06 | 3399.6 |
| 147 | 44.999 | 100.50 | 7955.8 | 1037.4 | 0.46941E+06 | 3053.5 |
| 148 | 76.370 | 205.54 | 7477.6 | 93758. | 0.46940E+06 | 2314.0 |
| 149 | 104.91 | 310.59 | 6969.5 | 0.18056E+06 | 0.46939E+06 | 1215.0 |
| 150 | 130.60 | 415.63 | 6432.3 | 0.26109E+06 | 0.46938E+06 | 209.43 |
| 151 | 153.44 | 520.67 | 5867.0 | 0.33499E+06 | 0.46937E+06 | 1925.0 |
| 152 | 173.44 | 625.72 | 5275.3 | 0.40195E+06 | 0.46935E+06 | 3897.7 |
| 153 | 190.62 | 730.76 | 4659.0 | 0.46165E+06 | 0.46933E+06 | 6093.3 |
| 154 | 205.00 | 835.80 | 4020.3 | 0.51381E+06 | 0.46932E+06 | 8478.1 |
| 155 | 216.61 | 940.85 | 3362.0 | 0.55817E+06 | 0.46930E+06 | 11019. |
| 156 | 225.52 | 1045.9 | 2686.7 | 0.59453E+06 | 0.46928E+06 | 13682. |
| 157 | 231.78 | 1150.9 | 1997.4 | 0.62268E+06 | 0.46926E+06 | 16436. |

***** POST1 SUMMED TOTAL NODAL LOADS LISTING *****

CALCULATED LOAD CASE= 0

THE FOLLOWING X,Y,Z SOLUTIONS ARE IN GLOBAL COORDINATES

| NODE | FX | FY | FZ | MX | MY | MZ |
|---|---|---|---|---|---|---|
| 158 | 235.47 | 1256.0 | 1297.3 | 0.64249E+06 | 0.46924E+06 | 19250. |
| 159 | 2666.5 | 1800.5 | 3333.3 | 0.65979E+06 | 0.46911E+06 | 22103. |
| 161 | 1965.2 | 3971.9 | 9682.3 | 0.42384E+06 | 0.46891E+06 | 1684.6 |
| 162 | 104.41 | 309.81 | 9545.4 | 0.40864E+06 | 0.46929E+06 | 1848.3 |
| 163 | 87.389 | 269.19 | 9405.5 | 0.37460E+06 | 0.46944E+06 | 2198.5 |
| 164 | 988.08 | | | | | |
| 165 | | 1996.7 | | | | |
| 166 | 5088.3 | 2784.5 | 9061.8 | 0.59114E+06 | 0.46889E+06 | 83261. |
| 167 | 5078.1 | 3329.0 | 12759. | 0.43635E+06 | 0.46876E+06 | 0.14422E+06 |
| 168 | 5073.2 | 3434.0 | 13474. | 0.27895E+06 | 0.46873E+06 | 0.20513E+06 |
| 169 | 5068.2 | 3528.1 | 14112. | 0.11275E+06 | 0.46871E+06 | 0.26597E+06 |
| 171 | 5059.1 | 3736.2 | 15491. | 62400. | 0.28796E+06 | 0.28272E+06 |
| 172 | 5055.8 | 3818.3 | 16005. | 62401. | 99292. | 0.23745E+06 |
| 173 | 5052.2 | 3900.8 | 16504. | 62403. | 96100. | 0.19109E+06 |
| 174 | 5048.6 | 3971.8 | 16919. | 62405. | 0.29697E+06 | 0.14381E+06 |
| 175 | 5044.9 | 4030.5 | 17251. | 62406. | 0.50232E+06 | 95740. |
| 176 | 5041.3 | 4076.3 | 17501. | 62407. | 0.71115E+06 | 47046. |
| 177 | 5037.7 | 4108.9 | 17674. | 62408. | 0.92250E+06 | 2118.3 |
| 179 | 5064.8 | 3593.6 | 14555. | 11638. | 0.46869E+06 | 0.30143E+06 |
| 180 | 5062.8 | 3634.6 | 14831. | 40512. | 0.44714E+06 | 0.31404E+06 |
| 181 | 5061.3 | 3674.9 | 15096. | 62399. | 0.39441E+06 | 0.30856E+06 |
| 182 | | 535.80 | | | | |
| 183 | | | 2786.4 | | | |
| 184 | 5034.4 | 3055.7 | 12197. | 62409. | 0.10686E+07 | 38735. |
| 186 | 5059.1 | 201.63 | 12241. | 45681. | 0.11550E+07 | 75500. |
| 187 | 5112.0 | 203.17 | 12242. | 43257. | 0.10941E+07 | 75504. |
| 188 | 5197.5 | 205.96 | 12242. | 40807. | 0.10324E+07 | 75508. |

## 4. CONCLUSIONS

The presented computational model was prepared for the evaluation of piping according to the ASME BVPC Subsection NC (piping systems of the other nuclear facilities) pro Service Levels C, D (normal operation loads + seismic loads) using a general FE Code.

The computed model showed good results and behaviour as far as the static loads are concerned but failed to pass the Seismic response analysis. Re-designing the supports-hangers-snubbers system now is a must for the proposed piping model in order to become compliant to the construction code.

## 5. REFERENCES


[1] ASCE Standard 4-98, *Seismic Analysis of Safety-Related Nuclear Structures and Commentary on Standard for Seismic Analysis of Safety-Related Nuclear Structures*; The American Society of Civil Engineers.

[2] ANS Standard 58.2, *Design Basis for Protection of Light-Water Nuclear Power Plants Against the Effects of Postulated Pipe Rupture*; The American Nuclear Society.

[3] ANS Standard 58.3, *Physical Protection for Nuclear Safety-Related Systems and Components—Appendix B;* The American Nuclear Society.

[4] Ansys Mechanical, Ansys, Inc., Canonsburg, PA, USA, www.ansys.com.

[5] API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, Eleventh Edition, 2008, API, Washington, DC, www.api.org.

[6] ASME Boiler and Pressure Vessel Code Section III, Division 1, Nonmandotary, Appendix N, *Dynamic Analysis Methods*; The American Society of Mechanical Engineers.

[7] ASME B31.1, Appendix II, *Non-Mandatory Rules of the Design of Safety Valve Installation;* The American Society of Mechanical Engineers.

[8] ASME O&M Standard, *Requirements for Preoperational and Initial Start-Up Vibration Testing of Nuclear Power Plant Piping*

[9] CHOPRA, A.K., *Dynamics of Structures*, Prentice Hall, Englewood Hills, H.J., 2001.

[10] Fluent, Ansys, Inc., Lebanon, NH, USA, www.fluent.com.

[11] International Building Code, International Code Council, Inc., 2006.

[12] NEWMARK, N. M., and HALL, W. J., *Development of Criteria for Seismic Review of Selected Nuclear Power Plants*, NUREG/CR-0098, The U.S. Nuclear Regulatory Commission, May 1978.

[13] NeiNastran, Noran Engineering, Inc., Westminster, CA, USA, www.nenastran.com.

[14] PLATYRRACHOS, M.A., and KARAMANOS, S.A., *Finite Element Analysis of Sloshing in Horizontal-Cylindrical Industrial vessels Under Earthquake Loading*, PVP2005-71499, ASME 2005.

[15] Regulatory Guide 1.61, *Damping Values for Seismic Design of Nuclear Power Plants*, Rev. 1, U.S. Nuclear Regulatory Guide, Oct.1973.

[16] SEI/ASCE Standard 7-02, *Minimum Design Loads for Buildings and other Structures*, The American Society of Civil Engineers, Reston, Virginia, USA, www.asce.org.

[17] XU, J., and DEGRASSI, G., *Program for the Evaluation of Methods to Analyze Non-classically Damped Coupled Systems,* Ed., Benchmark NUREG/CR-6661, USNRC, 2000.

# DOES THE "AVERAGED RESPONSE" OF A CHAOTIC SYSTEM EXHIBIT NEAR-PERIODICITY?

DELEANU DUMITRU

*Constanta Maritime University. Romania*

**ABSTRACT**

Chaotic motion of a harmonically excited square prism modelled as a Duffing oscillator and kept in fluid flow is considered. The fluid dynamic forces contribute additional non-linear terms to the inherent non-linearity of the system. As the flow velocity is increased, the nature of motion is changed from a periodic motion to a chaotic one. This paper wants to demonstrate the periodicities embedded in the averaged responses of this chaotic system. By discretizing the initial conditions on a chosen domain and averaging the corresponding responses, on finds that the averaged response exhibit near-periodicities with primary frequency components at excitation frequency, multiples or half multiples of excitation frequency. Numerical simulations confirm those results.

**Keywords:** *Chaotic and periodic motion, Duffing oscillator, averaged response*

## 1. INTRODUCTION

In flow-induced vibration problems such as aero-elastic flutter, vortex induced and galloping oscillations, vibrations due to fluid-elastic instability, the fluid dynamic forces inducing the vibrations are almost invariably non-conservative and non-linear functions of the structural motion, leading to a complex and wide variety of dynamical behavior characteristic of coupled fluid-structure interaction problems. In many cases they represent self-excited oscillating systems and exhibit such phenomena as frequency entrainment, hysteretic, multiple steady state motions and jump phenomena characteristic of non-linear systems. If the structure is inherently non-linear and also excited by external forces, the dynamics becomes still more complex and chaotic vibrations should naturally occur in such systems.

Parkinson and Smith proposed a model to describe the flow induced force of a bluff body with square cross-section. The flow induced force is expressed as a polynomial with odd powered terms of the ratio of the response velocity to the flow velocity [1]. Dowell described how the flow induced forces can be modeled for different geometries of bluff bodies [2].

Narayanan and Jayaraman investigated the response of a harmonically excited square prism modeled as a Duffing oscillator and subjected to flow induced excitation. By numerical integration studies it has been observed that for a certain combination of system parameters it undergoes a symmetry-breaking bifurcation resulting in dual solutions followed by a series of period-doubling bifurcations, leading to chaos when the flow velocity is increased [3].

Simiu and Cook have also considered the chaotic motions of a harmonically excited square prism kept in fluid flow. Both single-degree-of-freedom and two-degree-of-freedom oscillators were considered in their study. The seventh-order polynomial given by Parkinson and Smith was used to modal the fluid dynamic force on the prism. They have shown that the chaotic motion occurs through a quasi-periodic route [4].

Lu demonstrated that although the response of an impact oscillator, a chaotic system at same parameter ranges, does not exhibit periodicity in Euclideean space, it does show periodicity in Hausdorff space [5].

In order to explore the further possibility of periodicity embedded in chaotic motions, this paper succeeded in validating the periodicities of "averaged responses" which are obtained by averaging the responses over a pre-chosen domain in phase space.

## 2. MODEL PRESENTATION

Consider a square prism supported by a non-linear spring with a linear viscous damper (as shown in Figure 1). The prism is assumed to be excited harmonically and kept in a steady fluid flow. The equation of motion of the square prism is

$$m\ddot{y}+c\dot{y}+k_l\,y+k_n\,y^3=F\cos\omega t+F_L \tag{1}$$

where $y$ is the displacement, $m$ is the mass of the prism, $c$ is the linear viscous damping coefficient, $k_l$ and $k_n$ are, respectively, the coefficients of linear and cubic stiffness, $F$ and $\omega$ are, respectively, the amplitude and the frequency of the harmonic force, $t$ is the time and $F_L$ is the flow induced force given by

$$F_L=\frac{1}{2}\rho DLV^2\left[A_1\cdot\frac{\dot{y}}{V}+A_3\cdot\left(\frac{\dot{y}}{V}\right)^3\right] \tag{2}$$

in which $\rho$ is the flow density, $D$ is the length of the side of the square, $L$ the length of the prism and $V$ the velocity of the fluid.

Upon introducing the non-dimensional parameters

$$\begin{gathered} x=\frac{y}{L},U=\frac{V}{\omega L},\tau=\omega t,F_0=\frac{F}{m\omega^2L},\xi=\frac{c}{m\omega},\\ \omega_0=\sqrt{\frac{k_l}{m}},\gamma_l=\frac{k_l}{m\omega^2},\gamma_n=\frac{k_nL^2}{m\omega^2},\beta=\frac{\rho DL^2}{m},\\ \xi_1=-\frac{\beta A_1U}{2},\xi_3=-\frac{\beta A_3}{2U},\xi_0=\xi+\xi_1 \end{gathered} \tag{3}$$

equation (1) becomes

$$x'' + \xi_0 x' + \xi_3 (x')^3 + \gamma_l x + \gamma_n x^3 = F_0 \cos\tau \qquad (4)$$

The number of primes denotes the order of differentiation with respect to the non-dimensional time.

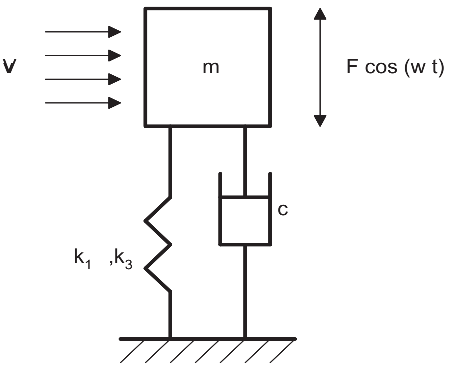



Figure1: The model of a square prism in a cross-flow

## 3. NUMERICAL SIMULATION

Equation (4), which includes the effect of fluid flow, has been numerically integrated for different flow velocities. The selected parameters were

$$\begin{aligned} &\xi = 0.1,\ \gamma_l = 1,\ \gamma_n = 1,\ F_0 = 10,\ \rho = 1.2256, \\ &D = 0.1,\ L = 1,\ A_1 = 2.7,\ A_3 = -31.0 \end{aligned} \qquad (5)$$

It was constructed a calculus program in MATLAB who permitted us to obtain the phase plane and the time histories. The non-dimensional flow velocity $U$ was taken as the bifurcation parameter and varied from 0 to 30. As the flow velocity is gradually increased different types of periodic motion of the prism are obtained. For $0 < U < 6.4$ one obtains a period motion with frequency equal to unity. At $U = 6.4$ the motion bifurcates into a frequency 2 motion. For further increase in flow velocities frequency 4, 8 and 16 responses are obtained. When the flow velocity in increased to $U = 9.5$ the response becomes chaotic. The time history, phase plane and frequency spectrum for six different values of $U$ are given in Figure 2.

Numerical simulations are next performed to obtain the "averaged responses". To achieve this goal we choose again the value $U = 10$ and initial conditions $x(0) = x'(0) = 2$, when the motion is obviously chaotic (see Figure 3). The upper line in Figure 3 gives us the time history, phase plane and frequency spectrum for this case.

The rectangular domain $(x, x') \in [-2,2] \times [-2,2]$ was discretized into $N^2$ square area by means of parallel lines to the coordinate axis. In the middle of each little square was taken the grid point. His coordinates are:

$$x_k = y_k = -2 + \frac{2(2k-1)}{N},\ k = \overline{1, N} \qquad (6)$$

These grid points are chosen as initial conditions. The averaged response is obtained by averaging the $N^2$ set of corresponding simulated time responses. To save memory we observe that if $m_k$ is the arithmetic mean of number $x_1, x_2, ..., x_k$, then the arithmetic mean $m_{k+1}$ of sequence $x_1, x_2, ..., x_k, x_{k+1}$ is $m_{k+1} = \frac{k \cdot m_k + x_{k+1}}{k+1}$.

The lower line in Figure 3 shows us the averaged response and the frequency spectra for $N = 10$ $(N^2 = 100)$. It can be seen from these two figures that the response is very close to a periodic response, with some noise in the frequency spectra due to smaller number of discretized initial conditions. If $N$ is increased, the response is much closer that of a perfect periodic response.

If the numerical study is repeated for other values of parameters $\xi_0, \xi_3, \gamma_l, \gamma_n, F_0$, the conclusion remains the same.

## 4. CONCLUSIONS

Using the results obtained by averaging $N^2$ responses for different initial conditions (which represents grid points into a discretized square area) it is concluded that the "averaged responses" of chaotic Duffing's equation, which model the motion of a square prism in a fluid flow, exhibit strong near-periodicity with fundamental frequency the same those of the excitation. The near-periodicity approaches a perfect periodicity if the $N$ is increased.

## 5. REFERENCES

[1] DOWELL, E.H., *Flutter of a buckled plate as an example of chaotic motion of a deterministic autonomous system,* Journal of Sound and Vibration, 85, pp. 333-334, 1982.

[2] JAYARAMAN, K., NARAYAMAN, S., *Periodic and chaotic oscillations of a harmonically excited square prism in fluid flow*, Proceedings of the National Seminar on Aerospace Structures, India, pp. 181-191, 1990.

[3] LU, L.Y., 2001, *The periodicity of chaotic impact oscillators in Hausdorff phase spaces*, Journal of Sound and Vibration, 235, pp. 105-116, 2001.

[4] PARKINSON, G.V., SMITH, J.D., *The square prism as an aero-elastic non-linear oscillator*, Quarterly Journal of Mechanics and Applied Mathematics, 17, pp. 224-239, 1964.

[5] SIMIU, E., COOK, G.R., 1991, *Chaotic motions of self excited forced and autonomous square prism,* Proceedings of the American Society of Civil Engineers, 117, pp. 241-259, 1991.

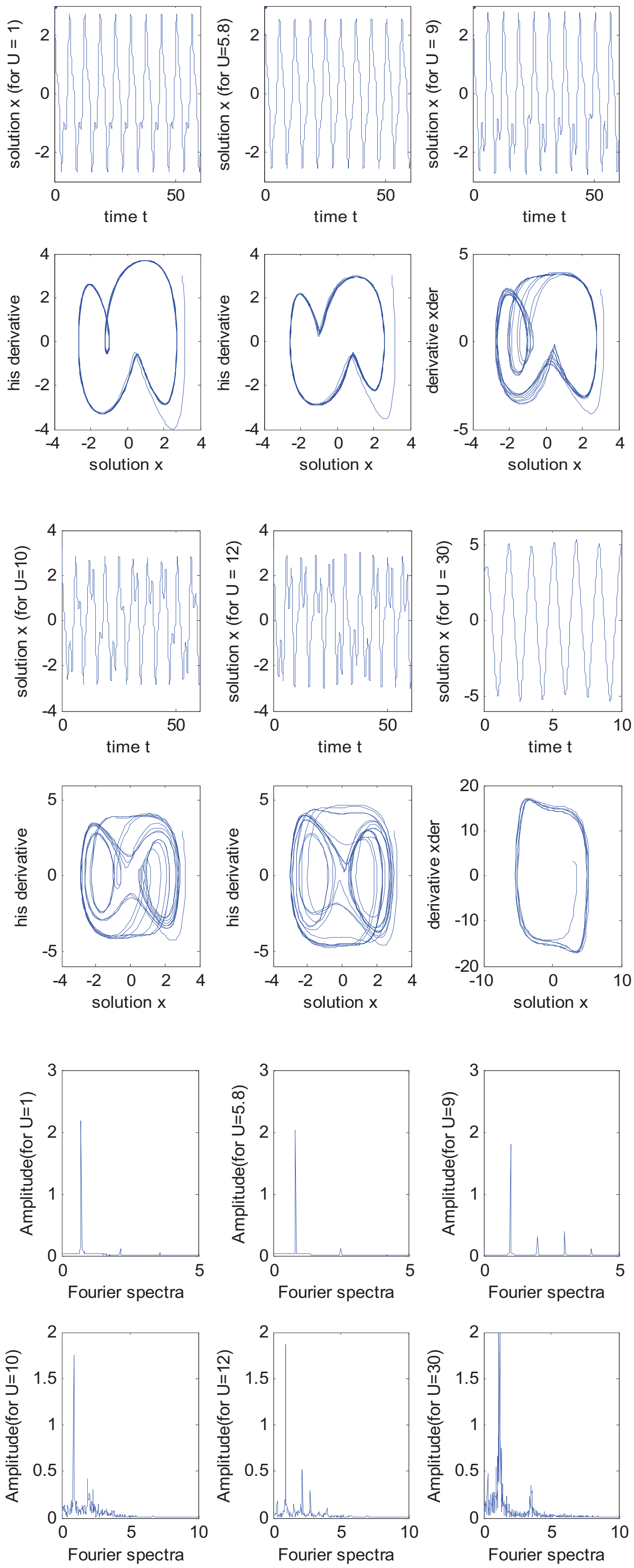



Figure 2: Time histories, phase planes and the frequency spectra for six values of U

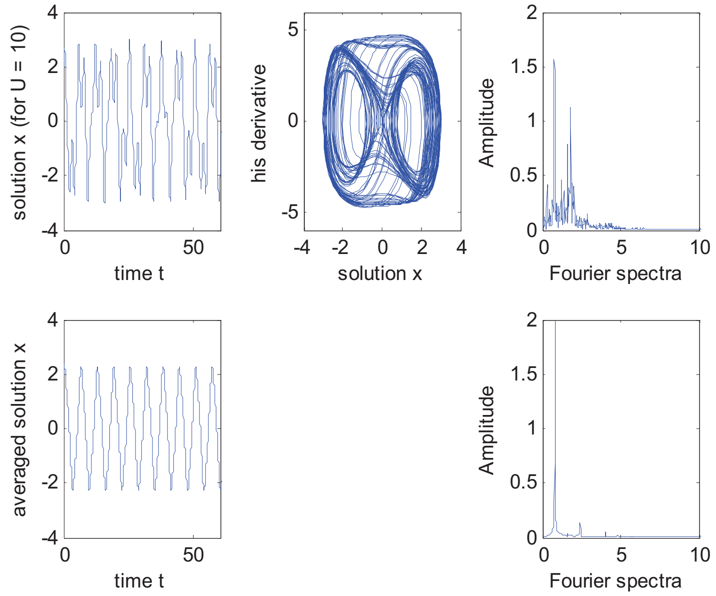



Figure 3: Averaged response and frequency spectra for averaged response in case $U = 10$

# CHAOS SYNCHRONIZATION OF SPROTT K AND ACT SYSTEMS USING BACKSTEPPING DESIGN

[1]DELEANU DUMITRU, [2]PANITESCU VIOREL

[1,2]*Constanta Maritime University, Romania*

**ABSTRACT**

This paper examines the synchronization performance of a widely used chaos synchronization scheme, called the back-stepping method. It consists in a recursive procedure that interlaces the choice of a Lyapunov function with the control. Because it needs only one controller to realize synchronization it is very attainable in engineering applications. In the paper, we have applied back-stepping design for the global chaos synchronization of two identical Sprott K systems and two identical Act systems. Numerical simulations are shown to validate and demonstrate the effectiveness of the scheme.

**Keywords:** *Back-stepping design, chaos, synchronization, Sprott K system, Act system*

## 1. INTRODUCTION

In the last two decades, chaos synchronization has become a popular research topic arousing interests of physical scientists. A variety of applications in secure communications, robotics, physics, ecology, economy and cardiology have been suggested [1-6].

The idea of synchronizing chaotic systems refers to a process where in two or many chaotic systems starting from different initial conditions adjust a given property of their motion to a common behaviour.

Today, there exist a large number of approaches for chaos synchronization, including Pecora-Carroll method, active and adaptive control methods, sampled-data feedback method, time-delay feedback method and back-stepping design method [7-15]. In most of these schemes, the drive-response (or master-slave) formalism is used. If a particular chaotic system is called the drive system and another chaotic system is called the response system, then the idea of the synchronization is to use the output of the drive system to control the response system so that its output tracks the output of the drive system asymptotically.

In this paper, we derive new results based on the back-stepping design for the chaos synchronization of two identical Sprott K systems and two identical Act systems. The method consists in a recursive procedure that links the choice of a Lyapunov function with the design of a controller. It has been successfully used to track chaotic systems like Lorentz system, Chua's circuit, Duffing system and Genesio system [16-18].

The rest of the paper is organized as follows: In Section 2 back-stepping design for chaos synchronization is presented. Numerical simulations are carried out in Section 3 to demonstrate the efficiency of the proposed method. Finally, the paper is concluded in Section 4.

## 2. DESIGN OF BACK-STEPPING CONTROL FOR CHAOS SYNCHRONIZATION

In this section, Sprott K system and Act system are discussed for synchronizing by back-stepping design.

### *2.1. Sprott K system*

Consider the drive-response Sprott K systems given below:

$$\begin{aligned} \dot{x}_1 &= x_1 y_1 - \alpha z_1 \\ \dot{y}_1 &= x_1 - \beta y_1 \\ \dot{z}_1 &= x_1 + \gamma z_1 \end{aligned} \tag{1}$$

and

$$\begin{aligned} \dot{x}_2 &= x_2 y_2 - \alpha z_2 \\ \dot{y}_2 &= x_2 - \beta y_2 \\ \dot{z}_2 &= x_2 + \gamma z_2 + u \end{aligned} \tag{2}$$

where $\mathbf{x}_d = (x_1, y_1, z_1)$ and $\mathbf{x}_r = (x_2, y_2, z_2)$ are the state vectors, $\alpha, \beta$ and $\gamma$ are positive, constant parameters of the system and $u$ is a control function to be determined. Observe that in back-stepping design only one controller is required. Defining the error states

$$e_x = x_2 - x_1,\ e_y = y_2 - y_1,\ e_z = z_2 - z_1 \tag{3}$$

and subtracting eq. (1) from eq. (2), we get the error dynamics given by

$$\begin{aligned} \dot{e}_x &= -\alpha e_y + e_x e_y + e_x y_1 + e_y x_1 \\ \dot{e}_y &= e_x - \beta e_y \\ \dot{e}_z &= e_x + \gamma e_z + u \end{aligned} \tag{4}$$

In the following, our objective is to find a control law such that system (4) is stabilized at the origin. To do that, we begin with the stability of the 1-D system

$$\dot{e}_y = e_x - \beta e_y \tag{5}$$

where $e_x$ is viewed as a virtual controller. Define the Lyapunov function

$$V_1(e_y) = \frac{1}{2}e_y^2 \tag{6}$$

and compute its derivative

$$\dot{V}_1(e_y) = e_y \dot{e}_y = -\beta e_y^2 + e_x e_y \tag{7}$$

A proper choice of an estimate stabilizing function $A_1(e_y)$ for the $e_x$ will make the system (5) asymptotically stable to the origin. That is $e_x = A_1(e_y) = 0$. Because $A_1(e_y)$ is only an estimate function for $e_x$ considered as controller, we may define the error variable

$$w_2 = e_x - A_1(e_y) = e_x \tag{8}$$

In the next step, we consider the 2-D system

$$\begin{aligned} \dot{e}_y &= w_2 - \beta e_y \\ \dot{w}_2 &= -\alpha e_z + e_y w_2 + w_2 y_1 + e_y x_1 \end{aligned} \tag{9}$$

with $e_z$ regarded as a virtual controller. When $e_z = A_2(e_y, w_2)$, with $A_2$ to be determined, the system (9) will be asymptotically stable to the origin (0, 0).

Consider the Lyapunov function

$$V_2(e_y, w_2) = \frac{1}{2}e_y^2 + \frac{1}{2}w_2^2 \tag{10}$$

Its derivative along the solutions of (9) is

$$\dot{V}_2(e_y, w_2) = e_y \dot{e}_y + w_2 \dot{w}_2 = -\beta e_y^2 < 0 \tag{11}$$

if

$$e_z = A_2(e_y, w_2) = \frac{1}{\alpha}\left[e_y(1 + w_2 + x_1) + w_2 y_1\right] \tag{12}$$

In the last step, we define the error variable

$$w_3 = e_z - A_2(e_y, w_2) \tag{13}$$

and analyze the full 3-D system

$$\begin{aligned} \dot{e}_y &= w_2 - \beta e_y \\ \dot{w}_2 &= -\alpha w_3 - e_y \\ \dot{w}_3 &= -\dot{A}_2 + w_2 + \gamma(w_3 + A_2) + u \end{aligned} \tag{14}$$

where

$$\dot{A}_2 = \frac{1}{\alpha}\left[(1 + e_x + e_y + x_1)\dot{x}_1 + (e_y + y_1)\dot{e}_x + e_x \dot{y}_1\right] \tag{15}$$

Choose the Lyapunov function

$$V_3(e_y, w_2, w_3) = \frac{1}{2}e_y^2 + \frac{1}{2}w_2^2 + \frac{1}{2}w_3^2 \tag{16}$$

Its derivative is

$$\dot{V}_3(e_y, w_2, w_3) = e_y \dot{e}_y + w_2 \dot{w}_2 + w_3 \dot{w}_3 = -\beta e_y^2 < 0 \tag{17}$$

if the control function u is selected as

$$u = (\alpha - 1)w_2 - \gamma w_3 - \gamma A_2 + \dot{A}_2 \tag{18}$$

Substituting (18) in (4), the error dynamics is obtained as

$$\begin{aligned} \dot{e}_x &= -\alpha e_y + e_x e_y + e_x y_1 + e_y x_1 \\ \dot{e}_y &= e_x - \beta e_y \\ \dot{e}_z &= \alpha e_x + \dot{A}_2 \end{aligned} \tag{19}$$

It will converge to zero as $t \to \infty$, so the synchronization of the drive-response systems is achieved.

### 2.2. Act system

As the second example we get the Act attractor, whose dynamics is described by a set of three first-order differential equations containing quadratic and cubic nonlinearities. We define the drive and response systems as follows

$$\begin{aligned} \dot{x}_1 &= \alpha(x_1 - y_1) \\ \dot{y}_1 &= -4\alpha y_1 + x_1 z_1 + \gamma x_1^3 \\ \dot{z}_1 &= -\alpha\delta z_1 + x_1 y_1 + \beta z_1^2 \end{aligned} \tag{20}$$

$$\begin{aligned} \dot{x}_2 &= \alpha(x_2 - y_2) \\ \dot{y}_2 &= -4\alpha y_2 + x_2 z_2 + \gamma x_2^3 \\ \dot{z}_2 &= -\alpha\delta z_2 + x_2 y_2 + \beta z_2^2 + u \end{aligned} \tag{21}$$

where $\alpha, \beta, \delta$ and $\gamma$ are positive, constant parameters of the system. The error dynamics is obtained as

$$\begin{aligned} \dot{e}_x &= \alpha(e_x - e_y) \\ \dot{e}_y &= -4\alpha e_y + e_x z_1 + e_z x_1 + \gamma(e_x^3 + 3e_x^2 x_1 + 3e_x x_1^2) \\ \dot{e}_z &= -\alpha\delta e_z + e_x(e_y + y_1) + e_y x_1 + \beta e_z(e_z + 2z_1) \\ &+ u \end{aligned}$$

(22

Consider first the stability of 1-D system

$$\dot{e}_x = \alpha(e_x - e_y) \tag{23}$$

where $e_y$ is regarded as a virtual control. The associated Lyapunov function and its derivative are

$$V_1(e_x)=\frac{1}{2}e_x^2\ ,\ \dot V_1(e_x)=e_x\dot e_x=\alpha e_x(e_x-e_y) \tag{24}$$

$\dot V_1(e_y)$ is negative definite if we choose an estimate stabilization function as follows

$$e_y=A_1(e_x)=2e_x \tag{25}$$

Let now the error variable

$$w_2=e_y-A_1(e_x)=e_y-2e_x \tag{26}$$

and study the 2-D system

$$\begin{aligned}
&\dot e_x=-\alpha(w_2+e_x)\\
&\dot w_2=-2\alpha w_2+e_x(e_z+z_1-6\alpha)+e_z x_1+\\
&\quad+\gamma e_x\left(e_x^2+3e_x x_1+3x_1^2\right)
\end{aligned} \tag{27}$$

In (27), $e_z$ is viewed as a controller. The Lyapunov function for (27) is of the form

$$V_2(e_x,w_2)=\frac{1}{2}e_x^2+\frac{1}{2}w_2^2 \tag{28}$$

Its derivative

$$\begin{aligned}
&\dot V_2(e_x,w_2)=e_x\dot e_x+w_2\dot w_2=-2\alpha w_2^2-\alpha e_x^2+\\
&+w_2\left[e_x(e_z+z_1-7\alpha)+e_z x_1+\gamma e_x\left(e_x^2+3e_x x_1+3x_1^2\right)\right]
\end{aligned}$$

is negative definite if consider the estimate function

$$e_z=A_2(e_x,w_2)=\frac{e_x\left[7\alpha-z_1-\gamma\left(e_x^2+3e_x x_1+3x_1^2\right)\right]}{e_x+x_1} \tag{29}$$

In the last stage, we define the error variable

$$w_3=e_z-A_2(e_x,w_2) \tag{30}$$

and study the 3-D system

$$\begin{aligned}
&\dot e_x=-\alpha(w_2+e_x)\\
&\dot w_2=-2\alpha w_2+\alpha e_x+w_3(e_x+w_1)\\
&\dot w_3=-\alpha\delta(w_3+A_2)+e_x(w_2+2e_x+y_1)-\dot A_2\\
&+(w_2+2e_x)x_1+\beta(w_3+A_2)(w_3+A_2+2z_1)+u
\end{aligned} \tag{31}$$

Choose the Lyapunov function

$$V_3(e_x,w_2,w_3)=\frac{1}{2}e_x^2+\frac{1}{2}w_2^2+\frac{1}{2}w_3^2 \tag{32}$$

and compute its derivative. If the control function takes the form

$$\begin{aligned}
&u=\dot A_2-\beta(w_3+A_2)(w_3+A_2+2z_1)+\alpha\delta A_2-\\
&-e_x y_1-2(e_x+x_1)(w_2+e_x)
\end{aligned} \tag{33}$$

then $\dot V_3$ is negative definite

$$\dot V_3=-\alpha e_x^2-2\alpha w_2^2-\alpha\delta w_3^2<0 \tag{34}$$

From (33), (34) and (12) it follows that the error dynamics is described by

$$\begin{aligned}
&\dot e_x=\alpha(e_x-e_y)\\
&\dot e_y=-4\alpha e_y+e_x z_1+e_z x_1+\gamma\left(e_x^3+3e_x^2 x_1+3e_x x_1^2\right)\\
&\dot e_z=\alpha\delta(A_2-e_z)+\dot A_2+(e_x+x_1)(2e_x-e_y)
\end{aligned} \tag{35}$$

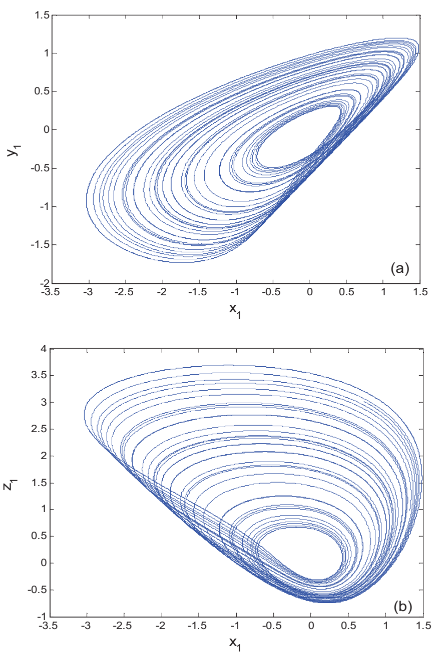
According to LaSalle-Yoshizawa theorem [19], the error dynamics will converge to zero as time tends to infinity and, as a consequence, the synchronization of the two Act systems will be achieved.

## 3. NUMERICAL SIMULATION

### *3.1. Sprott K system*

For the numerical simulations, the MatLab software was used. The Sprott K system is chaotic when $\alpha=1,\beta=1$ and $\gamma=0.3$. The initial conditions for the drive and response systems are taken as $x_1(0)=1$, $y_1(0)=2$, $z_1(0)=5$ and $x_2(0)=1.5$, $y_2(0)=3$, $z_2(0)=3$. Figure 1 illustrates the chaotic attractor in the $(x_1,y_1)$, $(x_1,z_1)$ and $(y_1,z_1)$ planes while the Figure 2 shows the time history of $x_{1,2}$, $y_{1,2}$, $z_{1,2}$ when the control is de-activated.

The error states $e_x$, $e_y$ and $e_z$ evolve independently and have not any tendency to decay, as shown in Figure 3. When the control is activated according to (18), the output of the response system (2) follows the output of the drive system (1) asymptotically. Figures 4 and 5 confirm that the coupled Sprott K systems are globally synchronized in less than 25 seconds.



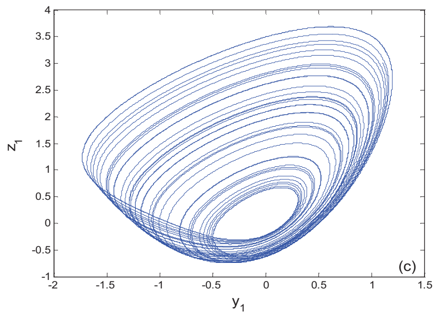



Figure 1: The Sprott K attractor in the: a) $(x_1, y_1)$ plane; b) $(x_1, z_1)$ plane; c) $(y_1, z_1)$ plane

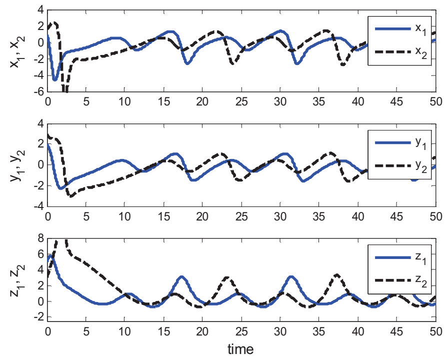



Figure 2: Time history of $x_{1,2}$, $y_{1,2}$, $z_{1,2}$ when the control is de-activated

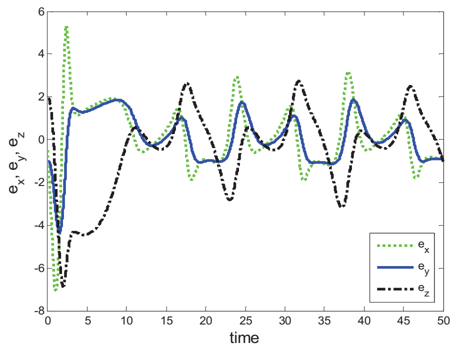



Figure 3: Time responses of error states when the control is de-activated

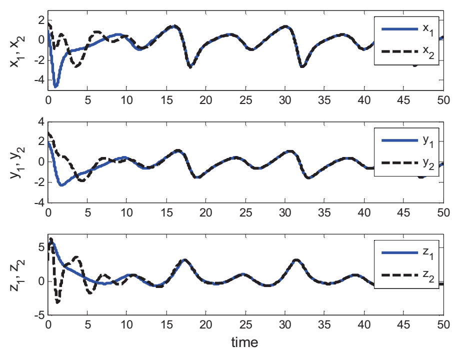



Figure 4: Time history of $x_{1,2}$, $y_{1,2}$, $z_{1,2}$ when the control is activated at $t = 0$

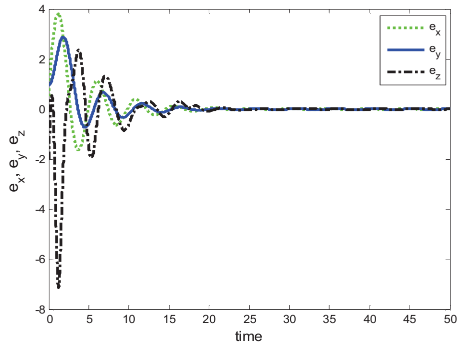



Figure 5: Time responses of error states when the control is activated

### 3.2. *Act system*

The 3-D Act system is chaotic when $\alpha = 1.8, \beta = -0.07, \delta = 1.5$ and $\gamma = 0.02$. In Figure 6 is displayed the dynamics of the chaotic system (20) for initial conditions $x_1(0) = 0.5$, $y_1(0) = 0.0$, $z_1(0) = 0.0$

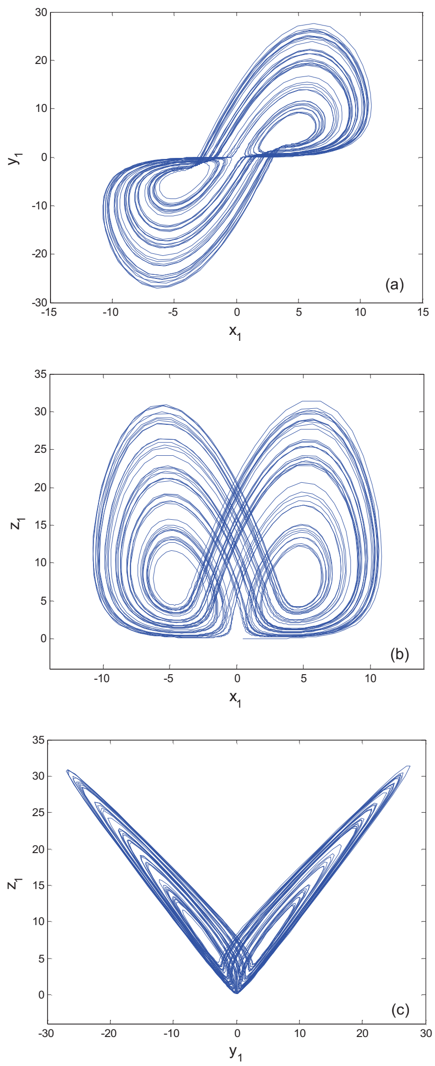



Figure 6: The Act attractor in the: a) $(x_1, y_1)$ plane; b) $(x_1, z_1)$ plane; c) $(y_1, z_1)$ plane

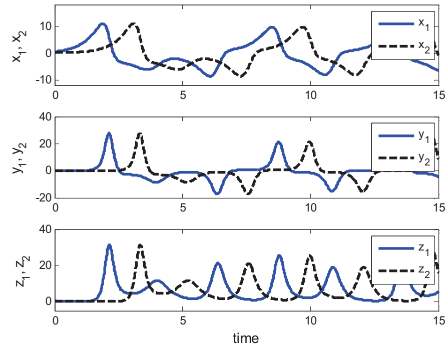



Figure 7: Time history of $x_{1,2}$, $y_{1,2}$, $z_{1,2}$ when the control is de-activate

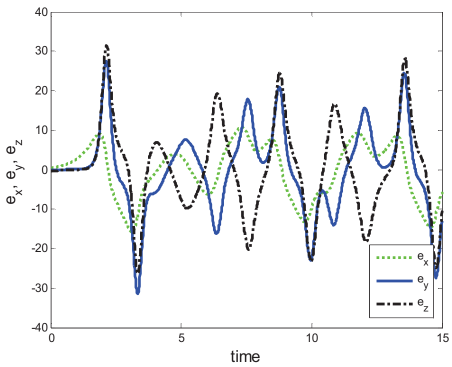



Figure 8: Time responses of error states when the control is de-activated

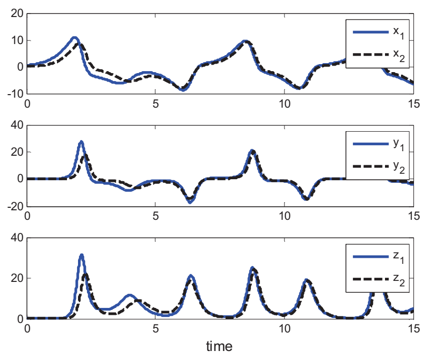



Figure 9: Time history of $x_{1,2}$, $y_{1,2}$, $z_{1,2}$ when the control is activated at $t = 0$

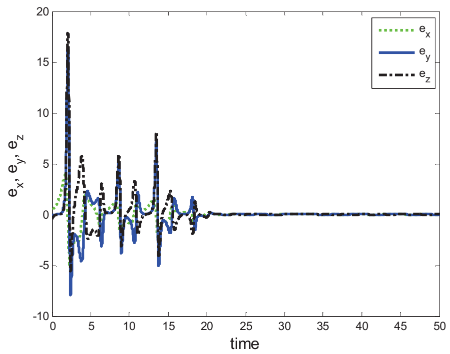



Figure 10: Time responses of error states when the control is activated

If the initial states of system (21) are $x_2(0) = 0.1$, $y_2(0) = 0.2$, $z_2(0) = 0.5$ and the control is de-activated then Figure 7 depicts the time series of state variables while Figure 8 presents the time responses of error states. By switching on the control law (33) at t = 0, the numerical resolves such as time history of $x_{1,2}$, $y_{1,2}$, $z_{1,2}$ are reported in Figure 9. Time needed for modules of the error states $e_x$, $e_y$ and $e_z$ to be less than $10^{-4}$ was about 25 seconds, as shown in Figure 10.

## 4. CONCLUSIONS

In the paper, back-stepping design has been used to synchronize chaotic systems like Sprott K and Act systems. It has been shown that the method has excellent performance in achieving global synchronization of the identical chaotic systems discussed in this paper.

Among the advantages of the scheme there are a few that are worth mentioning:

a) It is a systematic procedure and consists in a recursive procedure that interlaces the choice of a Lyapunov function with the control;
b) It needs only one controller to realize global synchronization no matter which is the dimensionality of the chaotic system;
c) It can be applied to a large class of chaotic systems.

Numerical simulations have verified the effectiveness of the method.

## 5. REFERENCES

[1] BLASIUS, B., HUPPERT, A., STONE, L., *Complex dynamics and phase synchronization in spatially extended ecological models,* Nature, 399, pp. 354-359, 1999

[2] CUOMO, K.M., OPPENHEIM, A.V., *Circuit implementation of synchronized chaos with applications to communications*, Physical Review Letters, 71, pp. 65-68, 1993

[3] FEKI, M., *An adaptive chaos synchronization scheme applied to secure communications,* Chaos, Solitons and Fractals, 18, pp. 141-148, 2003

[4] HAN, S.K., KERRER, C., KURAMOTO, Y., *D-phasing and bursting in coupled neural oscillators*, Physical Review Letters, 75, pp. 3190-3193, 1995

[5] LIAO, T.L., TSAI, S.H., *Adaptive synchronization of chaotic systems and its application to secure communications,* Chaos, Solitons and Fractals, 11, pp. 1397-1396, 2000

[6] SCHWARTZ, I.B., TRIADOF, I., *Controlling unstable Stratesin reaction-diffusion systems modelled*

*by time series*, Physical Review E 50(4), pp. 2548-2552, 1994

[7] HUANG, L., FENG, R., WANG, M., *Synchronization of chaotic systems via nonlinear control,* Physical Letters A., 320, pp. 271-275, 2005

[8] KHAN, M.A., *Adaptic synchronization of two coupled Newton-Leipnik system with uncertain parameter*, International Journal of Basic and Applied Sciences, 1, pp. 439-447, 2012

[9] KONISHI, K., HIRAI, M., KOKAME, H., *Sliding mode control for a class of chaotic systems,* Physical Letters A., 245, pp. 511-517, 1998

[10] NJAH, A.N., VINCENT, U.E., *Chaos synchronization between single and double wells Duffing Van-der Pol oscillators using active control,* Chaos, Solitons and Fractals, 37, pp. 1356-1361, 2008

[11] PARK, J.H., KWON, O.M., *A novel criterion for delayed feedback control of time-delay chaotic systems,* Chaos, Solitons and Fractals, 17, pp. 709-716, 2003

[12] VAIDYANATHAN, S., *Sliding controller design for the global synchronization of identical hyper-chaotic Yujun systems,* International Journal of Advanced Information Technology, 2, pp. 13-26, 2012

[13] VINCENT, U.E., *Synchronization of Rikitake chaotic attractor via active control,* Physical Letters A., 343, pp. 133-138, 2005

[14] YASSEN, M.T., *Adaptive control and synchronization of a modified Chua's circuit system,* Applied Mathematics and Computation, 135, pp. 113-128, 2003

[15] ZHANG, Y., *Controlling uncertain Lu system using back stepping design*, Chaos, Solitons and Fractals, 15, pp. 897-904, 2003

[16] VINCENT, U.E., *Chaos synchronization using active control and backstepping control: A comparative analysis,* Nonlinear Analysis, modeling and control, 13, pp. 253-261, 2008

[17] WU, X., LU, J., *Parameter identification and backstepping control of uncertain Lu system*, Chaos, Solitons and Fractals, 18, pp. 721-729, 2003

[18] XIAOHUI, T., ZHANG, J., Yang, Y., *Synchronizing chaotic systems using backstepping design*, Chaos, Solitons and Fractals, 16, pp. 37-45, 2003

[19] MASCOLO, S., GRASSI, G., *Controlling chaotic dynamics using backstepping design with application to the Lorenz system and Chua's circuit*, International Journal of Bifurcation and Chaos, 9, pp. 1425-1434, 1999.

# IMPACT EVALUATION OF A LARGE PELAMIS BASED ENERGY FARM ON THE WAVE FIELD IN THE ROMANIAN NEARSHORE AREA

[1]DIACONU SORIN, [2]RUSU EUGEN

[1,2]*Dunarea de Jos University of Galati, Romania*

**ABSTRACT**

The present work describes a study related to the influence on the shoreline dynamics of a large WEC array consisting of Pelamis devices. The target area is located in a coastal environment in the western side of the Black Sea. Various simulations based on the wave climate from this area have been made with SWAN spectral phase averaged wave model. Two situations have been considered in order to evaluate the impact of the wave energy farm: model simulations without any wave energy converter and simulations considering included in the computational domain of a system consisting 30 Pelamis devices. More analysis have been carried out in both geographical and spectral spaces. The results show that a significant influence appears in the area analyzed and is gradually decreasing to the coast line level.

**Keywords:** *Black Sea, SWAN, Pelamis,WEC, nearshore waves, coastal impact.*

## 1. INTRODUCTION

The need for pollution-free power generation has led to important developments of the wave energy devices, the most exciting developments at the present time are in extracting renewable energy in the nearshore and offshore areas. Wave energy can be accurately predicted using numerical models within a window of a few days and is depending on the location and weather conditions. Different types of such devices and an overview on the WEC evolution are given in [1].

This study presented in this paper represents the first step to assess the influence of wave farms on coastal circulation pattern and the surf dynamics.

The environment impacts are expected to be small in the initial phase where only a small number of devices will be deployed, but the impact caused by a large farm is expected to be high.

Although this impact should not be considered to be a negative factor, since reducing the wave energy might produce benefits in several coastal areas and the evaluation of the sensitivity of the nearshore wave area represents a very important issue and a lot of studies are necessary to be made in this direction.

The target area analyzed in the present work is located on the western side of the Black Sea, an area that is proving to be interesting due to the technological developments regarding harvesting renewable energy resources. Also this area was found to be one of the most energetic parts of the western side of the sea [2].

More evaluations of the wave conditions and resources in the Black Sea have been made [3-6] and in various zones near the coast have been reported to be significant differences in terms of wave conditions.

The objective of the present work is to evaluate the nearshore impact of a WEC array composed of 30 Pelamis devices disposed in two lines that would operate on the west side of the Black Sea.

The importance of such devices, which can be used also to reduce the wave height along the coastline protecting it by the erosion are presented by Nørgaard et al [7, 8].

Other studies are those of Millar [9] for the Wave Hub project and Ponce de Leon [10] that studied the influence of a wind farm in the nearshore. The influence of a Palemis farm on the shoreline wave climate situated close to the Portuguese coast is shown in the work of Palha [11].

Considering this, more evaluations must to be carried out in different coastal environment, energy farm type and farm alignment, factors that can affect in short, medium or long term changes induced in the shoreline wave climate and dynamics.

## 2. METHODS AND MATERIALS

The target area considered in the present work is situated south of the Sulina channel (Figure 1a), an area found to be the most energetic area in previous studies from the western side of the Black Sea and with significant wave variations in time (Rusu [12]).

Transforming the electricity from sea waves implies the use of convertors which transform the wave energy into mechanical energy. Pelamis systems [13] are using hydraulic systems and nowadays are considered among the most effective devices for the wave energy extraction.

The device is fixed at a location with a mooring system and his hydraulic system seem to be the most recommendable for areas where are generated high forces.

Following the results of the analysis related to the wave climate in the coastal area considered, most relevant case studies were analyzed and only a part of the analysis will be discussed in this paper.

The ISSM computational system was considered [14], in order to evaluate the impact of the wave energy farm operating in the target area. This tool has been designed to simulate waves and longshore currents and directs the integration of the SWAN wave model [15] with a 1D surf model [16] in the background.

Simulations with the SWAN model have been performed in various cases that reflect better the most relevant wave patterns in the target area and for accounting in the wave model of the Pelamis array geometry, the command obstacle was considered.

A detailed analysis has been performed, corresponding to two different situations that were considered in the present study, P0 (without any device operating in the target area) and P30 (with 30 Pelamis devices operating in two lines in the target area).

In Figure 1b, illustrates the configuration of the farm with the three configurations which have been analyzed. Also, the reference points are presented: the first reference point is denoted as BP and indicates the boundary point and three other reference points are defined at 1.8km down wave from the WD farm and they have been denoted as offshore points (OP).

This kind of device is semi-submerged structure, articulated and composed of cylindrical bodies. The length of the Pelamis device is of 150m and it is held in position by a flexible mooring system.

The configuration for grouping the Pelamis devices is the one recommended by the company and the devices are spaced by 150m. Also, the Wave Energy Centre performed a study regarding the large scale extraction of wave energy and it was recommended a maximum length of 4.5 km for the wave farms (WavEC [17]).

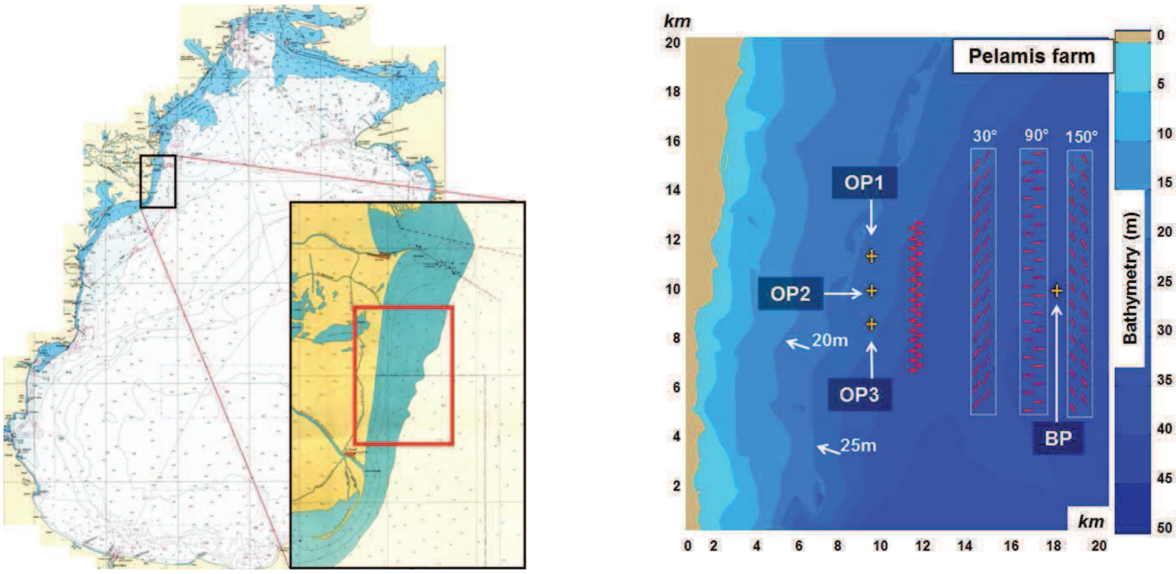



Figure1 a) Location of the target area b) Pelamis farm composed of 30 devices arranged in two lines and configured for waves that propagate in the northeast, east and southeast.

## 3. DISCUSSIONS AND RESULTS

Spatial configuration considered for the Pelamis farm is presented in Figure 2, where each system was positioned in the direction of the incident wave. Because of his system of anchoring Pelamis system automatically adjust to the direction of the incident wave, but on his way to stabilize the system may vary around the equilibrium position (left or right), which leads to a dynamic behavior of the Pelamis system. To include in the numerical simulations this dynamic behavior was considered useful to use multiple cases of transmission and reflection that can be encountered during the operation of the Pelamis systems.

The case when the transmission factor is 0.8 and reflection is 0.15 of the Pelamis farm is illustrated in Figure 2. At a first analysis of the numerical simulations is observed that the presence of the farm has no influence on the geographic space in the case of the small wave conditions (Hs = 1m, Tm = 4s). For medium wave case, behind the farm it is observed a presence of a wave field with wave heights of 1.7-1.8m, and close to the shoreline wave of 1.3m. For high waves, the presence of Pelamis farm can cause an effect of reducing the local wave heights up to 2.8m, this value being encountered also near the shoreline in the situation when the waves are coming from the north-east and south-east.

Table 1 presents a more detailed overview of the wave parameters development in the presence of the Pelamis wave farm. Results are reported for the control points (OP and BP) considering the same transmission and reflection factors and the three wave conditions studied (small, medium and large).

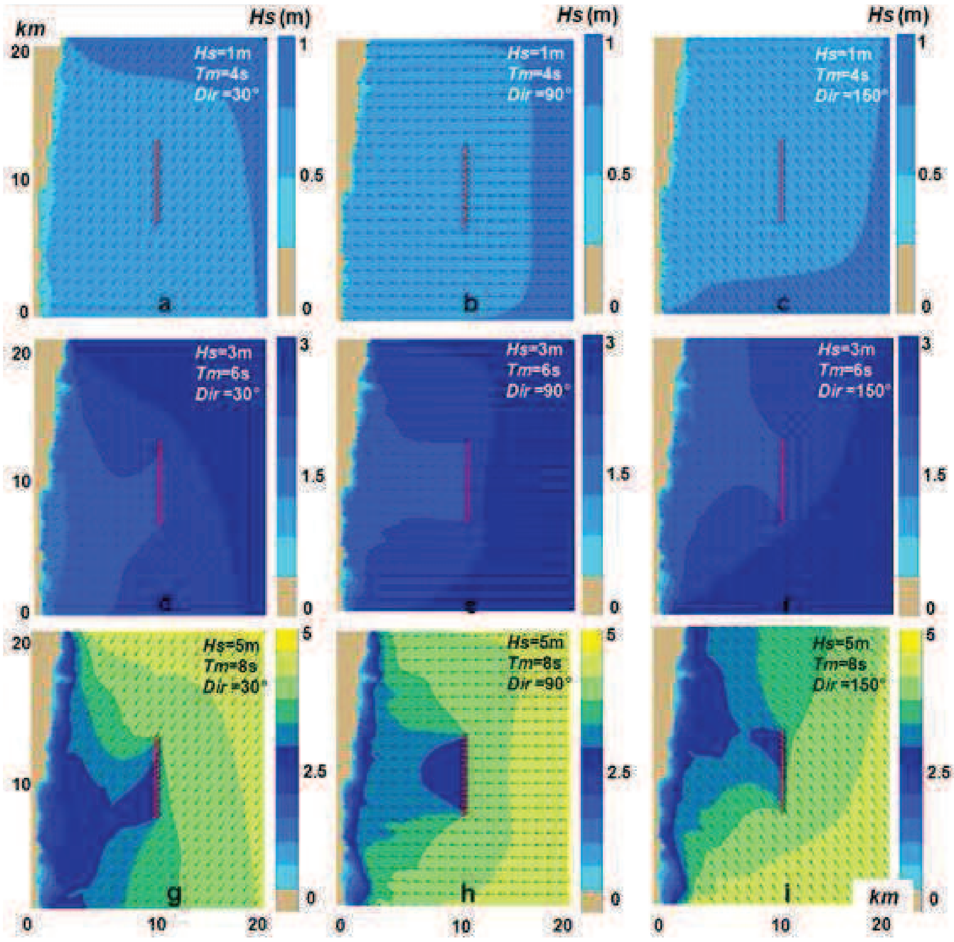


Figure 2 Evaluation in the geographical space of the impact on the wave field of a Pelamis wave farm that operates in the target area for the case when the transmission factor is 0.8 and reflection factor is 0.15. The results are reported for a), b), c) small waves (*Hs*=1m, *Tm*=4s) which are coming from northeast, east and southeast (30°, 90° şi 150° – nautic convention); d), e), f) average waves (*Hs*=3m, *Tm*=6s) which are coming from northeast, east and southeast; g), h), i) high waves (*Hs*=5m, *Tm*=8s) which are coming from northeast, east and southeast.

Tabele 1. Evaluation of the influence of a Pelamis farm on the target area for case when Trans = 0.8 and Ref = 0.15 indicated by four reference points (BP, OP1, OP2 and OP3). Numerical simulations reported for large waves (Hs = 5m, Tm = 8s) that propagate from: a) northeast (Dir = 30°), b) East (Dir = 90°) and c) Southeast (Dir = 150°).

| Punct | Hs (m) | Emax ($m^2$/Hz/grd) | Dir (°) | DSPR (°) | Tp/Tm (s) | Wlen (m) | Px ($m^3$/s) | Py ($m^3$/s) | Fx (N/$m^2$) | Fy (N/$m^2$) |
|---|---|---|---|---|---|---|---|---|---|---|
| a) *Dir*=30° | | | | | | | | | | |
| BP | 4.54 | 18.51 | 34.40 | 32.86 | 8.29/7.11 | 73.02 | -3.75 | -5.55 | -0.09 | -0.17 |
| OP1 | 3.62 | 15.07 | 32.98 | 26.45 | 8.29/7.23 | 72.92 | -2.75 | -4.14 | 0.47 | -0.39 |
| OP2 | 3.29 | 13.51 | 30.92 | 26.64 | 8.29/7.19 | 72.28 | -2.12 | -3.46 | 0.40 | -0.23 |
| OP3 | 3.08 | 12.14 | 31.41 | 27.82 | 8.29/7.17 | 72.18 | -1.85 | -2.95 | 0.31 | -0.23 |
| b) *Dir*=90° | | | | | | | | | | |
| BP | 4.73 | 18.77 | 90.21 | 33.99 | 8.29/7.04 | 71.11 | -7.14 | 0.03 | -0.20 | -0.04 |
| OP1 | 2.90 | 7.16 | 84.36 | 33.88 | 8.29/7.16 | 71.44 | -2.91 | -0.25 | 0.33 | -0.18 |
| OP2 | 2.76 | 6.94 | 90.79 | 34.27 | 8.29/7.17 | 71.83 | -2.63 | 0.06 | 0.26 | -0.04 |
| OP3 | 2.76 | 6.82 | 95.63 | 34.13 | 8.29/7.19 | 72.53 | -2.63 | 0.28 | 0.24 | -0.07 |
| c) *Dir*=150° | | | | | | | | | | |
| BP | 4.54 | 18.48 | 146.14 | 33.01 | 8.29/7.12 | 73.16 | -3.69 | 5.60 | -0.08 | 0.09 |
| OP1 | 2.99 | 13.59 | 150.63 | 28.13 | 8.29/7.15 | 71.09 | -1.66 | 2.86 | 0.32 | 0.05 |
| OP2 | 3.13 | 14.23 | 152.00 | 27.93 | 8.29/7.16 | 71.56 | -1.74 | 3.17 | 0.34 | 0.07 |
| OP3 | 3.29 | 15.32 | 153.25 | 27.06 | 8.29/7.17 | 71.99 | -1.85 | 3.58 | 0.37 | -0.01 |

The parameters considered in Tables 2-6 are significant wave height (*Hs*), maximum variance (*Emax*), mean wave direction (*Dir*), directional spreading (DSPR), peak period (*Tp*), mean period (*Tm*), wavelength (*Wlen*), the components of the energy transport (*Px, Py*) and the components of the wave forces (*Fx, Fy*).

The evolution in the spectral space of the wave conditions for two different cases of transmission is shown in Figure 3 considering three wave conditions: small, medium and large. For case 1 (Trans = 0.2, Ref = 0.3) when waves propagate in northeast and southeast directions it is observed a reduction in the direction domain of the energy distribution and a narrow of the spectral shapes in the frequencies domain. Regarding the waves which are coming from east there can be observed an energy dissipation resulting in a spectrum with two distinct peaks, as well as severe a change of the direction of the waves (in the case of large waves). As expected the less affected are the spectral shapes of case when the transmission and reflection factors are Trans = 0.8 and Ref = 0.15.

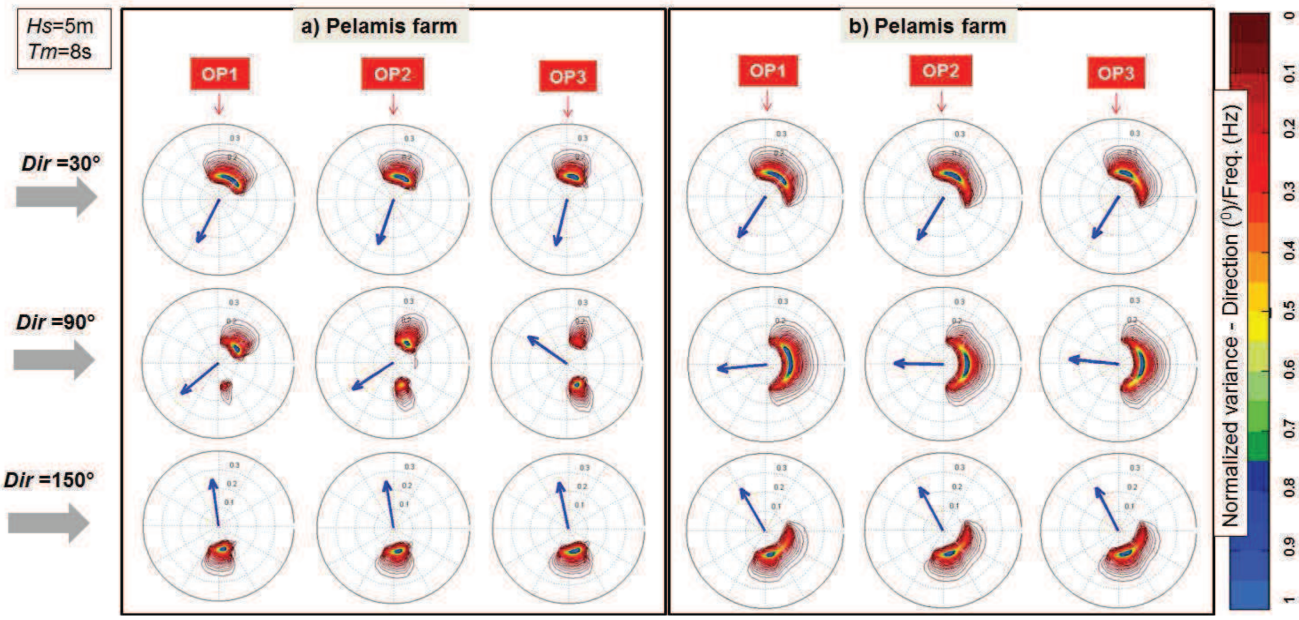



Figure 3 Evaluation in the spectral space of the impact on the wave field of a wave Pelamis farm in three directions: north east (30 °), east (90 °) and southeast (150°) for large wave conditions (Hs = 5m, Tm = 8s). Combinations of transmission and reflection coefficients were shown in two cases: (Trans = 0.2, Ref = 0.3) and (Trans = 0.8, Ref = 0.15).

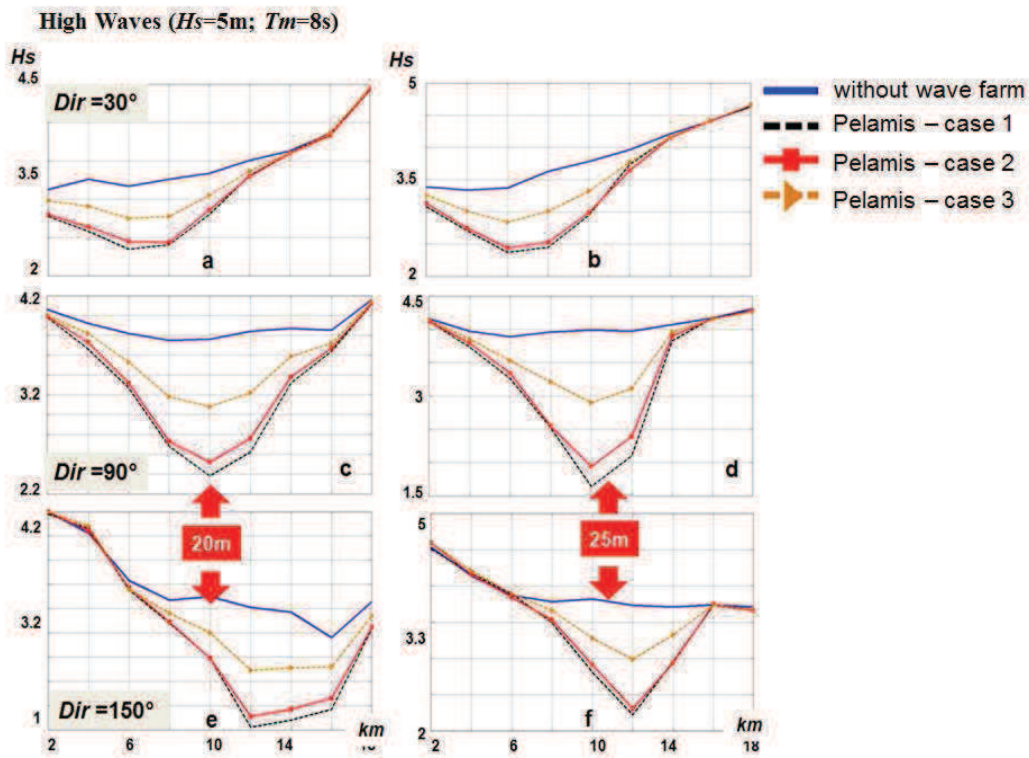



Figure 4 Evolution of the wave heights Hs along the bathymetry lines of 20m (left side) and 25m (right side) for large waves (Hs = 5m, Tm = 8s). Results are reported for the situation where there is no wave farm and when there is a

Pelamis farm (for three different cases of transmission and reflection factors: case 1 - *Trans = 0.2, Ref=0.3* / case 2 - *Trans = 0.5, Ref=0.225* / case 3 - *Trans = 0.8, Ref=0.15*) interacting to waves: a), b) north-east (30°); c), d) east (90°) and e), f) southeast (150°).

The distribution of the wave heights along the bathymetry lines (20m and 25m) in the presence of the farm, for the case of development of high waves is shown in Figure 4, where it can be seen that the largest differences are mostly concentrated in the center.

## 4. CONCLUSIONS

An important aspect in the direction of reducing the energy cost is represented by the implementation of large WEC arrays.

Thus, large scale WEC deployments are expected in the near future and a very important issue related to this perspective is to evaluate correctly the possible coastal impact of these power plants which can operate in the nearshore area. In this context, the present work presents an evaluation of the changes induced in the coastal wave climate by an array of 30 Pelamis devices and located in the western side of the Black Sea, but this methodology can be extended to any coastal environment.

As regards the wave transformation, the modelling system considered in these evaluations is based on the SWAN spectral model, which is a suitable tool for accounting the wave changes due to the presence of the energy farm. Evaluations were carried out in both geographical and spectral spaces for various relevant wave patterns and for different transmission and reflection factors. The results show that while immediately after the farm drastic changes occur in the wave fields, thus slowly gradually attenuate towards the coast, but can be noticed important changes of the field also near the coast.

In order to assess better the changes taking place in the spectral shapes due to the energy farm, more transformations of theoretical JONSWAP spectra were analyzed for different cases considered. The results usually show that the single peaked wave spectra are usually changed by the wave farm in double peaked spectra.

Further investigations needs to be made in order to study the environmental impact of these WEC farms. We can safely assume that this kind of farms have a positive role both in terms of renewable energy production and of protecting the coast, because it is known that the Romanian coast area is facing coastal erosion problems.

## 5. ACKNOWLEDGMENTS

The work of the first author has been made in the scope of the project EFICIENT (Management System for the Fellowships Granted to the PhD Students) supported by the Project SOP HRD - EFICIENT 61445/2009.

## 6. REFERENCES

[1] Babarit, A., Hals, J., Muliawan, M.J., Kurniawan, A., Moan, T., Krokstad, J.. "Numerical benchmarking study of a selection of wave energy converters," *Renewable Energy,* vol. 41, pp. 44-63, 2012.

[2] Rusu E. "Modelling of wave-current interactions at the Danube's mouths," *Journal of Marine Science and Technology,* vol. 15, no. 2, pp. 143-159, 2010.

[3] Rusu L. "Application of numerical models to evaluate oil spills propagation in the coastal environment of the Black Sea," *Journal of Environmental Engineering and Landscape Management*, vol. 18, no. 4, pp. 288-295, 2010.

[4] Rusu L., Ivan A., "Modelling wind waves in the Romanian coastal environment," *Environmental Engineering and Management Journal*, vol. 9, no. 4, pp. 547-552, 2010.

[5] Rusu, E., Macuta, S.. "Numerical Modelling of Longshore Currents in Marine Environment," *Environmental Engineering and Management Journal*, vol. 8, no. 1, pp. 147-151, 2009.

[6] Trusca, C.V. Reliability of SWAN model simulations for the Black Sea Romanian coast (2005) Proceedings of the 12th International Congress of the International Maritime Association of the Mediterranean, IMAM 2005 - Maritime Transportation and Exploitation of Ocean and Coastal Resources, 2, pp. 1159-1165.

[7] Nørgaard J.H., Andersen T.L., Kofoed J.P., "Wave Dragon Wave Energy Converters Used as Coastal Protection," I Coastal Structures 2011: tentative proceedings of the 6th international conference, Imperial College Press. 2011.

[8] Nørgaard J.H., Andersen T.L., Kofoed J.P., "Wave Dragon Wave Energy Converters Used as Coastal Protection: a physical model test study," I Coastal Structures 2011: International Conference September 6-8, 2001 Yokohama, Japan. The Coasts, Oceans, Ports, and Rivers Institute (COPRI) : The American Society of Civil Engineers. 2011.

[9] Millar, D.L., Smith, H.C.M. Reeve, D.E.. "Modelling analysis of the sensitivity of shoreline change to a wave farm," *Ocean Engineering,* vol. 34, pp. 884–901, 2007.

[10] Ponce de Leon, S., Bettencourt, J.H., Kjerstad, N.. "Simulation of irregular waves in an offshore wind farm with a spectral wave model," *Continental Shelf Research*, vol. 31, no. 15, pp. 1541–1557, 2011.

[11] Palha, A., Mendes, L., Fortes, C.J., Brito-Melo, A., Sarmento, A.. "The impact of wave energy farms in the shoreline wave climate: Portuguese pilot zone case study using Pelamis energy wave devices," *Renewable Energy*, vol. 35, pp. 62–77, 2010.

[12] Rusu, E., Wave energy assessments in the Black Sea, *Journal of Marine Science and Technology*, 14:3 (2009) 359-372.

[13] Henderson, R. Design, simulation, and testing of a novel hydraulic power take-off system for the Pelamis wave energy converter. *Renewable Energy,* 2006, 31, 271–283.

[14] Rusu, E., Conley, D.C. and Coelho, E.F. A Hybrid Framework for Predicting Waves and Longshore Currents. *Journal of Marine Systems*, 2008, 69(1-2), 59–73.

[15] Booij, N., Ris, R. C. and Holthuijsen, L. H. A third generation wave model for coastal regions. Part 1: Model description and validation, *J. Geophys. Res.* 1999, 104, C4, 7649-7666.
[16] Mettlach, T.R., Earle, M.D. and Hsu, Y.L.. Software Design Document for the Navy Standard Surf Model, Version 3.2, Naval Research Laboratory, Stennis Space Center, Mississippi, 2002, 187p.
[17] WavEC. The potential and strategy of wave energy exploitation in Portugal (document in Portuguese), a study for the Directorate General for Geology and Energy (DGGE); 2004.

# MODAL ANALYSIS OF NATURAL FREQUENCIES AND MASS PARTICIPATION COEFFICIENTS OF SIMPLY SUPPORTED THIN PLATES WITH DAMAGES

[1]HATIEGAN CORNEL, [2]NEDELONI MARIAN-DUMITRU, [3]TUFOI MARIUS, [4]PROTOCSIL CARLA, [5]RADUCA MIHAELA

[1,2,3,4,5]*„Eftimie Murgu” University of Resita, Romania*

**ABSTRACT**

This paper presents the results regarding the determination of natural frequency and mass participation coefficients of a simply supported plates types with 2 and 3 defects. The simulation was made by modal analysis through SolidWorks software. Interpretation of the results is embodied in table form and graphical form.

**Keywords:** *natural frequencies, mass participation coefficients, simply supported.*

## 1. INTRODUCTION

A plate is a solid body with the length and width relatively large compared to the thickness [1].

In this paper, it will be analyzed 4 cases of two types of thin plates namely simply supported plate and simply supported on width and free on length, both with 2 and 3 defects of 5x5 mm on longitudinal axis, respective of 250x5 mm on laterally/center of the plate.

To determine the natural frequency [2, 3] and the mass participation coefficients in the three directions X, Y and Z, was carried out a 16 vibration modes [4].

## 2. THE 3D MODELLING

For the 3D modelling was considered a thin plate with the 1000x500x2 mm dimensions.

For this study, the following steps were made [5]: the plate geometry was created; the frequency study was done; the material was chosen; the restrictions were applied [6]; the mesh was done [7, 8]; the calculation of modal analysis was made and the results were visualized, results that can be in word documents generated.

The material from SolidWorks library was the AISI 316 (DIN 1.4401 or X5CrNiMo17-12-2) austenitic stainless steel, with the following mechanical properties shown in Table 1:

Table 1. Mechanical properties

| Yield strength | Tensile strength | Mass density | Elastic modulus | Poisson's ratio |
|---|---|---|---|---|
| [N/mm2] | [N/mm2] | [kg/m3] | [N/mm2] | [-] |
| 172.369 | 580 | 8.000 | 193.000 | 0.27 |

The mesh was done by the solid mesh for „mesh type”, by the standard mesh for „mesher used” with 4 points for “Jacobian points” and by the option high for the „mesh quality”.

Tables 2 (for 2 defects) and 3 (for 2 defects) show the results of the mesh for the 4 cases.

Figures 1 (for defects on longitudinal axis of the plate) and 2 (for defects on laterally/center of the plate) shows the mesh details.

Table 2. The mesh results for 2 defects case

| Plate type | Total Nodes | Total Elements |
|---|---|---|
| Simply supported and simply supported on width and free on length | 36134 | 20059 |
| Defects of 5x5 mm on longitudinal axis | | |
| Simply supported and simply supported on width and free on length | 38312 | 20347 |
| Defects of 250x5 mm on laterally/center | | |

Table 3. The mesh results for 3 defects case

| Plate type | Total Nodes | Total Elements |
|---|---|---|
| Simply supported and simply supported on width and free on length | 46616 | 27428 |
| Defects of 5x5 mm on longitudinal axis | | |
| Simply supported and simply supported on width and free on length | 34314 | 16926 |
| Defects of 250x5 mm on laterally/center | | |

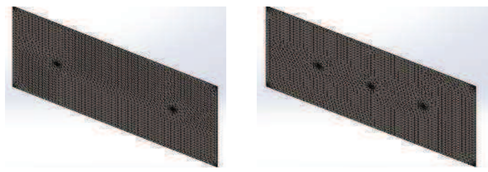


Figure 1 Mesh details for plates with 2 and 3 defects of 5x5 mm on longitudinal axis

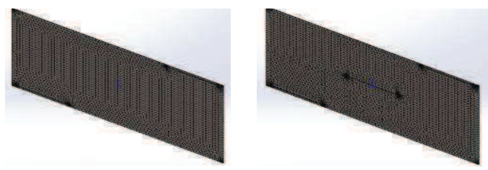


Figure 2 Mesh details for plates with 2 and 3 defects of 250x5 mm on laterally/center

Figures 3 ÷ 6 shows the a number of 16 vibration modes for only 4 analyzed plates with 2 and 3 defects.

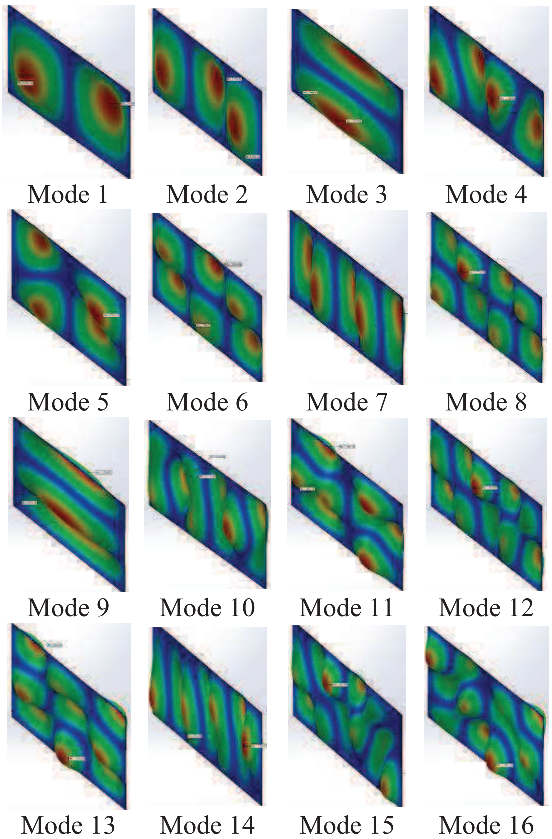



Figure 3 Vibration modes for simply supported plate with 2 defects of 5x5 mm on longitudinal axis

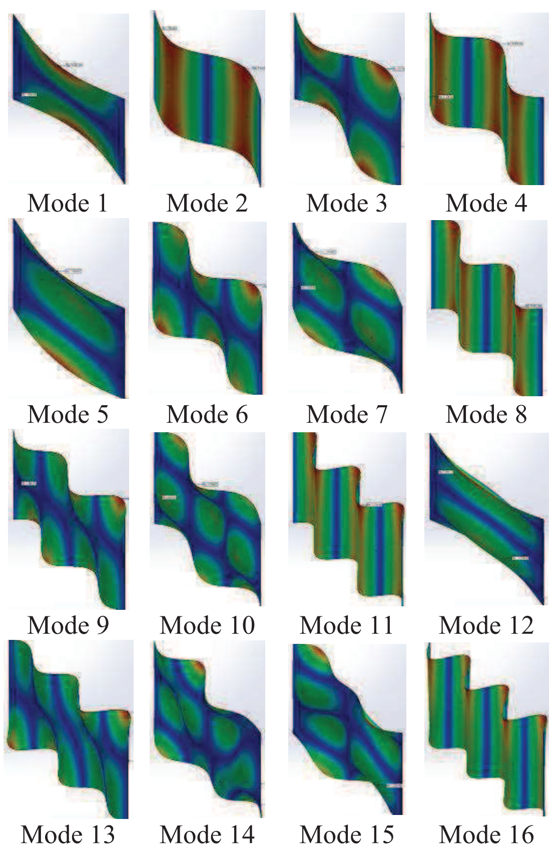



Figure 4 Vibration modes for simply supported on width and free on length plate with 2 defects of 5x5 mm on longitudinal axis

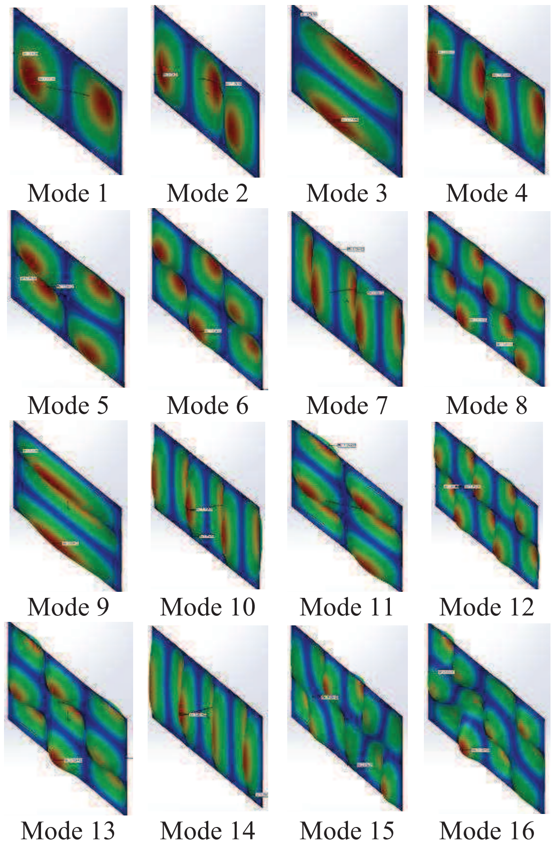



Figure 5 Vibration modes for simply supported plate with 3 defects of 250x5 mm on longitudinal axis

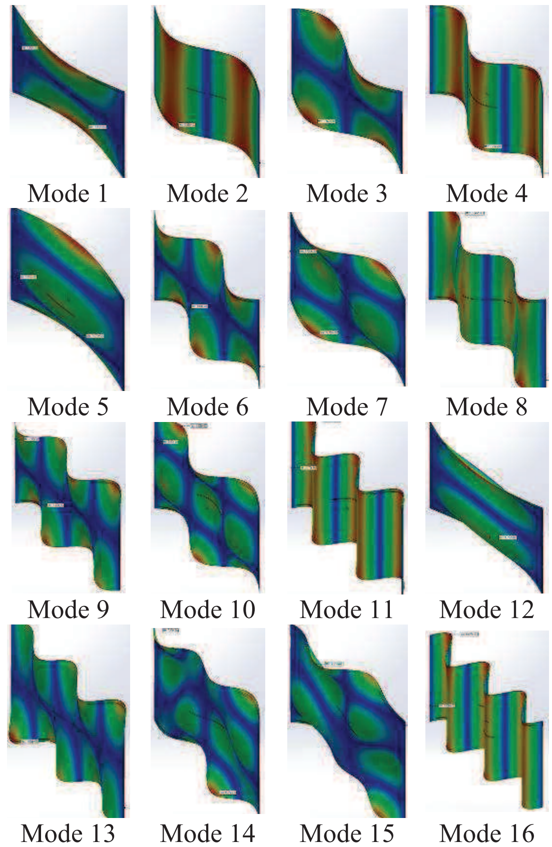



Figure 6 Vibration modes for simply supported on width and free on length plate with 3 defects of 250x5 mm on longitudinal axis

## 3. EXPERIMENTAL RESULTS

After the numerical simulation, the obtained results for natural frequencies [Hz] are numerically present in Tables 4÷7 and graphically in Figures 7 and 8.

Table 4. The values of natural frequency for 2 defects of 5x5 mm on longitudinal axis

| Mode Number | Simply supported | Simply supported on width and free on length |
|---|---|---|
| M1 | 38.395 | 13.273 |
| M2 | 63.225 | 18.237 |
| M3 | 80.742 | 31.676 |
| M4 | 97.615 | 41.422 |
| M5 | 99.59 | 50.412 |
| M6 | 127.61 | 58.059 |
| M7 | 142.85 | 72.943 |
| M8 | 166.43 | 74.275 |
| M9 | 176.06 | 93.115 |
| M10 | 197.34 | 106.62 |
| M11 | 199.54 | 117.02 |
| M12 | 214.67 | 125.76 |
| M13 | 233.81 | 137.91 |
| M14 | 261.83 | 149.29 |
| M15 | 271.34 | 154.13 |
| M16 | 285.64 | 169.65 |

Table 5. The values of natural frequency for 2 defects of 250x5 mm on laterally/center defects

| Mode Number | Simply supported | Simply supported on width and free on length |
|---|---|---|
| M1 | 38.886 | 13.334 |
| M2 | 63.644 | 18.223 |
| M3 | 80.929 | 32.546 |
| M4 | 98.002 | 41.346 |
| M5 | 100.84 | 51.202 |
| M6 | 132.52 | 59.891 |
| M7 | 141.95 | 74.013 |
| M8 | 175.58 | 75.18 |
| M9 | 176.59 | 97.209 |
| M10 | 195.88 | 110.06 |
| M11 | 203.02 | 116.46 |
| M12 | 230.88 | 126.41 |
| M13 | 243.19 | 145.05 |
| M14 | 259.85 | 155.42 |
| M15 | 297.68 | 156.18 |
| M16 | 299.47 | 168.89 |

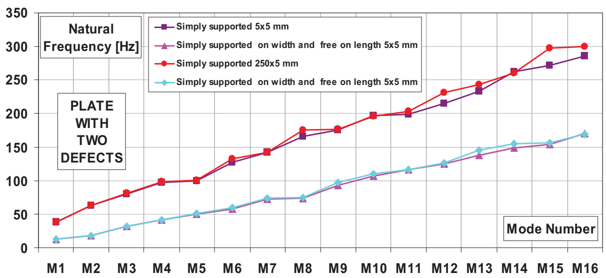



Figure 7 The values of natural frequency for plates with 2 defects

Table 6. The values of natural frequency for 3 defects of 250x5 mm on laterally/center defects

| Mode Number | Simply supported | Simply supported on width and free on length |
|---|---|---|
| M1 | 39.175 | 13.36 |
| M2 | 64.952 | 18.27 |
| M3 | 82.013 | 32.297 |
| M4 | 100.94 | 41.562 |
| M5 | 102.31 | 51.117 |
| M6 | 135.97 | 59.786 |
| M7 | 147.73 | 74.514 |
| M8 | 178.39 | 75.095 |
| M9 | 179.06 | 97.408 |
| M10 | 204.31 | 111.82 |
| M11 | 205.98 | 117.71 |
| M12 | 234.53 | 128.11 |
| M13 | 251.82 | 144.73 |
| M14 | 273.79 | 158.01 |
| M15 | 300.47 | 160.03 |
| M16 | 304.46 | 171.02 |

Table 7. The values of natural frequency for 3 defects of 250x5 mm on laterally/center defects

| Mode Number | Simply supported | Simply supported on width and free on length |
|---|---|---|
| M1 | 38.344 | 13.264 |
| M2 | 63.02 | 18.221 |
| M3 | 81.257 | 32.021 |
| M4 | 97.413 | 41.366 |
| M5 | 98.614 | 50.928 |
| M6 | 128.59 | 59.168 |
| M7 | 141.67 | 73.357 |
| M8 | 170.18 | 74.082 |
| M9 | 178.43 | 95.312 |
| M10 | 195.94 | 107.25 |
| M11 | 198.18 | 116.64 |
| M12 | 222.03 | 127.26 |
| M13 | 235 | 142.37 |
| M14 | 260.59 | 151.53 |
| M15 | 285.87 | 152.1 |
| M16 | 288.93 | 169.23 |

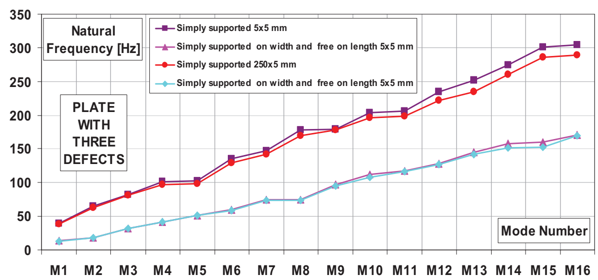



Figure 8 The values of natural frequency for plates with 3 defects

For the mass participation coefficients of X, Y and Z directions, the obtained results for the 4 analyzed cases of the two types of plates with 2 and 3 defects of 5x5 mm respective 250x5 mm are shown graphically in Figures 9 ÷ 14 for each direction.

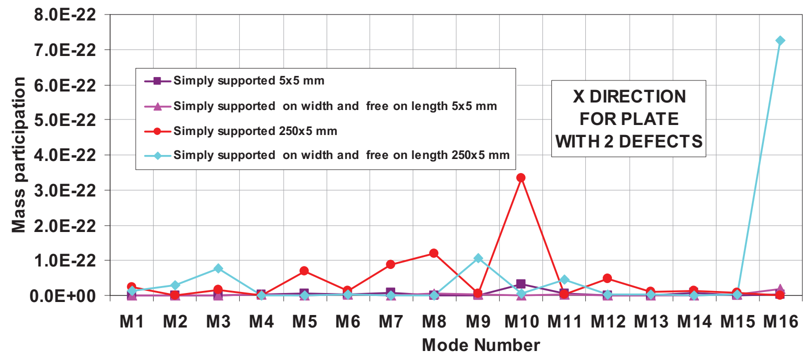



Figure 9 The mass participation coefficients for X direction of plates with 2 defects

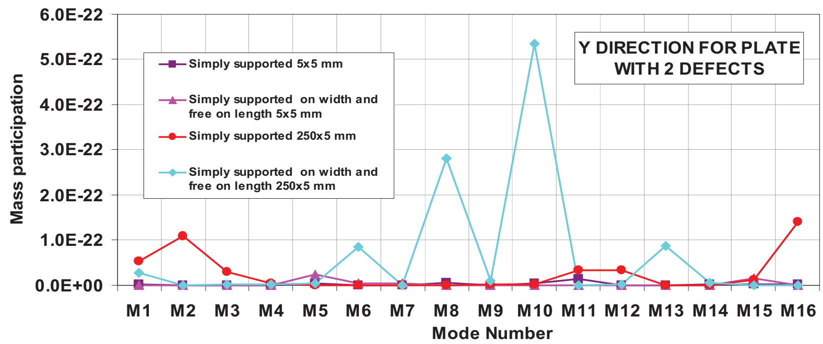



Figure 10 The mass participation coefficients for Y direction of plates with 2 defects

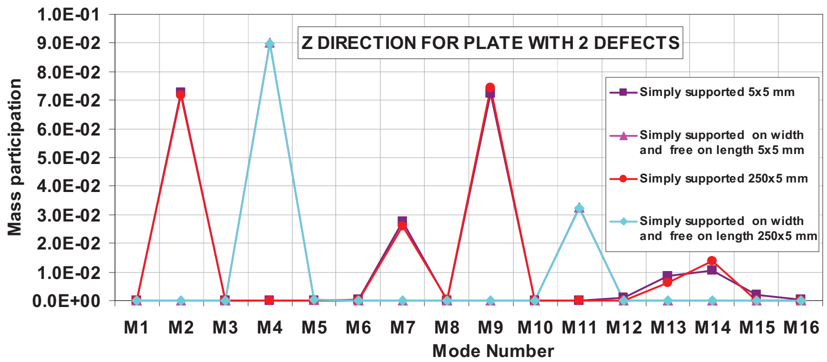



Figure 11 The mass participation coefficients for Z direction of plates with 2 defects

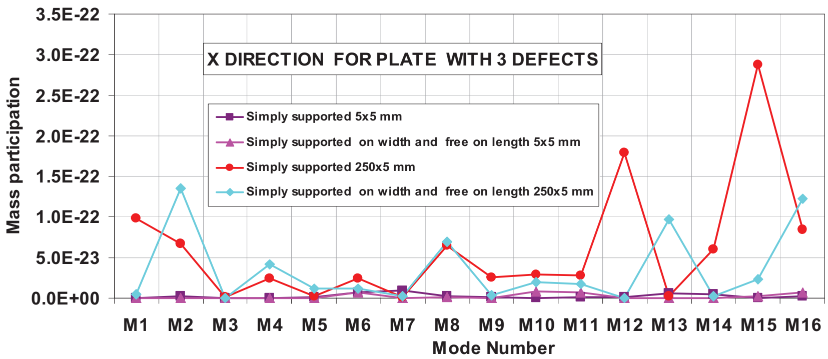



Figure 12 The mass participation coefficients for X direction of plates with 3 defects

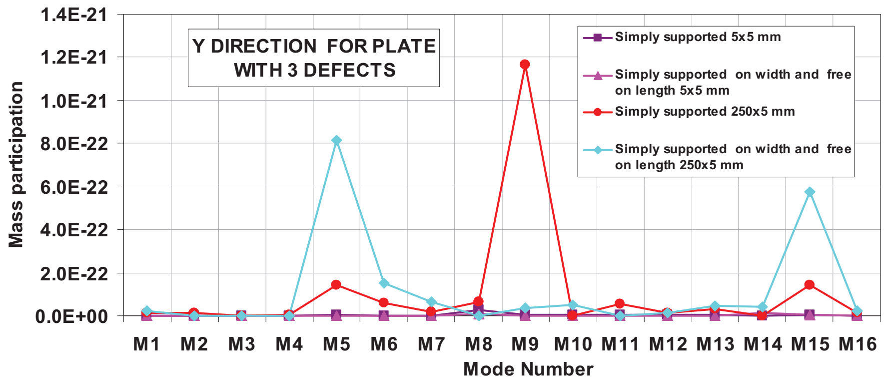



Figure 13 The mass participation coefficients for Y direction of plates with 3 defects

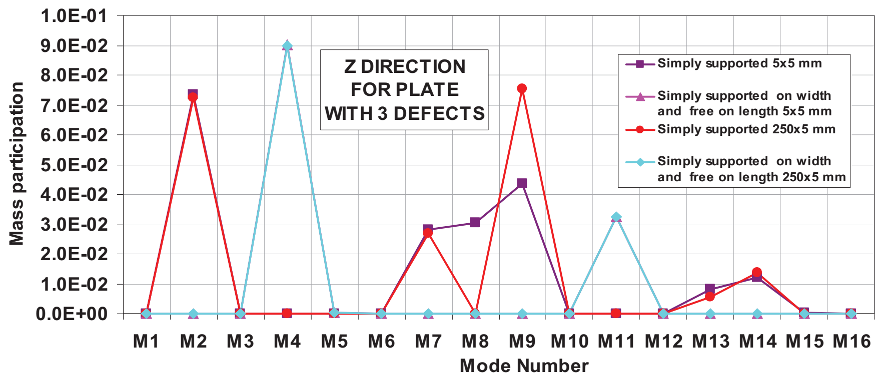



Figure 14 The mass participation coefficients for Z direction of plates with 3 defects

## 4. CONCLUSIONS

From the modal analysis for determining the natural frequency and the mass participation coefficients through SolidWorks software, can make the following conclusions:

- through finite element method, the mesh for all analyzed plates was made using the same type of solid mesh, where the resulting for total nodes and elements were different for the 4 analyzed cases;
- for each analyzed plate, the natural frequencies increase gradually from the first mode to the last vibration mode;
- the values of the simply supported plates frequencies are in all cases higher than those of plates simply supported on the width and free on length; this confirms that a simply supported plate without defect also, has higher values compared to other types of plates studied by the authors [9];
- the higher calculated natural frequency for the case with two defects, belongs to the simply supported plate in width and free on length with the defects of 250x5 mm on laterally/center of plate (figures 9÷11);
- in the case study with 3 defects, the higher calculated natural frequency, belongs to the simply supported thin plate of 250x5 mm and also to the cases with defects of 250x5 mm on laterally/center of the plate (figures 12÷14).

## 5. ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Managing Authority for Sectoral Operational Programme for Human Resources Development (MASOPHRD), within the Romanian Ministry of Labour, Family and Equal Opportunities by co-financing the project "Investment in Research-innovation-development for the future (DocInvest)" ID 76813.

## 6. REFERENCES

[1] Alămoreanu, E., Buzdugan, Gh., Iliescu, N., Mincă, I., Sandu, M., *Îndrumar de calcul în ingineria mecanică (Guidelines for calculating in mechanical engineering)*, Editura Tehnică, Bucureşti, 1996

[2] Ostachowicz, W.M., Krawczuk, C., *Analysis of the effect of cracks on the natural frequencies of a cantilever beam*, Journal of Sound and Vibration 150(2), 1991

[3] Gillich G.R., Minda, P.F., Praisach, Z.I., Minda, A.A, *Natural Frequencies of Damaged Beams - A New Approach*, RJAV vol. IX, issue 2, 2012

[4] Haţiegan, C., Gillich, G.R., Răduca, M., Răduca, E., Budai, A.M., Muntean, F., *Finite Element Analysis of Natural Frequencies and Mass Participation Coefficients for Thin Plates With Defects*, Scientific

Bulletin of "Politehnica" University of Timisoara, vol. 57 (71) 2, 2012
[5] Nedelcu, D., *Proiectare şi simulare numerică cu SolidWorks (Digital prototyping and numerical simulation with SolidWorks)*, Editura Eurostampa, Timişoara, 2011
[6] Cojocaru, V., *Deformation Analysis of Asymmetric Component Loaded by Centrifugal Force Using the Finite Element Method*, ROBOTICA & MANAGEMENT, vol. 15, no. 2, 2010
[7] Mănescu, T. S., Nedelcu, D., *Analiza structurală prin metoda elementului finit (Structural Analysis through Finite Element Method)*, Editura Orizonturi Universitare, Timişoara, 2005
[8] Praisach, Z.I., Gillich, G.R., Birdeanu, D.E., *Considerations on Natural Frequency Changes in Damaged Cantilever Beams Using FEM*, EMESEG'10 Proceedings of the 3rd WSEAS international conference on Engineering mechanics, structures, engineering geology, 2010
[9] Haţiegan, C., Gillich, G.R., Gillich, N., Tufoi, M., Răduca, M., *Modal Analysis of Thin Plates with Damage Simply Supported on all Edges*, Analele Universităţii Eftimie Murgu din Reşiţa, anul XX, 2013

# MODAL ANALYSIS THROUGH SOLIDWORKS SOFTWARE OF CLAMPED THIN PLATES WITH DAMAGES

[1]HATIEGAN CORNEL, [2]TUFOI MARIUS, [3]RADUCA EUGEN, [4]PROTOCSIL CARLA, [5]MITULETU CORNEL

[1,2,3,4,5] *„Eftimie Murgu" University of Resita, Romania*

**ABSTRACT**

This paper presents the results obtained by modal analysis through SolidWorks software for determining natural frequency of some types of clamped thin plates with 2 and 3 damages on longitudinal axis and on the laterally side/ center. Interpretation of results obtained from simulation for a total of 20 vibration modes is shown by comparison in tabular form and in graphical form.

**Keywords:** *modal analysis, clamped thin plates, damages.*

## 1. INTRODUCTION

In this paper 4 cases of 3 types of clamped thin plates [1] with damages will be analyze namely: clamped on width-free on length, clamped on width-simply supported on length, respective clamped on width and length.

All plates are with 2 and 3 damages, damages on longitudinal axis of 5x5 mm, respectively on laterally side/center of 250x5 mm [2, 3].

## 2. THE 3D MODELLING

For 3D modelling was considered a clamped thin plate with the dimensions of 1000x500x2 mm.

After creating the geometries of plates with SolidWorks, the study of frequency type [4] was made on determining the natural frequency of plates with a total of 20 vibration modes [5, 6].

The associated material is the AISI 316 stainless steel with the tensile strength of 580 N/mm$^2$.

## 3. EXPERIMENTAL RESULTS

The numerical simulation through the finite element method [7], was performed by the following options: High for *Mesh Quality*, Solid mesh for *Mesh type* and Standard mesh for *Mesher Used*.

Table 1 presents the results of the mesh for the 4 cases examined, regarding the total number of nodes and elements and Figures 1 and 2 shows examples of the 20 vibration modes.

Table 1. The mesh results

| Clamped thin plate type | Nodes | Elements |
|---|---|---|
| With 2 damages on longitudinal axis of 5x5 mm (max. aspect ratio: 72.927) | 36134 | 20059 |
| With 2 damages on longitudinal axis of 250x5 mm (max. aspect ratio: 63.455) | 38312 | 20347 |
| With 3 damages on laterally side/center of 5x5 mm (max. aspect ratio: 115.85) | 46616 | 27428 |
| With 3 damages on laterally side/center of 250x5 mm (max. aspect ratio: 53.717) | 34314 | 16926 |

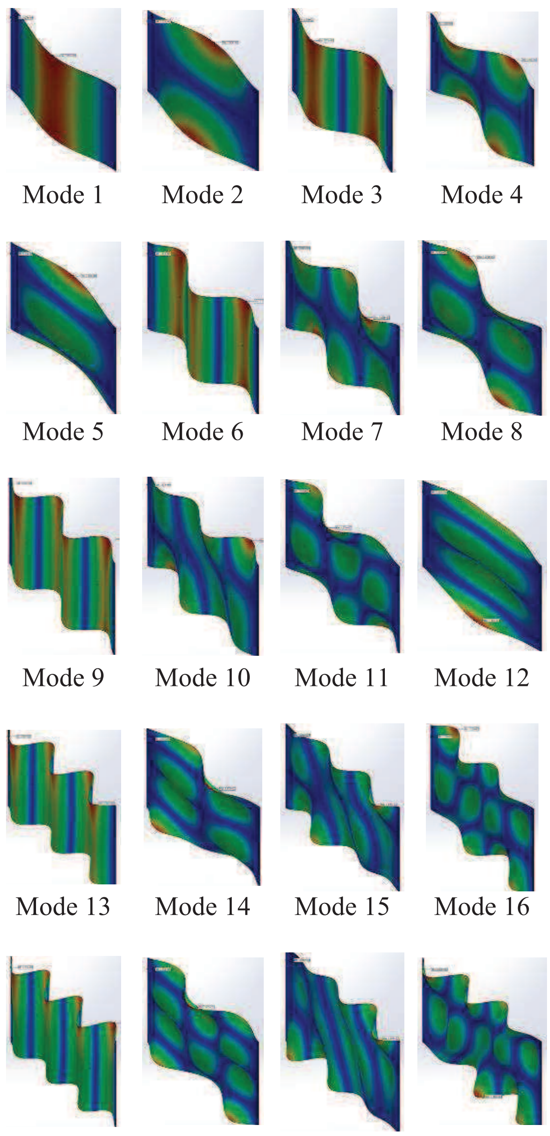



Figure 1 Vibration modes for clamped on width-free on length plate with 2 damages on longitudinal axis of 5x5 mm

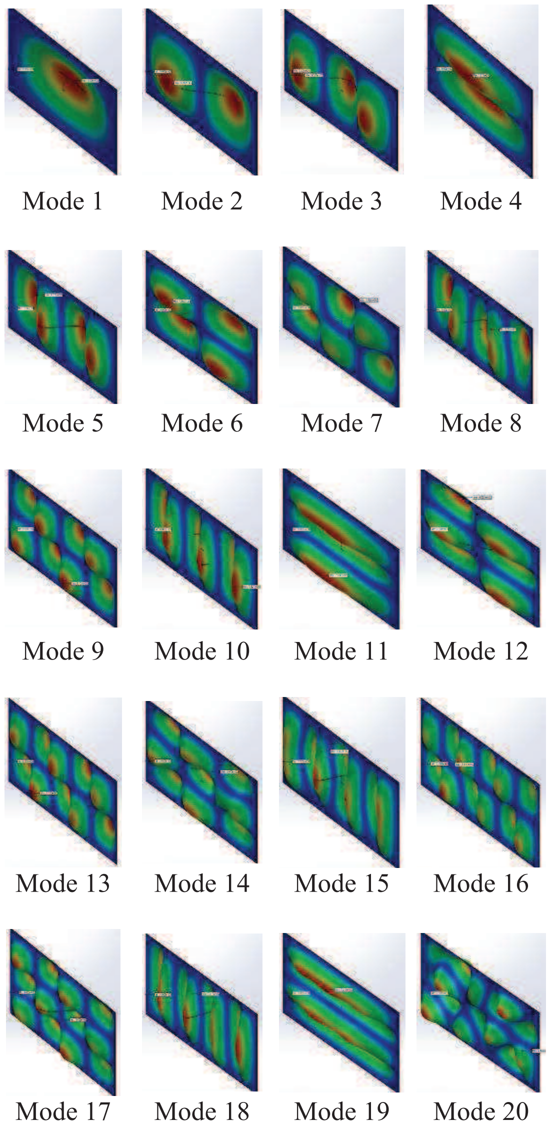



Figure 2 Vibration modes for clamped on width and length plate with 3 damages on the laterally side/center of 250x5 mm

Figures 3 and 4 shows the mesh and in Tables 2 and 3 are shows examples of values of the angular speed and values of the maximum displacement.

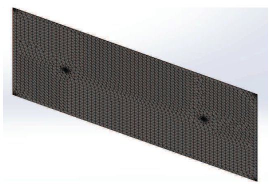


Figure 3 Mesh details for plates with 2 damages on longitudinal axis

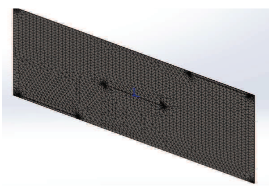


Figure 4 Mesh details for plates with 3 damages on laterally side/center

Table 2. Clamped plate on width-free on length with 2 damages on longitudinal axis of 5x5 mm

| Mode Number | Angular speed [rad/sec] | Maximum displacement [mm] | Node |
|---|---|---|---|
| M1 | 296.65 | 859.653 | 31955 |
| M2 | 396.99 | 831.782 | 14454 |
| M3 | 568.26 | 824.924 | 32957 |
| M4 | 780.95 | 821.609 | 11249 |
| M5 | 809.8 | 838.043 | 30252 |
| M6 | 917.3 | 788.348 | 3944 |
| M7 | 1106.4 | 988.463 | 6160 |
| M8 | 1128.9 | 939.338 | 26534 |
| M9 | 1367.3 | 928.591 | 23279 |
| M10 | 1504.8 | 866.287 | 11286 |
| M11 | 1511.3 | 871.398 | 11522 |
| M12 | 1676.3 | 1065.5 | 22065 |
| M13 | 1716.7 | 1011.45 | 29251 |
| M14 | 1916.8 | 901.207 | 26742 |
| M15 | 1948.5 | 904.276 | 26064 |
| M16 | 2094.9 | 1031.13 | 30932 |
| M17 | 2246 | 924.125 | 26257 |
| M18 | 2448 | 969.932 | 12551 |
| M19 | 2507.5 | 908.222 | 24485 |
| M20 | 2555.6 | 1035.49 | 24500 |

Table 3. Clamped on width and length plate with 3 damages on the laterally side/center of 250x5 mm

| Mode Number | Angular speed [rad/sec] | Maximum displacement [mm] | Node |
|---|---|---|---|
| M1 | 299.95 | 860.36 | 6141 |
| M2 | 396.7 | 829.905 | 2760 |
| M3 | 568.8 | 815.701 | 5054 |
| M4 | 793.02 | 787.041 | 9657 |
| M5 | 811.6 | 803.48 | 15558 |
| M6 | 909.07 | 784.89 | 17016 |
| M7 | 1116.5 | 899.552 | 19981 |
| M8 | 1126.1 | 828.528 | 3394 |
| M9 | 1408 | 812.354 | 25597 |
| M10 | 1500.5 | 782.725 | 21417 |
| M11 | 1543.3 | 756.369 | 19258 |
| M12 | 1673.2 | 803.485 | 8355 |
| M13 | 1772.5 | 811.99 | 17910 |
| M14 | 1928 | 897.039 | 31546 |
| M15 | 1946.2 | 844.224 | 16640 |
| M16 | 2211.1 | 889.452 | 14956 |
| M17 | 2309.4 | 863.271 | 9212 |
| M18 | 2456.7 | 791.676 | 8786 |
| M19 | 2576.3 | 724.072 | 19748 |
| M20 | 2698.1 | 966.127 | 3931 |

The results obtained for natural frequency are shown in Tables 4÷7 and in graphical form in Figures 5 and 6, where was used the notation A (for clamped plate on width-free on length), B (for clamped plate on width-simply supported on length) and C (for clamped plate on width and length).

Table. 4 Natural frequencies for plate with 2 damages on longitudinal axis of 5x5 mm

| Mode | A | B | C |
|---|---|---|---|
| M1 | 10.426 | 26.266 | 47.214 |
| M2 | 17.503 | 46.274 | 63.184 |
| M3 | 28.894 | 76.528 | 90.442 |
| M4 | 40.626 | 82.574 | 124.29 |
| M5 | 52.75 | 105.24 | 128.88 |
| M6 | 57.052 | 117.02 | 145.99 |
| M7 | 72.225 | 138.79 | 176.09 |
| M8 | 79.931 | 167.42 | 179.66 |
| M9 | 95.064 | 177.36 | 217.61 |
| M10 | 112.26 | 183.13 | 239.5 |
| M11 | 119.29 | 205.1 | 240.53 |
| M12 | 127.74 | 227.21 | 266.79 |
| M13 | 143.3 | 236.06 | 273.22 |
| M14 | 158.6 | 246.23 | 305.06 |
| M15 | 161.59 | 290.49 | 310.11 |
| M16 | 170.5 | 297.51 | 333.42 |
| M17 | 201.66 | 309.88 | 357.46 |
| M18 | 203.2 | 314.62 | 389.61 |
| M19 | 221.32 | 349.94 | 399.08 |
| M20 | 231.78 | 359.15 | 406.74 |

Table. 5 Natural frequency for plate with 2 damages on longitudinal axis of 250x5 mm

| Mode | A | B | C |
|---|---|---|---|
| M1 | 10.438 | 26.672 | 47.861 |
| M2 | 17.861 | 47.382 | 64.614 |
| M3 | 28.962 | 78.812 | 93.795 |
| M4 | 41.637 | 84.104 | 126.72 |
| M5 | 53.79 | 108.9 | 134.18 |
| M6 | 57.341 | 120.52 | 149.51 |
| M7 | 74.409 | 148.14 | 186.17 |
| M8 | 82.979 | 173.11 | 187.7 |
| M9 | 95.606 | 180.84 | 234.67 |
| M10 | 117.72 | 196.46 | 245.36 |
| M11 | 125.72 | 211.65 | 250.28 |
| M12 | 130.43 | 236.49 | 275.35 |
| M13 | 144.5 | 257.98 | 295.53 |
| M14 | 165.18 | 265.05 | 325.04 |
| M15 | 171.05 | 310.57 | 329.64 |
| M16 | 180.06 | 321.57 | 367.07 |
| M17 | 203.79 | 323.15 | 386.16 |
| M18 | 219.36 | 329.92 | 409.57 |
| M19 | 236.05 | 361.15 | 413.96 |
| M20 | 246.14 | 397.59 | 448.19 |

Table. 6 Natural frequency for plate with 3 damages on laterally side/center of 5x5 mm

| Mode | A | B | C |
|---|---|---|---|
| M1 | 10.407 | 26.63 | 47.624 |
| M2 | 17.758 | 47.023 | 64.062 |
| M3 | 28.836 | 77.253 | 91.798 |
| M4 | 41.599 | 82.999 | 124.84 |
| M5 | 54.106 | 107.65 | 130.43 |
| M6 | 56.901 | 117.16 | 148.03 |
| M7 | 74.683 | 144.93 | 179.87 |
| M8 | 83.629 | 166.67 | 184.71 |
| M9 | 94.639 | 178.52 | 232.81 |
| M10 | 117.85 | 193.69 | 238.89 |
| M11 | 124.6 | 209.71 | 241.29 |
| M12 | 129.12 | 226.21 | 272.98 |
| M13 | 142.36 | 254.74 | 295.97 |
| M14 | 164.82 | 255.51 | 308.34 |
| M15 | 171.87 | 296.04 | 320.39 |
| M16 | 176.57 | 313.88 | 368.67 |
| M17 | 200.35 | 317.38 | 383.86 |
| M18 | 216.02 | 328.15 | 389.23 |
| M19 | 237.04 | 354.75 | 397.68 |
| M20 | 238.72 | 375.96 | 439.5 |

Table. 7 Natural frequency for plate with 3 damages on laterally side/center of 250x5 mm

| Mode | A | B | C |
|---|---|---|---|
| M1 | 10.415 | 26.504 | 47.738 |
| M2 | 17.601 | 46.464 | 63.137 |
| M3 | 28.842 | 76.654 | 90.528 |
| M4 | 41.059 | 83.266 | 126.21 |
| M5 | 53.719 | 105.02 | 129.17 |
| M6 | 56.944 | 116.72 | 144.68 |
| M7 | 73.541 | 140.07 | 177.69 |
| M8 | 81.484 | 166.73 | 179.23 |
| M9 | 94.736 | 180.37 | 224.09 |
| M10 | 115.15 | 187.23 | 238.82 |
| M11 | 121.25 | 204.29 | 245.63 |
| M12 | 129.95 | 226.85 | 266.3 |
| M13 | 142.61 | 244.77 | 282.1 |
| M14 | 160.07 | 245.62 | 306.85 |
| M15 | 167.68 | 297.35 | 309.75 |
| M16 | 172.52 | 305.24 | 351.91 |
| M17 | 200.75 | 315.59 | 367.56 |
| M18 | 207.23 | 321.91 | 390.99 |
| M19 | 230.16 | 347.18 | 410.03 |
| M20 | 236.06 | 372.87 | 429.42 |

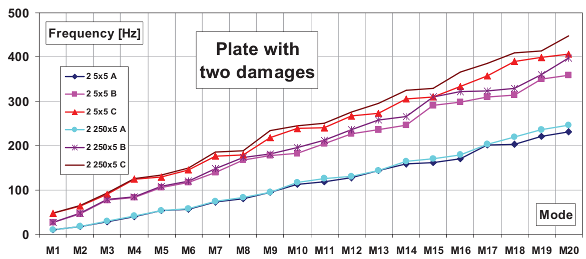



Figure 5 Natural frequencies for plates with 2 damages

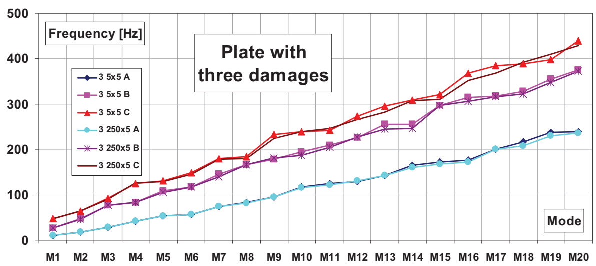



Figure 6 Natural frequencies for plates with 3 damages

In Figures 5 and 6, the note shall be construed as follows:

- 2 and 3 is the number of damages in plates;
- 5x5 and 250x5 are the size of damages in mm;
- with A, B and C were noted the plates for the 3 type of clamped.

## 4. CONCLUSIONS

From the frequency studies, the following conclusions can be made:

No matters of the imposed clamped type, the plates in case with 2 and in case with 3 damages have the same total number of nodes and elements;

The lowest values of natural frequency characterized the clamped on width-free on length plate and the highest values characterized the clamped on width and length plate and the natural frequency for analyzed plates tend to progressively increase from the vibration mode 1 to the vibration mode 20;

From the graphics shown in Figures 5 and 6, it's observed a grouping of plates curves with 2 and 3 damages of 5x5 mm and 250x5 mm in the clamped on width-free on length cases, respective in the clamped on width-simply supported on length and clamped on width and length;

For plates with 3 damages shown in Figure 6, can be observed a clear grouping of two by two curves namely: clamped on width-free on length, clamped on width-simply supported on length, respective clamped on width and length for damages of 5x5 mm and 250x5 mm, which means that the size of defects required very little influence the increasing of frequency;

## 5. ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Managing Authority for Sectoral Operational Programme for Human Resources Development (MASOPHRD), within the Romanian Ministry of Labour, Family and Equal Opportunities by co-financing the project "Investment in Research-innovation-development for the future (DocInvest)" ID 76813.

## 6. REFERENCES

[1] Monfared, A.H., *Numerical simulation of welding distortion in thin plates*, Journal of Engineering Physics and Thermophysics, Vol. 85, No. 1, January, 2012

[2] Hațiegan, C., Gillich, G.R., Răduca, M., Răduca, E., Budai, A.M., Muntean, F., *Finite Element Analysis of Natural Frequencies and Mass Participation Coefficients for Thin Plates With Defects*, Scientific Bulletin of "Politehnica" University of Timisoara, vol. 57 (71) 2, 2012

[3] Hațiegan, C., Gillich, R.G., Răduca, E., Nedeloni, M.D., Cîndea, L., *Equation of Motion and Determining the Vibration Mode Shapes of a Rectangular Thin Plate Simply Supported on Contour Using MATLAB*, Analele Universității Eftimie Murgu din Reşița, anul XX, 2013

[4] Nedeloni, M.D., Nedelcu, D., *Variants of sonotrode for a vibratory apparatus for test cavitation erosion by the indirect method*, Constanta Maritime University Annals, Vol.17, Year XIII, July 2012

[5] Gillich, G.R., Praisach, Z.I., Onchis-Moaca, D., Gillich, N., *How to Correlate Vibration Measurements with FEM Results to Locate Damages in Beams*, Proceedings of the 4th WSEAS International Conference on Finite Differences-Finite Elements-Finite Volumes-Boundary Elements (F-and-B '11), Paris, 2011

[6] Gillich, G.R., Praisach, Z.I., *Robust method to Robust method to identify damages in beams based on frequency shift analysis*, SPIE Smart Structures and Materials & Nondestructive Evaluation and Health Monitoring, San Diego, CL, USA, March 2012

[7] Praisach, Z.I., Minda, P.F., Gillich, G.R., Minda, A.A., *Relative Frequency Shift Curves Fitting Using FEM Modal Analyses*, Proceedings of the 4th WSEAS International Conference on Finite Differences-Finite Elements-Finite Volumes-Boundary Elements (F-and-B '11), Paris, 2011

# THE INFLUENCE OF SHELL'S SHAPE IN SHIP DESIGN

[1]NECHITA MANUELA, [2]MOCANU COSTEL-IULIAN, [3]POPESCU GABRIEL

[1,2,3]*"Dunarea de Jos" University of Galati, Romania*

**ABSTRACT**

The paper presents a study on shell-metal casing in order to improve the ship design process for respecting the International Maritime Organization (IMO) regulation. A ship, as a multifunctional marine structure on the sea, has structural vibration that may affect both the comfort of the crew and the life of the environment's fauna. An experimental modal analysis is made. The results from diagrams show that the decreasing of curvature is favourable in increasing natural frequency of the shell metal plate. This phenomenon allows avoiding the resonance of the shell during the machine running.

**Keywords:** Green Policy, hull design, impact, modal analysis, shape

## 1. INTRODUCTION

Ship structural vibration and damage problems are gradually getting more attention during ship design and construction [12]. Beside waves and winds excitation, the propeller and main machine influence the shipboard habitability. Improving standards of passenger's comfort on board demands to naval architects for finding new cruise ship designing approach [4]. The underwater - radiated noise by the ships became the stronger challenge that needed to be technically solved. New directives that shall affect the Shipbuilding Industry are given for reducing the environmental impact of vessels in order to respect the new EU's "Green Policy" and IMO regulation [3]. A series of ship's noise measurements was done in 2011 on the basis of a co-operation of several NATO nations [9]. Shipbuilding industry is moving ahead to reduce the impact of the new ships.

Vessels are elastic systems under periodic forces that come from different sources. The intensity or magnitude of the excitation forces, the stiffness of the structure and the dynamic amplification at different frequencies due to resonance phenomena are the main parameters that define the vibration levels obtained in the vessel. Different sources of disturbance that affect the comfort on board for passengers and the crew are shown in Figure 1.

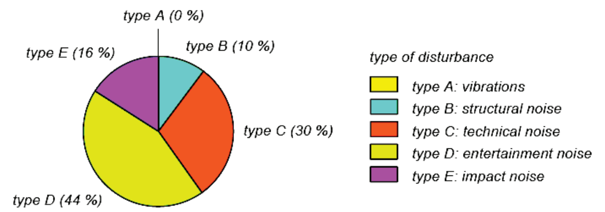



Figure 1 Different influence of the sources of disturbance [8]

Researcher Biot M. shows in his paper [4] that the source of higher disturbance is the hull response to the first propeller harmonic with the problematic frequency range between 0 and 20 Hz. The propeller cavitation is associated with medium and high frequencies, between 20 Hz and 65 Hz. Very low frequencies, up to 2 Hz. for hull girder's mode, are considered from habitability point of view, connected only with sea waves in calm water [5], even if in open sea, the waves are main disturbances for surface vessels [13]. Only the global ship free vibrations are discussed because the dynamic analysis results establish if the ship hull girder can occur special phenomena as: springing, whipping or other interferences at the shipboard [7].

The ship hull vibrations have influence also on environment as presented in Figure 2. Water, as an excellent medium for sound transmission, allows sound to travel almost five times faster through sea water than through air (about 1500 vs. 300 m/s), and low frequencies can travel hundreds of kilometer with little loss in energy, thereby enabling long distance [13, 11].

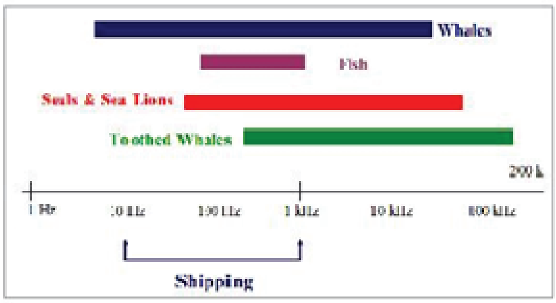



Figure 2 Typical frequency sound bands produced by marine mammals (and fish) compared with the nominal low-frequency sounds associated with commercial shipping [after OSPAR 2009]

From an elastic-acoustic point of view, the hull becomes a wave radiator to the water due to the acceleration induced on it by the action of the main mechanical excitation sources and to the propeller [3]. For this reason is necessary to reduce the vibrational energy transmitted to the hull by the main machinery and by the propeller.

The participants to Convention on the biological diversity held at Monreal in 2012 asked the following:

"Currently, and based on these experimental data, the message to the Shipbuilding Industry is clear: The abatement of the URN (underwater radiate noise) signature of the "new vessels" will require a preventive control of the sources and actions focused on reducing the vibration energy transmission from the main mechanical sources, as the main machinery, to the hull"[13]. In order to answer to this message, in designing ship hull is necessary to consider the information from Figure 3 that referred to the URN contributors.

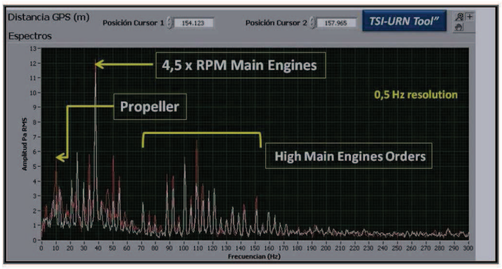



Figure 3 Narrow band analyses for accurate identification of URN contributors [13]

Some researches are already done for diminishing URN. At the end of August 2011 the Fishing Research Vessel (FRV) "Ramón Margalef", which is considered one of the *"most silent"* vessels of all the European Fleet, was delivered to the IEO- Spanish Oceanographic Institute [3].

Technological advances in vessel propulsion and design have resulted in a noisier underwater realm [13]. Most of the acoustic field surrounding large vessels is the result of propeller cavitation (when vacuum bubbles created by the motion of propellers collapse), causing ships at their service speed to emit low-frequency tonal sounds and (high-frequency) noise spectra up to tens of kHz quite close to vessels [13]. Also amounts of radiated noise can arise from on-board machinery (engine room and auxiliary equipment).

Minimizing the excitation forces of the system and avoiding flexible structures from a dynamic point of view are recommended as possible action that could be implemented to keep control on vibration levels. Avoiding the coincidence of structural frequencies with excitation frequencies is also necessary.

Some researches on the geometries presented in this paper are already done. The influence of the shell's shape on displacement of the plate [2] and on dumping process, as in Table 1 [8], are studied.

The ratio between the area models, $A_2$ and $A_1$ , measured in longitudinal sections, is used to analyse the influence of the shape on the dumping process, described by $\Delta$ , logarithmic decrement.

Table 1 The influence of curvature perturbation on logarithmic decrement

| Test | $A_2/A_1$ [8] | AB/ g | $\Delta_2/\Delta_1$ [8] |
|---|---|---|---|
| 1 | 1.045 | 4.28 | 2.202855 |
| 2 | 1.045 | 4.28 | 1.882789 |

Because the shape analysis is an important subject, both in hull and propeller design, this paper deals with the influence of the shape on the natural frequency of the shell plate.

Figure 4 presents the model that simulates the physical process of our experiment.

The equation 1 [6] is used for describing this process.

$$m\frac{d^2y}{dt^2} + c\frac{dy}{dt} + ky = f(t) \qquad (1)$$

Elements of equation are:

- mass, m;
- elastic constant, k;
- dump coefficient, c.

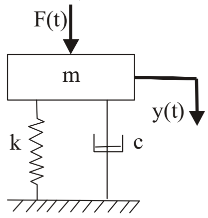



Figure 4 Liniar dump system with one degree of freedom

The real structure are analysed considering modal analyses that allow generalization of Eq. 1 to more freedom degrees system. It is known that the points of this system have harmonic displacements, in phase, during eigen mode motion, which is the single synchronized harmonic movement. [6]. We are interested in finding magnitude values because lower frequencies are studied. The maximum magnitude gives information for short time impact as used in our experiment.

Fouries serie is used for determining the natural frequencies values. The results show that strain energy stored during impact process is more influenced by geometry plates than frequency values.

Study of natural frequencies value is needed because the response in frequency acts as a complex amplifier in resonance phenomenon.

The modal analysis presented in this paper allows controlling the shape in order to diminish the noise on the board in according with ship design rules.

## 2. EXPERIMENT

Modal analysis is the study of the dynamic properties of structures under vibrational excitation. In our study it was done with, one excitation point, the response being measured at 16 other points. Two models with different geometry and the same thickness, g=3 mm, as presented in Figure 5, are used. Two tests have been done for each model.

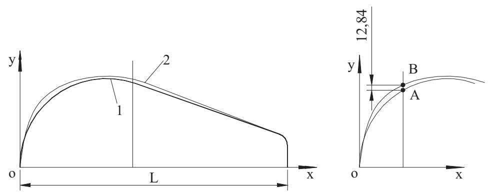



Figure 5 Axial sections of the models, 1and 2

Modal analysis needs information both excitation and the responses. These experimental data are obtained during experiment made on the stand shown in Figure 6. It contains: models of steel mounted in a rigid support, an iron ball, and equipment to measure excitations and responses data. An accelerometer is used at the iron ball launching to determine the excitation.

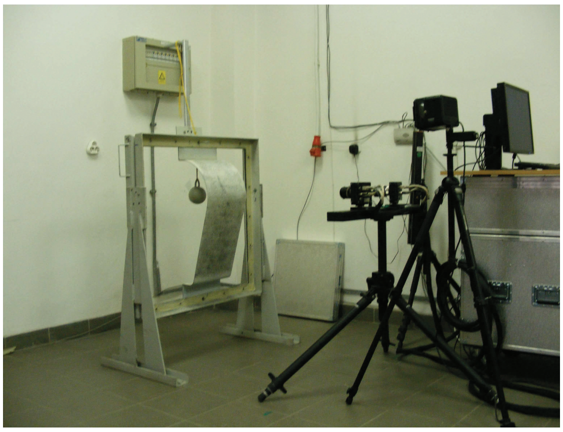


Figure 6 Aramis HS GOM Equipment [2]

The force of impact was 1950 N and the dynamic responses are picked by Aramis HS GOM equipment, during 1.6 seconds on 800 stages.

The experimental data given by Aramis HS GOM equipment are used in Matlab9 programming soft to process data for calculating natural frequency values.

## 3. RESULTS AND DISCUSSION

The displacements of the analysed points are presented, as a dynamic response, in Figure 7, Figure 8, Figure 9 and Figure 10. Only data, for a period of 1.024 seconds corresponding to 512 stages ($2^9$), are used for getting natural frequency values. The first and the second natural frequencies are observed in Figure 11 and Figure 13 for each model and test.

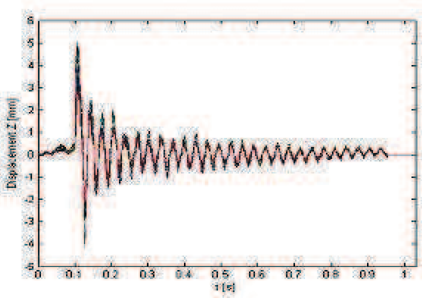



Figure 7 Dynamic response of the model 1structure test 1

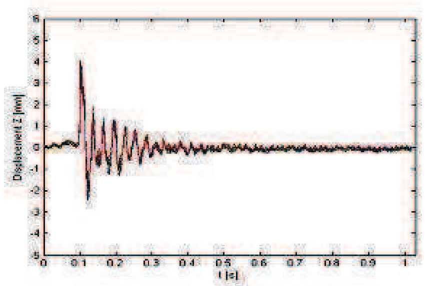



Figure 8 Dynamic response of the model 2 structure test 1

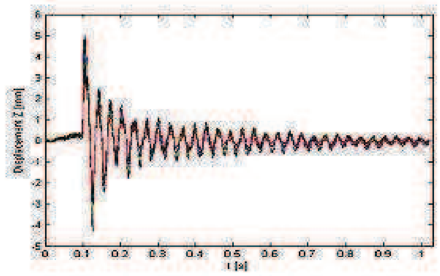



Figure 9 Dynamic response of the model 1 structure test 2

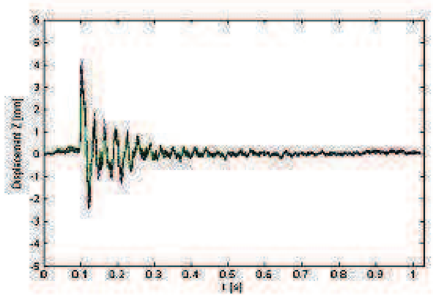



Figure 10 Dynamic response of the model 2 structure test 2

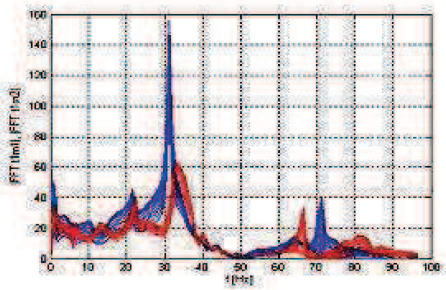



Figure 11 Compared analysis of dynamic response of the model's structures, test 1

For better visualization detailed views are given in Figure 12 and Figure 14.

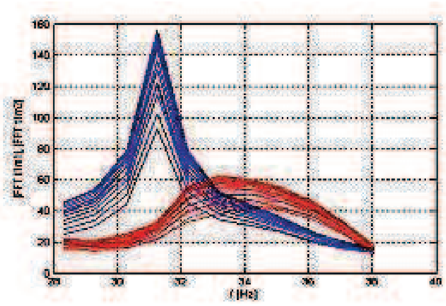



Figure 12 Compared analysis of dynamic response of the model's structures, test 1-detail

In all diagrams frequencies and magnitudes are presented on X-axis, respectively Y-axis. The magnitudes are calculated as a modulus of Fourier function transform, FFT, and give a measure of signal frequencies content.

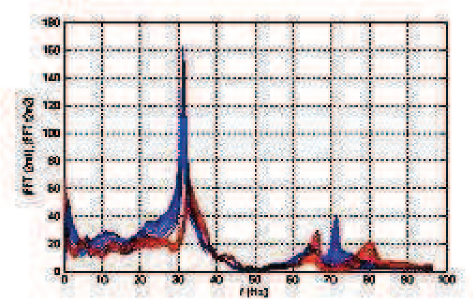


Figure 13 Compared analysis of dynamic response of the model's structures, test 2

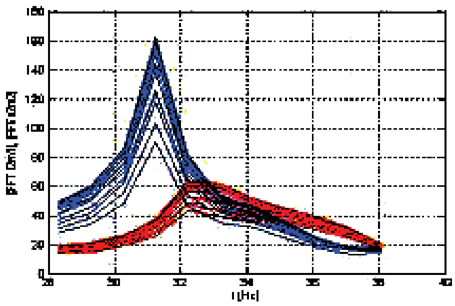


Figure 14 Compared analysis of dynamic response of the model's structures, test 2-detail

It is observed that in the both experiments the natural frequencies of model 2 are greater than frequencies corresponding to model 1, for each test. In Table 2 the frequency ratio is proportional with area ratio.

Considering experimental data as displacements of an elastic linear system [6] was calculated strain energy stored during impact process for the impact point on both models during test 2. The ratio of energy $E_2/ E_1$ is 0.4933. A small decreasing of curvature has an influence on diminishing the strain energy stored during impact process. In order to keep small deformations and high frequency stiff structure are generally wanted. If the same structure is intended to resist accidental actions a more ductile design with high-energy dissipation capability may be preferable [1].

Table 2 The influence of curvature perturbation on the structure response

| Test | $A_2/ A_1$ [8] | $\Delta_2/ \Delta_1$ [8] | $d_2/d_1$ [2] | AB/ g | $f_2/f_1$ |
|---|---|---|---|---|---|
| 1 | 1.045 | 2.202855 | 0.798 | 4.28 | 1.064 |
| 2 | 1.045 | 1.882789 | 0.842 | 4.28 | 1.032 |

## 4. CONCLUSIONS

Decreasing of curvature has a „positive" influnce on vibration mode by increasing natural frequency values. Generally, motor ships have small angular resonant frequencies, the resonance phenomenon being possible only for motors with great ones.

The results of the tests show that diminishing the flexibility structure decrease the strain energy stored during an impact loads with respect to avoid resonance phenomenon.

It is observed that designing the optimal shape claims multicriterial perspecive that have to be solved in future works.

## 5. REFERENCES


[1] ALSOS, H. S., AMDAHL, J., *On the resistance to penetration of stiffened plates, Part I- Experiments*, Journal of Impact Engineering, 2008, pp. 799-807

[2] BALAN, M., LAVRENTE, D., NECHITA, M., MUSCALU, A., MOCANU, C. I., *The plate shape influence over the stress variation under the impact loads*, Proceedings of ModTech International Conference - New face of TMCR, ModTech Publishing House, Volume 2, Sinaia, Romania, 2012, pp.69-72

[3] BELTRÁN, P., DIAZ, J.I., SALINAS, R., *Achievement of the new underwater-radiated noise requirements by the Spanish shipbuilding industry. The FRV "Ramón Margalef*, Proceedings of The 11th POMA - ECUA 2012, vol.17, 2012, available at: ISSN1939-800X

[4] BIOT, M., *Noise and vibration on board cruise ships: are new standard seffective?* In Proceedings of 2th ICMRT'07, Ischia, Italy, 2007, pp. 93-100

[5] BIOT, M., *Criteria for Designing Noise and Vibration Comfort of Passengers on Board of Ships*

[6] BUZDUGAN, G., FETCU, L., RADES, M., *Mechanical vibrations*, 1982 (in Romanian)

[7] DOMNISORU, L., *Structural analysis and hidroelasticity of ships,* The University Foundation "Dunarea de Jos" Publishing House, Galati, 2006, pp.261- 303

[8] NECHITA, M., NICOLAU, V, TEODOR, R.F., *Metalic plate behaviour under impact loads*: submitted to Scientific Bulletin of the "Politehnica" University of Timisoara, Transactions on Hydrotechnics, Tom 57(71), Fascicola 1, 2013

[9] NEJEDL, V., STOLTENBERG, A., SCHULZ, J., *Free-field measurements of the radiated and structure borne sound of RV "Planet",* Proceedings of The 11th POMA – ECUA, vol. 17, 2012, available at: ISSN1939-800X

[10] NICOLAU, V., POPA, R., MIHOLCA, C., *Spectral density correction of a signal at frequency variable transformation*, The Annals of "Dunarea de Jos" University of Galati, Fascicle III- Electrotechnics, Electronics, Automatic Control, Informatics, ISSN 1221-454x, pp.43-48, 2006

[11] URICK, R.J., *Principles of Underwater Sound*, McGraw-Hill Co, New York, 1983

[12] XU, J.C., HONG, M., CUI, H.Y., *The contrast experimental study on operational modal analysis of ship structural model*, Applied Mechanics and Materials, Vol.226-228, pp.241-246, 2012, Available at: www.scientific.net

[13] ***, *Scientific synthesis on the impacts of underwater noise on marine and coastal biodiversity and habitats, Convention on the biological diversity, Monreal,* 2012

# RESEARCH REGARDING THE CAVITATION EROSION RESISTANCE OF THE STAINLESS STEEL WITH 13% Cr AND 4% Ni USED TO MANUFACTURE THE COMPONENTS OF KAPLAN, FRANCIS AND PELTON HYDRAULIC TURBINES

[1]NEDELONI MARIAN-DUMITRU, [2]NEDELCU DORIAN, [3]CAMPIAN VIOREL-CONSTANTIN, [4]CHIRUS DANIEL, [5]AVASILOAIE RAOUL-CRISTIAN,[6] DANUT FLOREA

*[1,2,3,4,5,6]„Eftimie Murgu” University of Resita, Romania*

**ABSTRACT**

The paper presents the experimental results on testing the cavitation erosion resistance of 2 batch types of the X3CrNi13-4 martensitic stainless steel used to manufacture the components of hydraulic turbines. The experimental research was performed through the stationary specimen method on the cavitation stand of CCHAPT research center from „Eftimie Murgu” University of Resita. The experimental obtained results are shown in tables and graphs regarding the reproduction of the mass loss and cavitation erosion rate function of time curves.

**Keywords:** *cavitation erosion, martensitic stainless steel, micro-/macrostructure.*

## 1. INTRODUCTION

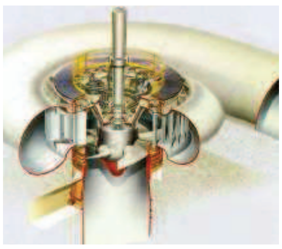
The hydraulic turbines of the hydropower plant structure, are working in the so-called admissible cavitation [1].

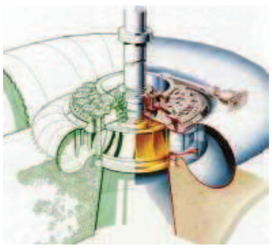
Cavitation is a physical phenomenon that occurs inside the liquid while moving. In time it causes damages through cavitation of the metallic materials used to manufacture the hydraulic turbines, pumps or marine propellers [2].

The most commonly used materials to manufacture hydraulic turbines are stainless steels, because they have a good resistance against the cavitation erosion [3, 4, 5].

For the manufacture of Kaplan, Francis and Pelton hydraulic turbines components (like in Fig. 1) is used also the martensitic stainless steel with 13% Cr and 4% Ni for the following [6]:

- guide vanes and runner for Kaplan turbines;
- guide vanes, runner and labyrinth seals for Francis turbines;
- nozzle and runner for Pelton turbines.


a) Kaplan turbines


b) Francis turbines

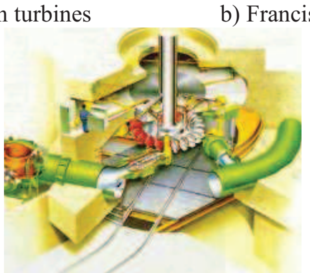

c) Pelton turbines

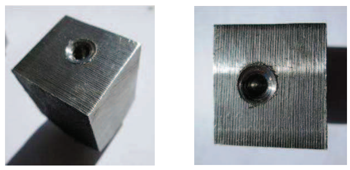
Figure 1 Types of hydraulic turbines according with [6]

The components most affected by cavitation erosion are the runner blades for Kaplan and Francis turbines and for the Pelton turbines are the nozzles.

## 2. THE WORK PROCEDURE

From the runner blades of a hydraulic turbine from a hydropower plant in Romania, were taken two different batches of specimens of the X3CrNi13-4 martensitic stainless steel.

The images of the two specimens are shown in Figure 2, noted as batch number 1 and batch number 2.


a) Batch number 1: X3CrNi13-4 (1)

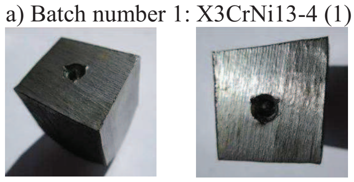

b) Batch number 2: X3CrNi13-4 (2)

Figure 2 Images of the specimens

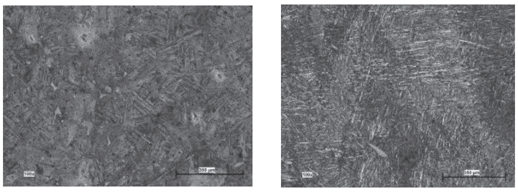
Table 1 shows the chemical composition of the X3CrNi13-4 martensitic stainless steel specimens.

Table 1. The specimens chemical composition [%]

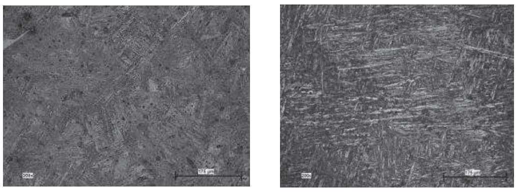
| | | | | | |
|---|---|---|---|---|---|
| a) Batch: X3CrNi 13-4 (1) | C | Si | Mn | P | S |
| | 0,07 | 0,41 | 0,56 | 0,027 | 0,014 |
| | Cu | Ni | Cr | Mo | Fe |
| | 0,16 | 5,17 | 11,15 | 0,35 | 82,08 |
| b) Batch: X3CrNi 13-4 (2) | C | Si | Mn | P | S |
| | 0,06 | 0,43 | 0,42 | 0,015 | 0,009 |
| | Cu | Ni | Cr | Mo | Fe |
| | 0,07 | 3,81 | 12,5 | 0,32 | 82,36 |

From the two specimens, two samples were made in cylindrical form of Φ16 x 10 mm.

Figure 3 shows the microstructure of the 2 batches at 100X and 200X increase before the cavitation, images taken with a metallographic optical microscope.



The increase of 100X



The increase of 200X

a) Batch X3CrNi13-4 (1) b) Batch X3CrNi13-4 (2)

Figure 3 The microstructure of the batches

The cavitation tests were prepared through the stationary specimen method according to the standards and the total cumulated time for each sample subjected to cavitation erosion was 1080 minutes or 18 hours.

This total cumulated time was divided into 36 time periods of 30 minutes, and after each time period by means of a digital balance, the mass of samples and also the loss of eroded material was measured.

## 3. EXPERIMENTAL RESULTS

From the experimental results were drawn the characteristic cavitation process curves, ie the material loss and cavitation erosion rate versus time curves with the help of XlXtrFun.xll module for the derived calculus which has the dydx (abscissae area - $X_i$, ordered area - $Y_i$, derived abscissa) function [7].

### 3.1 *Sample X3CrNi13-4 (1)*

Table 2 shows the obtained values for the sample X3CrNi13-4 (1) - batch 1 and figures 4 and 5 shows the graphs for eroded mass and cavitation erosion rate versus time curves.

Table 2. The values for X3CrNi13-4 (1)

| Cumulated time | Sample mass | Cum. eroded mass | Cavitation erosion rate |
|---|---|---|---|
| t [min] | m [mg] | $m_c$ [mg] | $v_{ec}$ [mg/h] |
| 0 | 15007.36 | 0 | 0.000 |
| 30 | 15007.16 | 0.2 | 0.260 |
| 60 | 15007.1 | 0.26 | 0.120 |
| 90 | 15007.04 | 0.32 | 0.250 |
| 120 | 15006.85 | 0.51 | 0.770 |
| 150 | 15006.27 | 1.09 | 1.710 |
| 180 | 15005.14 | 2.22 | 2.750 |
| 210 | 15003.52 | 3.84 | 4.030 |
| 240 | 15001.11 | 6.25 | 4.600 |
| 270 | 14998.92 | 8.44 | 4.840 |
| 300 | 14996.27 | 11.09 | 5.080 |
| 330 | 14993.84 | 13.52 | 5.010 |
| 360 | 14991.26 | 16.1 | 5.030 |
| 390 | 14988.81 | 18.55 | 5.280 |
| 420 | 14985.98 | 21.38 | 5.280 |
| 450 | 14983.53 | 23.83 | 5.100 |
| 480 | 14980.88 | 26.48 | 5.180 |
| 510 | 14978.35 | 29.01 | 5.270 |
| 540 | 14975.61 | 31.75 | 5.160 |
| 570 | 14973.19 | 34.17 | 5.300 |
| 600 | 14970.31 | 37.05 | 5.440 |
| 630 | 14967.75 | 39.61 | 5.160 |
| 660 | 14965.15 | 42.21 | 5.240 |
| 690 | 14962.51 | 44.85 | 5.090 |
| 720 | 14960.06 | 47.3 | 5.160 |
| 750 | 14957.35 | 50.01 | 5.220 |
| 780 | 14954.84 | 52.52 | 5.300 |
| 810 | 14952.05 | 55.31 | 5.290 |
| 840 | 14949.55 | 57.81 | 5.300 |
| 870 | 14946.75 | 60.61 | 5.290 |
| 900 | 14944.26 | 63.1 | 4.970 |
| 930 | 14941.78 | 65.58 | 5.350 |
| 960 | 14938.91 | 68.45 | 5.260 |
| 990 | 14936.52 | 70.84 | 5.370 |
| 1020 | 14933.54 | 73.82 | 5.470 |
| 1050 | 14931.05 | 76.31 | 5.240 |
| 1080 | 14928.3 | 79.06 | 5.760 |

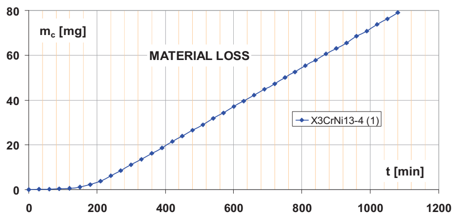



Figure 4 Material loss curve for X3CrNi13-4(1)

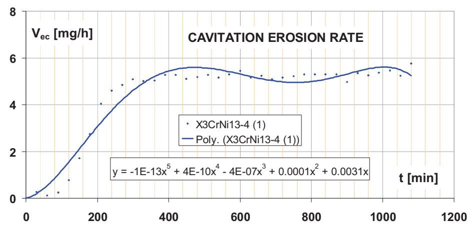



Figure 5 Cavitation erosion rate curve - X3CrNi13-4(1)

### *3.2 Sample X3CrNi13-4 (2)*

In Table 3 are presented the obtained values for the sample X3CrNi13-4 (2) - batch 2.

Table 3. The values for X3CrNi13-4 (2)

| Cumulated time | Sample mass | Cum. eroded mass | Cavitation erosion rate |
|---|---|---|---|
| t [min] | m [mg] | $m_c$ [mg] | $v_{ec}$ [mg/h] |
| 0 | 14759.45 | 0 | 0.000 |
| 30 | 14759.41 | 0.04 | 0.110 |
| 60 | 14759.34 | 0.11 | 0.160 |
| 90 | 14759.25 | 0.2 | 0.490 |
| 120 | 14758.85 | 0.6 | 1.210 |
| 150 | 14758.04 | 1.41 | 2.480 |
| 180 | 14756.37 | 3.08 | 3.740 |
| 210 | 14754.3 | 5.15 | 4.740 |
| 240 | 14751.63 | 7.82 | 5.370 |
| 270 | 14748.93 | 10.52 | 5.750 |
| 300 | 14745.88 | 13.57 | 5.780 |
| 330 | 14743.15 | 16.3 | 5.700 |
| 360 | 14740.18 | 19.27 | 5.790 |
| 390 | 14737.36 | 22.09 | 5.970 |
| 420 | 14734.21 | 25.24 | 6.040 |
| 450 | 14731.32 | 28.13 | 5.880 |
| 480 | 14728.33 | 31.12 | 5.770 |
| 510 | 14725.55 | 33.9 | 5.830 |
| 540 | 14722.5 | 36.95 | 6.260 |
| 570 | 14719.29 | 40.16 | 6.160 |
| 600 | 14716.34 | 43.11 | 6.010 |
| 630 | 14713.28 | 46.17 | 5.860 |
| 660 | 14710.48 | 48.97 | 5.920 |
| 690 | 14707.36 | 52.09 | 5.990 |
| 720 | 14704.49 | 54.96 | 6.100 |
| 750 | 14701.26 | 58.19 | 6.200 |
| 780 | 14698.29 | 61.16 | 6.210 |
| 810 | 14695.05 | 64.4 | 6.270 |
| 840 | 14692.02 | 67.43 | 6.180 |
| 870 | 14688.87 | 70.58 | 6.040 |
| 900 | 14685.98 | 73.47 | 6.070 |
| 930 | 14682.8 | 76.65 | 6.050 |
| 960 | 14679.93 | 79.52 | 5.920 |
| 990 | 14676.88 | 82.57 | 5.900 |
| 1020 | 14674.03 | 85.42 | 6.070 |
| 1050 | 14670.81 | 88.64 | 6.250 |
| 1080 | 14667.78 | 91.67 | 5.870 |

Figures 6 and 7 present the graphs for eroded mass and cavitation erosion rate versus time curves according with the values obtained in Table 3.

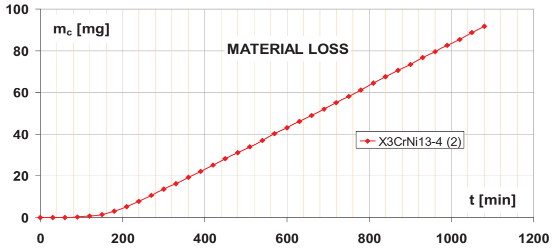



Figure 6 Material loss curve for X3CrNi13-4 (2)

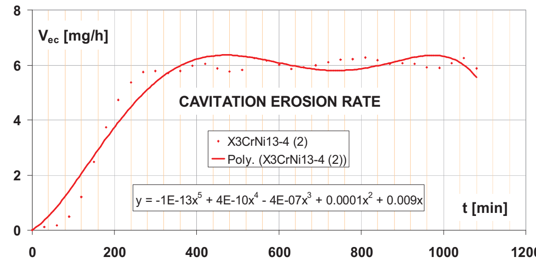



Figure 7 Cavitation erosion rate curve (experimental and analytical) for X3CrNi13-4 (2)

### *3.3 Comparative study between the analysed samples*

Table 4 shows a comparison between value obtained for the 2 samples after the tests for the minimum and maximum eroded mass on period and cumulated, as well for the cavitation erosion rate.

Table 4. Minimum and maximum obtained value

| Batch type | Value of eroded mass [mg] | | Value of cavitation erosion rate | |
|---|---|---|---|---|
| | Period | Cumulated | [mg/min] | [mg/h] |
| Batch 1 | 0.06 | 0.2 | 0.0020 | 0.120 |
| Batch 2 | 0.04 | 0.04 | 0.0018 | 0.110 |
| Minimum value | | | | |
| Batch 1 | 2.98 | 79.06 | 0.0960 | 5.760 |
| Batch 2 | 3.24 | 91.67 | 0.1045 | 6.270 |
| Maximum value | | | | |

The analytical curves from Figures 5 and 7, were interpolated resulting the polynomial equation 1 (with standard deviation $R^2$ = 0.9547) and equation 2 (with standard deviation $R^2$ = 0.9528).

$$v_{ec} = -1 \cdot 10^{-13} \cdot t^5 + 4 \cdot 10^{-10} \cdot t^4 - 4 \cdot 10^{-7} \cdot t^3 + + 0.0001 \cdot t^2 + 0.0031 \cdot t \tag{1}$$

$$v_{ec} = -1 \cdot 10^{-13} \cdot t^5 + 4 \cdot 10^{-10} \cdot t^4 - 4 \cdot 10^{-7} \cdot t^3 + + 0.0001 \cdot t^2 + 0.009 \cdot t \tag{2}$$

Figures 8 and 9 present a comparison between the two batches of the material loss and cavitation erosion rate versus time curves, where the upper curve is characteristic for batch 2 and the lower curve is characteristic for batch 1.

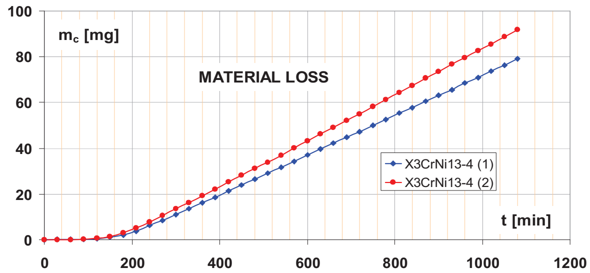



Figure 8 Comparison between the material loss curves for X3CrNi13-4 (1) and X3CrNi13-4 (2)

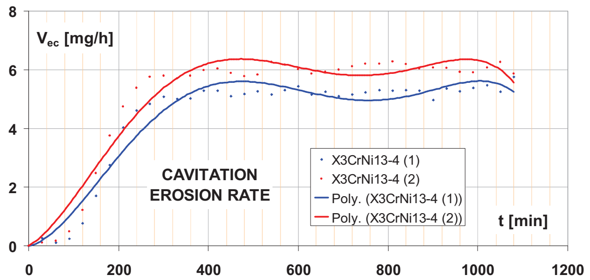
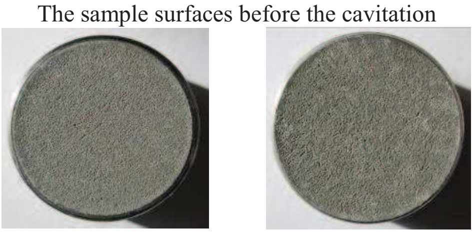


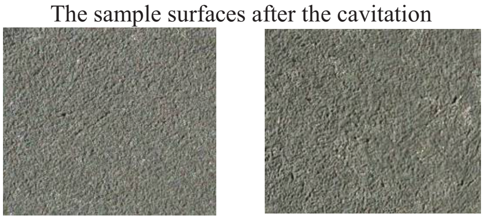

Figure 9 Comparison between the cavitation erosion rate curves for X3CrNi13-4 (1) and X3CrNi13-4 (2)

Figure 10 shows images of surfaces of the two samples before and after the cavitation.

The sample surfaces before the cavitation



The sample surfaces after the cavitation



The macrostructure of sample eroded surfaces

a) Batch X3CrNi13-4 (1) b) Batch X3CrNi13-4 (2)

Figure 10 The surfaces of the samples before and after the cavitation

## 4. CONCLUSIONS

The following conclusions can be made:

- both curves according to Figures 8 and 9 are similary having the same form, since both samples are from the same X3CrNi13-4 material;
- for the sample 1, the total loss of eroded material was 79.06 mg and for the sample 2, the total loss of eroded material was 91.67 mg, which means that the batch 1 is more resistance than the batch 2, but both batches have a low resistance to the erosion through cavitation, comparative with other materials; the cavitation erosion rate confirm this difference;
- from the sample surfaces images after cavitation, there is a difference between the 2 batches, regarding their cavitation resistance, the difference being due to different proportions of chemical elements values, such as Mn, Cu, Ni and Mo in growth, and Cr and Fe decreasing, that favored cavitation erosion resistance.

## 5. ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of the Managing Authority for Sectoral Operational Programme for Human Resources Development (MASOPHRD), within the Romanian Ministry of Labour, Family and Equal Opportunities by co-financing the project "Investment in Research-innovation-development for the future (DocInvest)" ID 76813.

## 6. REFERENCES

[1] Anton, I., *Cavitația (The Cavitation)*, vol. I, Editura Academiei Republicii Socialiste România, Bucureşti, 1984

[2] Bordeaşu, I., *Eroziunea cavitațională a materialelor (Cavitation erosion of materials)*, Editura Politehnica, Timişoara, 2006

[3] Bordeasu, I., Popoviciu, M.O., Balasoiu, V., *Studiul eroziunii prin cavitație a unui oțel martensitic folosit în turnarea rotoarelor de turbine hidraulice (Cavitation erosion study of a martensitic steel used in casting of the hydraulic turbines impeller)*, A patra conferinta a hidroenergeticienilor din Romania - Dorin Pavel, 2006

[4] Ciubotariu, R., Şerban, V.A., Frunzăverde, D. Mărginean, G., Câmpian, V., *Comparative study regarding the repair techniques for protection against cavitation,* Scientific Bulletin of the "Politehnica" University of Timisoara Transactions on Mechanics, vol. 55 (69), Spec. Iss. S1, Timişoara, 2010

[5] Cojocaru, V., Câmpian, C.V., Micloşină, C.O., *Experimental Analysis of Residual Stresses in Samples of Austenitic Stainless Steel Welded on Martensitic Stainless Steel Used for Kaplan Blades Repairs,* ANALELE UNIVERSITĂȚII "EFTIMIE MURGU", ANUL XVIII, NR. 1, Reşița, 2011

[6] www.ivt.ntnu.no/ept/fag/tep4200/innhold

[7] Nedeloni, M.D., *Cercetari privind eroziunea cavitationala pe materiale utilizate la fabricatia componentelor de turbine hidraulice (Research regarding the cavitation erosion on materials used to manufacture the components of hydraulic turbines)*, Ph.D. thesis, „Eftimie Murgu" University of Resita, December 2012

# THE TEMPERATURE FIELD OF THE EXHAUST VALVE AT A SLOW SHIP'S ENGINE

OMOCEA ION

*Constanta Maritime University, Romania*

**ABSTRACT**

This paper is made to determine the temperature field in the exhaust's valve periodical action of burnt gases and to the contact with the valve seat.

The exhaust valve of a slow ship's engine with parallel flow ablution is submitted to variable thermal applications, as during an engine cycle, it heats up from the burning gases and it cools through the contact with the valve seat. The valve seat gives in at it's turn the heat of the water from the cooling circuit of the engine.

In order to determine the deformations to which the exhaust valve is subjected, deformations that may influence the tightness of the burning room, it is necessary for us to determine the temperature distribution.

Knowing the temperature distribution, depending on the known parameters, we can determine the thermal state of the valve in different functioning regimes of the ship's engine.

The equations that describe the temperature field in the valve are the differential non-linear equations with partial derivative.

**Keywords:** *heat transfer, conductivity, ship, engine, burning room.*

## 1. INTRODUCTION

Knowing the temperature distribution, depending on the known parameters, we can determine the thermal state of the valve in different functioning regimes of the ship's engine. The equations that describe the temperature field in the valve are the differential non-linear equations with partial derivative.

## 2. THE SCHEME OF THE HEAT EXCHANGE

The valve has been split in five areas.

According to figure 1 the balance equation is.

$$Q_1 + Q_2 + Q_3 + Q_4 + Q_5 = 0\,[W] \tag{1}$$

with:

$$Q_1 = \int_0^{\tau_0} \alpha_{t1} S_1 (t_g - t_1)\, d\tau \quad [W] \tag{2}$$

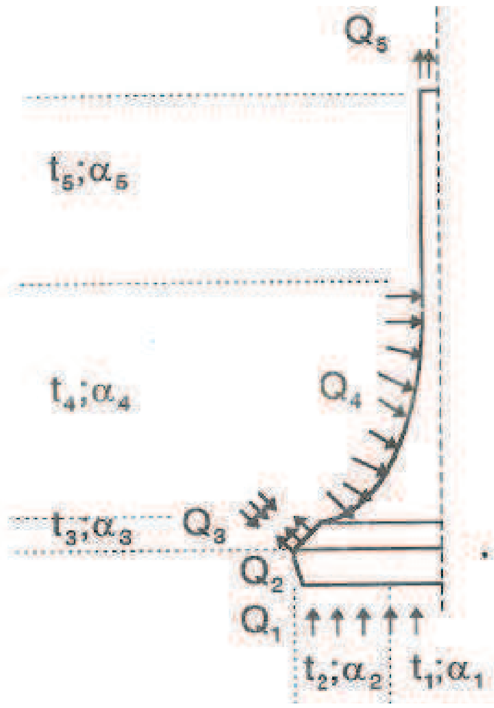



Figure 1 The scheme of the heat transfer

$$Q_2 = \int_0^{\tau_1} k_2 S_2 (t_{se} - t_a)\, d\tau \quad [W] \tag{3}$$

$$Q_3 = \int_0^{\tau_2} \alpha_3 S_3 (t_g - t_{se})\, d\tau \quad [W] \tag{4}$$

$$Q_4 = \int_0^{\tau_2} \alpha_4 S_4 (t_g - t_r)\, d\tau \quad [W] \tag{5}$$

$$Q_5 = k_5 S_5 (t_t - t_a) \tau_0 \quad [W] \tag{6}$$

where:

$\alpha_{t1}$ – thermal convection coefficient of the burning gases at the inferior valve of the cup, [W/m$^2$grd]
$S_1$ – the inferior valve of heat exchange of the cup, [m$^2$]
$t_g$ – the temperature of the cylinder gases, [$^o$C]
$t_1$ – the temperature of the inferior surface of the cup, [$^o$C]
$\tau_0$ – the duration of the work cycle, [s]
$k_2$ – global coefficient of heat transfer from the valve's cup to the cooling water, [W/m$^2$grd]
$S_2$ – the surface of tightness of the valve, [m$^2$]
$t_{se}$ – the temperature of the tightness surface, [$^o$C]
$t_a$ – the temperature of the water from the cylinder cotter, [$^o$C]
$\tau_1$ – the duration of the valve's closure, [s]
$\alpha_3$ – thermal convection coefficient of the gases at the drag, [W/m$^2$grd]
$S_3$ – the tightness surface of the valve, [m$^2$]
$\tau_2$ – the duration of the valve opening, [s]
$\alpha_4$ – the coefficient of thermal convection of the gases at the drag, [W/m$^2$grd]
$S_4$ – the drag surface, [m$^2$]
$t_r$ – the temperature in the area of drag, [$^o$C]
$k_5$ – global coefficient of heat transfer from the valve's plug to the cooling water, [W/m$^2$grd]
$S_5$ – the cooling surface of the piston's plug, [m$^2$]
$t_t$ - the temperature of the valve's plug, [$^o$C]

## 3. THE DETERMINATION OF THE HEAT TRANSFER COEFFICIENTS

The calculation relations used to determine the coefficients, in the case of the exhaust valve of a slow ship's engine with parallel flow ablution are:

$\alpha_{t1}$ for compression

$$Nu = 5{,}5\, p_e^{0{,}5} \tag{7}$$

$\alpha_{t1}$ for expansion

$$Nu = 3{,}35\, p_e^{0{,}5} (1 + 0{,}027\, k_b) \tag{8}$$

with

$$k_b = \frac{A_p}{\rho w^2} \tag{9}$$

$$A_p = \frac{dp}{d\varphi} 6n \frac{1}{4} \tau_{osc} \quad \left[\frac{N}{m^2}\right] \tag{10}$$

$$\tau_{osc} = 2{,}3 \frac{D}{c} \quad [s] \tag{11}$$

$$c = \sqrt{kRT} \tag{12}$$

where:

$A_p$ – pressure amplitude corresponding to 1/4 from the period of oscillation of the gases from the cylinder
$\tau_{osc}$ - the period of oscillation of the pressure of the gases from the cylinder
D – the cylinder's diameter
c – the speed of sound
$k_2$ – is determined with the proportion:

$$k_2 = \left[ d_{t1} \left( \frac{1}{\alpha_{ct}(\tau) d_{t1}} + \frac{1}{2\lambda_{ch}} \ln \frac{d_{ech}}{d_{t1}} + \frac{1}{\alpha_a d_{ech}} \right) \right]^{-1} \quad \left[\frac{W}{m^2 grd}\right] \tag{13}$$

with:

$$\lg Nu_{ct} = n \lg \frac{p_\phi}{\sigma_c} + \lg c \tag{14}$$

$$Nu_{ct} = \frac{\alpha_{ct} \delta_g}{\lambda_g} \tag{15}$$

where:

$\alpha_{ct}$ ($\tau$) – coefficient of heat transfer at the contact between the valve and the cylinder cover, [W/m$^2$grd]
$p_\phi$ – the contact pressure of the valve, [N/m$^2$]
$\lambda_{ch}$ – the thermal conductivity coefficient at the contact between the valve and the cylinder cover, [W/m grd]
$\sigma_c$ – the flow limit of the material, [N/m$^2$]
$\lambda_g$ – the coefficient of thermal conductivity of the gas between the cup and the valve's seat, [W/m grd]
$\delta_g$ – the thickness of the layer of gas, [m]
$\alpha_a$ – convection coefficient of the cooling water from the cylinder cover, [W/m$^2$ grd]
$\alpha_3$ and $\alpha_4$ are being determined with the criterial proportion:

$$Nu = 0{,}0377\, Re^{0{,}8}\, Pr^{0{,}43} \tag{16}$$

with

$$Re = \frac{w_g d_{ech}}{\nu} \tag{17}$$

where:

$w_g$ – the speed of the exhaust gases
$d_{ech}$ – the equivalent diameter
$\nu$– kinematic tack
$k_5$ – is being determined with the proportion:

$$k_5 = \left[ d_e \left( \frac{1}{\alpha_{tg} d_1} + \frac{1}{2\lambda_g} \ln \frac{d_e}{d_1} + \frac{1}{\alpha_{gc} d_e} + \right. \right. \tag{18}$$

$$\left. \left. + \frac{1}{2\lambda_u} \ln \frac{d_u}{d_e} + \frac{1}{\alpha_a d_a} \right) \right]^{-1} \quad \left[ \frac{W}{m^2 grd} \right]$$

with

$$\alpha_{gc} = \frac{\lambda_{ul}}{\Delta} \quad \left[ \frac{W}{m^2 grd} \right] \tag{19}$$

$$\alpha_{gc} = \frac{2\lambda_{air}}{h_1 + h_2} + 2{,}1 \frac{p\bar{\lambda}_m}{3\sigma_c l_g} 10^4 \quad \left[ \frac{W}{m^2 grd} \right] \tag{20}$$

$$\bar{\lambda}_m = \frac{2\lambda_{m1}\lambda_{m2}}{\lambda_{m1} + \lambda_{m2}} \quad \left[ \frac{W}{m\, grd} \right] \tag{21}$$

where:

$d_i$ – the exponent's inner diameter, [m]
$d_e$ – the exponent's outer diameter, [m]
$\alpha_{tg}$ – the heat's transfer coefficient at the contact between the plug and the exponent, [W/m$^2$grd]
$\lambda_g$ – the thermal conductivity coefficient of the exponent valve, [W/m grd]
$\alpha_{gc}$ – the coefficient of heat transfer from the exponent to the cylinder cover, [W/m$^2$grd]
$\lambda_u$ – the coefficient of thermal conductivity of the oil, [W/m grd]
$\alpha_a$ – the thermal convection coefficient of the water in the area of the exponent, [W/m$^2$grd]
$\Delta$ – the radial game plug-exponent, [m]
$h_1$ – the highs of the exponent's asperities, [m]
$h_2$ – the highs of the cylinder cover asperities, [m]
$l_g$ – the length of the valve exponent, [m]
$\lambda_{m1}$ – the thermal conductivity coefficient of the exponent's material, [W/m grd]
$\lambda_{m2}$ – the thermal conductivity coefficient of the material of the cylinder cover, [W/m grd]

## 4. CONCLUSIONS

Thus knowing the manner of heat transfer and the temperatures of the parts, we can determine the deflections that occur in the valve.

With these deflections we can evaluate the functioning regime at which the leakiness of the burning room may appear.

## 5. REFERENCES

[1] POPA, B., MĂDĂRĂSAN, T., *Thermal demands in the building of cars*. The technical publishing house.
[2] HAMBURGER, L., *Introduction in the heat's propagation theory*. The technical publishing house.
[3] DAVIDESCU, A., MUCICA, M., *The heat transfer in the industrial pluming*. The technical publishing house
[4] RADCENCO, V., MARINESCU, M., *Heat and aggregation transfer*. The technical publishing house

# THE MODELING OF THE CYCLE OF THE COMPRESSION IGNITION ENGINE ON THE GROUNDS OF THE EXERGETIC METHOD OF THERMODYNAMIC ANALISYS

OMOCEA ION

*Constanta Maritime University, Romania*

**ABSTRACT**

The actual development stage of the know how has imposed the necessity to use new methods of investigation to determine with a higher accuracy the factors that lead to the optimal solutions. In this context, the actual text is dealing with the study of the cycle of functioning of an engine on the ground of thermodynamic analysis of the causes, things, gravities, and effects of the functional processes irreversibility, in particular, of the compression ignition engine.

**Keywords:** *engine, compression, irreversibility, processes, exergy.*

## 1. INTRODUCTION

The actual development stage of the know how, characterized among others through the tendency to realize equipments with better and better performances that can be exploited in optimal conditions, has imposed the necessity to use new methods of investigation and of calculation, to determine with a higher accuracy the factors that lead to the optimal solutions.

In this context, the actual text is dealing with the study of the cycle of functioning of an engine on the ground of thermodynamic analysis of the causes, things, gravities, and effects of the functional processes irreversibility, in particular, of the compression ignition engine.

## 2. THE ACCAUNT OF THE LOSSES CAUZED BY THE IREVESIBILITY OF THE FUNCTIONAL PROCESSES OF THE COMPRESSION IGNITION ENGINE

In order to specify this account one uses the representation in diagram T – s of the evolution of a kilo of thermal agent through the Diesel engine cylinder as shown in figure 1.

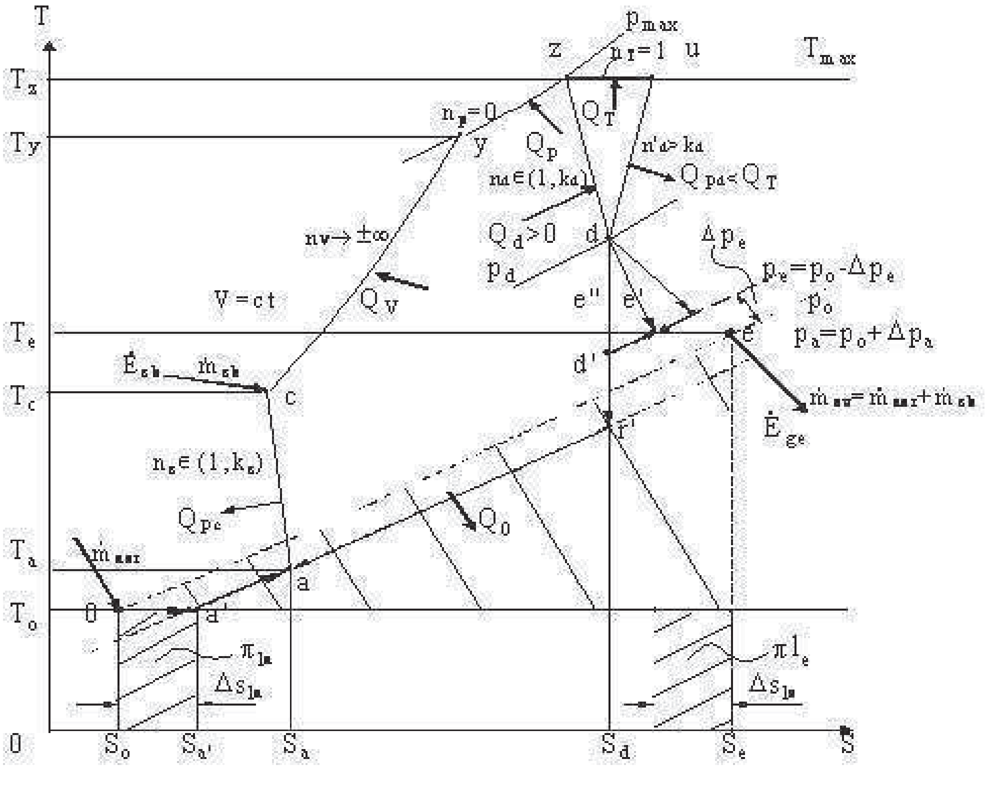



Figure 1 Representation of the Diesel engine cycle in the T – S coordinates

The represented processes, some conventionally, in this diagram are the following:

- lamination O – a' of the air at the passage through the section of the inlet valve in which the pressure diminishes from $p_0$ to $p_a = p_0 - \Delta p_a$;
- the heating a' – a determined, mainly, by the influence of residual gases burnt with state r';
- compression a – c from $p_a$ to $p_c$ in which the enthalpy of the fresh load diminishes, as follows from the heat concession $Q_{pe}$ towards the cylinder's walls thus $n_c<k_c$;
- the isochore heating c – y fallowed by the isobar one y – z that define the visible burning; in the post-burning process z – u considered isothermal meaning $T_u = T_z = T_{max}$ pressure diminishes to $p_z = p_{max}$ to $p_u$;
- the detente u – d is accompanied by the enthalpy's diminishing, as a consequence of heat concession $Q_{pd}< Q_r$ towards the cylinder's walls thus $n'_a > k_a$;
- the combining of the processes z – u and u – d leads to global detente characterized through $n_d < k_d$ as the heat received by the burning products is $Q_d = Q_r – Q_{pd}$;
- during the burning process c – y – z – u, a part of the heat developed through the burning of fuel $Q_{cb}$ is evacuated through the walls of the burning room $Q_{par}$ towards the cooling liquid;
- free evacuation d – d' from $p_d$ to $p_c = p_0 + \Delta p_c$ theoretically considered adiabatic reversible in the cylinder but irreversible d – e' in the evacuation conduct; after the forced evacuation, through the mixing of the two quantities of gases of different temperatures state c'' comes out, having temperature $T_c$. After lamination e'' – e at the passage of the burning products through the section of the exhaust valve pressure diminishes from $p_e$ to $p_0$ the temperature of these produces considered perfect gases is remaining constant;
- in the expansion process r(d') – r' considered reversible the gases temperature decreases from $T_d'=T_r$ up to $T_r$; through combining state r' of the gases with state a' a of the air after lamination the state a a of the fresh load comes up.

The analysis that has been undertaken has as base a simplifying hypothesis that is that according to which the development of the inlet and exhaust processes takes place in adiabatic but irreversible conditions.

The hypothesis is justified through the followed purpose that is the one to allow a simpler calculation of the entropy's production caused by the irreversibility of the two processes in the maximum power regimes, respectively, of maximum economy at the functioning of the engine.

Also the states 0 ($p_0$, $T_0$) and z ($p_{max}$, $T_{max}$) have been fixed, among which the functional processes from which it's cycle is made of, are developing.

On the ground of the mentioned hypothesis the components of the exergetic balance of the cycle that has at it's base it's general equation have been fixed:

$$\sum E_Q = \Delta E + \sum L_t + \sum \Pi ir_{int} \quad (1)$$

Without further details, the terms that intervene have the fallowing meanings:

$$\begin{aligned}\sum E_Q &= E^{-}_{Qp_c} + E^{-}_{Qp_{ar}} + E^{+}_{Q_d} = \\ &= -\Pi_{Qp_c} - \Pi_{Qp_{ar}} + E_{Qd}\end{aligned} \quad (2)$$

they represent the sum of the exergies of the ceded heats by the thermal agent in the compression processes $E_{Qpc}$ and of burning $E_{Qpar}$ while $E_{Qd}$ is stating the heat's exergy taken by the agent during the detente z – d as fallows from the heat $Q_r$ received and $Q_{pd}$ ceded;

$$\Delta E = E_{g_e} - \left(E_{aer} + E_{cb}\right) \quad (3)$$

it is the variation of the exergy of the agent between the exhaust sections of the burning produces and of the inlet of the air and of the injected fuel;

$$\sum L_t = L_i \quad (4)$$

it defines the indicated mechanical labor of the cycle, that has come up from the summation i]of the mechanical things (technical) of the processes that compose this cycle:

$$\sum \Pi_{ir_{int}} = \Pi_{ir_a} + \Pi_{ir_{ar}} + \Pi_{ir_e} \quad (5)$$

it determines the sum of the losses provoked by the inner irreversibility of the inlet, exhaust and burning processes.

These terms given the exergetic balance proportion becomes:

$$\begin{aligned}&E_{cb} + E_{Q_d} = L_i + \Pi_{Q_0} + \Pi_{Qp_c} + \\ &+ \Pi_{Qp_{ar}} + \Pi_{ir_a} + \Pi_{ir_{ar}} + \Pi_{ir_e}\end{aligned} \quad (6)$$

where $\Pi_{Q_0} = E_{g_e} - E_{aer}$ represent the exergy loss due to the difference between the evacuation temperature $T_c$ of the burning produces and that of the atmospheric air $T_0$ both having the pressure $p_0$.

For the simplification of the calculation program one can assume that:

$Q_p^- = Q_r^+$ thus $Q_d = 0$ and so $n_d = k_d$ thus $E_{Qd} = 0$.

Thus it implies that:

$$E_{cb} = L_i + \sum_{j=1}^{3} \Pi_{ir_{ext}} + \sum_{j=1}^{3} \Pi_{ir_{int}} \quad (7)$$

where:

$$\sum_{j=1}^{3}\Pi_{ir_{ext}} = \Pi_{Qp_c} + \Pi_{Qp_{ar}} + \Pi_{Q_0};$$

$$\sum_{j=1}^{3}\Pi_{ir_{int}} = \Pi_{ir_a} + \Pi_{ir_{ar}} + \Pi_{ir_e} \tag{8}$$

define the sum of the losses caused by external irreversibility, respectively, internal of the cycle thus:

$$E_{cb} = m_{cb}E_0 = L_i + \sum_{j=1}^{6}\Pi_{ir_{i,e}} \tag{9}$$

where $\sum\Pi_{ir_{i,e}}$ determine the sum of the two losses categories.

The degree of thermodynamic perfection of the cycle is expressed by the exergetic yield defined in the shape of:

$$\eta_{ex_i} = \frac{L_i}{E_{cb}} = \frac{L_i}{m_{cb}E_0} = \frac{P_i}{\dot{m}_{cb}E_0} = 1 - \frac{\sum\Pi_{ir_{i,e}}}{E_{cb}} \tag{10}$$

One the other hand, the classical thermal yield of it is determined through the proportion:

$$\eta_i = \frac{L_i}{Q_{cb}} = \frac{L_i}{m_{cb}H_i} = \frac{P}{\dot{m}_{cb}H_i} = \eta_{ex_i}\frac{E_0}{H_i} \tag{11}$$

Because, as it was underlined in the introduction, $H_i < E_0$ it implies that $n_i > n_{ex\ j}$; for liquid fuels of diesel oil type $E_0 = H_g > H_i$ it implies that:

$$\eta_i = \eta_{ex\,i}\frac{H_s}{H_i} > \eta_{ex\,i} \tag{12}$$

Indifferent from the used criteria for the assessment of the engine's economicity, in a last case scenario, the magnitude that allows the definition of it's economicity is the specific indicated fuel consumption meaning:

$$c_i = \frac{m_{cb}}{L_i} = \frac{\dot{m}_{cb}}{P_i} = \frac{3{,}6\cdot 10^3}{\eta_i H_i} = \frac{3{,}6\cdot 10^3}{\eta_{ex_i}E_0} \tag{13}$$

As follows, because the classical energetic study method of the cycle of the thermal engines uses on a large scale the notion of indicated thermal yield it is rational that as well in the exogeric analysis method to use in a conventional manner, in quality of reference level the magnitude $Q_{ch}$ instead of $E_{ch}$.

In this way the introduction in the energetic study method of the consequences of the second principle of thermodynamics with reference to the effects of irreversibility of the functioning processes of the inner ignition engine become possible.

With this observation meaning $E_0 = H_i$, <u>in a conventional manner</u>, one can define an energetic-exergetic balance under the form of:

$$Q_{cb} = m_{cb}H_i = L_i + \sum\Pi_{ir_{i,e}}$$

Through reporting at $Q_{ch}$ implies:

$$\eta_i = \frac{L_i}{Q_{cb}} = 1 - \frac{\sum\Pi_{ir_{i,e}}}{Q_{cb}} = 1 - \sum\overline{\pi}_{i,e} \tag{14}$$

where $\sum\overline{\pi}_{i,e}$ represent the sum of the gravities caused by the irreversibility in the developed heat through the complete and perfect burning of the fuel and that conditions the level of $n_i$.

If the proportion of energetic-exergetic balance is reporting to $p_0\,V_s$ it implies:

$$\overline{p}_{mi} = \overline{q}_{cb} - \sum\overline{\pi}'_{i,e} \tag{15}$$

where $\sum\overline{\pi}'_{i,e}$ determines the sum of the losses gravities in the product $p_0V_s$ that conditions the level of $\overline{p}_{mi}$ and in which $\overline{q}_{cb} = C\frac{\eta_V}{\alpha}$; is obvious that:

$$\eta_i = \frac{\overline{p}_{mi}}{\overline{q}_{cb}} = 1 - \frac{\sum\overline{\pi}'_{i,e}}{\overline{q}_{cb}} \equiv 1 - \sum\overline{\pi}_{i,e} \tag{16}$$

The energetic-exergetic balance has been expressed on the ground of the flows meaning:

$$\dot{Q}_{cb} = \dot{m}_{cb}H_i = P_i + \sum\dot{\Pi}_{ir_{i,e}}\quad [W] \tag{17}$$

By means of reporting to $Kp_0\sqrt{RT_0}$ according to thermodynamics in an finite time it implies:

$$\overline{P}_i = \overline{Q}_{cb} - \sum\overline{\Pi}_{i,e} \tag{18}$$

where $\sum\overline{\Pi}_{i,e}$ represents the sum of the gravities of flows of losses caused by the irreversibility in $Kp_0\sqrt{RT_0}$ [W] and $\overline{Q}_{cb} = C\overline{K}_a\frac{\psi_a^{0,5}}{\alpha} = C\frac{\eta_V}{\alpha}\overline{n}$; in consequence:

$$\eta_i = \frac{\overline{P}_i}{\overline{Q}_{cb}} = 1 - \sum\frac{\overline{\Pi}_{i,e}}{\overline{Q}_{cb}} \equiv 1 - \sum\overline{\pi}_{i,e} \tag{19}$$

on the ground of the realized analysis the classical indicated yield can be expressed under the shape of:

$$\eta_i = \frac{L_i}{Q_{cb}} = \frac{L_i}{E_{Q_g}}\frac{E_{Q_g}}{Q_{cb}} = \eta_{ex_{cl}}\eta_{ex_{ar}} \qquad (20)$$

This means that $n_i$ can be seen as a produce between the exergetic yield of the real cycle that compares $L_i$ with the maximum work $E_{Qg}$ that might be obtained from heat $Q_g$ meaning $\eta_{excl}$ and that of burning $\eta_{exar}$ that compare this last one with the heat $Q_{ch}$ that reflects chemical exergy $E_{ch}$ of the fuel.

In the study the correlation between the energetic and the exergetic balance has been established under the shape of:

$$\overline{P}_i = \overline{Q}_g - \left|\overline{Q}_{cb}\right| \equiv \overline{Q}_{cb} - \sum \overline{\Pi}_{i,e} \qquad (21)$$

where $\overline{Q}_g = \eta_{ar}\overline{Q}_{cb}$ thus:

$$\overline{P}_i = \eta_{ar}\overline{Q}_{cb} - \left|\overline{Q}_0\right| \equiv \overline{Q}_{cb} - \sum \overline{\Pi}_{i,e} \qquad (22)$$

As fallows:

$$\left|\overline{Q}_0\right| = \sum \overline{\Pi}_{i,e} - (1-\eta_{ar})\overline{Q}_{cb} \qquad (23)$$

and if $\eta_{ar} = 1$ it implies that $\left|\overline{Q}_0\right| = \sum \overline{\Pi}_{i,e}$ .

## 3. THE CALCULATION OF THE LOSSES PROVOQUED BY THE IRREVERSIBILITY OF THE FUNCTIONAL PROCESSES OF THE CYCLE OF THE COMPRESSION IGNITION ENGINE

The expressions of the most important gravities of the losses caused by the inner and outer irreversibility of the MAC cycle have been established, them being for the inner ones:

- the loss provoked by the irreversibility of the lamination process at the air inlet in the cylinder:

$$\overline{\Pi}_{ir_a} = \overline{K}_a \psi_a^{0,5} \ln\frac{1}{1-\psi_a} = \eta_V \overline{n} \ln\frac{1}{1-\psi_a} \qquad (24)$$

- the loss caused by the irreversibility of the burning process:

$$\overline{\Pi}_{ir_{ar}} = \overline{K}_a \psi_a^{0,5}\left[\left(1+\frac{1}{\alpha L_0}\right) + \frac{1+\psi_e}{\eta_V}\frac{1}{\varepsilon-1}\frac{T_0}{T_r}\ln\lambda^{\frac{1}{k_V-1}}\rho^{\frac{k_p}{k_p-1}} + \frac{\eta_{ar}-\xi_z}{\tau}\frac{C}{\alpha}\right] \qquad (25)$$

where $\overline{K}_a \psi_a^{0,5} = \eta_V \overline{n}$ .

- the loss determined by the irreversibility of the evacuation process that includes the one of free evacuation, forced and lamination at the passage of the gases through the section of the evacuation valve:

$$\overline{\Pi}_{ir_e} = \overline{K}_a \psi_a^{0,5}\left(1+\frac{1}{\alpha L_0}\right)\ln\frac{p_d}{p_0}\left(\frac{T_e}{T_0}\frac{T_0}{T_d}\right)^{\frac{k_e}{k_e-1}} \qquad (26)$$

The exergetic yield of the burning has been defined as taking the shape of:

$$\eta_{ex_{ar}} = \frac{E_{Q_g}}{Q_{cb}} = \eta_{ar}\left(1-\frac{\overline{\Pi}_{ir_{ar}}}{\overline{Q}_g}\right) \qquad (27)$$

unde

$$\overline{Q}_g = C\eta_{ar}\frac{\overline{K}_a}{\alpha}\psi_a^{0,5}$$

As a fallows, the sum of the gravities of the losses caused by the inner irreversibility of the analyzed cycle is specified by:

$$\sum \overline{\Pi}_{ir_{int}} = \overline{\Pi}_{ir_a} + \overline{\Pi}_{ir_{ar}} + \overline{\Pi}_{ir_e} \qquad (28)$$

With reference to the outer losses one notices that:

- the loss with the heat's exergy ceded by the fresh load in the process of compression:

$$\overline{\Pi}_{Q_{p_c}} = \overline{K}_a \psi_a^{0,5}\frac{k_c-n_c}{(n_c-1)^2}\frac{1-\psi_a}{\eta_V}\,\varepsilon\frac{\varepsilon^{n_c-1}}{\varepsilon-1}\left(1-\frac{T_0}{T_a}\frac{\ln\varepsilon^{n_c-1}}{\varepsilon^{n_c}-1}\right) \qquad (29)$$

- the loss with the heat's exergy ceded by the gases to the walls of the burning room:

$$\overline{\Pi}_{Q_{p_{ar}}} = \overline{K}_a \psi_a^{0,5}(1-\eta_{ar})\frac{C}{\alpha}\left(1-\frac{T_0}{T_{m_{ar}}}\right) \qquad (30)$$

- the loss with the heat's exergy ceded by the burning produces to the surrounding environment:

$$\overline{\Pi}_{Q_0} = \overline{K}_a \psi_a^{0,5}\left(1+\frac{1}{\alpha L_0}\right)\frac{k_g}{k_g-1}\left(\frac{T_e}{T_0}-1\right)\left(1-\frac{\ln\frac{T_e}{T_0}}{\frac{T_e}{T_0}-1}\right) \qquad (31)$$

The mentioned conditions given, it implies the sum of the losses of the gravities due to the outer irreversibility of the cycle:

$$\sum \overline{\Pi}_{ir_{ext}} = \overline{\Pi}_{Q_{Pc}} + \overline{\Pi}_{Q_{Par}} + \overline{\Pi}_{Q_0} \qquad (32)$$

## 4. THE NUMERICAL ANALYSIS

In the given numerical example it has implied that the maximum power corresponds, in the case when $\overline{K}_a = 0,5$, to a relative diminishing coefficient of the inlet pressure $\psi_a = 0,3$.

There have been chosen and respectively the fallowing values of some parameters have come out:

$\varepsilon = 17$; $\pi = 70$; $\eta_{ar} = 0,9$; $\xi_Z = 0,78$; $T_a/T_0 = 1,1$; $\lambda=2,12$; $\rho = 1,237$; $\psi_e = 0,471$; $\psi = 0,476$; $T_r/T_0 = 3,474$; $\eta_v = 0,651$; $T_e/T_0 = 3,56$; $\overline{p}_{mi} = 6,782$; $\eta_i = 45,513$; $p_d/p_0 = 2,51$; $T_d/T_0 = 3,943$; $\overline{n} = 0,42$; $\overline{Q}_{cb} = 6$; $\overline{P}_i = 2,853$; $\overline{Q}_g = 5,406$; $|\overline{Q}_0| = 2,648$.

On the ground of the precedent relations the fallowing values of the gravities of the losses caused by the irreversibility based on thermodynamics in a finite time have come out:

$\overline{\Pi}_{ir_a} = 0,097$; $\overline{\pi}_{ir_a} = 1,617\%$; $\overline{\Pi}_{ir_{ar}} = 1,1285$; $\overline{\pi}_{ir_a} = 18,8\%$; $\overline{\Pi}_{ir_e} = 0.139$; $\overline{\pi}_{ir_e} = 2,317\%$; $\overline{\Pi}_{Q_0} = 4,782$; $\overline{\pi}_{Q_0} = 23,17\%$; $\overline{\Pi}_{Q_{Par}} = 0,474$; $\overline{\pi}_{Q_{Par}} = 7,9\%$; $\overline{\Pi}_{Q_{Pc}} = 0,041$; $\overline{\pi}_{Q_{Pc}} = 0,683\%$

It implies that: $\sum_{j=1}^{6} \overline{\pi}_{i,e} = 54,487\%$, $\eta_{ex_{ar}} = 71,2\%$, $\eta_{excl} = 66,7\%$, thus $\eta_i = 100 - 54,487 = 45,513\%$.

The energetic-exergetic balance of the cycle in maximum power circumstances is graphically represented in figure 2.

In the numerical example considered it has implied that the maximum saving corresponds, in the situation for $\overline{K}_a = 0,5$, to a $\psi_a = 0,1$. With that occasion the fallowing have turned out:

$\varepsilon = 17$; $\Pi = 70$; $\tau = 8$, $\eta_{ar}=0,9$; $\xi_Z = 0,78$): $\lambda = 1,65$; $\rho = 1,634$; $\psi_e = 0,119$; $\psi=0,8$; $T_r/T_0 = 3,23$; $\eta_V = 0,876$; $T_e/T_0 = 3,568$; $\overline{p}_{mi} = 10,255$; $\alpha = 1,515$; $\eta_i = 47,412$; $p_d/p_0 = 3,57$; $T_d/T_0 = 4,25$; $\overline{n} = 0,18$; $\overline{Q}_{cb} = 3,708$; $\overline{P}_i = 1,851$; $\overline{Q}_g = 3,337$; $|\overline{Q}_0| = 1,534$.

The energetic-exergetic balance in a state of maximum saving is shown in figure 3 in both states, the calculation being made with a margin of error under 4% the initial calculation terms being identical.

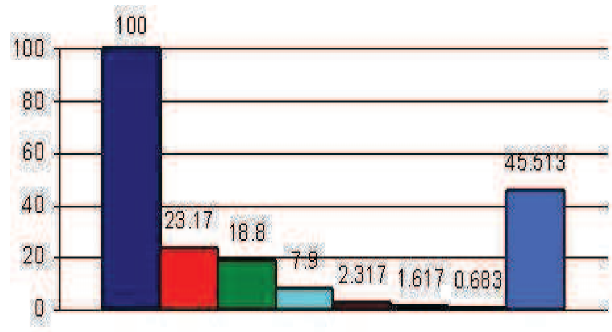



Figure 2 The energetic-exergetic balance in a maximum power state

Introduced heat
*The heat's exergy ceded by the burning products to the environment*
*The lost exergy due to the irreversibility of the burning*
*The evacuated heat's exergy through the burning room's walls*
*The lost exergy due to the irreversibility of the evacuation process*
*The lost exergy due to the irreversibility of the inlet process*
*The heat's exergy ceded by the fresh load in the compression process*
*The indicated yield*

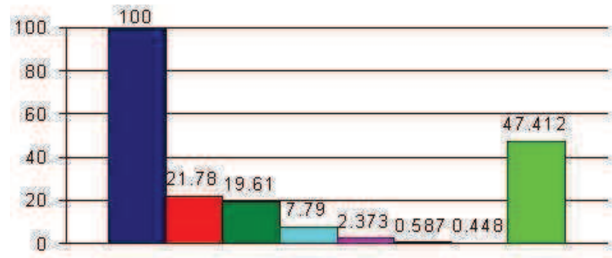



Figure 3 The energetic-exergetic balance in a state of maximum saving

Introduced heat
*The heat's exergy ceded by the burning products to the environment*
*The lost exergy due to the irreversibility of the burning*
*The evacuated heat's exergy through the burning room's walls*
*The lost exergy due to the irreversibility of the evacuation process*
*The lost exergy due to the irreversibility of the inlet process*
*The heat's exergy ceded by the fresh load in the compression process*
*The indicated yield*

## 5. REFERENCES

[1] RADCECO, V.,*Termodinamica thenica si masini termice. Procese ireversibile*, The Didactic and Pedagogical Publishing House, Bucharest 1976
[2] RADCENCO, V., *Criterii de optimizare a proceselor termice (ireversibile,* The Technical Publishing House, Bucharest, 1997

[3] RADCENCO, V., *Termodinamica generalizata,* The Technical Publishing House, Bucharest, 1994.

[4] NERESCU, I., RADCENCO, V., *Analiza exergetica a proceselor termice,* The Technical Publishing House, Bucharest, 1970.

# EVALUATION OF THE ENVIRONMENTAL CONDITIONS IN THE VICINITY OF THE ROMANIAN PORTS AT THE BLACK SEA

[1]ONEA FLORIN, [2]DIACONU SORIN, [3]RUSU EUGEN

[1,2,3]*Dunarea de Jos University of Galati, Romania*

**ABSTRACT**

Starting from the fact that the coastal environment in the vicinity of the main ports is subjected to the highest risks of accidents, especially due to the intense navigation traffic taking place in these areas, the objective of the present work is to evaluate the environmental conditions in the neighborhood of the Romanian harbors at the Black Sea. These are Mangalia, Constanta and Midia-Navodari. Additionally the conditions in the coastal environment at the mouth of the Danube River, close to the Sulina harbor are also assessed. The environmental parameters analyzed are waves, wind and currents and the main data source is represented by the satellite measurements. Additionally, wind model data provided by the European Centre for Medium-range Weather Forecasts and current fields from the web site of the Romanian National Institute for Marine Research and Development are also considered. The results of the analysis are structured on total and winter time, respectively and they provide valuable information concerning the navigation risks in the vicinity of the Romanian harbors at the Black Sea.

**Keywords:** *Black Sea, Romanian ports, environmental conditions, navigation risks.*

## 1. AIMS AND BACKGROUND

Currently in the international trade the cheapest and easiest way to carry high load capacity of materials and supplies is through maritime transport. International ports and shipping manage almost 80% of the world trade, providing in this way crucial connections between countries involved in the global markets [1].

From the Black Sea region the Port of Constanta is the largest one being also an important harbor at European level (on the fourth place). This is ensured by the favorable geographical location and by the presence of two important Pan-European corridors: Corridor VII–Danube (inland waterway) and Corridor IV (railway) [2]. International dimension of the Danube perspective is of great significance: it is an important waterway that runs 2400km from Bavaria to the Danube Delta, passing through no less than ten countries. It is a part of the Rhine-Main-Danube link between the North Sea and Black Sea representing the VII Pan-European transportation corridor and, as integral part of the Network, is also a multimodal transport corridor and a link to other Corridors. A particular feature of the Port of Constanta is that his activity is also supported by two adjacent satellite ports, Mangalia and Midia, mainly designed to supply the local necessities and the petrochemical industry, respectively.

The Sulina port is located close to the northern border with Ukraine being mainly used by the local shipyard which has the possibility to operate ship of 15000tdw capacity [3]. Sulina channel represents also the main entrance in the seventh pan European transportation corridor and is subjected to high traffic. On the other hand, due to the interactions between waves and currents at the mouths of the Danube the navigation is subjected in this area to elevated risks [4].

As regards the navigation in the Black Sea, although the fetch is considerably smaller in such an inland sea than in an open-ocean [5-9], very strong storms that are sometimes characteristic to that region can generate waves comparable even with the high ocean waves [10,11]. Moreover, freak waves are often reported in the Black Sea. Some coastal sectors are very dangerous for navigation, as for example the so called Triangle of Bermuda in the Black Sea (or Whirlpool of Death) located very close to the mouths of the Danube.

Furthermore, taking into account that accidental spillages into the coastal waters can harm seriously the environment and cause substantial disruptions of the marine transportation with potential widespread economic impact, a special attention should be given to a better evaluation of the marine conditions from the Romanian nearshore area [12].

## 2. METHODS

In this study four reference points from the north-west area of the Black Sea basin (Figure 1), are being considered for the analysis based on their locations close to the most important Romanian harbors, namely: Mangalia, Constanta, Midia and Sulina. For the analysis of the wind and wave conditions two sources of data are considered: satellite measurements provided by AVISO web site (www.aviso.oceanobs.com) and reanalysis wind data coming from the European Centre for Medium-range Weather Forecasts (ECMWF) through the ERA-Interim dataset.

The data collected by AVISO come from a multi-mission system, in which measurements coming from various operating satellites are being processed by removing large differences between various databases [13]. Finally, a consistent set of wave and wind measurements is obtained, with the wind data being reported at a 10m height above the mean sea level. For this study the satellite measurements are available for a two-year period: January 2010-December 2011.

Regarding the reanalysis ECMWF model, this uses available observations, which are recompiled by a global atmospheric model to create an archive of gridded output data [14]. The ERA-Interim dataset used in the present study has been obtained from the ECMWF Data Server, and consists in daily wind data (at 10m height), available for every 6 hours (00-06-12-18 UTC), covering the time period January 2001-December 2009.

More details about the considered locations of the reference points and the available wind and wave data are provided in Table 1.

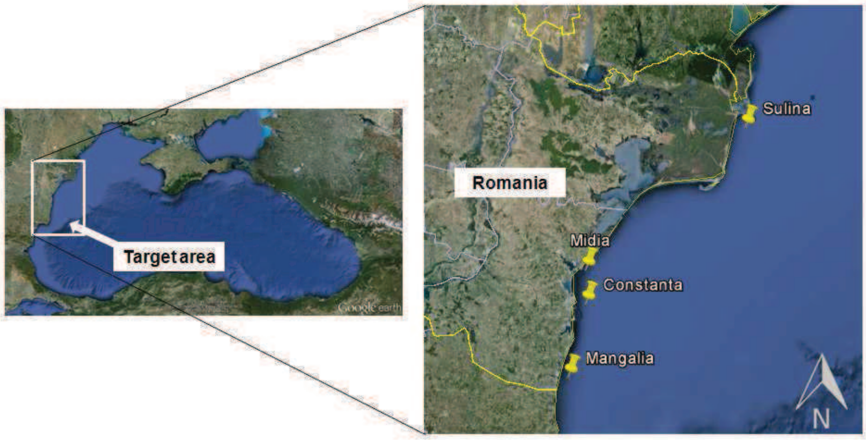



Figure 1 a) Map of the Black Sea indicating the locations of the reference sites considered in the present study: Sulina, Midia, Constanta and Mangalia.

**Table 1**. Main characteristics regarding the reference points and the available dataset.

| Location | Latitude (N) | Longitude (E) | DATASET | | | |
|---|---|---|---|---|---|---|
| | | | satellite – wind &wave | | ECMWF - wind | |
| | | | data per day / time period | | data per day / time period | |
| Sulina | $45^0 05'$ | $29^0 46'$ | 1 | Jan 2010-Dec 2011 | 4 | Jan 2001-Dec 2009 |
| Midia | $44^0 20'$ | $28^0 43'$ | 1 | Jan 2010-Dec 2011 | 4 | Jan 2001-Dec 2009 |
| Constanta | $44^0 10'$ | $28^0 44'$ | 1 | Jan 2010-Dec 2011 | 4 | Jan 2001-Dec 2009 |
| Mangalia | $43^0 48'$ | $28^0 39'$ | 1 | Jan 2010-Dec 2011 | 4 | Jan 2001-Dec 2009 |

Information concerning the maritime currents from the target area were obtained from the main page of the National Institute for Marine Research and Development “Grigore Antipa” [15] which monitor the local marine conditions through a program called *Oceanographic Forecast in North-Western Black Sea*. The monitoring of the hydrodynamic parameters specific to this area was carry out by considering the Princeton model (POM) [16], implemented in the framework of the European COastal sea Operational observing and Forecasting system (ECOOP) [17].

## 3. RESULTS

a) Wind conditions

At this level only the wind speed conditions (*Vw*) are being considered. In Figure 2 is illustrated the monthly evolution of the wind conditions based on the satellite measurements, for the time period January 2010-December 2011. From the analysis of the mean value (Fig. 2a) is highlighted the seasonal variation between summer and winter time (from October to March), while between the reference points there are small differences. Usually for the more energetic winter time there are reported values between 4.70-5.40m/s with much higher value registered during February, while the month of November is an exception for this season presenting values less than 3.80m/s. During the summer time the most energetic month is September (3.80m/s), followed by April (3.32m/s) while the lowest values are being reported during May (2.32m/s). From the maximum value analysis (Fig. 2b) can be notice that more energetic conditions are reported during March (12.34m/s), and also quite energetic during June (11.24m/s) exceeding winter months like January, October or November.

In Figure 3 a similar analysis is presented, this is based on the ECMWF dataset which covers the time period January 2001-December 2009.

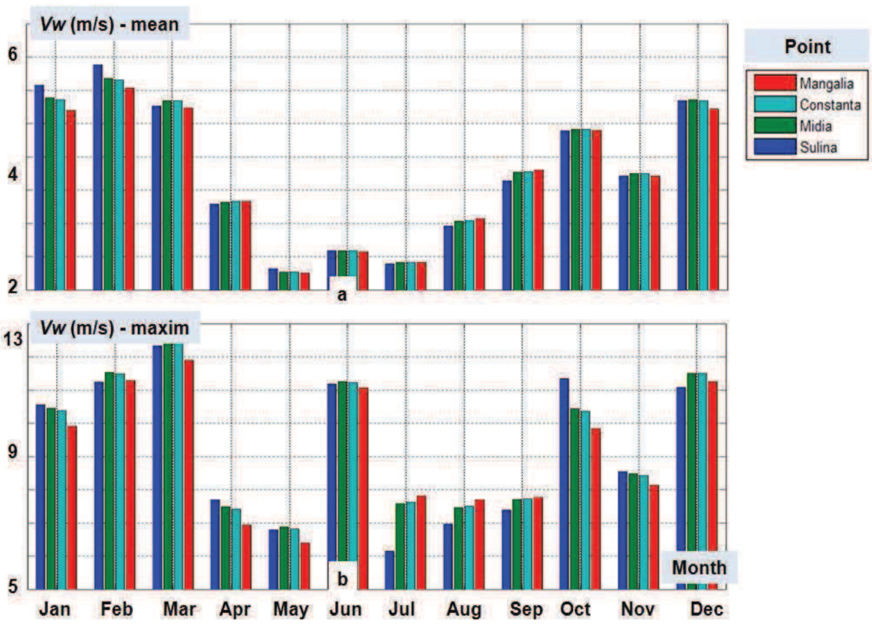



Figure 2 Distribution of the wind speed conditions as reflected by the satellite measurements. analysis corresponding to the time interval january 2010-december 2011, for: a) mean value and b) maximum value.

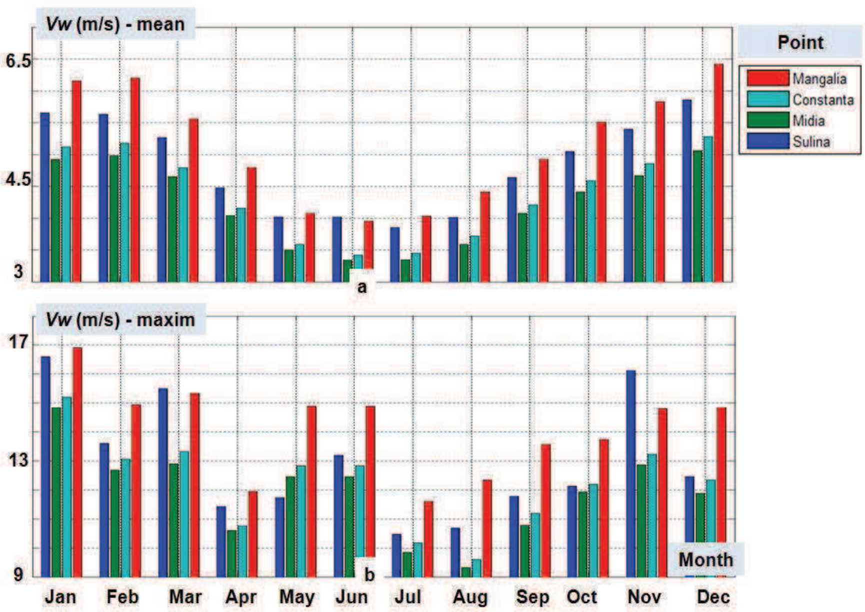



Figure 3 Distribution of the wind speed conditions as reflected by the ecmwf dataset. analysis corresponding to the time interval january 2001-december 2009, for: a) mean value and b) maximum value.

Compared to the satellite data, this dataset indicates the locations Mangalia and Sulina as being more energetic, while more moderate wind conditions seem to be reported at the Midia site. From the analysis of the mean value there are more clear highlighted the seasonal

variations between summer and winter time, in which Mangalia site reports maximum values of 6.38m/s (December), and 6.21m/s (January and February).

The Sulina reference points show values of 5.89m/s (December) and 5.67m/s (January and February). During the summer time a maximum value of 4.85m/s is accounted by the Mangalia point (in August). Usually the Constanta points report mean wind speed conditions much higher with almost 0.20m/s (per each month) than Midia location, indicating a maximum of 4.85m/s (December) and a value of 3.41m/s (in June).

Figure 4 reveals the wind speed distribution by classes for all the locations based on the satellite and ECMWF datasets, corresponding to the time interval from Table 1. For all the locations, during the summer time (Fig. 4a) the satellite dataset indicates a large part of the data distribution between the interval 1-3m/s and no significant presence of wind speed higher than 8m/s. During the winter time, the general distribution is shifted to the interval 3-5m/s with the maximum peak registered in the interval 3-4m/s especially for the locations

Mangalia and Sulina. The winter season is characterized by a large occurrence of the wind speed from the 7-10m.s interval and also the influence of the wind conditions ≥12m/s.

During the summer time the ECMWF dataset reports much higher wind conditions than the satellite data, with the locations Midia and Constanta indicating a large data distribution in the range of 0-4m/s, while the occurrence of the wind speed from the interval 5-10m/s are more representative for the remaining locations. During the winter time there is a similar distribution as the one indicated by the satellite, with the mention that the locations Sulina and Mangalia present much higher values for the classes 7-12m/s.

Also in the maritime navigation an important factor which must be taken in to account is the wind direction. Such distribution is presented in Figure 5 based on the ECMWF data, during the ten-year time interval: January 2001-December 2009. The north-east sector corresponding to the offshore area, accounts for the main wind distribution indicating also the presence of the wind conditions from the interval 9-12m/s, and even the presence of events ≥12m/s for the Mangalia location.

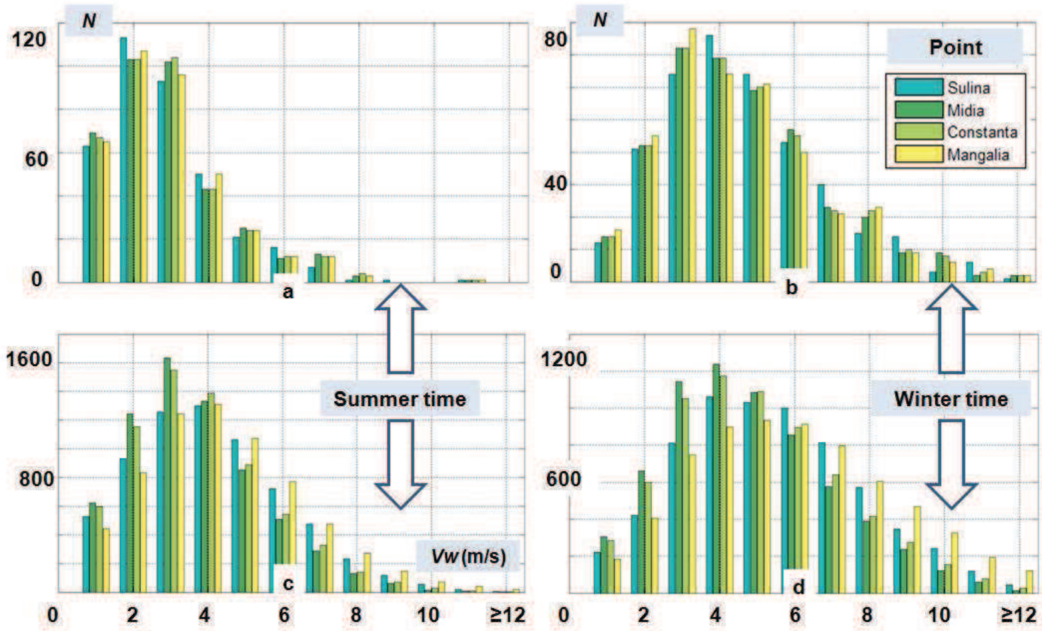



Figure 4 Wind frequency distribution (x-axis $vw$, y-axis number of occurrences) reported for: summer time (left side) – a) satellite data and c) ecmwf data; winter time (right side)-b) satellite data and d) ecmwf data.

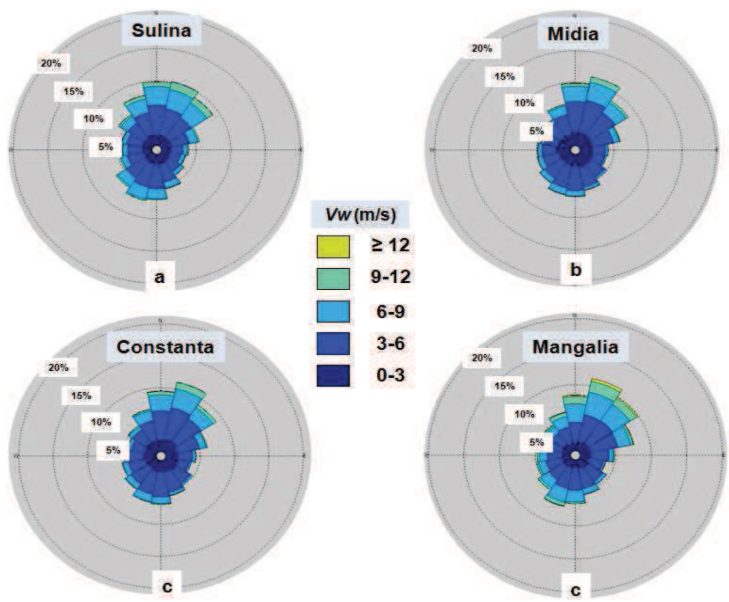



Figure 4 Wind roses based on ecmwf data coresponding for the total time period january 2001-december 2009, where: a) sulina point, b) midia point, c) constanta point and c) mangalia point.

b) Wave conditions

In this section the significant wave height (*Hs*) conditions from the Romanian nearshore area is analyzed by considering satellite measurements, available for the time period: January 2010-December 2011. In Figure 6, the time series of the wave conditions only for the locations Sulina and Midia are presented, this because for the remaining locations the correspondent time series are quite similar. In general it can be notice the presence of the

summer and winter seasons, with most of the data distributed under the 2m value, a small occurrence of 0m value (calm water) and some energetic peaks which can reach 2.5-3m.

Figure 7 reveals the monthly distribution of the wave conditions in which for the mean wave conditions (Fig. 7a) the location Mangalia presents slightly higher values. In terms of the mean values, it can be noticed that the maximum values do not exceed 1.4m, revealing the month of February to be more energetic (for all the points) with a value of 1.3m, followed by the months of January, March and October with values close to 1.14m.

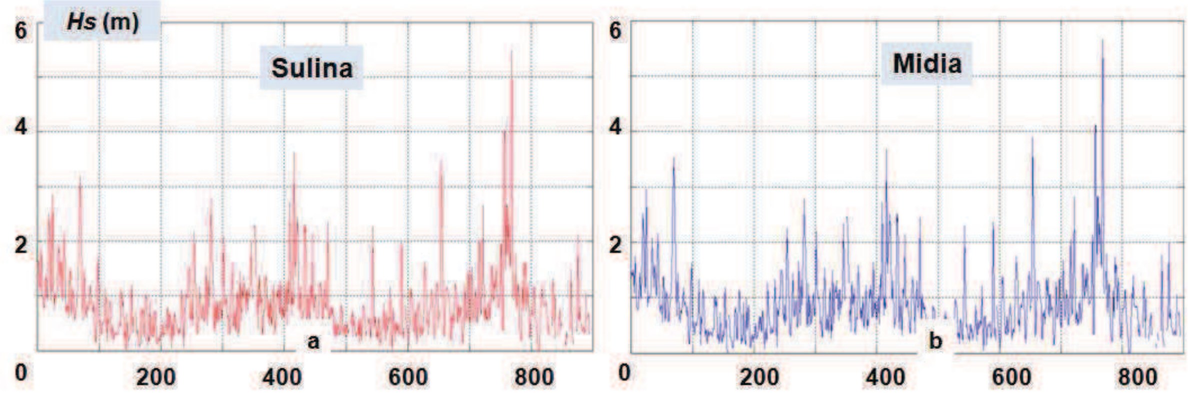



Figure 6 Time series of the significant wave height conditions based on the satellite data, for the time period: January 2009-December 2011. Results available for: a) Sulina location and b) Midia location.

From the summer season, the September month is the most energetic one indicating a mean value of 0.83m (0.76m for Sulina), followed by April with 0.76m (0.69m for Sulina) while the less energetic can be considered to be May with 0.43m.

Regarding the maximum wave height, the month of October can be considered problematic for the ship navigation because of the occurence of the wave height close to 3.9m, followed by the months of February and March with maximum wave occurence of 3.7m, respectively 3.5m. From this point of view the summer season can be considered quite energetic with maximum values of 2.4m, except for the months of May and July which do not exceed waves of 1.2m amplitude.

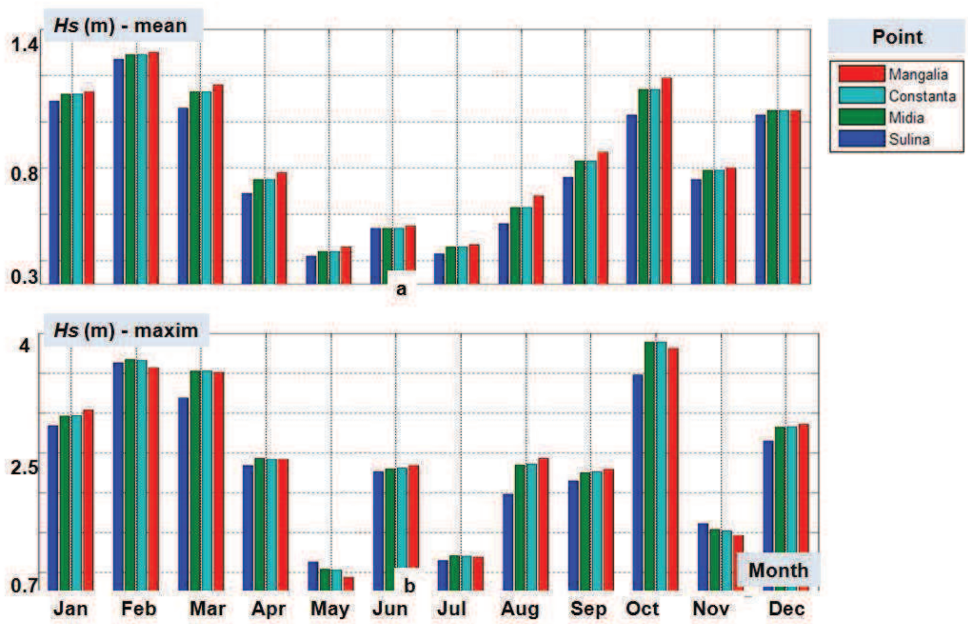



Figure 7 Distribution of the monthly wave height (*hs*) indicated by the satellite data. analysis corresponding to the time interval january 2010-december 2011 for: a) mean value and b) maximum value.

From the analysis of the significant wave distribution presented in Figure 8, can be notice the moderate wave conditions reported during the summer time. For this season the predominant occurrence of the waves is in the interval 0-0.5m, followed by the classes 0.5-1m. Also there is reported a significant occurrence of the waves from the interval 1-1.5m, while higher than this limit, wave occurrence are insignificant. The winter season is characterized by the distribution of the wave conditions in the range of 0.5-1.5m, with a higher peak for the 0.5-1m interval and also it can be noticed the presence of the events where waves are equal (or higher) than 3m.

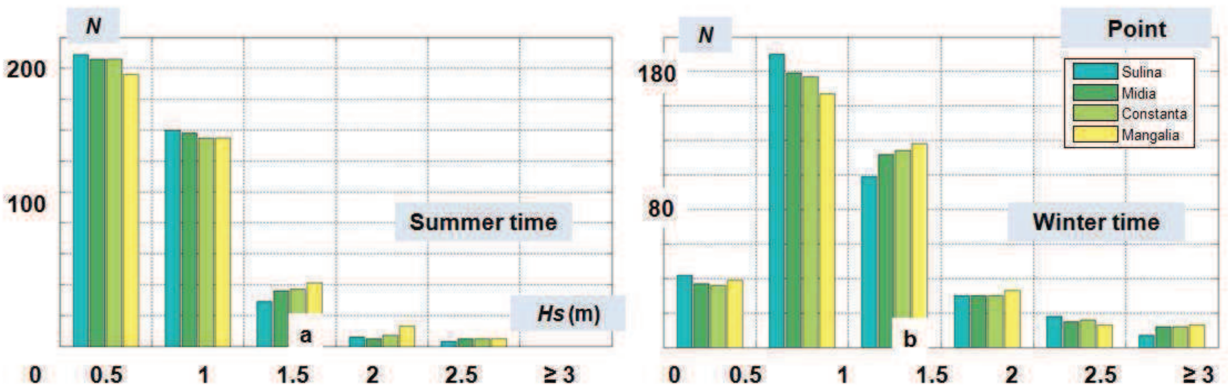



Figure 8 Significant wave height distribution (x-axis *Hs*, y-axis number of occurrences) based on satellite measurements, reported for: a) summer time and b) winter time

c) Marine currents

To give a complete picture of the marine conditions from the vicinity of the Romanian ports which could influence the maritime traffic, the current circulation from the north-east sector of the Black Sea is analyzed based on the results presented on the web site of the Romanian National Institute for Marine Research and Development[15]. The focus is being placed on the identification of the most energetic condition, reported in the target area during the summer and winter season for a three year period (2010, 2011 and 2012).

Thereby, in Figure 8a is presented a winter time current pattern from 2010 (February) in which for this time period a maximum current velocity of 0.40m/s is registered in the Sulina location.

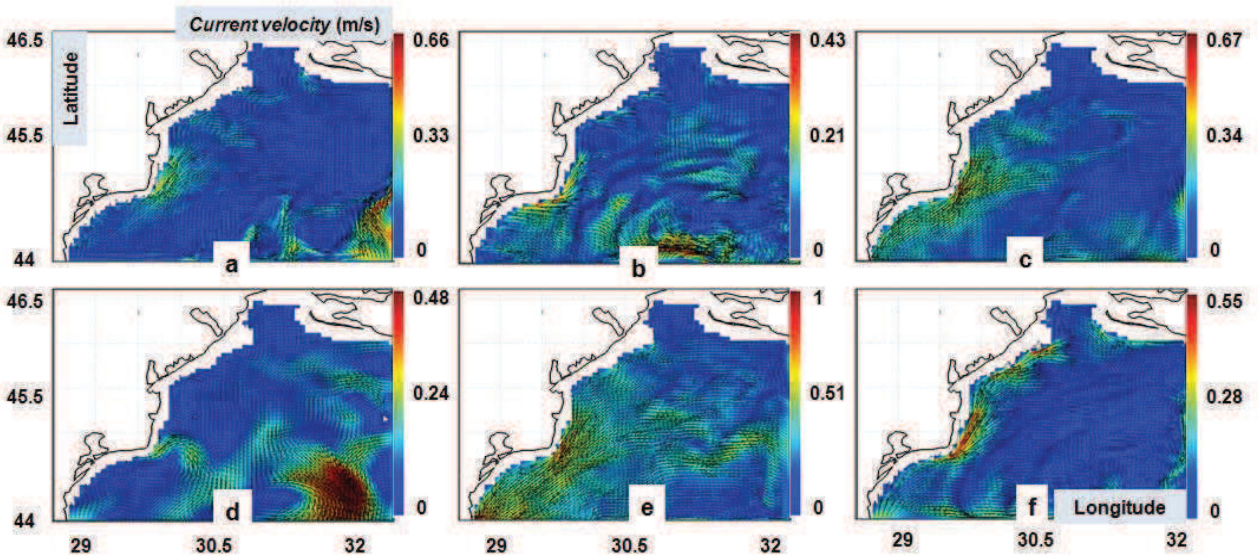



Figure 9 Spatial distribution of the current conditions from the north-western sector of the Black Sea, obtained from the Romanian National Institute for Marine Research and Development[15]. Current field evolution for: a) 22 February 2010; b) 8 July 2010; c) 3 January 2011; d) 11 July 2011; e) 26 January 2012; f) 12 July 2012.

The rest of the stations, report values close to 0.15m/s which are similar with the ones reported in the offshore area. For the same year during the summer time (July) it can be expected to encounter a much lower current velocity with values between 0.25-0.40m/s which will occur in the adjacent area of Sulina and possible close to the Midia location. For the year 2011, during the winter time (January) a maximum value of 0.67m/s is reported for the Sulina location, while for the remaining points current velocities between 0.30-0.40m/s can be considered representatives. For the summer period (July) it is reported a similar value as in 2011 which will influence only the Sulina site. For this case study it can be noticed the moderate circulation of the local currents, which on the offshore area will account only for a maximum value of 0.48m/s.

For 2012, during the winter time (January) it is reported the highest occurrence of the current velocity of 1m/s in all the reference locations, which could significant influence the activity of the considered Romanian ports. The summer time represented by the July month indicates a maximum value of 0.55m/s in the adjacent area of Sulina location, situation which is not reflected by the rest of locations which typically encounter currents velocity of 0.14m/s.

## 4. DISCUSIONS AND CONCLUSIONS

Usually the black sea is considered to be a sheltered sea with a moderate wave climate suitable for ships navigation, but there are some geographic regions in this basin which could significantly influence the maritime activity. one example is the novorossiysk region (russia) which is dominated by the presence of the bora events, when wind speeds close to the value of 50m/s can be reported [18]. Another important region is located in the romanian sector, which is characterized also by the interaction between the danube river and the black sea. in particularly, the combination of the local high wind speed and the current circulation has the potential to modify the local wave conditions with negative impact on the large ship operations.

In the present work, a complete evaluation of the marine conditions from the vicinity of the major Romanian Ports was carried out by considering various dataset and numerical simulations. From the analysis of the wind conditions based on the satellite data very small differences for the reference locations were noticed and the presence of the summer and winter seasons, which are dominant for this region, was also highlighted. During the summer time, September can be considered to be more energetic in terms of the mean value (3.80m/s) while maximum conditions of 11.24m/s are dominant during July. For the more energetic winter time (October-March) the February month report mean wind speed value of 5.40m/s, close to the one reported in January and March, while maximum wind speeds of 12.30m/s are reported only in February.

The wind speed data coming from the ECMWF dataset reveal similar seasonal variations, indicating the Mangalia and Sulina locations to be more energetic. From the analysis of the mean conditions, Mangalia reports a value of 6.40m/s (winter time) and a value of 4.85m/s (summer time). Also for the same location it is possible to encounter maximum wind speed of 17m/s in January and almost 15m/s during May and June. For all the locations, the dominant wind direction is from the offshore area (north-east) with the mention that the Mangalia locations reveal a significant occurrence of wind conditions ≥12m/s (≈10% from the total data). It has to be highlighted also that the data sets from satellite, especially for the wind speed is different than ECMWF data, even that both of them they have same pattern. The most probable explanation is related to the fact that the satellite data are time (for the last 48 hours) and space (for squares with the lengths of 1°) averaged while the model data are the exact values corresponding to the respective time frame and location. A detailed discussion concerning the differences between the two wind fields is given in Onea and Rusu [19].

Regarding the wave conditions (significant wave height), there is a similar evolution for all the reference points with a large distribution of the data between 0-1m (summer time) and 0.5-1.5m (winter time). During the summer time it is reported a mean value of 0.83m (September) and a maximum of 2.4m (except for May and July), while in the winter time a maximum value of 3.9m (October) is encountered.

By analyzing the current circulations from the north-west area of the Black Sea, it was highlighted the fact that the Sulina location is subject to more energetic conditions. In general in the this area, a maximum value of 0.55m/s can be expected during the summer time while during the winter it is possible to encounter currents of 1m/s.

Finally it can be concluded that the joint combination of the local wind, wave and currents could lead to the occurrence of hazardous conditions for the maritime navigation in the Romanian area, especially during the winter time and in the vicinity of the Sulina port.

## 5. ACKNOWLEDGMENTS

The work of the first author has been made in the scope of the project EFICIENT (Management System for the Fellowships Granted to the PhD Students) supported by the Project SOP HRD - EFICIENT 61445/2009.

## 6. REFERENCES

[1] J.S. Fuglestvedt, T. Berntsen, G. myhre, K. rypdal, R. B. skeie: Climate forcing from the Transport sectors. Proceedings of the National Academy of Sciences, 105, 454-458 (2008).

[2] Port of Constanta Ranking. www.eosnap.com. (accessed June 2012).

[3] Port of Sulina website. http://www.azlsulina.3x.ro/id19.htm (accessed April 2012).

[4] E. Rusu: Modelling of Wave-current Interactions at the Danube's Mouths. J. of Marine Science and Technology, 15 (2), 143 (2010).

[5] S. Ryanzhin, N. Kochkov, N. Akhmetova, N. Weinmeister: Coastal Lakes in the Black Sea. J. of Environm. Protection and Ecology, **12** (1), 25 (2011).

[6] R. Mateescu, C. Coman: Evolution of the Romanian Black Sea Shore under the Actual Anthropogenic Impact. J. of Environm. Protection and Ecology, **9** (2), 357 (2008).

[7] S. D. Keremedchiev, E. V. Trifonova, N. K. Andreeva, P. T. Eftimova: Assessment of the Vulnerability of the Coastal Areas along Varna Coast Related to Extreme Hydroclimatic Events in The

Western Part of the Black Sea. J. of Environm. Protection and Ecology, **11** (3), 930 (2010).
[8] N. Valchev, I. Davidan, Z. Belberov, A. Palazov, N. Valcheva: Hindcasting and Assessment of the Western Black Sea Wind and Wave Climate. J. of Environm. Protection and Ecology, **11 (**3), 1001 (2010).
[9] A. A. Kordzadze, D. I. Demetrashvili: About Coupled Regional Modelling System: the Black Sea Atmosphere. J. of Environm. Protection and Ecology, **12** (1), 317 (2011).
[10] E. Rusu: Wave Energy Assessments in the Black Sea. J. of Marine Science and Technology, **14** (3), 359 (2009).
[11] V. Maslova, E. Voskresenskaya, M. Bardin: Variability of the Cyclone Activity in the Mediterranean-Black Sea Region. J. of Environm. Protection and Ecology, 11 (4), 1366 (2010).
[12] M. Golumbeanu, F. K. Vosniakos, S. Avdimiotis, P. Mentzelou, C. Constantin, M. Teohareva: Upgrade Black Sea scene. Developing a Research Infrastructure for the Black Sea. J. of Environm. Protection and Ecology, **12** (3), 1150 (2011).
[13] G. Dibarboure, J. Dorandeu, P. Y. Le Traon, N. Picot: SSALTO/DUACS: 15 years of precise and consistent multi-mission altimetry data. European Space Agency, (Special Publication) ESA SP 614 (2006).
[14] D. K. Woolf, P.G. Challenor: Statistical comparisons of satellite and model wave climatologies. Ocean Wave Measurement and Analysis, Ed.s B.L. Edge and J.M. Hemsley, ASCE, Virginia, Virginia, 640-649 (2002).
[15] http://www.rmri.ro/menu.ro.html (accessed February 2013).
[16].http://www.aos.princeton.edu/WWWPUBLIC/htdocs.pom/ (accessed July 2012).
[17] http://www.ecoop.eu/ (accessed July 2012).
[18] W. Alpers, A.Y.Ivanov, K. F. Dagestad: Investigation of coastal wind fields over the Black Sea using Envisat synthetic aperture radar images. Proceedings of the ESA Living Planet Symposium, Bergen, Norway. ESA publication SP-686 (2010).
[19] F. Onea, E. Rusu: Wind energy assessments along the Black Sea basin. Meteorological Applications, DOI: 10.1002/met.1337 (2012).

# STUDY REGARDING THE INFLUENCE OF TRIBOLOGYCAL FACTORS ON THE SUPERFICIAL LAYERS OF STEELS TREATED WITH PLASMA NITRIDING

PAPADATU CARMEN- PENELOPI

*"Dunarea de Jos" University of Galati, Romania*

**ABSTRACT**

We have hereby considered some 42MoCr11 (SAE 4142) steel grade samples. This material was subjected to the plasma nitriding treatments regimes. The structural and diffractometrical aspects of the superficial layers of the steel are studied after the wear tests by friction, using an Amsler type machine, taking two sliding degrees at different contact pressures and testing time. The tests were performed to detect the evolution of the superficial layer through different tests and to establish the influence of the tribological factors (operating parameters) on the superficial layers.

The tests were done to detect the sustainability of this material.

**Keywords**: *plasma nitriding process, wear process, tribological parameters*

## 1. INTRODUCTION

Plasma nitriding modify the strain limit, and the fatigue strength of the metals being treated. For instance, mechanical properties of austenitic stainless steel like wear process can be significantly reduced and the hardness of tool steels can be double on the surface [1,2,3,5].

Plasma nitriding and plasma nitrocarburation are often coupled with physical vapor deposition (PVD) process and labeled Duplex Treatment, with enhanced benefits. Many users prefer to have a plasma oxidation step combined at the last phase of processing to produce a smooth jetblack layer of oxides which is resistant to wear process and corrosion process too.

The superficial layer is defined according to the type of interaction between the external action and materials.

One of the first model of the superficial layer [2,4,5] was presented in figure 1.

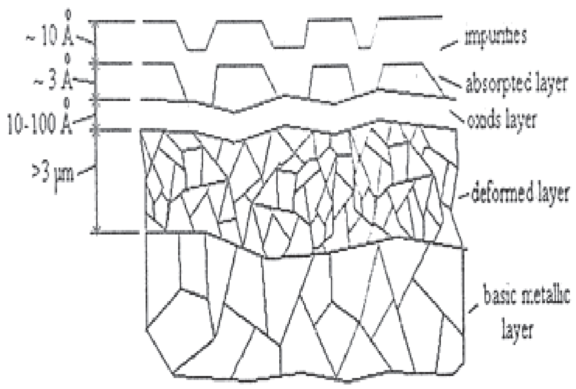



Figure. 1. One model for the superficial layer

Introducing a surface treatment as nitriding process with plasma (ionic nitriding), increase the wear resistance and the resistance of corrosion increase too.

The diffusion process and the interaction of the nitrogen and carbon with the basic material lead to structural constituents whose nature determines a major hardness of the nitrided layer.

The chemical combination area consists of two phases:

- *the ε phase* is a solid solution based on the chemical compound of $Fe_3N$, rich in nitrogen (8.2 % to 11.2% of N) having a hexagonal compact (HC), crystal lattice and it is highly resistant to wear, [1,4,5],and corrosion;
- *the γ' phase* – a solid solution based on the $Fe_4N$ compound, presents a centred-face cube (C.F.C.) crystal lattice, has a lower nitrogen solubility (5.7 to 6.1%N), showing very high values of hardnessand tenacity.

The diffusion area is composed of the following elements:

- *the α phase (the nitrided ferite)* – is a nitrogen connate solid solution in Feα crystallizing in centre volume cube (C.V.C.) lattice, showing a maximum solubility of 0.11% at a temperature of 590°C;
- *the γ phase (the nitrided austenite)* – a nitrogen connate solid solution in Feγ (C.F.C.), having a maximum nitrogen solubility of 2.8%at a temperature of 650°C(see Figure 2) *[4,6]*.

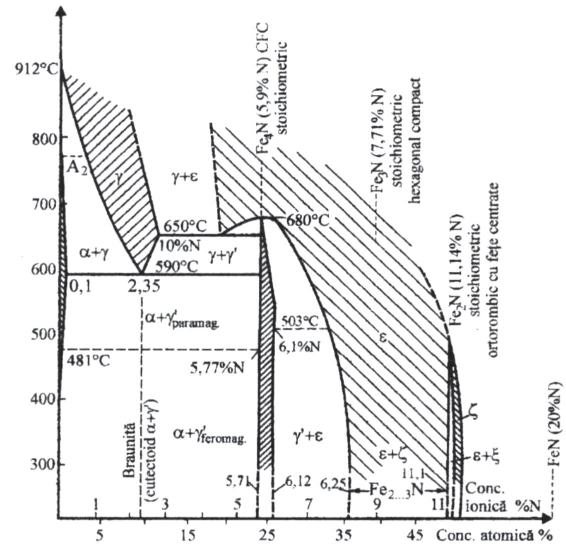


Figure 2. Fe-N diagram of equilibrum

The transformation of $\gamma \rightarrow \alpha$'- martensite with nitrogen (a suprasatured solution of nitrogen in Fe$\alpha$),showing a very high values of hardness, takes place from the nitriding temperature, in case of a rapid cooling of austenite with nitrogen ($\gamma$).

The hardness and the depth of nitrided layer, are determined both by the chemical composition of the chosen material and by the technological parameters of the thermo-chemical treatment [4].

In case of hard worn out parts [4], the layer structure selection has three areas corresponding to the rule as it is advised by the tribology studies:

**a.** – a thin layer of 0.02 to 0.04mm, not so rigid, showing a crystal lattice separate to the basic (hexagonal compact) material;

**b.** – a very tough and flexible layer,which is not breakable or deformable under very high stresses;

**c.** – a basic material showing adequate hardness, mechanical strength as well as a suitable tenacity in order to avoid material cracking under stress.

Figure 3 presents the layer hardness evolution in their sequence[5,6].

The wear behavior of coated surface is controlled by several factors such as the geometry of the contact, the topography of the surface, mechanical properties of the material, microstructures of the material and the operating parameters (Q, ξ, Δt).

In this paper we present a series of research regarding the structural and the tension state changes that appear and develop in the superficial layer of this material subjected to damages processes as: running-in, friction, wear or fatigue.

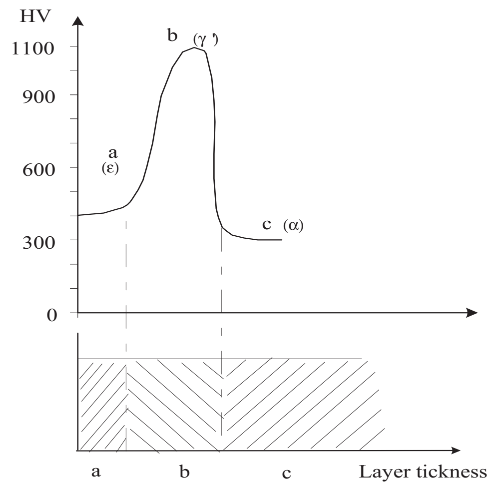



Figure 3. Hardness of the superficial layer according with the layer thickness evolution.

For this aim, the tribo-modelling operation has been used. The material tested on tribo-models present some advantages versus in situ ones. Thus, the multi-factorial planning of the experiments can be used and the testing optimal conditions, for a given material, can be found.

The friction and wear processes are complex, being of physical, chemical, mechanical or metallurgical nature [2,3]. These processes appear during dynamic or static contact between surfaces of two solid bodies where may be or not be in a gaseous atmosphere, liquid or solid lubricant. The depth of the superficial layer varies between some atomic layers, in case of wear and chemical processes, and can attain up to (50÷100) µm – in case of dry friction.

## 2. EXPERIMENTAL RESEARCH

For experiments 42MoCr11 steel grade samples were used. The material was subjected to the plasma nitriding treatment regime.

The structural and diffractometric aspects of the superficial layers of the steel are studied after the wear tests by friction. It was used an Amsler type machine, taking two sliding degrees at different contact pressures and testing time(see Figure 4).

The tests were done to detect the sustainability to the material, the evolution of the superficial layer through different tests. The influence of these tribological factors (operating parameters) on the superficial layers was established.

Table 1 presents the 42MoCr11 steel grade composition. The steel analyzed reach a max score 4.5 from inclusions and a fine grain (score 8-9). Table 2 presents the mechanical characteristics of the steel 42MoCr11 (SAE 4142)[2,4].

Figure 4. The Amsler Stand

Table 1. Chemical composition of the materials

| Steel grade | C(%) | Mn(%) | Si(%) | P(%) | S(%) | Cr(%) | Cu(%) | Mo(%) | Al(%) |
|---|---|---|---|---|---|---|---|---|---|
| 42MoCr11 (Code V) | 0.42 | 0.68 | 0.33 | 0.030 | 0.026 | 1.02 | 0.220 | 0.17 | 0.02 |

Table 2.Mechanical characteristics of the steel

| Steel grade | $Rp_{0,2}$ | $R_m$ | $A_5$ | Z | $KCU_{300/2}$ | $KCU_{300/5}$ | HB (State of annealing) |
|---|---|---|---|---|---|---|---|
| | [daN/mm$^2$] | | [%] | | [daJ/cm$^2$] | | [daN/mm$^2$] |
| 42MoCr11 AISI(SAE) 4142 | 75 | 95 | 11 | 50 | 8 | 6 | 217 |

The treatment applied was t1 (classic treatment) followed by nitriding process at 530º C.

The samples of the steel suffered the following treatments regimes: a Martensitic hardening process at 850°C and high recovery at 580°C (classic improvement treatment which was noted with "t1") followed by nitriding process at 530°C. It was noted T1= t1 + ionic nitriding (plasma nitriding) at 530°C.

The treated samples were used for wear tests on Amsler machine (see Figure 4). It were determined the durability of the rollers and the surface structure evolution for different parameters of testing regimes.

Other factors influencing the wearing process could not be neglected: the contact geometry of the friction couple (roller on roller, roller on ring etc.), the technological parameters (surface quality, heat treatments etc.) and the exploitation conditions (the thermal solicitation, for example).

Wear tests were carried out on an Amsler machine, using several couples of rollers, each couple corresponding to different sliding degrees ξ, defined as:

$$\xi=[ (\nu_1-\nu_2 ) / \nu_1 ] 100 [\%] \quad (1)$$

where $v_1$ and $v_2$ are the peripheral velocities of the rollers in contact, each one having their specific peripheral velocity due to a particular combination of angular speeds ($n_1$, $n_2$) and diameter sizes ($d_1$, $d_2$).

Index 1 or 2 are added for the roller 1 or 2, respectively, both of the same tested friction couple. For instance, ξ=*10%* is obtained for a pair of tested rollers having $d_1$=40 mm, $n_1$=180 rpm and $d_2$=40 mm, $n_2$=162 rpm; ξ=*18%* is obtained for a pair of tested rollers having $d_1$=44 mm, $n_1$=180 rpm and $d_2$=40 mm, $n_2$=162 rpm; the level of the stress is corresponding to a specific load of 150 daN (as normal load is *Q*=1.500 N) and the contact between roller is *b*=10 mm [2,4,8].

## 3. EXPERIMENTAL RESULTS

The phases and their characteristics identified at diffractometry analysis for 42MoCr11 steel grade after thermal treatment followed by plasma nitriding, are presented in table 3[see 4,*9,11*].

In this table the following information was considered: Δθ represents the angular displacement of a diffraction lines, Q represents the force applied, ξ represents the sliding degrees [%] and c/a represents the tetragonality degree of martensite.

Table nr.3

| *Code of samples* | *~ % $I_{Fe3N}$* | *~ $\sigma_{II}$ $B_{Fe3N}$* | *~ % $I_{Fe4N}$* | *~ $\sigma_{II}$ $B_{Fe4N}$* | *~ c/a $B_{211}$* | *~ $\sigma_I$ Δθ* | *t [h]* | *Q [daN]* | *ξ [%]* |
|---|---|---|---|---|---|---|---|---|---|
| *121* | *4* | *2.66* | *18* | *1.80* | *0.896* | *0* | *0* | *-* | *-* |
| *121* | *6* | *3.00* | *22* | *2.44* | *0.894* | *0* | *1* | *75* | *10* |
| *121* | *4* | *2.00* | *14* | *2.56* | *0.894* | *-0.09* | *2* | *75* | *10* |
| *121* | *4* | *2.53* | *19* | *3.16* | *0.893* | *-0.12* | *3* | *75* | *10* |
| *221* | *6* | *3.00* | *23* | *1.96* | *1.16* | *-0.10* | *0* | *-* | *-* |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *221* | *8* | *3.25* | *25* | *2.57* | *1.20* | *-0.09* | *1* | *150* | *10* |
| *221* | *6* | *3* | *19* | *2.67* | *1.16* | *-0.09* | *2* | *150* | *10* |
| *221* | *10* | *5.00* | *37* | *2.96* | *1.29* | *-0.05* | *3* | *150* | *10* |
| *321* | *2* | *2.00* | *17* | *1.54* | *2.86* | *-0.10* | *0* | *-* | *-* |
| *321* | *4* | *2.66* | *14* | *1.98* | *2.22* | *-0.10* | *1* | *150* | *20* |
| *321* | *2* | *2* | *19* | *2* | *2.22* | *-0.10* | *2* | *150* | *20* |
| *321* | *4* | *3.07* | *26* | *4.33* | *2.07* | *-0.12* | *3* | *150* | *20* |
| *421* | *4* | *4* | *17* | *1.54* | *1.41* | *-0.09* | *0* | *-* | *-* |
| *421* | *6* | *6* | *19* | *4.33* | *1.45* | *-0.05* | *3* | *190* | *20* |

For code 121 sample, after each hour of wear process, we couldn't obtain the modification of Phases quantities inside in the superficial layer. But, it was an exception, for Feα quantity, which increase simultaneous with the increase of wear process time.

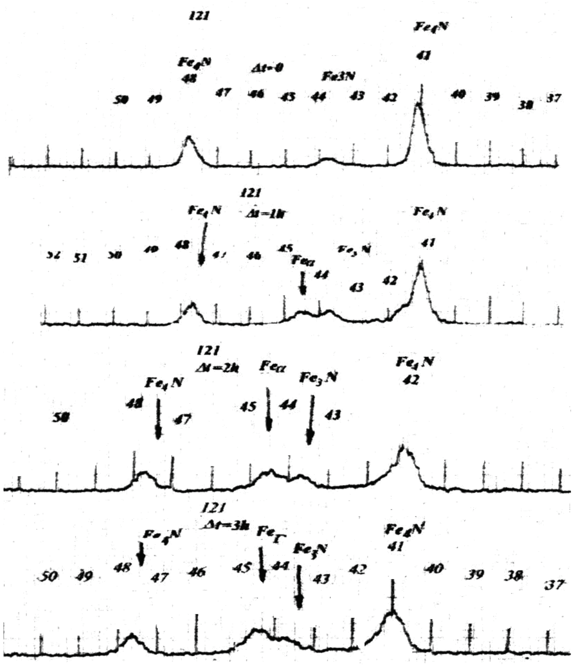


Figure 5. Diffractometry aspects regarding the evolution of the 121 code samples layers, during the wear processi):at initial stage, after one hour of wear process, after two hours of wear preocess and after three hours of wear process. The operating conditions were the following :Q=75daN, ξ=10%.

The width of the $Fe_4N$ (40° - 42°) phase decreases after three hours of wear process. By comparing the code 221 sample with the code 121 sample, we can observe the following aspects:

- at code121 sample - after three hours of wear process, the increase of Feα (M) phase quantity was visible. The $Fe_4N$ phase quantity decreased and the $Fe_3N$ phase quantity increase.

- at code 121 sample, the internal tensions of second order for $Fe_3N$ phase alternate with maximum and minimum. The $Fe_3N$ phase suffered a fatigue process through cyclic action. For this situation, there is a danger of superficial layer exfoliation.

-at code of sample 121, the internal tensions of second order for $Fe_4N$ phase present an un-linear increases, during three hours of the wear process. At the end of the wear tests, the internal tensions of second order for $Fe_4N$ phase are higher than the internal tensions of second order for $Fe_3N$ phase. But, the fatigue process of $Fe_4N$ phase is smaller than the $Fe_3N$ phase case.

-at code 221 of sample, the $Fe_4N$ phase quantity decreased during three hours of wear process.

At code 321 of sample the greatest quantity of martensite (M) was observed. For the samples code 321 and 221, the same treatment was applied: T1 (Classic treatment), the difference between them is the different value of each sliding degrees (ξ).

For code 321 sample was concerned at three hours with Q=150 daN (as the code 221 sample), but the sliding degrees was double then 221 sample case.

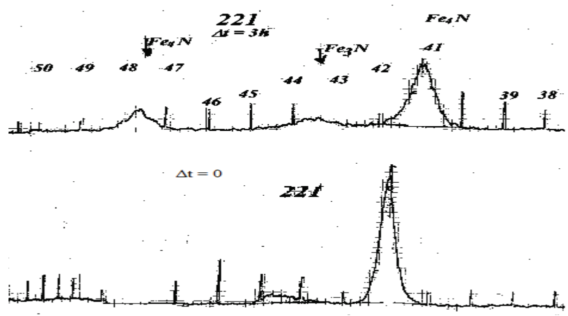


Figure 6. Diffractometry aspects regarding the evolution of the 221 code samples layers, during the wear process): at initial stage and after three hours of wear process. The operating conditions were the following :Q=150daN, ξ=10%.

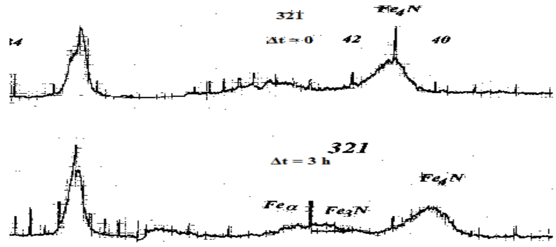


Figure 7. Diffractometry aspects regarding the evolution of the 321 code samples layers, during the wear processes): at initial stage and after three hours of wear process. The operating conditions were the following: Q=150daN, ξ=20%.

Between code 421 sample and code 321sample, the only difference is the increase of the effort value (Q).

In the figures: 8….13, we present some aspects regarding the characteristics evolution of the superficial nitrided layers during three hours of wear process.

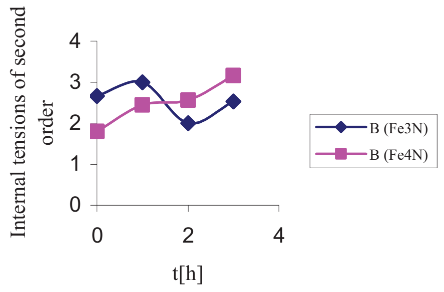



Figure 8. Evolution of the internal tensions of second order (B211~σ $_{II}$) during the wear process, for $Fe_3N$ and $Fe_4N$ phases, corresponding to 121code of sample ($T_1$, Q=75daN, ξ=10%)

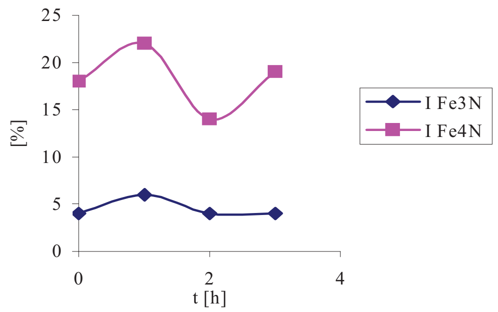



Figure 9.The distribution of $Fe_4N$ and $Fe_3N$ phases quantities on nitrided layer depth,during three hours of wear process (code 121,$T_1$ , Q=75daN, ξ=10%)

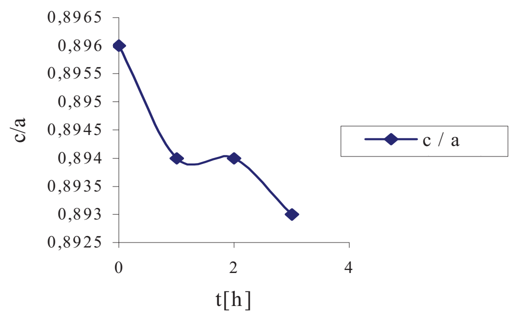



Figure 10. Evolution of the martensite thetragonality grade (c/a) vs. the wear process test time (code 121 sample, $T_1$, Q=75daN, ξ=10%)

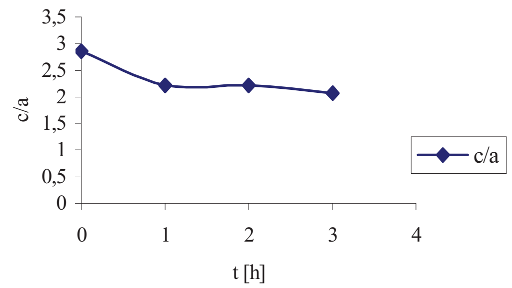



Figure 11. Evolution of the martensite thetragonality grade (c/a) vs. the wear process test time (code 321sample, $T_1$, Q=150daN, ξ=20%)

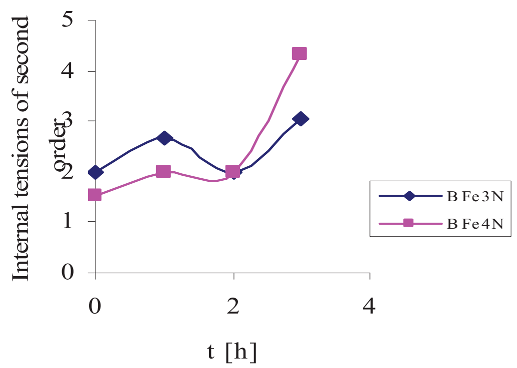



Figure 12. Evolution of the internal tensions of second order (B211~σ $_{II}$) during the wear process, for $Fe_3N$ and $Fe_4N$ phases, corresponding to 321code of sample ($T_1$, Q=150daN, ξ=20%)

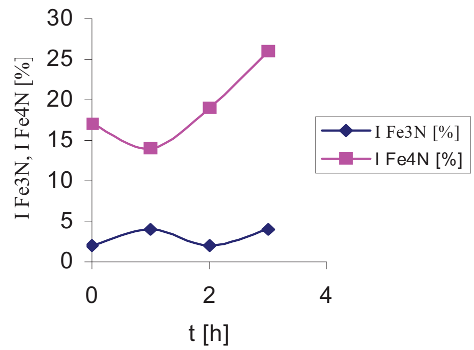



Figure 13. The distribution of $Fe_4N$ and $Fe_3N$ phases quantities on nitrided layer depth,during three hours of wear process (code 321,$T_1$ , Q=150daN, ξ=20%)

## 4. CONCLUSIONS

We have made a study for Fe3N, Fe4N and Feα (M) phases distribution in the superficial nitrided layers, for 42MoCr11 steel grade case.

The treatment applied (T1) was an improvement followed by plasma nitrided process. The treated samples were subjected to an wear process for three hours each of them (see table 3).

Analyzing the evolutions characteristics from figures: 8…13 and the diffractometrical aspects from figures: 5,6,7, the conclusions are that the evolution of the superficial layers characteristics depends by the sliding degree values and by the force applied during wear tests.

In the case of classic treatment (T1), when the sliding degrees (ξ) increase (because the increase of the specific load), the quantities Fe4N phase (hard phase) decrease. It is an exception: the quantity of Feα(M) which increase simultaneous with the wear process length. The width of the dimension for the quantity of phase $Fe_3N$ increase constantly following three hours of wear process.

The diffusion and the interaction of the nitrogen with the basic material lead to structural constituents whose nature determines a major hardness of the nitrided layer.

A decrease of hardness values inside in the superficial layers was obtained, after the wear process through friction. This variation was correlated and verified with the mass loss evolution during and after wear process.

The friction and wear processes are complex, being of physical, chemical, mechanical or metallurgical nature. These processes appear during dynamic or static contact between surfaces of two solid bodies where may be or not be in a gaseous atmosphere, liquid or solid lubricant. The depth of the superficial layer varies between some of atomic layers, in case of wear or chemical processes, and can attain up to 50-100 μm – in case of dry friction.

In the case of 121 code samples and 22 1code samples, the sliding degrees (ξ =10%) was constant. The applied force was Q =75 daN in the 122 code sample case and the applied force was double (Q=150 daN), in the case of 221 code sample.

The variation of the phases quantities after each hour of wear process was studied. It was observed that the increase of the tribological factor (ξ) determine the decreases of the $Fe_4N$ phase quantity, after three hours of wear process. The quantity of the Fe4N phase decreases during three of wear process and the quantities of $Fe_3N$ phase increase.

At the end of the wear tests, the internal tensions of second order for $Fe_4N$ phase are higher than the internal tensions of second order for $Fe_3N$ phase. But, the fatigue process of $Fe_4N$ phase is smaller than the $Fe_3N$ phase case.

The internal tensions of second order (B211~σII) increases uniform, until at maximum (corresponding to Δt=1.5h) and after that, these tensions decrease until Δt=2h. After that, the internal tensions of second order (B211~σII) increases uniform, until at maximum (corresponding to Δt =2.5h) and these tensions decrease until Δt = 3h. A cyclic evolution was observed.

For the case of $B_{Fe4N}$, the evolution is cyclic (increase-decrease) for the each 0,5 hour length. This evolution is constantly for all the wear process length (Δt =3h).

The distribution of the $Fe_3N$, and $Fe_4N$ phases corresponding to an alternate evolution, with minimum and maximum points, during three hours process means that it is possible to obtain a fatigue process which has exfoliation superficial layers consequences.

## 5. REFERENCES


[1]. Gheorghies, C., Papadatu, C.P., Ştefănescu, I. - "*Study on the model of behaviour of some non-conventional treated steels, during friction process*", CENTIMFE, Marinha Grande, Portugal, 2004;

[2]. Preda,A., Levcovici,S., Papadatu,C. - "*Research works regarding the influence of the nitrided layer structural properties on the wear behaviour of the turbo-blowers pinions and gear wheels*", ROTRIB 2003, Galati.

[3]. Popescu, N. et al. – "*Tratamente termice neconvenţionale*", Ed. Tehnica, Bucureşti, 1990.

[4]. Papadatu, C.P. – "*Cercetări privind ameliorarea proprietăţilor şi creşterea fiabilităţii unor oţeluri folosite în construcţia utilajelor metalurgice*", PhD Thesis, University "Dunarea de Jos" of Galati, 2005;.

[5]. Crudu, I., Palaghian, L., Gheorghies, C. -"*Structural modifications in the superficial layer of metallic material in wear and fatigue process"*, Japan International Tribology Conference, Nagoya, 2004;

[6]. Levcovici, S, s.a.- *Ingineria suprafetelor*, Note de curs.

[7]. Gheorghieş C., Crudu I. - "*A Cybernetic Structural Model Applied to the Study of Friction Process*", NORDTRIB 2000, Porvoo, Finland.

[8]. Gheorghies C. - *Modificari structurale in procese de uzura si oboseala*, Editura Tehnica, 1999, Bucuresti.

[9]. Gheorghieş C. - *Metode fizice de control nedistructiv*, Editura Porto-Franco, Galati, 1999.

[10]. Bucşă M., Crudu I., Gheorghies C. – "*Experimental study of the failure processes within some metallic and ceramiccoatings*", Thesaloniki, Greece, 1999;

[11]. Papadatu, C.-P., Bordei, M. - "*Changes in Tribological Behaviour of Thermo-Chemical Treated Steels after Thermo- Magnetic Treatments*", Metalurgia International Revue, vol. XV, Special Issue no. 8, ISSN 1582-2214 , pag..41 – 49, 2010.

# NUMERICAL MODELING OF DOUBLE BOTTOM PANEL IN THE CENTER OF THE VESSEL

[1]PAVEL ADRIAN, [2]CRISTEA ANIŞOARA-GABRIELA

[1,2]*"Dunarea de Jos" University of Galati, Faculty of Naval Architecture, Romania*

**ABSTRACT**

This paper presents the steps for manufacturing a double bottom panel for a bulk carrier ship, using Femap finite element program based on data obtained from sampling the ship in Poseidon and description of ship nomenclature in AutoCAD.

**Keywords:** *mechanical structures, numerical modelling, stress calculation.*

## 1. INTRODUCTION

The main concern regarding the development with finite element is to generate a model providing the best possible results of the structural strength.

Sizing of the model was made in accordance with the rules of the classification company Germanischer Lloyd.

For modelling and analysis of the stresses around the relief cut-outs of a frame element, in this case of a floor, we used finite element software system FEMAP version 9.3.1.

The study is performed on a bulk carrier of 80.000tdw, designed to carry loads with different specific weights.

Figure 1 shows the universal bulk carrier WEST FORTUNE built by “Koyo Dockyard Co” shipyard in Hong Kong in the autumn of 1994.

Figure 1 Universal bulk carrier WEST FORTUNE

Some of the main dry goods which are transported in bulk are: ores, coal, phosphates, grain, cement and sugar with stowage factors for these goods varying from 0.20 $m^3/t$ for iron ore up to 1.30 $m^3/t$ for sugar.

A cost-effective transport of these goods requires the use of bulk carrier ships, with high loading capacity. Also, these marine carriers can be provided with their own loading / unloading equipment to reduce the laying off in offshore terminals.

Figure 2 shows ANGEL WING carrier vessel built in May 1994 by ’’Albiero Maritima S.A’’ shipyard in Panama.

Figure 2 ANGEL WING carrier vessels

Loading and unloading operations are performed using high capacity grabs. Distribution of goods in holds must be even to avoid the hull’s stress to bending and twist and to ensure proper trim during navigation.

Numerical modeling of double bottom panel in the central area was performed on a panamax bulk carrier.

The size of a Panamax vessel is limited by the Panama canal's lock chambers , which can accommodate ships with a beam of up to 32.31 m, a length overall of up to 294.13 m, and a draft of up to 12.04 m. [25] The size of a Panama vessel is limited by Panama Canal lock, which can accommodate vessels with a width of up to 32.31 m and a total length of up to 294.13 m.

Figure 3 shows a part of the Panama Canal crossing of a bulk carrier.

Figure 3

Due to the high economic efficiency, universal bulk carriers became widespread nowadays. Among the improved universal bulk carriers, entered lately in the structure of the shipping fleets, the following can be mentioned: OBO-type bulk carriers (ore bulk-oil) that can carry at full capacity merchandise with high stowage factor and PROBO type bulk carriers which can transport oil besides the goods shipped by OBO vessel.

*1.1 Construction system*

Since the bulk carrier chosen has a 219 m length, the general framework system adopted is longitudinal framing.

This framework system is specific to great lengths vessels that are highly stressed at longitudinal bending both on calm water and especially on the waves.

The system is characterized by the fact that in the construction of the resistance structure of the floors that form the hull longitudinal framing elements are prevalent.

*1.2 Steps for manufacturing double bottom panel*

Given the desire to shorten the time required for the installation of a ship in the building slip or in the dock, it was necessary to direct the assembly technologies predominantly towards the volume sections, id est sections consisting of several flat sections so that transport and lifting equipment can be used at full capacity, and the ship is installed quickly, accurately and efficiently.

The study of the execution documentation is the first step for building the panel.

Components with structural member components are taken from the cutting section - all of them are made of high quality steel - and edges are polished.

Double bottom panel is executed at stand, on stands with flow cushion. When assembling the panel on stand check measures for width and length of the plate; they should match the rates within the documentation.

After placing the plate, fixing will be made by hafts of 20-30 mm at a distance between them of 300 mm. At the end of the plate, haft is placed at 100 mm from the end of the plate and ultimately end plate is placed.

Seam and plate are checked; they should be free of grease, pores, etc. so as to correspond to the welding process.

During welding the elements, panel will need to have weights on it to avoid deformations.

After welding the elements, it will be positioned upside down and the “root of weld” will be cleaned with arcair; then, the second layer will be welded, followed by a check of tracing (as contractions occur from welding).

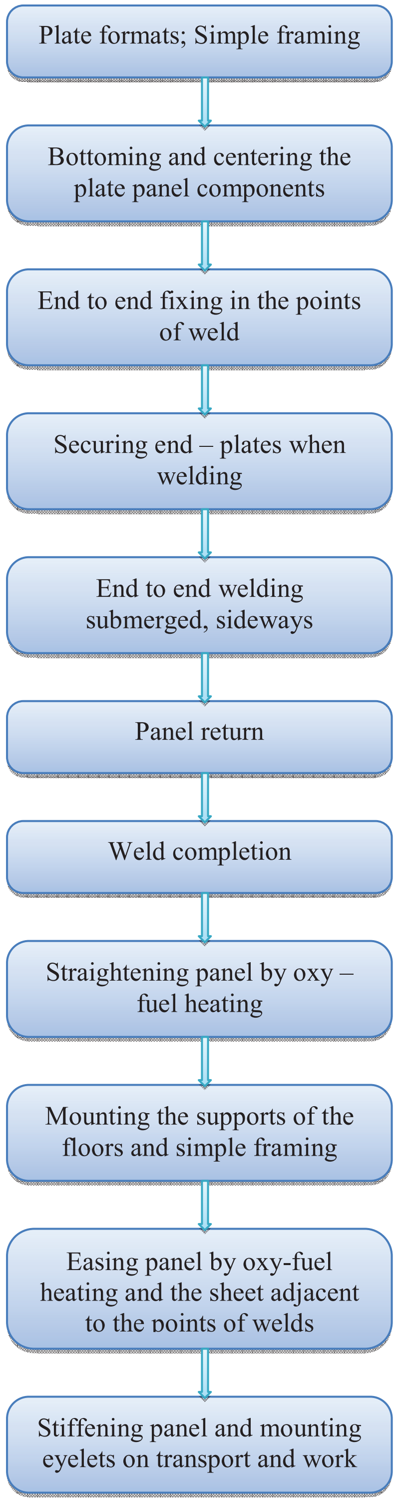
Once the supports, floors and simple framing are mounted, the panel will be flattened out and removed stress (where problems exist).

It should be noted that all welds shall be made according to the scheme of welding and welding tables.

After checking, bilge and keel will be mounted.

The last operation of manufacturing the panel consists of the arrangement of connectors and handling elements named eyelets which serve for maximum safety handling of the section.

*1.3 Stages of panel production*




## 2. SAMPLING IN THE CENTRAL AREA OF THE SHIP USING POSEIDON PROGRAM

For sizing the structural elements that are used in the master section POSEIDON ND v.9.0 software package belonging to the classification society Germanischer Lloyd was used.

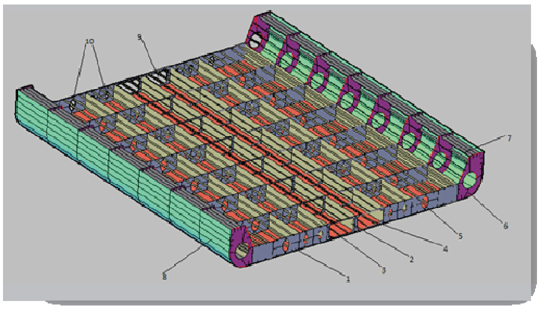
*Main dimensions and characteristics*

| | |
|---|---|
| Length between perpendiculars | $L_{pp}$ = 217,3 m |
| Length of water line at T | $L_{wl}$ = 219 m |
| Breadth | B = 32,2 m |
| Depth | H = 19 m |
| Scantling draught | T = 13,83 m |
| Block coefficient | $C_b$ = 0,79 |
| Max. speed in calm water | v = 14 kn |
| Displacement | Δ = 80000 dwt |

## 3. DESCRIPTION OF THE FUNCTIONAL ELEMENTS AND OF THE DOUBLE BOTTOM PANEL

For the description of the nomenclature AutoCAD program was used by creating geometric patterns on surfaces.

The panel shown in the following image is designed on the distance of a loading hatch according to data obtained from sampling conducted in Poseidon program.



1. Floor;
2. Central support;
3. Side support;
4. Bottom fore and aft;
5. Longitudinal framing of double bottom;
6. Stiffened bilge frame;
7. Longitudinal framing of the bilge frame;
8. Bottom plating;
9. Central tunnel;
10. Manholes / relief holes.

The geometric patterns have been generated in AutoCAD software using the commands ”edge surf’’ and ’’rule surf’’ making use of the graphics facilities in Autodesk Inventor.

It should be noted that first central supports have been geometrically modeled followed by the floors (obviously positioned on the double bottom plate).

Therefore, all functional elements of the double bottom panel were represented superposed forming the bottom of the vessel with the bilge excepting double bottom panel which makes it possible for the observer to see the component structural elements.

### *3.1 Numerical modelling study using FEMAP*

The main module of an application FEM manages the computer system resources and controls the usage of specialized modules of the subprogram, depending on the specific analysis.

In most current FEM programs classic introduction of data based on a text file was replaced with CAD interface modules, making much easier the operation of FEM model generation for the idealized structure.

These CAD modules also called preprocessing modules show in most cases the automatic generating facility of FEM model based on CAD model.

The following information is included in the category of input data for the FEM program:

-CAD model based on entities like: points, curves, surfaces; FEM model based on entities like: nodes, finite elements, geometric properties, material properties, external loads, boundary conditions and type of analysis.

The ship considered is a universal bulk carrier vessel type, designed to carry bulk cargo.

The material selected for construction of the hull is steel type A, STAS 8324 - 80 with a yield strength ReH = 315 N/mm².

Register Conditions recommend - for the finite element analysis of a ship structure - to consider two or three cargo holds (cargo tanks) to reduce the boundary conditions, along pressure distribution in the master section. In this case the study will be done for a hold.

Table 2 shows CAD-FEM model characteristics and the material of the ship.

Table 1. CAD-FEM characteristics of the model

| | |
|---|---|
| The number of the elements of plate and membrane PLATE (QUAD) | 273536 |
| The number of bends | 322817 |
| Young’s modulus | 2,1E+5 $N/mm^2$ |
| Poisson’s coefficient | 0,3 |
| Steel density, ρ | 7,7E-6$kg/mm^3$ |
| Steel flow limit, $R_{eH}$ | 315 $N/mm^2$ |

### *3.1 Description of the model*

Finite element model was reduced at the bottom, double bottom and bilge and was extended on the length of a hold; it is a combination of 4-node plate elements and 2-node bar elements.

Global mesh size is half the longitudinal distance (477mm).

The plate elements have been used for bottom, double bottom, supports, and bar elements have been used for simple framing.

To highlight as correct as possible stress distribution on the floor made of fine mesh both simple framing on the floor and fore and aft were made with plate-type finite elements, with 4 nodes.

The global coordinate system of the finite element model is defined as follows:

X-axis: Longitudinal, positive from aft to fore;

Y-axis: Transverse (athwart ships), positive toward portside;

Z-axis: Vertical, positive upwards;

Origin: Base-line.

The following units are used for analysis

- Length: millimetres (mm)
- Pressure: Megapascals (N/mm$^2$)
- Mass: kilogramme (kg)
- Stress: N/mm$^2$ (MPa)

It should be noted that all structural elements were modeled geometrically in the standard order of construction stages of the double bottom panel.

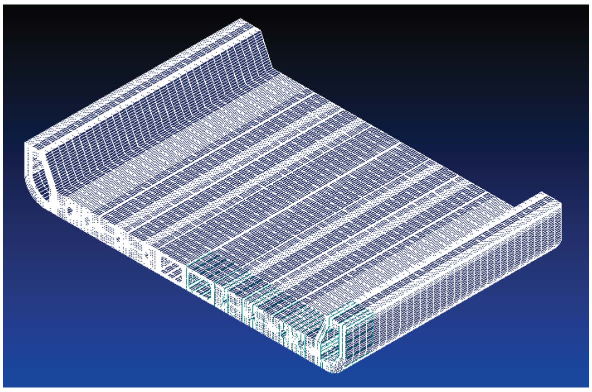


Figure 4 Global model

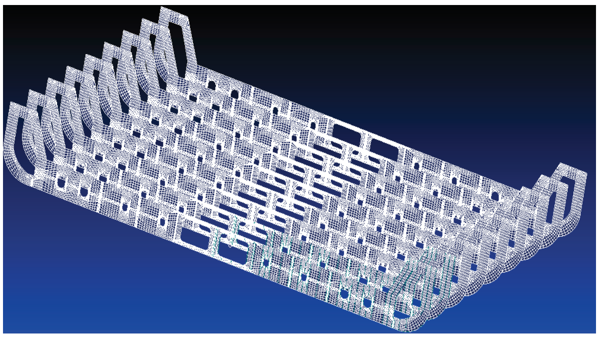


Figure 4(a)

*3.2 Loading the structure*

The loading cases include:

- external pressures (still water and wave);
- internal pressures (hydrostatic, dynamic effect, safety pressure valve, sloshing, heeling);
- self gravity of the model;
- specific balanced boundary loads.

The section was modelled both with the pressure from the merchandise and the pressure on plating due to sea water.

- The static pressure of the merchandise

The static pressure of the merchandise, $P_{hys}$ is:

$$P_{hys} = \rho_{sw} g (T_{LC} - z), \text{ kN/m2} \quad (1)$$

where:

$z$ - the vertical coordinate of loading point in [m] and it should not be higher than $T_{LC}$ ;

$\rho_{sw} = 1{,}025 t/m^3$ - density of sea water;

$T_{LC}$ - draft in m;

$g = 9{,}81 m/s^2$ - gravitational acceleration.

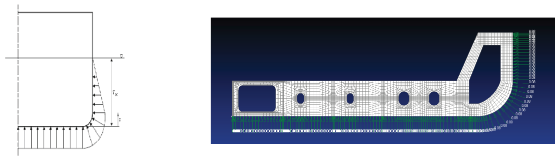


Figure 5 Hydrostatic watter pressure

- The static pressure from the tank (Figure 5)

The static pressure of the merchandise, $P_{in-tk}$ , is:

$$P_{in-tk} = \rho g z_{tk}, \text{ kN/m}^2 \quad (2)$$

where:

$z_{tk}$ - vertical distance the highest point of the merchandise in the tank, [m];

$\rho$ - density of the merchandise in the tank, [t/m$^3$];

$g = 9{,}81 m/s^2$ - gravitational acceleration.

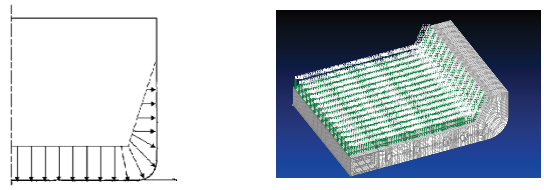


Figure 6 Hydrostatic cargo pressure distribution

## 4. CALCULATION AND EVALUATION OF THE RESULTS

The purpose of the 3D static analysis is to determine the overall structural response of the hull girder, and also to obtain appropriate boundary conditions for use in the 3D fine-mesh analysis of local structures.

Below we present the results obtained following the linear static analysis carried out for the ship loaded with merchandise and with the pressure of calm water.

These results are mainly charts with distribution of Von Misses stresses.

There is a colour scale in the right of each figure, corresponding to stress levels plotted on each element of the structure represented. Stresses obtained correspond to the elements with the highest values of stresses.

Generally, one can say that, the edge conditions were chosen properly, reason for which there are no visible effects on the stress field.

In fig.2.13-4 (a, b) presents the results of FEM analysis: tension in double bottom structure.

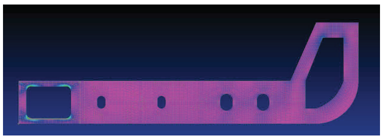


Figure 7 (a) – Global stress (Von Misses)

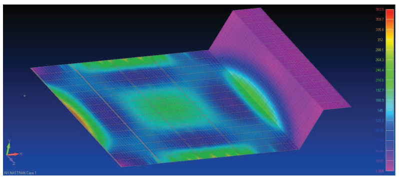


Figure 7 (b) – Global stress (Von Misses)

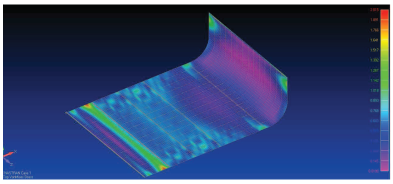


Figure 7 (c) – Global stress (Von Misses)

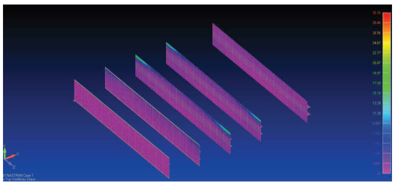


Figure 7 (d) – Global stress (Von Misses)

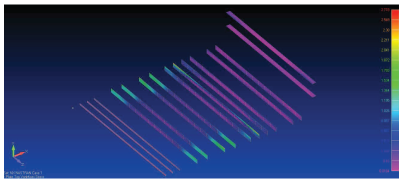


Figure 7 (e) – Global stress (Von Misses)

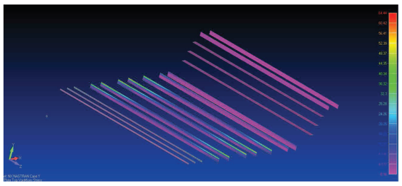


Figure 7 (f) – Global stress (Von Misses)

## 5. CONCLUSION

The maximum stress in floor plate in cargo and ballast case does not exceed the admissible stress for AH32 material which is 315 N/mm$^2$.

## 6. REFERENCES

[1] Cristea A. G., *Determination of the induced stresses at the level of a floor usi the finite element method",* Editura Nautica, Constanta, 2010

[2] Domnişoru L., *Analiza structurilor navale prin metoda elementului finit . Aplicatii numerice*, Editura Fundației Universitare "Dunărea de Jos", Galați, 2009

[3] Domnişoru L., Găvan E., Popovici O., *Analiza structurilor navale prin metoda elementului finit,* Editura Didactică şi Pedagogică, Bucureşti, 2005

[4] **X X X** – FEMAP 9.3.1 / NX NASTRAN 5.0 User's Guide, UGS Corporation / Siemens PLM Software Inc., 2007

# "COMARNA" ORTHOSIS – CALCULATION OF THE SHEAR RIVETS AND MATERIALS USED

[1] RANCEA ADY, [2] MACUTA SILVIU

[1] "Gheorghe Asachi" Technical University of Iaşi, Romania, [2] University Dunarea de jos of Galati, Romania

**ABSTRACT**

If the Achilles tendon stalks, the emergency surgery involves the ligation and the recovering of the tendon of interest. The interest in physical therapy is for a model that would allow adjustment dorsiflexed stages, the number of degrees, and the final stage the same orthosis to submit a joint motion for free care. The Comarna orthosis solution is for these stages, a cut in the leg support in making a dynamic orthosis to assist. The paper addresses the leg in terms of biomechanical and choosing the right type of mechanism.

**Keywords:** *biomechanics, rivets, orthosis, tendon.*

## 1. INTRODUCTION

Orthosis is used for the recovery of the Achilean tendon after surgical treated injury. "Comarna" orthosis was used for the first time in 2007 by Bogdan Dimitriu for the recovery of a patient from the village with the same name.

The fact that it is an evolutionary orthosis has a huge advantage is saving money and working progressively with the patient without wasting time waiting for a new product.

In addition to the joint continuous adjustment allows proper positioning of the orthosis. Orthosis design evolved with the rear support leg orthosis to support earlier in the shank. It should be noted that the size of this device is made to be used in hospitals to patients' recovery, in the fitness rooms at the sports clubs and the home user.

## 2. MODEL

So while walking and at rest, the patient's weight is taken over by rivets, a hinge plate that secures the arm and its axis [1, 2, 3, 4]. These elements are submitted to shear forces (fig. 1).

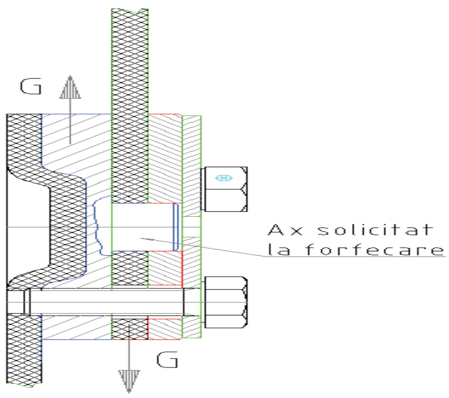



Figure 1 Scheme application shear axis [5]

Shaft diameter is determined from the condition that the shear stresses are lower than allowable shear strength of the material.

$$\tau_f = \frac{G \cdot \psi}{\frac{\pi}{4} \cdot d_{ax}^2} \le \tau_{af} \quad [\text{N/mm}^2] \tag{1}$$

where:
$\psi$ = 1.8 is a factor of impact;
$\tau_{af}$= 0,2 $R_{p0,2}$ N/mm$^2$- allowable shear strength of the material;
$d_{ax}$ = diameter of rotating shaft (mm);
G = static force acting on the shaft, taken as the weight of the patient.

$$d_{ax} = \sqrt{\frac{G \cdot \psi}{\frac{\pi}{4} \cdot \tau_{af}}} \quad [\text{mm}] \tag{2}$$

*2.1. Calculation of the shear rivets on share stress*

Riveted joints are part of the orthosis, and function as a couple of 5 class type that enables the controlled rotation of angle of the arms [1, 2, 3, 4].

The calculus total static shear strength is given by the patient's weight.

Total dynamic shear force is given by:

$$F_{df} = \psi \cdot G \quad [\text{N}] \tag{3}$$

The constructive solutions consists in a number of 4 rivets that secure the hinge plate subsequently the share force by rivet becomes:

$$T = F_{df} / 4 \quad [\text{N}] \tag{4}$$

Shear stress of the rivet must be less than the allowable shear tension.

$$\tau = \frac{T}{A} \le \tau_{af} \quad [\text{N}] \tag{5}$$

$$A = \frac{\pi \cdot d^2_{riv}}{4} \quad [\text{mm}^2] \tag{6}$$

Where: A is the sectional area mm2 rivet;

$\tau_{af}$ = 22 N/mm$^2$ - voltage is allowable shear for aluminum;

$d_{riv}$ = rivet diameter is mm.

Rivet diameter is given by:

$$d_{riv} \geq \sqrt{\frac{4 \cdot T}{\pi \cdot \tau_{af}}} \quad [\text{mm}] \qquad (7)$$

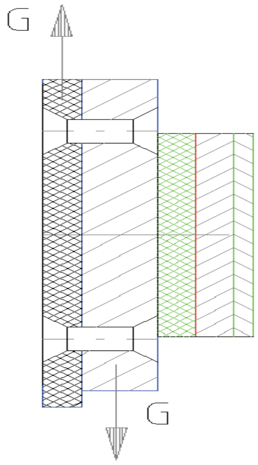



Figure 2 Scheme application shear rivets

Comarna orthosis resulting from the design and implementation is shown in fig. 3. Figures 3 (a, b, c) are drawings of Comarna orthosis landmarks.

***a. right side view***

*b. left lateral view*

*c. front view*

Figure 3 Images of Comarna orthosis

To allow rotation of arm 2 of the orthosis, which is mounted on the lower leg compared to arm 1, we used a cylindrical joint, with the possibility of creating a continuously adjustable swivel and mounting screws. I hinge plate fixed to the arm I orthosis by riveting. It has a shaft around which rotates plate 2 package of joint orthosis and arm 2, which are provided with elongated channels for this purpose. Rotate arms is viewed with a graduation provided on a plate and the plate 2 riz joint. After positioning arms tighten bolts.

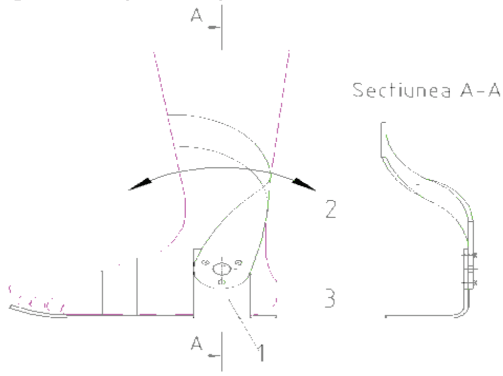



Figure 4 Scheme of the Comarna orthosis;
1-the part that’s fixed on the foot; 2-the part that’s fixed on the leg; 3-the articulation that allows the adjustment and the fixation of the first two parts

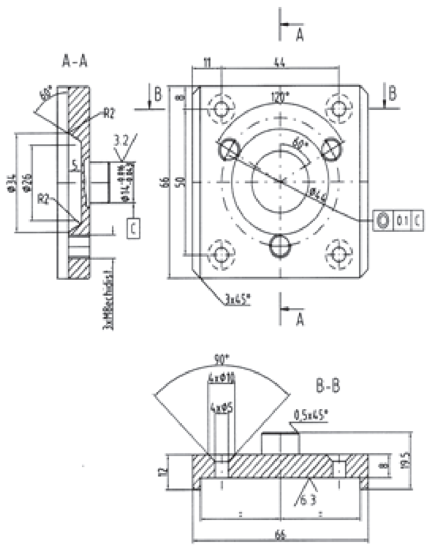



Figure 5 A joint orthosis plate code Comarna OC-O1

A plate material used for the joint Comarna orthosis is a stainless steel AISI 304 mark, which is not a factor for surgical site infection, provide the required strength to requests: D14mm shear shaft, mounting screws and 3 x M8 D5 rivets securing an arm orthosis (fig.5).

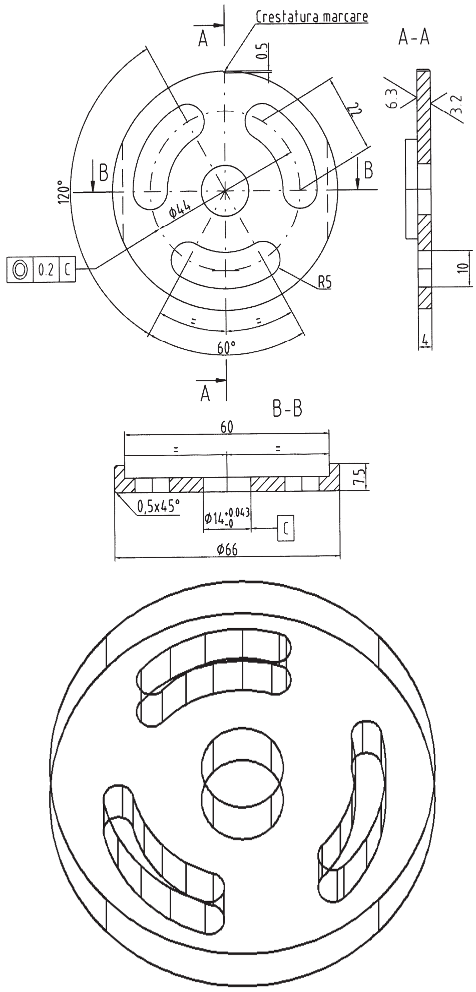



Figure 6 Place 2 of the orthosis joint Comarna OC-02 code

The material used for the hinge plate 2 Comarna orthosis is a stainless steel AISI 304 mark, which is not a factor for surgical site infection, provide the required strength to requests: a crushing bore D14mm, mounting screws and 3 x M8 2 mounting arm orthosis (fig.6).

The material used for the joint orthosis Comarna plate is a stainless steel, AISI 304 mark, which is not a factor for surgical site infection, provide the required strength at the request of crushing 3 x M8 fixing screws (fig.7).

Kinematic coupling is blocked by three screws placed equidistant on the circumference of a certain radius where Comarna orthosis, only to jam through a central screw for orthopedic orthosis. Given the structural elements of the composition of the two orthoses may signal the following advantages:

- establishing joint guaranteed if Comarna orthosis, insecure attachment to requiring additional measures to strengthen the bandages for orthopedic orthosis;

- smoother and easier adjustment of the orthosis by controlling the angle tightening screws secure if Comarna orthosis compared to less secure control by manipulating a single screw and had the same office if orthopedic orthosis;

- restrict severely the rotating elements within the cinematic covers by the existence of a circumferentially elongated hole where Comarna orthosis, lack or complicated to design for orthopedic orthosis.

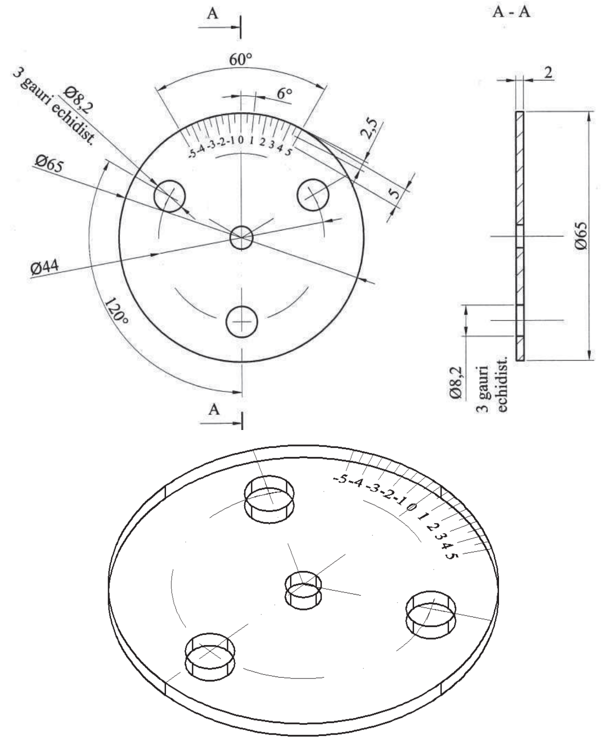



Figure 7 Plate position adjustment code Comarna joint orthosis OC-03.00

## 3. CONCLUSIONS

The standard SR EN 13291:2007 (EN 132921: 2007) “Individual protection equipment. Ergonomic principles” is a guide related to the ergonomic characteristics of such products. Among the things that must be taken in consideration we are mentioning:

- “Comarna” orthosis ensures the protection against specified risks and is from an ergonomically point of view proper for the provided utilization;
- “Comarna” orthosis allows making specifically movements
- “Comarna” orhosis achieves adaptability and maintaining on the body: adjustment, stability of adjustments
- “Comarna” orthosis doesn’t causes rashes and discomfort;
- the orthosis doesn’t make worst the biomechanically characteristics: weight distribution, inertial forces distribution on the human body, limitation or stopping movements, abrasion or compression on teguments and muscles, raising of vibration;
- the orthosis isn’t a stress factor for the patient.

## 4. REFERENCES

[1] BUZDUGAN, Gh., *Rezistența materialelor*. Editura Tehnică, Bucureşti, 1980.
[2] BUDESCU, E., Iacob, I., *Bazele biomecanicii în sport*, Editura Universității "Alexandru Ioan Cuza" , Iaşi, 2005
[3] DENISCHI, A., MARIN, I.G., Antonescu, D., Petrescu, L., *Biomecanica*, Editura Academiei, Bucureşti, 1989
[4] DRĂGULESCU, D., Toth Taşcău, M. *Elemente de inginerie mecanică*, vol. I-II, Curs litografiat, Universitatea Tehnică Timişoara, 1993
[5] RANCEA, A., Referat nr. 3 la teza de doctorat, Orteza „Comarna" pentru recuperarea traumei pe tendonul lui Ahile post traumatic, U.T. Iaşi, Facultatea de Mecanică, 2011.
[6] RANCEA, A., PhD Thesis - U.T.Iasi-2011

# STUDY OF INJECTION INFLUENCE ON DIESEL ENGINE COMBUSTION

SABAU ADRIAN

*Constanta Maritime University, Romania*

**ABSTRACT**

Computational simulation for the combustion process in a DI diesel engine was performed through a code made by the author [4]. Two conditions of different injection pressure were examined in the simulation. The injection pressures are 1500 bars and 500 bars. The combustion phenomenon was modeled as a combined process of formation of a combustible mixture and a chemical reaction. The rate of mixture formation was assumed to be dependent on the turbulence characteristics and the concentration of species in each computational cell. The rate of chemical reaction is described as an Arrhenius equation. The result of the simulation agrees with the experimental result qualitatively, and the effect of injection pressure on the combustion process is well predicted.

**Keywords:** *spray, turbulence, injection, heat release, injection pressure.*

## 1. INTRODUCTION

In this paper, we are interested in problems, such as high-pressure fuel injection in an internal combustion engine, in which the spray carries sufficient momentum to entrain and set into motion the surrounding gas. In turn, the motion of the gas in the vicinity of the particles reduces the resistance to their motion and allows the spray to penetrate much further than would otherwise be the case. It is important, therefore, to account for the interaction between the particles and the gas. This interaction is of course always present, but it is particularly significant whenever the particles are sufficiently small so that the coupling of a particle to the gas is strong.

The procedure is to represent the spray by discrete particles, rather than by continuous distributions. This amounts to a statistical (Monte Carlo) formulation of the problem, since the finite number of particles used represents a sample of the total population of particles.

The developed method [5] is of multi-dimensional type and it solves the specific combined equation systems of:

- Compressing eddying flow by using:
  - SGS (Subgrid scale turbulent viscosity) model for turbulence ;
  - wall logarithm law for the turbulent boundary layer;
  - altered Reynolds formula for the caloric boundary layer;
  - approximating the fluid as Newtonian to compute its viscosity
- Chemical reactions of fuel combustion by using :
  - A kinetic equation of fuel combustion;
  - Splitting equations of combustion products treated on equilibrium;
  - Extended Zeldovich mechanism solved kinetically for NO.
- The flow and evaporation of liquid jet of particles by using:
  - The general equation of jet simplified in stochastic approach ;
  - The equation of drops' evaporation as deducted by O'Rouke;

The formula is bi-dimensional in space and thus allows a plane and axial symmetrical approach of the geometry of the combustion chamber. The axial symmetrical formula, the most often case met in practice, allows us to take into account the swirl movement as well, enhancing thus the spatial resolution and partially implementing the third geometric dimension.

Computational simulation for the diesel combustion is an active area of research. For practical applications, there are some requirements in the computational code. They are accuracy of the simulation, ability of dealing with several input variables such as geometry of the combustion chamber, operating conditions, and fuel specifications.

## 2. FUEL SPRAY MODEL

It will be assumed that no particle coalescence or particle breakup occurs. This implies that the particles are sufficiently dispersed that particle collisions are infrequent. The initial breakup of liquid sprays or jets is not considered It is assumed that initial conditions for the particles are known. That is, the initial particle size distributions, positions, and velocities are independently specified.

This leads to two sets of equations, one set for the gas and the other for the particles. These equations will be coupled primarily by two mechanisms, the displacement of gas by the volume occupied by the particles and momentum interchange between particles and the gas.

*2.1 Spray equations* [1]:

$$\frac{\partial f}{\partial t}+\nabla_x\left(fu_p\right)+\nabla_{u_p}\left(fF_p\right)+\frac{\partial}{\partial r_p}\left(fR_p\right)+\frac{\partial}{\partial T_p}\left(f\dot{T}_p\right)=\dot{Q} \quad (1)$$

where $u_p$, $F_p$, $R_p$ and $T_p$ is the velocity, force, rate of radius variation and the temperature of an arbitrary droplet in the spray at $x$ position. $fdr_p dv_p dx dT_p$ is the probably number of droplets at $x$ position, in the space

$dx$, with $u_p$, $F_p$, $R_p$ and $\dot{Q}$ is f rate of change, made by collision, and coalescention.

*2.2 Continuity equation for the gas:*

$$\frac{\partial \theta}{\partial t} + \nabla \cdot \theta u_g = 0\,, \tag{2}$$

where $\theta$ is the void fraction, or the fraction of the volume occupied by the gas, and $u_g$ is the gas velocity. The presence of the void fraction in this equation accounts for the displacement effect of the particles.

*2.2 Momentum equation:*

$$\frac{\partial}{\partial t}\theta u_g + \nabla \cdot \theta u_g u_g = \theta g - \frac{\theta}{\rho_g}\nabla p + \nabla \cdot \theta \mu_g \nabla u_g + \frac{1}{\rho_g} M_p \tag{3}$$

where $g$ is the acceleration of gravity, $p$ is the pressure, $\mu_g$ is the kinematic viscosity (or eddy viscosity if the flow is turbulent), and $Mp$ is the term defining momentum exchange with the particles, per unit volume. An alternative form of this equation can be obtained by subtracting out the continuity equation [2]:

$$\frac{\partial}{\partial t} u_g + u_g \cdot \nabla u_g = g - \frac{1}{\rho_g}\nabla p + \frac{1}{\theta}\nabla \cdot \theta \mu_g \nabla u_g + \frac{1}{\theta \rho_g} M_p \tag{4}$$

This is the form of the equation used. The terms containing $M_p$, will be defined later.

In a turbulent flow, the gas equations of the previous section are written in terms of the mean velocity $u_g$. For particles, gas turbulence is important as a mechanism for diffusion; and it is convenient to write the instantaneous, rather than averaged, equations for the particles. To do this, we define the instantaneous gas velocity, $U_g = u_g + u_g^{'}$, where $u_g^{'}$, is the turbulent component of the gas velocity.

Each particle, individually labeled by subscript k, is assumed to obey the following equations:

*2.3 Particle velocity:*

$$u_{pk} = dx_{pk} / dt \tag{5}$$

*2.4 Particle momentum equation:*

$$m_k \frac{d}{dt} u_{pk} = m_k g - \frac{m_k}{\rho_k}\nabla p + D_k[U_g](U_g - u_{pk}); \tag{6}$$

where $x_{pk}$ is the particle position, $u_{pk}$ is its velocity, $m_k$ is its mass, and $\rho_k$ is its density. The notation $D_k[U_g]$ is used to denote the drag function, evaluated using the velocity $U_g$, which is the coefficient in the force acting on the particle due to its motion through the gas. It will be convenient to abbreviate the notation to $D_k$ when referring to the drag function evaluated at the mean gas velocity.

It is more convenient to consider the effect of turbulence on the particles to be due to a force $f_{pk}$, in which case the momentum equation is written [3]:

$$f_{pk} = D_k[U_g](U_g - u_{pk}) - D_k(u_g - u_{pk})\,, \tag{7}$$

$$\Rightarrow m_k \frac{d}{dt} u_{pk} = m_k g - \frac{m_k}{\rho_k}\nabla p + D_k(u_g - u_{pk}) + f_{pk} \tag{8}$$

The terms in the gas equations (eqs. 2 – 4) dependent on the particles have not yet been defined. Taking ensemble averages, we can write:

$$\theta = 1 - \sum_k \overline{4/3\pi r_k^3 \delta(x - x_{pk})}\,, \tag{9}$$

$$M_p = -\sum_k \overline{D_k(U_g)(U_g - u_{pk})\delta(x - x_{pk})}\,. \tag{10}$$

For modeling purposes, it is not possible to deal with the large number of droplets, so that a sampling technique be employed in which each single particle represents a characteristic group of particles. This is equivalent to the following distributions function:

$$f(r,x,u_p,t) = \sum_k N_{pk}\delta(r - r_k)\delta(x - x_k)$$
$$\delta(u_p - u_{pk}) \cong \frac{\Delta N}{\Delta r \Delta x \Delta u_p} \tag{11}$$

where $N_{pk}$ is the number of identical particle by particle $k$, $\Delta N$ is the number of particles in the volume $\Delta r \Delta x \Delta u_p$.

The droplet size distribution is:

$$f_r(r) = \frac{6}{D_{32}}\exp\left(\frac{-6r}{D_{32}}\right), \tag{12}$$

where $D_{32}$ is Sauter mean diameter which is consider to varying very little.

Eddy viscosity was estimated using a value appropriate to a turbulent gaseous jet:

$$\mu_g = 0.0161\sqrt{0.25\pi d^2 V^2}\,, \tag{13}$$

where d is the orifice diameter and V is the droplet injection velocity.

No attempt was made to calculate particle diffusion accurately. Particle turbulence was modeled using the assumption, that the fluid turbulence is isotropic and has a Gaussian distribution in velocity. Given the turbulent kinetic energy $k$, is $k = 0.1 u_g u_g$, and turbulent velocity is:

$$u_g^{'} = k^{0.5}\,\mathrm{sgn}(X) \cdot erf^{-1}(|X|)\,, \tag{14}$$

where, as before, $X$ and $Y$ are random variables selected for a uniform distribution in the range $-1 < X, Y < 1$. To complete the description, the relevant turbulence time scale $\tau$ is required. The velocity $u_g^{'}$ is assumed to act for a time equal to $\tau = \Delta t$. An elementary analysis suggests that the produces particle diffusion corresponding to:

$$D_T \approx 0.66\left(\frac{D_k}{m_k}\right)^2 q\tau^3 \quad (15)$$

The resulting particle concentration, which is Gaussian, forms a distribution function for the location of the particle. Particle positions are randomly selected from within this distribution, such that on each time step the diffusional increment in particle position is

$$\Delta x_{pk} = (4D_T \Delta t)^{0.5}\,\mathrm{sgn}(X)\,erf^{-1}(|X|) \quad (16)$$

This is equivalent to selecting the following random particle force on each time step

$$f_{pk} = m_k \frac{\Delta x_{pk}}{\Delta t^2} \quad (17)$$

Each particle injected or entering the mesh must be assigned a velocity $u_{pk}$, a radius rk, and the number of particles in the group $N_{pk}$. Let the number of computational particles injected per cell per time step be k. The radius of each particle is then chosen from a uniform random distribution that verified the relation.

$$\sum_{k=1}^{K} N_{pk} m_k = Q\Delta t \,. \quad (18)$$

If the pressure drop across the nozzle is known, then

$$V = C\left(\frac{2\Delta p}{\rho_p}\right)^{0.5}, \quad (19)$$

The transverse velocity is derived in terms of the initial spray angle using the relationship $0 < (u_{pk})_t \le Max(u_{pk})_t$ [4] where:

$$Max(u_{pk})_t = V\,tan(\alpha/2), \quad (20)$$

$$tan(\alpha/2) = C(\rho_g/\rho_p)^{1/2} \quad (21)$$

## 3. CHEMICHAL MODEL

The model involves twelve species and the consequent equations are:

1. A stoichiometric, irreversible, kinetic equation (22), a single-step hypothetical fuel combustion ($C_nH_mO_r$, given by elemental analysis where *m*, *n* and *r* may be not integers);

$$C_nH_mO_r + (n+\frac{m}{4}-\frac{r}{2})O_2 + \frac{79}{21}(n+\frac{m}{4}-\frac{r}{2})N_2 \Rightarrow nCO_2 + \frac{m}{2}H_2O + \frac{79}{21}(n+\frac{m}{4}-\frac{r}{2})N \quad (22)$$

2. Three partial equilibrium reversible equations expressing the extended Zeldowich mechanism (23) for NO evaluation;

$$\begin{cases} N_2 + O \xleftrightarrow{k1/k2} NO + N \\ N + O_2 \xleftrightarrow{k3/k4} NO + O \\ N + OH \xleftrightarrow{k5/k6} NO + H \end{cases} \quad (23)$$

3. Six reversible equilibrium equations for main combustion products dissociation (24) [2].

$$\begin{cases} H_2 \leftrightarrow 2H \\ O_2 \leftrightarrow 2O \\ N_2 \leftrightarrow 2N \\ O_2 + H_2 \leftrightarrow 2OH \\ O_2 + 2H_2O \leftrightarrow 4OH \\ O_2 + 2CO \leftrightarrow 2CO_2 \end{cases} \quad (24)$$

The chemical source term in continuity equation is given by equation (6), and the chemical heat release term in the energy equation is given by equation (25) [4].

$$\dot{\rho}_k^C = W_k \sum_r (b_{kr} - a_{kr})\dot{\omega}_r \,, \quad (25)$$

$$\dot{Q}_C = \sum_r q_r \dot{\omega}_r \,, \quad (26)$$

where $a_{kr}$ and $b_{kr}$ stoichiometric coefficients, $W_k$ is the molecular weight, $\dot{\omega}_r$ is the rate of progress of r-th reaction, $q_r$ is the negative of the heat of reaction at 0º K. If *r* is a kinetic reaction, then $\dot{\omega}_r$ is computed by equation (27) which is an equilibrium reaction and $\dot{\omega}_r$ is implicitly determined by the condition expressed by equation (28):

$$\dot{\omega}_r = k_{fr}\prod_k (\rho_k/W_i)^{a'_{kr}} - k_{br}\prod_k (\rho_k/W_i)^{b'_{kr}} \,, \quad (27)$$

$$\prod_k (\rho_k/W_k)^{(b_{kr}-a_{kr})} = K_C^r(T)\,, \quad (28)$$

where: $k_{fr}$ and $k_{br}$ are the rate coefficients for reaction (generalized Arrhenius form) *r*, $a'_{kr}$ and $b'_{kr}$ are orders of the reaction and $K_C^r(T)$ is the concentration equilibrium constant.

It was supposed that the equilibrium constant is given by an expression, such as:

$$K_C^r = \exp\left(A_r \ln T_A + B_r/T_A + C_r + D_r T_A + E_r T_A^2\right) \quad (29)$$

where $A_r$, $B_r$, $C_r$, $D_r$ and $E_r$ are constants for each reaction, and $T_A = T/1000$.

## 4. COMPUTATIONAL CONDITIONS

The model presented in the paper was used for numerical simulation of the T684 engine manufactured by "Tractorul" Plant of Brasov, a four stroke automotive engine specifications are shown in Table 1. The calculating conditions are shown in Table 2. The difference of injection pressure is given through the input parameters of fuel injection shown in Table 3. The engine has a centrally located 4-holes nozzle and an accumulator type fuel injection system. A periodicity was assumed. So, the calculation was performed for a part of the combustion chamber which includes one fuel spray.

Table 1. Engine specifications

| | |
|---|---|
| Bore mm | 105 |
| Stroke mm | 115 |
| Compression ratio | 17.5 |
| Piston bowl mm | 60 |
| Injection nozzle | 4 holes, diameter=0.25 |

Table 2. Calculation data

| | | |
|---|---|---|
| Engine speed rpm | 1400 | |
| Injection quantity g/st | 55 | |
| Injection timing TDC deg | -5 | |
| Injection pressure bar | 1500 | 500 |

Table 3. Data for fuel spray

| Injection pressure bar | Injection Duration deg | Sauter Radius mm | Initial Velocity m/s |
|---|---|---|---|
| 1500 | 11.7 | 0.025 | 374 |
| 500 | 17.8 | 0.045 | 215 |

Simulation is done from -20 TDC degrees to 60 TDC degrees. The calculus is done under the hypotheses that the reactions are de-coupled and the pressure is constant.

The reaction speed for the equilibrium conditions, $\dot{\omega}_r$, (where $r$ is the number of chemical reactions in equilibrium conditions) is computed by the use of an iterative algorithm. Thus, every reaction is relaxed until the equilibrium constant given by equation (27) becomes equal to the value resulted from equation (28), with an acceptable error.

The temporal differentiate is based on ICE (Implicit Continuous-fluid Eulerian) algorithm which is a partial implicit method. This iterative technique joins the continuity and moment equations and solves them simultaneously by using the state equation; the energy equation is solved explicit apart from the other two. To move forward in time some values several steps in time are needed. This approach is in direct connection to the spatial digitization based on ALE (Alternate Lagrangean Eulerian Method) method [6].

The grid is adjustable and is made up of generalised quadrangle whose corners is specified by coordinates dependent on time and is reported to the inferior position of the piston, which allows us to approach the problem Eulerian or Lagrangean as necessity should arise.

The code is written in MATLAB [4].

## 5. RESULTS AND DISCUSSION

Figure 1-3 show the predicted spray evolution for 1500 bar injection pressure and Figure 4-6 for 500 bar. Concentrations of vaporized fuel $O_2$ and NOx is shown as representative species in parallel whit spray evolution, Figures shows a section includes the axis of fuel injection. The concentration of fuel increases in the injection duration only near the fuel spray axes, and is low at the wall. After the end of injection, the concentration of fuel decreases rapidly. The concentration of product species increases around the fuel spray. Strong turbulence is formed along the

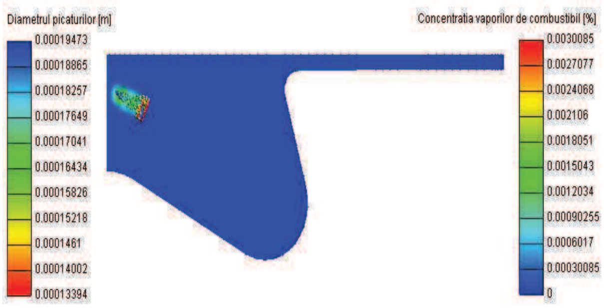



Figure 1 Spray at – 1 degrees of TDC

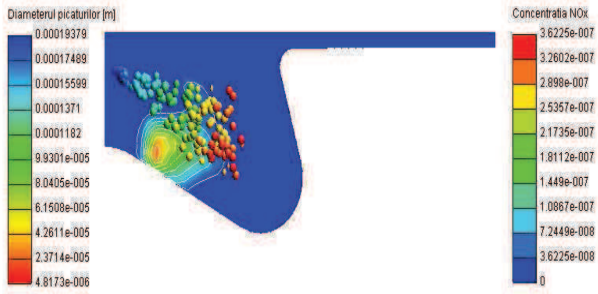



Figure 2 Spray at TDC.

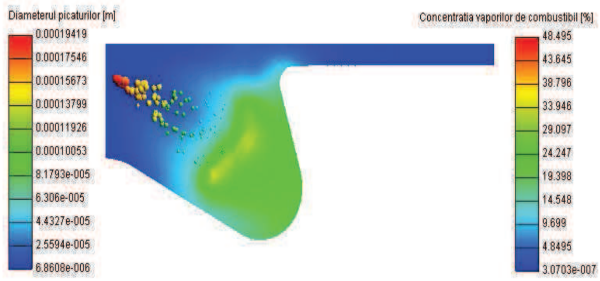



Figure 3 Spray at 3 degrees of TDC

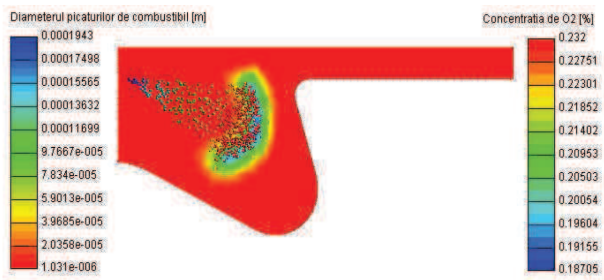



Figure 4 Spray at -3 TDC

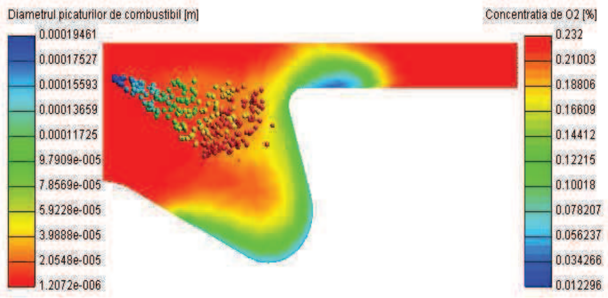



Figure 5 Spray at 5 degrees of TDC

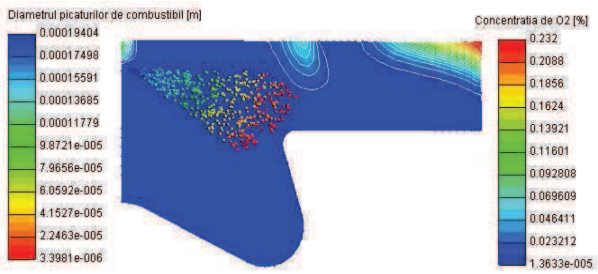



Figure 6 Spray at 10 degrees of TDC

axes of fuel spray in the injection duration (from -1 to 3 TDC degree for 1500 bar, from -4 to 15 TDC degree for 500 bar). From these observations, the combustion process seems to occur mainly around the axes of fuel spray. Therefore, the fuel spray characteristics such as the penetration and the shape have essential effects on the combustion process in this kind of simulation for DI diesel engines.

The results of the simulation well agree with the observed combustion process qualitatively, and the simulation well predicts several features of the effect of high pressure fuel injection on the combustion process. When the fuel injection pressure is high, the flame develops more rapidly than that in the ordinary pressure condition. In the high pressure condition, the flame development near the wall starts at -3 TDC degrees; in the ordinary injection pressure, it starts at 3 TDC degrees.

Figure 7 shows the predicted pressure in the combustion chamber.

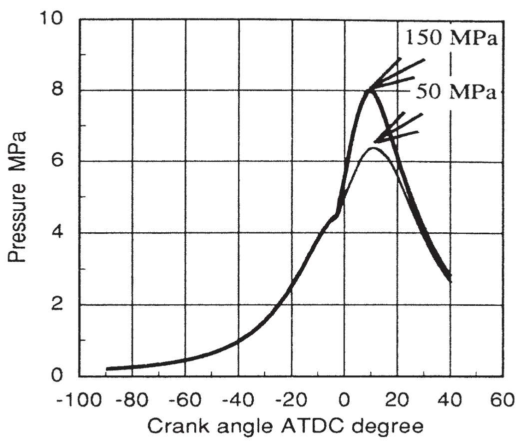



Figure 7 Predicted pressure

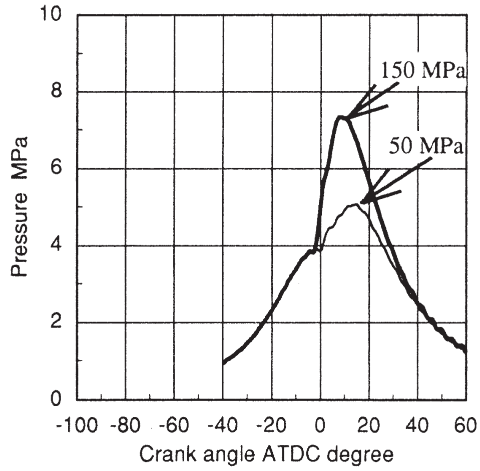



Figure 8 Measured pressures.

Corresponding result of the experiment is shown in Fig. 8. The high pressure condition gives a higher peak pressure and earlier peak pressure timing. These features are commonly found in both the simulation and the experiment.

Quantitatively, the simulations agree with the experiment in the peak pressure timing, however, the peak pressure in the simulation is higher than that observed in the experiment. The predicted pressure is about 4 bar higher than experimental result at injection timing (-5 TDC degrees).

At first, the author thought the cause of higher peak pressure was due to simplified model for chemical reaction without thermal dissociation. However, it was found that the peak pressure was not varied even if the chemical equilibrium is counted, though the peak temperature decreases about 150 K when chemical equilibrium is counted. In addition, the simulation gives higher pressure in the combustion chamber before the combustion process initiates. Therefore, there will be other causes of the discrepancy in the predicted pressure and the observed pressure. One possible cause is a blow-by gas in the compression stroke. In the simulation, the effect of blow-by gas was simply neglected. However, there is some blow-by gas in real engine systems.

Figure 9 and fig. 10 show the predicted rate of heat release (ROHR) and the experimentally obtained ROHR respectively. There are some fluctuations on the ROHR curves Fig. 9.

The experimentally obtained ROHR curves were calculated from the pressure indicator obtained in only one cycle of the engine operation, and the fluctuations in Fig. 9 is not essential. Due to these fluctuations, it is difficult to discuss precisely about the propriety of the combustion model, however, the essential effect of the injection pressure on the ROHR seems to be well predicted at least qualitatively. The ROHR in the injection duration increases when the fuel injection pressure increases. In general, the constants used in the equations must be optimized through the comparison of the prediction and the observation. This kind of optimization will be the next step of the study.

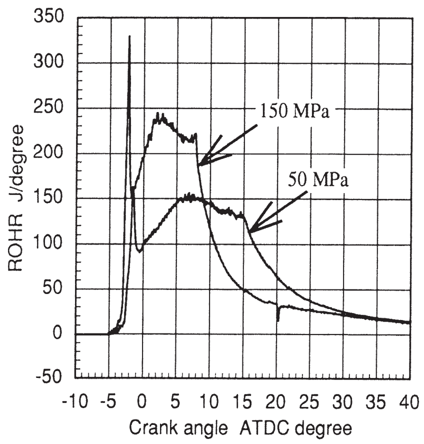



Figure 9 Predicted heat release.

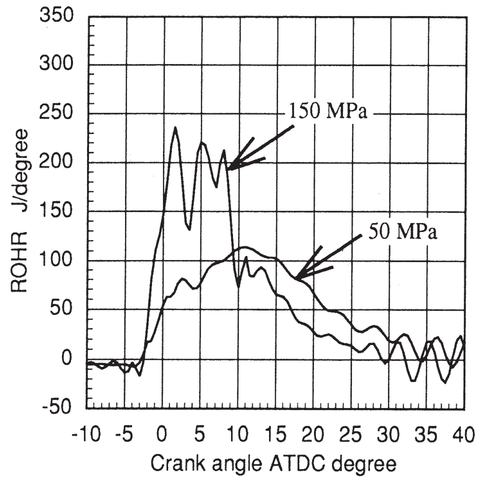



Figure 10 Calculated from measured data.

For the condition of high pressure fuel injection, a chemical equilibrium was also tested. The ROHR was not significantly varied whether the chemical equilibrium is counted or not.

## 6. CONCLUSIONS

A computational simulation for a DI diesel engine was performed through the code. Two conditions of the fuel injection pressure were tested. The difference of the fuel injection pressure is given in the input parameters of diameter and velocity of initially injected fuel droplets. From the comparison of the results of experiment and simulation, it was concluded as follows.

1. As fuel injection pressure increases, flame develops rapidly, and the timing of flame development near the wall becomes earlier. These are well predicted by the simulation.
2. It was suggested that the combustion process in the injection duration of DI diesel engines is strongly dependent on the behavior of the fuel spray and the characteristics of the turbulence formed by the fuel spray.
3. When injection pressure increases, the peak pressure in the combustion chamber increases and the timing of the peak pressure becomes earlier. Qualitatively, the simulation well predicts these observed effects of high pressure fuel injection. Quantitatively, predicted pressure in the combustion chamber is higher than that observed in the experiment.
4. Results largely depend on the constants of the models and for this reason they have to be closely analysed and carefully interpreted as they may carry a subtle mistake and this would lead to wrong conclusions;
5. The performances of the programme are limited by the models used and for this reason the cases and values studied must be carefully selected so that we do not surpass their applicability range.
6. The programme is open and for this reason it is difficult to be used since it requires advanced knowledge of programming and theory of engines.

As mentioned above, the simulation well predicts the effect of high pressure fuel injection in many aspects qualitatively. Fine computational grids and appropriate submodels for the fuel spray is essentially important in this kind of simulation.

## 7. REFERENCES


[1] Chung, K. L. (2006). Combustion Physics, Cambridge University Press, ISBN 0521870526, New York.

[2] Patterson, M.A., Kong, et al. (1994). Modeling the Effects of Fuel Injection Characteristics on Diesel Engine Soot and NOx Emissions, SAE 940523, 1994.

[3] Poinsot, T. & Veynante D. (2005). Theoretical and Numerical Combustion, R.T. Edwards Inc., ISBN 1930217102, Paris.

[4] Sabau, A. (2007). Studies regarding the combustion process in marine diesel engines in order to reduce the pollutant emissions, PhD Thesis, 'Transilvania' University of Brasov

[5] Sabau, A. & Buzbuchi, N. (2006). Model of spray in Diesel engine, Annals of Maritime University of Constanta, Vol. 9, No. 9 (June, 2006), pp. 82-89, ISSN 1582-3601

[6] Stiesch, G. (2003). Modeling Engine Spray and Combustion Processes, Springer; ISBN 3540006826, Berlin

# USING PROFESSIONAL SOFTWARE TO CALCULATE THE DRAG

[1]TICU RODICA-IONELA, [2]BOCANETE PAUL

[1,2]*Constanta Maritime University, Romania*

**ABSTRACT**

For differential equations with derivatives, the possible ways of discretization are not unique, although it is assumed that all will offer the same solution. The most popular discretization methods are: the finite element method and respectively, the finite differences method. Although the finite element has the advantage of using unstructured networks that give more flexibility in mapping irregular and complicated fields, some particular problems reduce its progress in hydrodynamics by comparison to solid mechanics. The most important issue concerns the nature of the flow.

**Keywords:** *the finite element, the finite differences, pressure-velocity, velocity components, boundary*

## 1. INTRODUCTION

The theoretical formulation of the mathematical pattern for calculating the drag will be based on several assumptions about the physical behavior of the fluid. Thus, the calculation will be based on the pressure field obtained depending on the distribution of the main hydrodynamic parameters that characterize the flow around hulls (velocity and pressure), obtained on the basis of integration in time of Navier-Stokes differential equations and on the continuity under not permanent regime. This enables us to determine the exact value of the drag. From this point of view, the report aims at developing a fast and efficient way to optimize the steering of the ship in relation to the wind direction in order to reduce power requirements, and therefore to reduce the fuel consumption on board.

If the standard finite element is directly applied, a similar formulation of finite differences is obtained. In such cases, to find a way to avoid false solutions means to use counter-current or exponential schemes which are difficult to apply to irregular areas.

Therefore, we can use two ways of writing the Navier-Stokes equations. The first is the method of the power-vorticity function, and the second is the formulation of primary variables (pressure-velocity). The main difficulty in calculating the velocity field is by not knowing the pressure field. The pressure gradient is part of the initial condition for the momentum equation. Therefore, for a given pressure field, solving the momentum equation is simple. The pressure solution can not be obtained directly without the use of iterative procedures. From this point of view, the formulation of the power-vorticity function seems to offer some advantages, as the pressure is removed from the momentum equation by cross differentiation. In addition to this feature, there are some major drawbacks. The most serious drawback is that the method can not be easily extended to the three-dimensional case, where there is no power function. On the other hand, a 3D approach based on vortex formulation operates with 6 dependent variables (three for each speed potential and velocity vector), while the formulation of primary variables has only four (three components of velocity and pressure).Although, currently the *Marker-and-Cell* MAC method is extensively used, it calculates the free surface elevation in Lagrangean way, displacing particles depending on the local velocity. The consideration of wave properties (propagation, slope, etc.) may raise doubts whether such an independent local particle displacement is an effective treatment or not. However, it was found that 2D numerical calculations performed, even a coarse discretization, can lead to almost the same results, which is beneficial for the efficiency of numerical calculation.

## 2. BOUNDARY CONDITIONS ON THE BOUNDARY OF THE SHIP HULL

On the border of the ship hull, the adherence or the non slide condition is applied, which means that in points from the hull surface, the normal and tangential velocity components are zero. In the physical space, this condition is written as $u_{i,jS,k} = v_{i,jS,k} = w_{i,jS,k} = 0$, respectively, in the space calculation:

$$U_{i,jS,k} = \frac{\partial \xi}{\partial x} u_{i,jS,k} + \frac{\partial \xi}{\partial y} v_{i,jS,k} + \frac{\partial \xi}{\partial z} w_{i,jS,k} = 0;$$

$$V_{i,jS,k} = \frac{\partial \eta}{\partial x} u_{i,jS,k} + \frac{\partial \eta}{\partial y} v_{i,jS,k} + \frac{\partial \eta}{\partial z} w_{i,jS,k} = 0;$$

$$W_{i,jS,k} = \frac{\partial \zeta}{\partial x} u_{i,jS,k} + \frac{\partial \zeta}{\partial y} v_{i,jS,k} + \frac{\partial \zeta}{\partial z} w_{i,jS,k} = 0;$$

Neumann's boundary condition for pressure on the ship hull surface results from the Navier-Stokes equations of motion in which the previous relations are introduced.

A system of equations is obtained where the unknown elements are the derivatives $\partial\phi/\partial\xi,\ \partial\phi/\partial\eta,\ \partial\phi/\partial\zeta$.

## 3. BOUNDARY CONDITIONS ON THE FREE SURFACE BOUNDARY

The free surface boundary condition requires that the tangential tension should be zero and the normal tension should balance any externally applied normal tension. Applying these conditions involves the knowledge not only of the location of the free surface at each point of the grid, but also of the slope and its curvature. In accordance with techniques based on the MAC method, the fluid particle motion is calculated knowing the new coordinates x, y and z and speeds determined in the previous time step. The movement of the particle is given by $\Delta x = u\Delta t$ ; $\Delta y = v\Delta t$ ; $\Delta z = w\Delta t$ where $\Delta t$ is the increment of time. Relations are of first order of approximation. Determining the location of the free surface by using the above equations means to define the position of the free surface, locally, without taking into account the movements of neighboring particles which can accelerate the development of the wave. In these circumstances, the use of an Euler type expression is proposed for the cinematic boundary condition for the free surface, which allows the use of a higher order differential scheme. The condition can be formulated as follows:

$$\frac{\partial h_i^{n+1}}{\partial t} + \left( u_i + \frac{\partial u_i}{\partial z}\Delta h_i \right)\frac{\partial h_i^{n+1}}{\partial x} + \\ + \left( v_i + \frac{\partial v_i}{\partial z}\Delta h_i \right)\frac{\partial h_i^{n+1}}{\partial y} - w_i = 0$$

where $h = h\ (x, y, t)$ is the ascension of the wave. For derivative $\partial h_i^{n+1} / \partial t$ the next time finite differences scheme is used:

$$\frac{\partial h_i^{n+1}}{\partial t} = \frac{1}{2\Delta t}\left( h^{n-1} - 4h^n + 3h^{n+1} \right).$$

For derivative $\partial h_i^{n+1} / \partial x$ a third order differential scheme of the following type is used:

$$c\frac{\partial h}{\partial x} = c\frac{1}{6\Delta x}(-2h_{i-3} + 9h_{i-2} - 18h_{i-1} + 11h_i)$$

which can be decomposed into two terms. The first is a term in centered differences

$$c\frac{1}{24\Delta x}(-h_{i-3} + 27h_{i-2} + 27h_{i-1} - h_i)$$

while the other is a diffusion term that has the significance of the fourth-order derivative of velocity:

$$c\frac{3}{8\Delta x}(-h_{i-3} + 7h_{i-2} - 11h_{i-1} + 5h_i)\ .$$

Following some simple mathematical processing, it is obtained

$$c\frac{\partial h}{\partial x} = c\frac{1}{6\Delta x}(-h_{i-3} + 6h_{i-2} - 15h_{i-1} + 10h_i)\ .$$

The last equation has the same expression as that used by Dawson in stationary flow study, using the Rankine sources method where the derivatives, for example $\partial h / \partial x$ are calculated intuitively. Based on the same considerations, a similar expression for *y* direction is obtained:

$$c\frac{\partial h}{\partial y} = c\frac{1}{6\Delta y}(-h_{j-3} + 6h_{j-2} - 15h_{j-1} + 10h_j)\ .$$

On the other hand, knowing that

$$\frac{\partial h^{n+1}}{\partial x} = \frac{\partial h^n}{\partial x} + \frac{\partial \Delta h^n}{\partial x};\ \frac{\partial h^{n+1}}{\partial y} = \frac{\partial h^n}{\partial y} + \frac{\partial \Delta h^n}{\partial y};$$

and believing in the free surface particle kinematics,

$$\Delta h_{i-1}^n = h_{i-1}^{n+1} - h_{i-1}^n;\ \Delta h_{j-1}^n = h_{j-1}^{n+1} - h_{j-1}^n$$

one can determine the vertical coordinate increment of the free surface at each time step. The expression is of second order accuracy for *h (O (h2))*.

## 4. THE NUMERICAL MODEL

The calculation is performed in a series of cycles, each advancing the entire configuration of the flow with an increment of time *Δ t* sufficiently small, but finite. The result of each iteration is taken as initial condition for the next and calculation is effected up to T*max*. For the time progressing procedure, an explicit Euler type scheme for time progressing is used. Pressures are obtained in the whole field with the relation $\nabla^2\varphi = F_x + H_y + G_z$ in accordance with limitations imposed by the boundary conditions.

Poisson equation is solved iteratively by successive relaxation method:

*φ K +1 = k + ω φ (φ φ k +1- k)*

where ω is the relaxation factor. Iterations stop when the pressure difference between two successive approximations is less than a quantity ξ chosen a priori. The new pressure field generates a new field of speeds. The new components of velocity are determined by using the momentum equation:

$u^{n+1}=(F^n - \varphi_x)\Delta t,\ v^{n+1}=(H^n - \varphi_y)\Delta t,\ w^{n+1}=(G^n - \varphi_z)\Delta t$

where

$$F = \frac{u^n}{\Delta t} + \frac{1}{Rn}\nabla^2 u^n - (u^n u_x^n + v^n u_y^n + w^n u_z^n)$$

$$G = \frac{w^n}{\Delta t} + \frac{1}{Rn}\nabla^2 w^n - (u^n w_x^n + v^n w_y^n + w^n w_z^n)$$

$$H = \frac{v^n}{\Delta t} + \frac{1}{Rn}\nabla^2 v^n - (u^n v_x^n + v^n v_y^n + w^n v_z^n)$$

Marker particles are moved to their new positions using either the Euler technique or the Lagrange technique. As initial conditions of the flow, the calm water condition must be provided. The current is accelerated in a few time steps, up to the indicated speed for greater numerical stability. All spatial derivatives involve the using of second order centered differences. To make possible the use of centered differences even at boundaries, a false grid is used. The false grid's nodes are defined as images of corresponding points inside the domain. The calculations are performed on a "staggered" grid. This means that velocity components are calculated in the faces centers while pressures are calculated in the center of the cell. As in most calculation methods for fluid dynamics, this method too uses the iteration in time. This means that calculations are advancing in a series of cycles, each cycle advancing the entire configuration of the fluid with a small, but finite time increment, $\delta t$. The results of each cycle act as initial conditions for the next time step, and calculations continue as long as the programmer wishes. Each iteration is divided into several phases:

1) The pressure on each cell is obtained by solving the Poisson equation (the source term of which is the velocity function), written in finite differences. This equation was derived for the resulting momentum equation to produce a new velocity field that would satisfy the incompressibility conditions;

2) Navier - Stokes equations expressed in finite differences are used to determine new speeds in the entire grid;

3) The marker particles are moved to their new positions, using the linear interpolation of velocity from adjacent cells in order to determine their speed;

4) The record process of results is related to the construction or destruction of cells, the entry or exit of cells into/from the field, the advancing of the timer.

The basic idea of this method is to transform the physical area outside the ship hull in a fictional area of calculation, of rectangular form, which generates a discretization network the nodes of which are located at the intersection of families of parallel and equidistant lines, parallel with the coordinate axes and the network in the physical area is obtained by transforming, in reverse, the network obtained in the fictional field. To achieve this transformation, the conversion of O-H type network is required in order to determine the relation between the physical field $D(x, y, z)$ and the calculation field, imaginary, transformed, $D1$ ($\xi$, $\eta$, $\zeta$). The system of curvilinear coordinates (O, $\xi$, $\eta$, $\zeta$) is aviated on the ship hull form, with the plan $[O\xi\eta]$ situated in the plan of the free surface of water, and the plan $[O\xi\zeta]$ located in the centerline of the ship. The physical domain D $(x, y, z)$ is bordered by the following boundaries: ship hull surface, surfaces from diametrical plane exterior to the hull surface, free surface plane of water, input boundary and output boundary and outer boundary. The input and output boundaries are vertical planes, parallel to the plane [Oyz], located in the bow and stern of the ship. The outer border is a cylindrical surface of given radius, with symmetry axis Ox. Considering also the free surface deformation, the curvilinear coordinates are time-dependent so that the coordinate transformation can be expressed in the generic form through the relations:

$\xi = \xi$ (x, y, z, t), $\eta = \eta$ (x, y, z, t ), $\zeta = \zeta$ (x, y, z, t), t $= \tau$.

With this transformation of coordinates, equations governing the flow must be also transformed, so that they could keep their validity on the calculation domain $D1$ ($\xi$, $\eta$, $\zeta$). After transformation, the equations are expressed by finite differences on the nodes of the network of the imaginary calculation field. The transformed equations of motion expressed by finite differences are solved numerically by the method of advancing the solution in time. Although this method is used mainly for numerically solving the flow of incompressible viscous fluid in impermanent moving, it can be applied successfully also to numerically solve permanent movements.


Fig.1.1a Free surface topology to confirm the numerical simulation by pool tests.

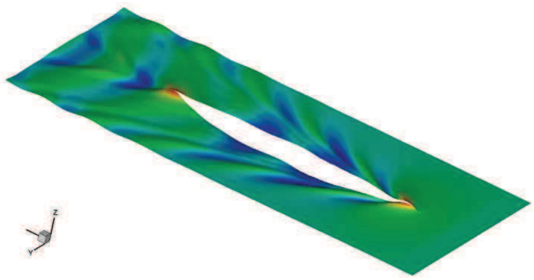


Fig. 1.1 b Numerical modeling of free surface when the ship goes through water

**REFERENCES:**

[1] Semyonov - Tyan - Shansky V., *Statics and dynamics of the Ship*, Sudostroenie, Leningrad, 1973;
[2] *S.T.C.W. Convention - International Convention on Standards of Training, Certification and Watchkeeping for Seafarens*, 1978, as amended in 1995 and 1997, International Maritime Organization (I.M.O.), London, 1976.
[3] Roberts P., *Watchkeeping safety and cargo management in port.* A practical guide, The Nautical Institute, London, 1995.

[4] *Principles of naval architecture* - Second revision, (vol. I). Stability and strenght, S.N.A.M.E. , NJ, 1988.
[5] Popa T., Pintilie A., *Instalații navale de bord*, Briza mării Publishing House, Constanta 2007.
[6] Popovici O., Chiricã I., Ioan A., *Calculul şi construcția navei*, Galati University, 1984.

# NUMERICAL SIMULATIONS OF THE CURRENT FIELD IN THE BLACK SEA BASIN

[1]TODERASCU ROBERT, [2]RUSU EUGEN

*[1,2]"Dunarea de Jos" University of Galati, Romania*

**ABSTRACT**

The objective of this work is to present the implementation of a circulation modeling system for the entire basin of the Black Sea. In this regard, two simulations using Mohid water modeling system were performed for the months of February and August 2010. The input data considered for the current simulations are salinity and temperature fields, obtained from the Black Sea Forecast System, coastlines, bathymetry from ETOPO2 website and wind forcing provided by the European Centre for Medium Range Weather Forecasts (ECMWF). Model validations were performed considering satellite data. Moreover, the simulation results were compared to an implementation of the Princeton Ocean Model (POM) realized by the National Institute for Marine Research and Development "Grigore Antipa".

**Keywords:** *current velocity, Black Sea, circulation, Mohid, satellite data, comparisons*

## 1. INTRODUCTION

The Black Sea is an enclosed sea situated between Europe, Anatolia and Caucasus, bounded by latitudes 40.56° - 46.33°N and longitudes 27.27° - 41.42°E. With a surface of 423.000km$^2$, the Black Sea is the second largest enclosed water body, after Caspian Sea. The only connection bounding the Black Sea to the Global Ocean is by Bosphorus strait, an 0.7-3.5km narrow channel with 31 kilometers in length and a depth that can vary from 39 to 100m.

The sea contains three distinct vertical layers of water that usually do not mix. The surface layer is located on the sea surface, spreading to 50m depth and is the most active layer of the sea, being strongly affected by the seasonal temperature variations and wind fields. The second layer known as the intermediate cold layer is located at depths that vary from 50m to 180m. It is characterized by the constant cold temperatures that range from 6° to 8°C at all times of the year. The cold intermediate layer is formed convective processes associated with the winter cooling of the surface waters [1-3]. Below the intermediate cold layer is the bottom layer, where waters are mostly stagnant, showing little changes in properties, except near boundaries. The bottom layer is also the largest anoxic water body on Earth. After 1700m in depth, the bottom layer is subjected to geothermal heating from the sea floor, the temperature being about 8.8°C [4]. According to Etopo bathymetry data, the maximum depth of the Black Sea is of 2588m. However these are isolated points located in the South and South-East of the basin. The average maximum depth of the sea is 2100m.

Due to the enclosed state and river discharges, the Black Sea's salinity is lower than the open seas or oceans. The average salinity in the Black Sea is of 18.2 PSU but this value decreases near the river discharges. Due to the fact that the bottom and the surface layers do not mix, the salinity in the bottom layer has increased values, of about 21.8 PSU.

The cyclonic character of the Black Sea circulation resulting from the cyclonic state of the wind field patterns was first described by Knipovich [5] and Newmann [6, 7]. The matter was also addressed later on by Filipov [8], Boguslavskiy et al [9], Blatov et al [10], Stanev et al [11], Stanev [12] and Eremeev et al [13] but the model proposed by Knipovich did not suffer significant modifications. The surface circulation is defined by a persistent cyclonic coastal current known as the Rim current. The Rim current flows with an average speed of 0.2ms$^{-1}$ with a width of 75km. Between the Rim current and the coast a number of seasonal anticyclonic gyres are formed. Figure 1 shows a scheme of the Black Sea's surface circulation. As it flows eastward along the Anatolian coast, the Rim current forms two anticyclonic coastal eddies identified as Sinop and Kizilirmak. The Batumi eddy, located in the eastern side of the Black Sea is the largest anticyclonic formation. Along the Caucasian coast, the Rim current flows to the narrow continental coast, creating the Caucasus eddy. The Rim current continues then to meander to the south of the Crimean Peninsula. The eddies located in the north of the Black Sea are known as the Crimea and Sevastopol. While it proceeds southwest towards the Bosphorus area, the Rim current creates the Kali-Akra and Bosphorus eddy. The Rim current's basin wide circulation is closed with the Sakarya eddy, situated in the southwest area.

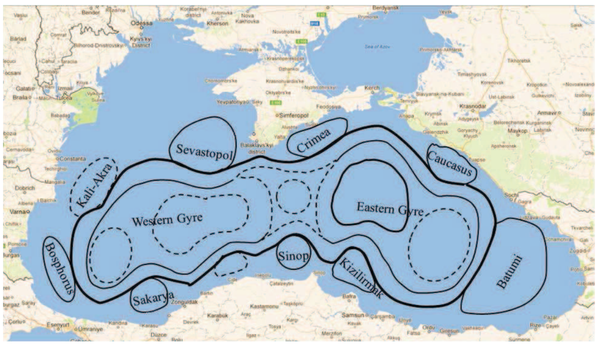



Figure 1 Schematic of the Black Sea surface circulation. The solid lines indicate recurrent features of the general circulation.

## 2. BASIC FEATURES OF THE MOHID MODELING SYSTEM

Mohid is a three-dimensional water modelling system, developed by MARETEC (Marine and Environmental Technology and Research Center) at IST (Instituto Superior Tecnico) that belongs to the Technical University of Lisbon. [14]

Mohid evolved from a sequential FORTRAN 77 model to an object oriented model programmed in FORTRAN 95. The structure of the system is divided into several FORTRAN modules. Each of the modules has the functionality of an object class. The modules are combined by geometric requirements and groups of state variables. There is a central module (Module Model) that is in charge of controlling the whole system, which is formed by key modules as WaterPropreties, Hydrodynamics, Geometry, AdvectionDiffusion, Atmosphere and Benthos that are used to simulate free surface flows. The Mohid model uses HDF files as input of the different properties, and also for writing the results.

Most Mohid applications use parallelepiped control volumes with orthogonal horizontal axes to simplify the calculations; however Mohid can also use curvilinear grids to compute calculate flows in horizontal anisotropic systems.

The Mohid modeling system was successfully implemented in various coastal areas and estuaries like Minho, Lima, Douro, Mondego, Tejo, Sado, Mira, Arade and Guadiana along the Portugal coast, Rias de Vigo by Taboada [15, 16], Ria de Pontevedra by Taboada and Villarreal [16] and some European estuaries – West Scheldt Holland, Giorde France and Carlingford Ireland by Leitao [17, 18]. Regarding the open sea the model was implemented and validated for the northeast Atlantic area by Neves and Coelho [19].

## 3. MODEL SIMULATIONS IN THE BLACK SEA

In this work, two months of simulations for the current movements over the Black Sea are presented. The simulated months are February and August 2010. The water movement is computed using Mohid water modelling system by taking into account salinity and temperature fields, wind field, coastlines and bathymetry. The water density fields were obtained from MyOcean website with a geographic coverage of 27.4°E-41.9°E and 40.9°N-46.9°N. The data included in this product are water temperature and salinity with a spatial resolution of about 5km, on 35 depth levels, starting from 2.5m to 2100m. The data variables are gridded in a 238x132x35 mesh. The wind fields were provided by ECMWF (European Centre for Medium-Range Weather Forecasts) and are interpolated to fit the water density grid. The initial bathymetry was provided by ETOPO2 Global Gridded 2 minute Database from NOAA website and was modified with the Mohid GIS module to accommodate the chosen grid. The coastlines were also drawn in Mohid GIS module, around the water density fields in order for the digital terrain to fit the available data. Prior to the analysis a number of scripts were created to convert the available water density and wind fields into HDF5 format required by Mohid.

The simulations were carried out daily, on a 238x132x35 mesh using the Cartesian domain, for a period of 28 days starting 1$^{st}$ of February and 31 days starting 1$^{st}$ of August. Figures 2 and 3 present the current vectors for 14 February and 15 August 2010. In the background, the velocity modulus is presented, ranging from 0 to 2.1 $ms^{-1}$ in Figure 2 and 0 to 0.47$ms^{-1}$ in Figure 3. With the purpose of achieving a better view of the current systems, in the figures the vector size was increased by a factor of 2 and the total number of vectors was divided by a factor of 3.

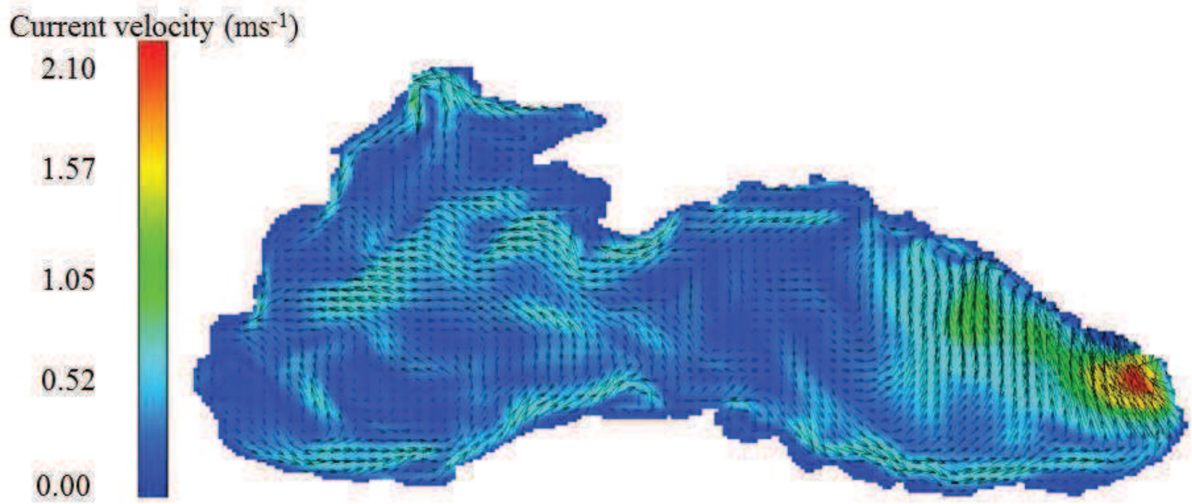



Figure 2 Current vectors as resulted from the simulation for 14-th February 2010.

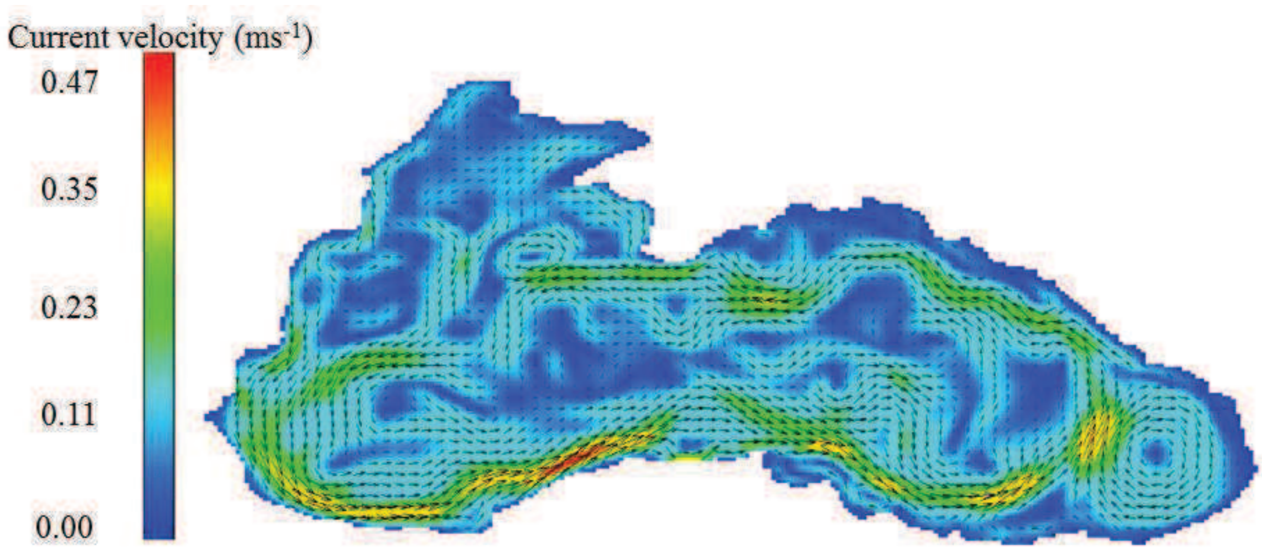



Figure 3 Current vectors as resulted from the simulations for 15$^{-th}$ of August 2010

In Figures 2 and 3 the specific formations described by Knipovich can be observed, especially the flow of the Rim current circling the Black Sea.

## 4. VALIDATIONS AGAINST SATELLITE DATA AND COMPARISONS WITH EXISTING IMPLEMENTED MODELS OVER THE BLACK SEA

The simulation results were compared against the satellite data from Aviso website. Moreover, the simulations regarding the Romanian nearshore area were also compared with simulations of the Princeton Ocean Model (POM) implemented by the National Institute for Marine Research and Development "Grigore Antipa", available on the institute website.

Figure 4 shows the comparison between satellite data and simulation results in one point for the month of February 2010, daily. The point is situated in the western part of the Black Sea at the coordinates 44°31'N and 29°34'E, the location of the Gloria drilling platform. Figure 5 presents the comparison between the satellite data and simulation results for the month of August 2010, daily.

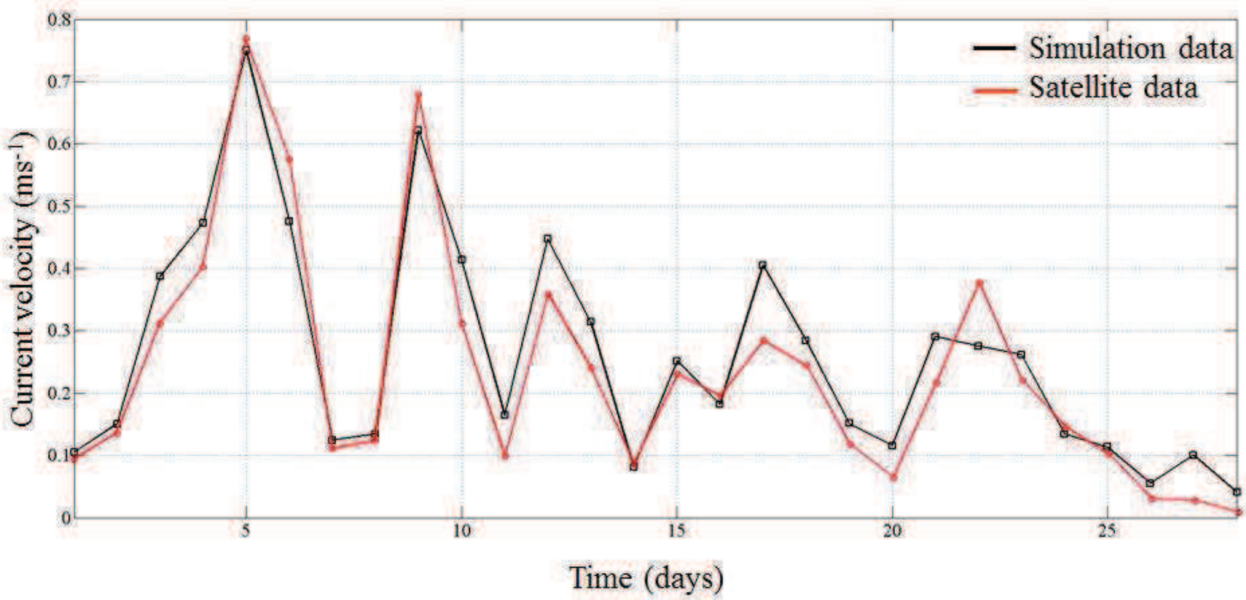



Figure 4 Comparison between the satellite data and simulation results at the Gloria drilling platform for the month of February 2010.

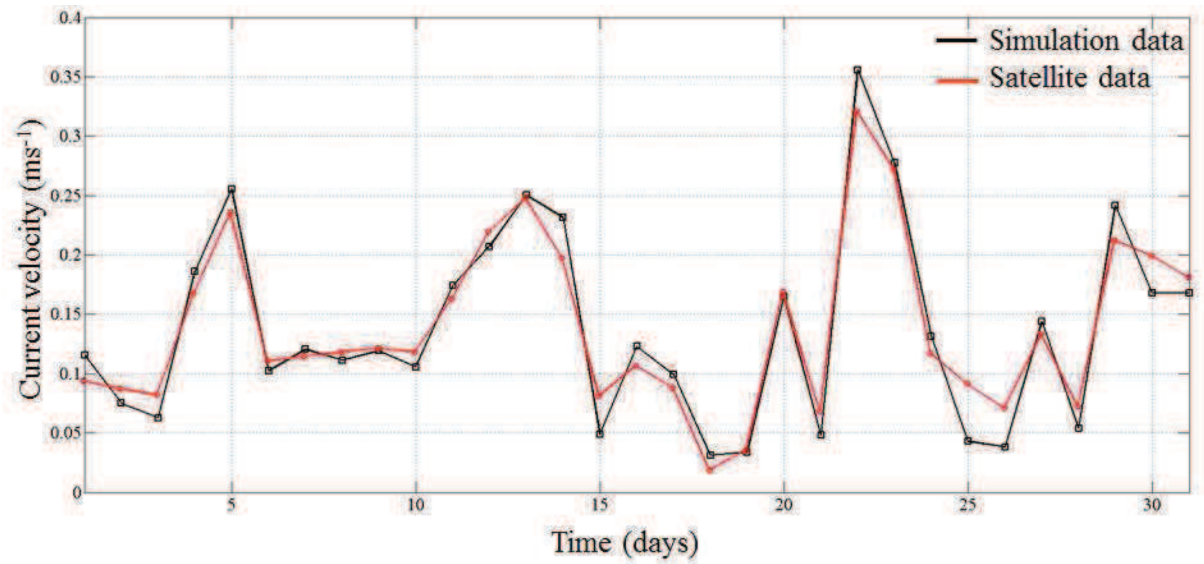



Figure 5 Comparison between satellite data and simulation results at the Gloria drilling platform for the month of August 2010

Comparisons were also made between the satellite data and simulation results for the entire area of the sea. Figure 6 shows a comparison of the current vectors between the satellite data (with red) and simulation results performed with Mohid (with black) for the day of 20 February 2010. Figure 7 shows a similar comparison for the day of 15 August 2010.

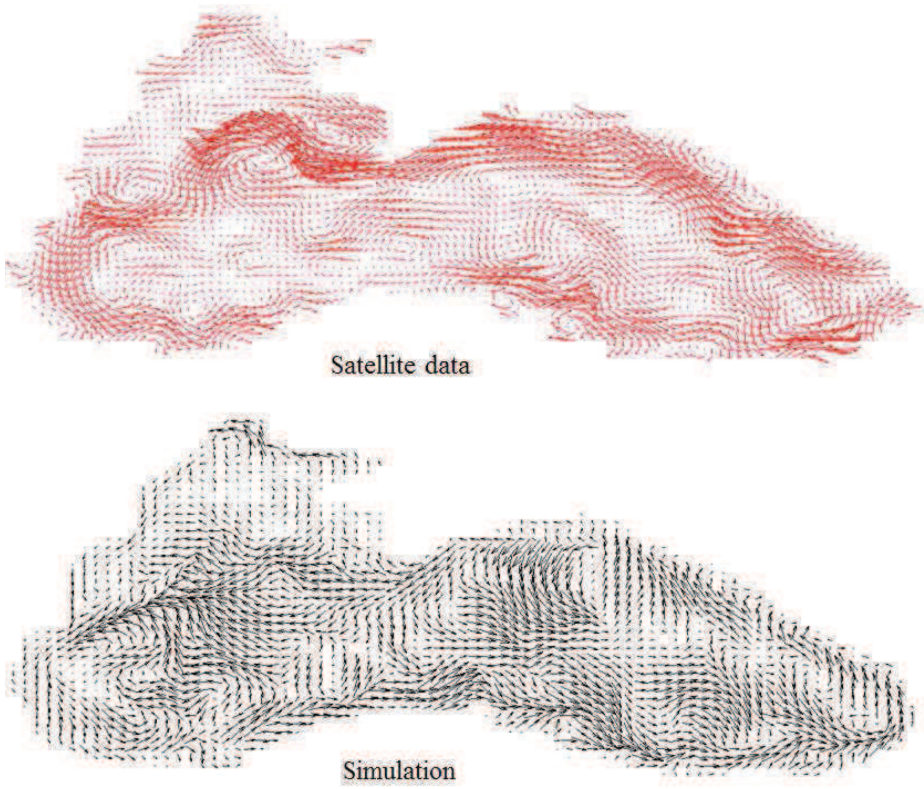



Figure 6 Comparison between satellite data and simulation vectors for the day of 20 February 2010.

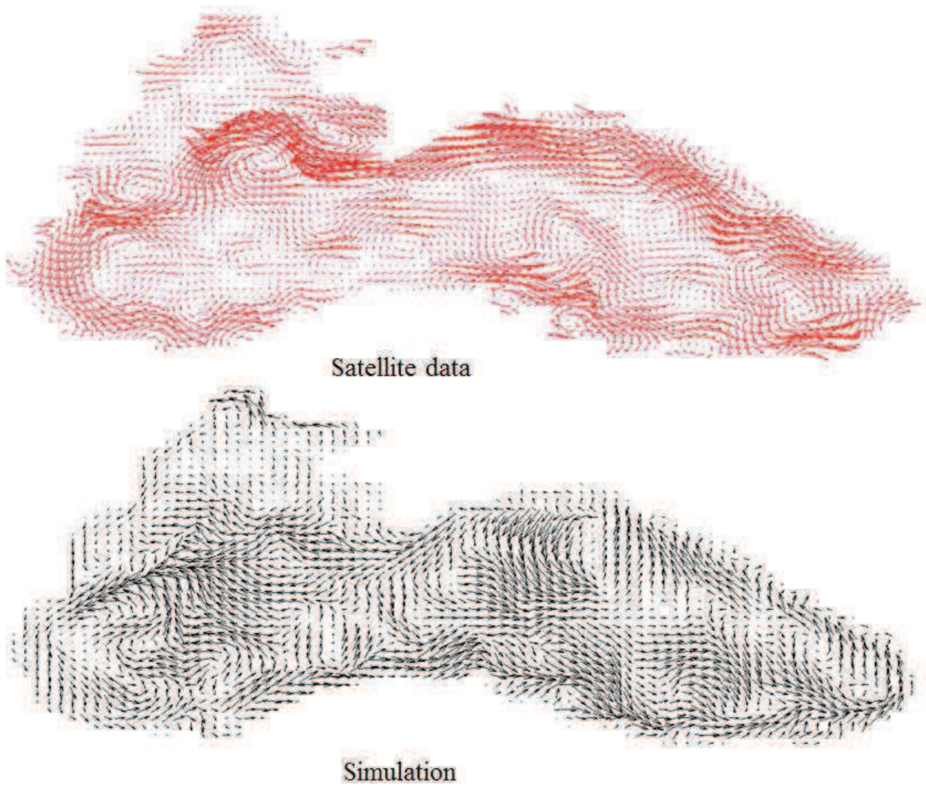



Figure 7 Comparison between satellite data and simulation vectors for the day of 15 August 2010.

Regarding the simulations performed by the National Institute for Marine Research and Development “Grigore Antipa”, the simulations were performed under the European Coastal Sea Operational Observing and Forecasting system (ECOOP) project. The simulations are performed on a 324x289 grid, with 18 sigma depth levels on a domain contained between 44°019'-46°597' N latitude and 28°512'-32°484'E longitude. The bathymetry used was obtained from various databases, mostly from the Marine Hydrophysical Institute from Sevastopol. The ocean-atmosphere interface used in the simulations was given by the ALADIN model, from the National Meteorological Administration from Romania [20]. Figure 8 shows a comparison of the current vectors between the simulations performed with POM (a) and the ones performed in the current work, with Mohid (b) for the day of 26 February 2010. Figure 9 shows a comparison of the current vectors between the simulation results performed with POM (a) and the simulations performed with Mohid (b). In both images the presented vectors are located at the depth of 2.5 meters, the surface layer of the simulations. In the background, the module vector between U and V vectors is presented, in color.

## 5. CONCLUSIONS

In most of the cases a good correlation between the satellite data and simulation results can be observed.
Figures 2 and 3 prove that the simulation results show the same general features that are characteristic for the Black Sea basin. Both the cyclonic and anticyclonic features are present and can be observed. The current velocity graphics presented in figures 3 and 4 show a good correlation between the satellite data and simulation results at the specific point considered. While not identical, the current velocity value varies in the same patterns for both the satellite data and simulations.
Figures 6 and 7 both show that the current velocity vectors flow in similar ways, proving that the present simulations accurately describe the current movements in the Black Sea basin. The simulations performed with Mohid model also present similar characteristics with the ones performed by the National Institute for Marine Research and Development “Grigore Antipa” performed with POM. As it can be observed, the maximum current velocity is higher for Mohid simulations, compared to POM ones. There are a number of factors for this fact. The models use different wind fields: while Mohid uses the wind fields from ECMWF website, interpolated to fit the grid, while the POM model uses ALADIN wind fields. Also, the Mohid simulations take into account the temperature and salinity fields, while the POM model is based on the wind influence. Taking these into account, small differences are to be expected between the two models, but the main fact remains that even if with a bigger current velocity speed, the simulations performed with Mohid model do not contradict the known facts about the Black Sea basin. In fact the present simulations prove that Mohid water movement model can be a proper tool able to investigate the current circulation in the Black Sea basin.

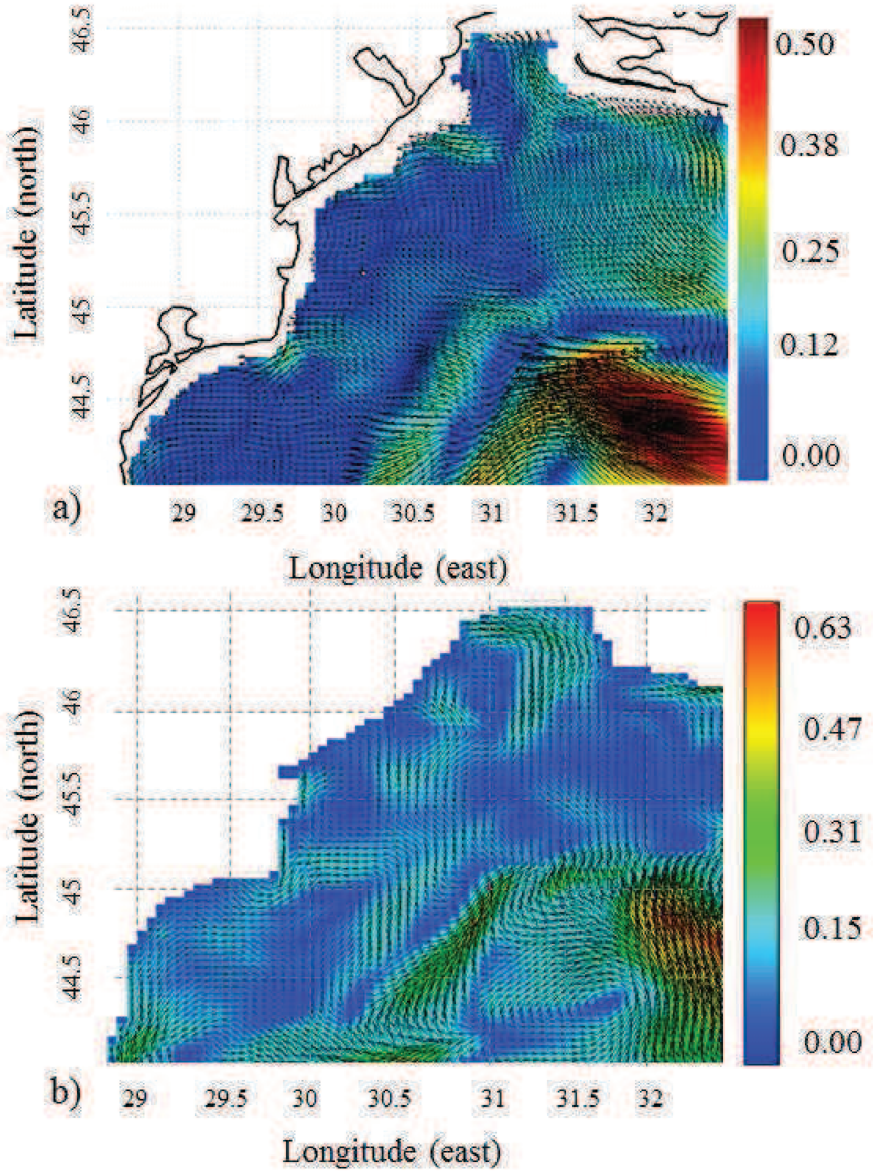



Figure 8 Comparison of the current vectors between the simulations performed with POM (a) and the ones performed in the current work, with Mohid (b) for the day of 26 February 2010.

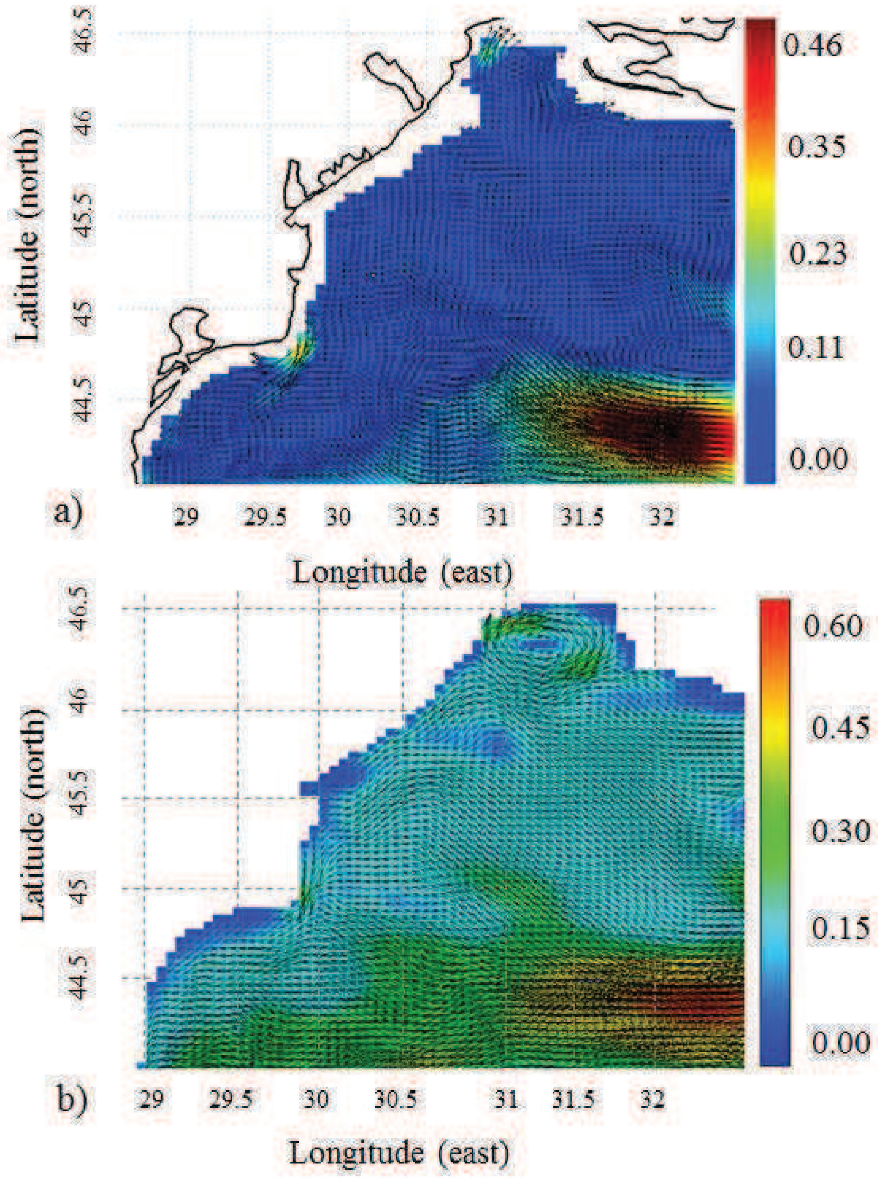



Figure 9 Comparison of the current vectors between the simulations performed with POM (a) and the ones performed in the current work, with Mohid (b) for the day of 23 August 2010.

## 6. ACKNOWLEDGMENTS

The work of the first author has been made in the scope of the project EFICIENT (Management System for the Fellowships Granted to the PhD Students) supported by the Project SOP HRD - EFICIENT 61445/2009. The altimeter products were produced by Ssalto/Duacs and distributed by Aviso with support from Cnes.

## 7. REFERENCES

[1] D. M. Filippov, “The cold intermediate layer in the Black Sea”, “Oceanology”, vol. 5, pp. 47-52, 1965.
[2] D. Tolmazin, “Changing coastal oceanography of the Black Sea in Northwestern shelf”, “Progress in Oceanography”, vol. 20. pp. 217-276, 1985.
[3] I. M. Ovchinnikov and Yu. I. Popov, “Evolution of the cold intermediate layer in the Black Sea.”, “Oceanology”, vol. 27, pp. 555-560, 1987.
[4] C. E. Enriquez, “Mesoscale Circulation in the Black Sea: A Study Combining Numerical Modelling and Observations”, PhD Thesis, School of Earth, Ocean and Environmental Sciences, 257 pp., 2005.
[5] N. M. Knipovich, “The hydrological investigations in the Black Sea area”, “Trudy Azova-Chernomorskoy nauchnopromyslovoy ekspeditsii”, no. 10, 274 pp., 1932 (in Russian).
[6] G. Newman, “Die absolute Topografie des physikalischen Meeresniveanus und die Oberflachen-stromungen des Schwarzen Meeres”, “Ann. Hydrog. Berl.”, no. 70, pp. 265-282, 1942 (in German).
[7] H. Caspers, “Black Sea and Sea of Azov”, “Treatise on marine ecology and paleoecology”, Geological Society of America Memoire, no 67, pp. 803-890, 1957.

[8] Filipov, "Circulation and structure of the waters in the Black Sea", Nauka, Moscow, 136 pp., 1968.
[9] S. G. Boguslavskiy and A. S. Sarkisyan, T. Z. Dzhioyev, L. A. Koveshnikov, "Analysis of Black Sea current calculations", "Izv. Atmospheric and Oceanic Physics", no. 12, pp. 205-207, 1976.
[10] A. S. Blatov, N. P. Bulgakov, V. A. Ivanov, A. N. Kosarev, V. S. Tuljulkin, "Variability of the Black Sea hydrophysical fields", "Leningrad Gydrometeoizdat", 240 pp., 1984.
[11] E. V. Stanev, D. Truhchev, V. Roussenov, "Black Sea circulation and its numerical modeling.", Kliment Ohridski University Press, 222 pp., 1984.
[12] E. V. Stanev, "On the mechanisms of the Black Sea circulation", "Earth Science Reviews", no. 28, pp. 285-319, 1990.
[13] V. N. Eremeev, A. V. Ivanov, V. S. Tuljulkin, "Climatic interannual variability of geostrophic circulation in the Black Sea", Ukranian Academy of Sciences, 53 pp., 1991.
[14] http://www.mohid.com/what_is_mohid.htm
[15] J. J. Taboada, M. Ruíz-Villarreal, M. Gómez-Gesteira, P. Montero, A. P. Santos, V. Pérez-Villar and R. Prego, "Estudio del transporte en la Ría de Pontevedra (NOEspaña) mediante un modelo 3D: Resultados preliminares, In: Estudos de Biogeoquímica na zona costeira ibérica." Servicio de Publicaciones da Universidade de Aveiro in press, 2000.
[16] P. Montero, M. Gómez-Gesteira, J. J. Taboada, M. Ruiz-Villarreal., A. P. Santos, R. J. J. Neves, R. Prego and V. Pérez-Villar, "On residual circulation of Vigo Ría using a 3D baroclinic model", "Boletín Instituto Español de Oceanografía", no 15., Suplemento 1, 1999.
[17] L. Cancino, and R. Neves "Hydrodynamic and sediment suspension modelling in estuarine systems. Part II: Application to the Western Scheldt and Gironde estuaries", "Journal of Marine Systems", vol. 22, pp. 117-131, 1999.
[18] P. C. Leitão, "Modelo de Dispersão Lagrangeano Tridimensional." Ms. Sc. Thesis, Universidade Técnica de Lisboa, Instituto Superior Técnico, 1996.
[19] R. Neves, H. Coelho, P. Leitão, H. Martins, and A. Santos, "A numerical investigation of the slope current along the western European margin.", "Computational Methods in Water Resources XII", vol. 2, pp. 369-376, 1998.
[20] http://www.rmri.ro/RMRI/Forecasts/aboutRO.html

# VERTICAL STRUCTURE OF THE CURRENTS IN THE BLACK SEA BASIN

[1]TODERASCU ROBERT, [2]RUSU EUGEN

*Dunarea de Jos University of Galati, Romania*

**ABSTRACT**

The present work is focused on the investigation of the vertical structure of the currents in the Black Sea basin. In order to accomplish this objective, relevant information concerning the vertical current fields was acquired from the Black Sea Physical Forecasting System. The above data contain horizontal and vertical current fields, up to 2100 meters in depth. The present analysis was carried out considering 18 points that cover the entire Black Sea basin. The depth variations of the current velocities were analyzed in the present work with a detailed analysis for 6 reference points.

**Keywords:** *Black Sea, current fields, vertical profiles, circulation patterns.*

## 1. INTRODUCTION

The objective of the present work is to analyse the vertical structure of the currents in the Black Sea basin. It is of common knowledge the fact that the Black Sea contains three vertical layers of water that usually do not mix. This particularity has a significant influence for the vertical structure of the currents. The first is the surface mixed layer and it responds strongly both to the wind fields and to the seasonal heating and it ranges to a depth of roughly 50 meters. Here the currents reach the highest speeds. The second layer is called the intermediate cold layer and ranges from 50 to 180 meters, sometimes even to 200m. This second layer is characterized by smaller temperature values than the rest of the sea, between 6˚-8˚ C for the most parts of the basin. The majority of the circulation in the Black Sea happens in these two surface layers [1]. The third layer, which represents the rest of 90% of the sea, is considered to be the largest anoxic water body in the world. This third layer does not mix with the upper layers fact proven also by the small current values at higher depths. Below 500 meters in depth the waters are mostly stagnant with small changes in their properties, except for the cases located near the boundaries. Below the depth of 1700 meters, the bottom layer is subjected to geothermal heating from the sea bottom with a potential temperature of 8.8˚to 9˚ C as stated by Enriquez (2005) [1]. The maximum depth in the Black Sea is about 2588 meters; however such high depths are rarely seen. A most realistic common maximum depth is considered to be around 2100 meters. The Black Sea's salinity is lower than the open seas due to the fact that the sea is enclosed and subjected to strong river discharges. The average salinity is considered to be about 18.2 PSU but it can be considerably lower near the river discharges areas. Nevertheless, the bottom layer salinity is higher being about 21.8 PSU. This difference is maintained mostly due to the fact that the bottom layer is not benefiting of the water exchange common for the surface layers, layers that receive lower saline waters from rivers discharge, and another reason is the fact that the bottom layer is receiving more saline waters from the Mediterranean Sea [2].

For a better understanding of the current field in the surface layer a comprehensive picture is provided by Toderascu and Rusu (2012a) [3]. The implementation of a circulation model for the Black Sea was treated in Toderascu and Rusu (2012b) [4]. In relationship with the wave modelling in the Black Sea, there can be mentioned the works of Rusu (2009) [5] and Rusu and Ivan (2010) [6].

## 2. VERTICAL PROFILES OF THE CURRENT FIELD

The objective of the present work is to analyse the vertical structure of the currents and correlate it with the known facts about the special state of the non-mixing water layers of the Black Sea. In this case, the current velocity fields provided by the Black Sea physical Forecasting System were analysed. The above data contain temperature, salinity, depth, u and v components of the current velocity, and time archived in a NETCDF CF 1.4 format. The data are produced in a regular grid of 238x132x35 reference points (with about 5km horizontal resolution). As regards the depth variation of the currents this is given on 35 levels with variable spatial step that varies from 5 meters close to the surface and arrives at 100 meters close to the bottom layer. 18 points were considered in the analyses that cover almost the entire area of the Black Sea basin. Among them 6 reference points have been selected for a more detailed analysis of the vertical profiles of the currents, due to the fact that the highest depth is not reached in all the cases. It has to be highlighted also that, the vertical current profiles presented and analysed in this work are the average values corresponding to 1st of January 2020. Figure 1 presents in background the bathymetry of the Black Sea and the 18 reference points considered in foreground, while Table 1 gives the coordinates of the 18 reference points, along with the current velocity at various depths. As it can be observed from Table 1, the current velocity decreases with depth.

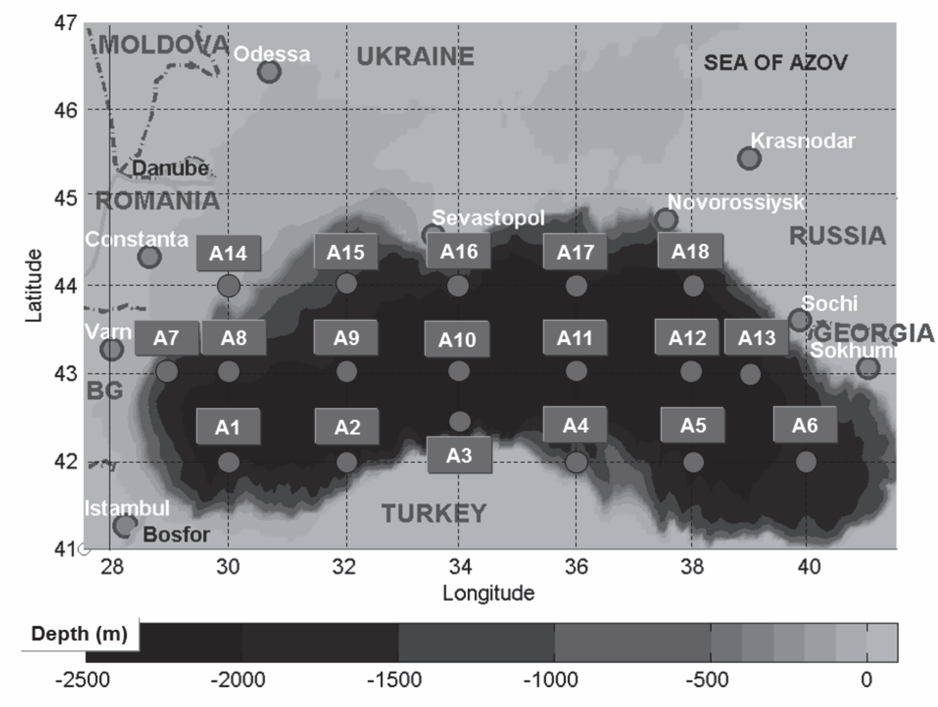



Figure 1 Bathymetric map of the Black Sea with the 18 referencepoints considered.

Table 1. Current velocity for the reference points at different depths.

| Points | 2.5 m | 5 m | 10 m | 50 m | 62.5 m | 75 m | 87.5 m | 100 m | 200 m | 400 m | 1200 m | 1500 m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 (42N, 30E) | 0.15 | 0.09 | 0.07 | 0.06 | 0.07 | 0.08 | 0.09 | 0.09 | 0.06 | 0.05 | 0.01 | 0.01 |
| A2 (42N, 32E) | 0.34 | 0.26 | 0.30 | 0.14 | 0.13 | 0.12 | 0.12 | 0.11 | 0.02 | 0.02 | 0.03 | 0.03 |
| A3 (42.5N, 36E ) | 0.32 | 0.36 | 0.25 | 0.05 | 0.06 | 0.06 | 0.06 | 0.07 | 0.05 | 0.05 | 0.03 | 0.03 |
| A4 (42N, 36E) | 0.48 | 0.39 | 0.26 | 0.11 | 0.11 | 0.10 | 0.09 | 0.07 | 0.05 | 0.02 | - | - |
| A5 (42N, 38E) | 0.47 | 0.48 | 0.37 | 0.13 | 0.10 | 0.08 | 0.06 | 0.05 | 0.08 | 0.02 | 0.01 | 0.01 |
| A6 (42N, 40E) | 0.05 | 0.08 | 0.10 | 0.08 | 0.07 | 0.06 | 0.05 | 0.04 | 0.02 | 0.03 | 0.01 | 0.01 |
| A7 (43N, 29E) | 0.14 | 0.26 | 0.20 | 0.17 | 0.19 | 0.21 | 0.22 | 0.22 | 0.11 | 0.06 | 0.01 | 0.00 |
| A8 (43N, 30E) | 0.37 | 0.15 | 0.14 | 0.09 | 0.08 | 0.07 | 0.06 | 0.06 | 0.03 | 0.01 | 0.01 | 0.01 |
| A9 (43N, 32E) | 0.14 | 0.26 | 0.14 | 0.10 | 0.08 | 0.07 | 0.05 | 0.04 | 0.01 | 0.03 | 0.01 | 0.01 |
| A10 (43N, 34E) | 0.25 | 0.32 | 0.18 | 0.07 | 0.06 | 0.05 | 0.06 | 0.06 | 0.05 | 0.03 | 0.02 | 0.02 |
| A11 (43N, 36E) | 0.43 | 0.46 | 0.36 | 0.07 | 0.06 | 0.05 | 0.04 | 0.03 | 0.04 | 0.03 | 0.02 | 0.02 |
| A12 (43N, 38E) | 0.07 | 0.31 | 0.25 | 0.08 | 0.07 | 0.06 | 0.05 | 0.04 | 0.01 | 0.01 | 0.02 | 0.02 |
| A13 (43N, 39E) | 0.25 | 0.07 | 0.15 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.03 | 0.02 | 0.01 | 0.01 |
| A14 (44N, 30E) | 0.05 | 0.19 | 0.23 | 0.10 | 0.08 | 0.06 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | - |
| A15 (44N, 32E) | 0.41 | 0.57 | 0.45 | 0.15 | 0.13 | 0.12 | 0.12 | 0.12 | 0.10 | 0.03 | 0.03 | - |
| A16 (44N, 34E) | 0.48 | 0.46 | 0.23 | 0.09 | 0.08 | 0.07 | 0.06 | 0.05 | 0.02 | 0.02 | 0.00 | 0.00 |
| A17 (44N, 36E) | 0.47 | 0.57 | 0.39 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.02 | 0.01 | 0.02 | 0.01 |
| A18 (44N, 38E) | 0.47 | 0.38 | 0.43 | 0.16 | 0.14 | 0.12 | 0.11 | 0.10 | 0.07 | 0.02 | 0.00 | 0.01 |

At the surface, the values are consistent with satellite observations and also with the existent in situ measurements, ranging in this case from 0.25 to 0.48 m/s, except for the point A6 that presents smaller values for all depths. As the depth increases, various drops in the current speed can be noticed. A slight speed drop is observed at the depth of 10 meters; however this does not seem to occur for the reference points denoted as A6, A12 and A15 where the speed is actually increasing up to this depth. From this point forward there will be no surprises; and the speed slowly drops up to 100 meters. At 200 meters depth we witness another speed drop, this time a more dramatically one, the current velocity being reduced by 50% in most of the cases. From 200 meters to 400m the speed will mostly remain constant, decreasing generally with 0.01m/s. After 400 meters the current velocity slowly decreases up to a value of 0.03m/s for the cases of A2, A3 and A15, but for the majority of the reference points analysed it settles at about 0.01m/s. From 1500 meters to 1700 and 2100 meters (maximum depth in the presented data set) the current speed remains the same for the most of the points, suggesting a state of calm regarding the bottom currents. Nevertheless, there are no cases where the current velocity reaches the zero value. No matter how small, there is always a water movement.

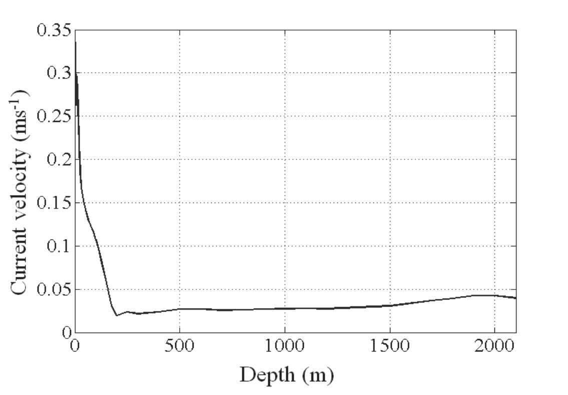



Figure 2 Current velocity variation by depth for A1

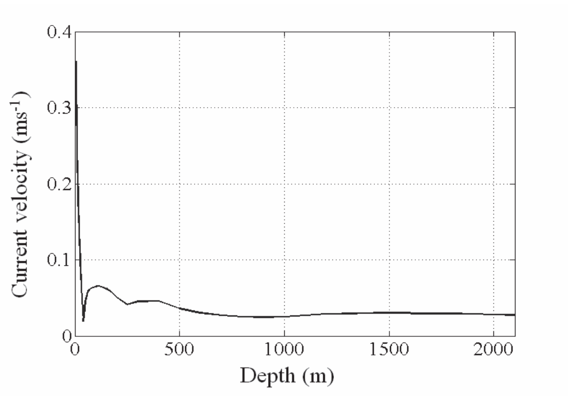



Figure 3 Current velocity variation by depth for A3

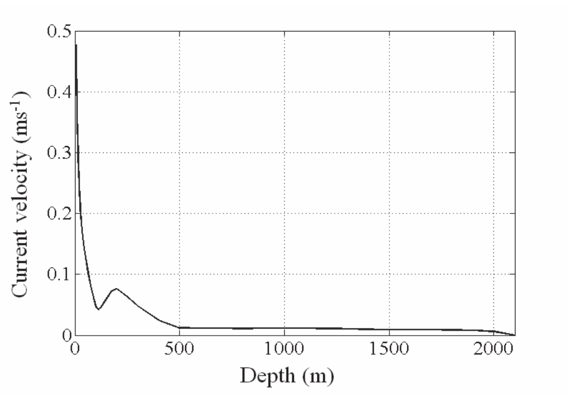



Figure 4 Current velocity variation by depth for A5

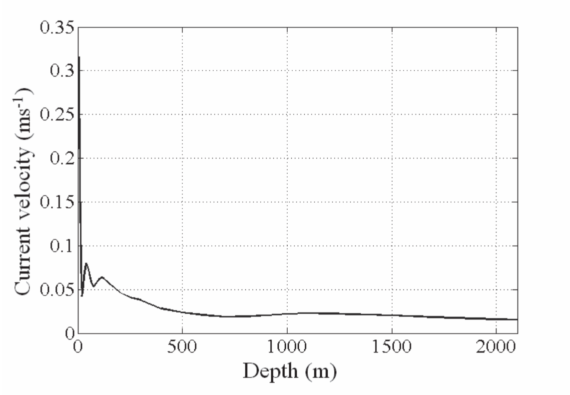



Figure 5 Current velocity variation by depth for A10

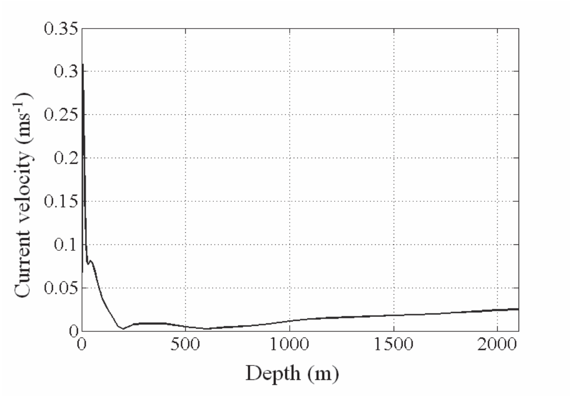



Figure 6 Current velocity variation by depth for A12

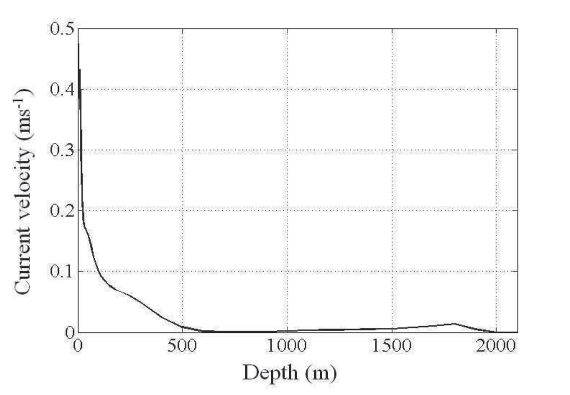



Figure 7 Current velocity variation by depth for A18

## 3. DISCUSSION OF THE RESULTS

In Figure 2, the current velocity variation by depth is presented for the reference point A1. As it can be seen in the plot, after roughly 200 meters the speed decreases to a maximum of 0.05m/s. This case is somehow isolated since the velocity near the maximum depth is not asymptotic and it actually increases a bit close to the bottom. Figure 3 presents the current velocity drop for the point of A3, case that also does not present an asymptotic line, but the current velocity stays constant for most depths under 500 meters. Figures 4, 5, 6 and 7 also present the current velocity drops for the A5, A10, A12 and A18 reference points where similar behaviors can be observed.

In general, close to the surface the current velocity is in the range of 0.15-0.50 m/s. It varies between these two values up to 50 meters. As mentioned before, up to 50 meters is considered to be the surface mixed layers. The currents here suffer lots of variations being subjected to wind, waves and seasonal heating. From 50 to 200 meters there is the intermediate cold layer, layer also reflected in current movements. For this section the current velocities reach a semi-stable condition. There is still a velocity drop, but a very slow one of roughly 0.01-0.02 m/s. In some cases the speed will remain constant as the cases of the points A10 and A15. In other cases there might be seen a slight increase in the current speed as for example for the reference point A7. In this case the current velocity starts to grow from 62.5 meters up to 100 meters in depth, however the growth will stop till the depth of 200m is reached. The currents in the third and last layer are not influenced by the elements common to the surface. There is still little known about the Black Sea's bottom currents. As it can be observed here, they are rather small and do not present many surprises. Even close to the bottom there is still movement, even if this is very small.

## 4. CONCLUSIONS

The present work provides a more comprehensive picture of the vertical structure of the current fields in the Black Sea basin. The Black Sea presents a series of unique characteristics, with three vertical layers containing water bodies that do not mix while the third layer being anoxic. The current velocity values are generally small, even at the surface the maximum current velocity is usually limited to 1m/s, and only sometimes during strong storms this could reach about 2m/s. It is expected that at higher depths the current velocity will be small, with no surprises and small variations.

The knowledge of the current patterns on the vertical and on the horizontal is important as it can reduce shipping costs and can help also in diminushing the risks of accidents . Also, a lot of marine life species depend on these patterns so it is important to know what areas of the sea can or can not be disturbed with ship traffic. Knowing the current patterns is also important for the cases of chemical hazards as the currents move the chemical substances in water.

## 5. ACKNOWLEDGMENTS

The work of the first author has been made in the scope of the project EFICIENT (Management System for the Fellowships Granted to the PhD Students) supported by the Project SOP HRD - EFICIENT 61445/2009.

## 6. REFERENCES

[1]. Enriquez Ortiz C. E., 2005. Mesoscale Circulation in the Black Sea: A Study Combining Numerical Modelling and Observations, PhD Thesis, School of Earth, Ocean and Environmental Sciences, 257 pp.

[2]. Mee L, Maiboroda O., 2006. Black Sea Study Pack: A Resource for Teachers, Black Sea Ecosystem Recovery Project, 87 pp.

[3]. Toderascu R., Rusu L. 2012a. Study on the currents variability and patterns in the Black Sea, 12-th International Multidisciplinary Scientific GeoConference SGEM 2012, 3, pp. 825-832 (8)

[4]. Toderascu R., Rusu E. 2012b. Implementation of a global circulation modeling system for the Black Sea basin, 12-th International Multidisciplinary Scientific GeoConference SGEM 2012, 3, pp. 739-746 (8)

[5]. Rusu E., 2009. Wave energy assessments in the Black Sea, Journal of Marine Science and Technology 14 (3), pp. 359-372 (24), Rusu E., 2010a. Modelling of wave-current interactions at the mouths of the Danube, Journal of Marine Science and Technology 15 (2), pp. 143-159 (17)

[6]. Rusu L., Ivan A., 2010. Modelling wind waves in the Romanian coastal environment, Environmental Engineering and Management Journal 9 (4), pp. 547-552 (6).

# LINEAR OSCILLATING SYSTEM WITH IMPULSE EXCITATION IN CASE OF NAVAL AND MARITIME SPECIAL PRODUCTS

VLADU GABRIEL-LIVIU

*Constanta Maritime University, Romania*

**ABSTRACT**

This paper aims to address some aspects of linear oscillating system with impulse excitation in the case of special naval and maritime products based on the analysis in terms of the relationship between disturbance applied to their and response represented by vibratory motion.

Experimental measurements were carried out during shooting experiments with a special naval and maritime product.

**Keywords:** *motion analysis, linear oscillating system, motion impulse, naval weapons.*

## 1. INPUT-OUTPUT RELATIONSHIP FOR A LINEAR SYSTEM

An oscillating system can be analyzed in terms of the relationship between disturbance applied to him and answer represented by vibratory movement.

Excitation is described by the function x(t) named input size and the answer by the function y(t) named output.

Input size can represent a force or a movement and the output is commonly a variable movement in time (figure 1).

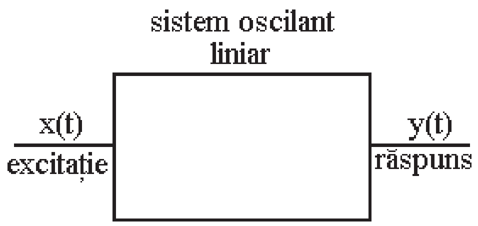



Figure 1

Linear systems have the property of invariance in time. If the excitation is stationary harmonic the answer will be also stationary harmonic of the same frequency. To describe amplitude dependence and the initial phase of the frequency it determine the frequency transfer function H(ω). The property of this function is that if the excitation is the real part of a complex harmonic functions $e^{i\omega t}$ then the answer will be the real part of the complex function $H(\omega)\cdot e^{i\omega t}$.
Frequency transfer function is obtained by putting the condition that the functions:

$$x = e^{i\omega\omega},\ y = H(\omega)\cdot e^{i\omega\omega} \tag{1}$$

satisfy the differential equations of motion.

Because H(ω) is the output function of the system for the input function unit it result that the size coincides with the size of the ratio x/y. If we know H(ω) for all the frequencies we can determine y(t) for a given excitation x(t).

In the case of linear systems can be applied superposition principle in the frequency domain. So if x(t) is a periodic function It can be broken down into Fourier series that each term of this series will meet one size H(ω).

If x(t) is non-periodic and has Fourier transform:

$$X(\omega) = \int_{-\infty}^{\infty} x(t)\cdot e^{-i\omega\omega}dt \tag{2}$$

then for each component of a certain frequency it obtain:

$$Y(\omega) = H(\omega)\cdot X(\omega) \tag{3}$$

where Y(ω) will be the Fourier transform of the function y(t), resulting:

$$y(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} H(\omega)\cdot e^{i\omega\omega}d\omega \int_{-\infty}^{\infty} x(\tau)\cdot e^{i\omega\omega}d\tau \tag{4}$$

If we know the frequency transfer function H(ω) and if the convergence is provided the general relationship (4) allow measure of output function y(t) for any arbitrary function x(t).

## 2. IMPULSE EXCITATION

If the excitation is a unit impulse x(t) function expressed in the theory distributions by Dirac function:

$$x(t) = \delta(t-\tau) \tag{5}$$

The temporary response function of the system was initially at rest:

$$y(t) = h(t-\tau) \tag{6}$$

the named share function is obtained by integrating the differential equations of motion with zero conditions for t<τ.

If h(t-τ) known we can determine the response y(t) for any arbitrary excitation x(t). Relationship linking the two quantities is obtained by applying the superposition effect in the time domain.

Consider an arbitrary excitation x = x(t) which may be an interference power per unit mass whose variation in time (fig. 2) is considered as a sequence of elementary impulses x(τ)dτ applied at times t = τ. Each impulse strike linear system a speed:

$$dv = x(\tau)d\tau \tag{7}$$

that will create at "t" time that is, after a period of time "t-τ", movement:

$$dy = x(\tau)d\tau \cdot h(t-\tau) \tag{8}$$

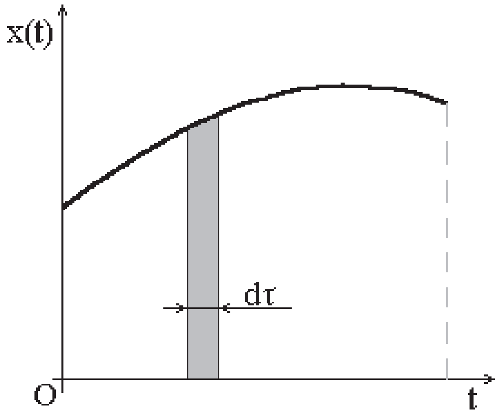



Figure 2

Due to the linearity, the response y(t) in the case of the deterministic excitation is obtained by summing the effects of all elementary impulses:

$$y(t) = \int_{-\infty}^{\infty} x(\tau)\cdot h(t-\tau)d\tau$$

$$= \int_{-\infty}^{\infty} h(\tau)\cdot x(t-\tau)d\tau = h * x \tag{9}$$

that is the convolution integral or integral of Duhamel.

Since the answer may not precede excitation any realizable system satisfies the condition h(t-τ) = 0 for t < τ.

In view of this condition of causality, the integral limits are changed, resulting:

$$y(t) = \int_{-\infty}^{t} x(\tau)\cdot h(t-\tau)d\tau = \int_{0}^{\infty} h(\tau)\cdot x(t-\tau)d\tau \tag{10}$$

If the initial time the system is at rest effect of initial conditions can be treated separately and added under the principle of superposition.

## 3. CELERATION VS TIME DIAGRAMS OBTAINED EXPERIMENTALLY

Electronic system for measuring the vibration level is carried out by SIMULTEC SA Bucuresti (NC-4062).

To determine the acceleration has been used:

- accelerometer type 8319 Bruel & Kjaer (2 pieces);
- line preamplifier type 2813 Bruel & Kjaer (1 piece – dual);
- acquisition card NI: AT-MIO 16 F, 16 single or 8 differential channels;

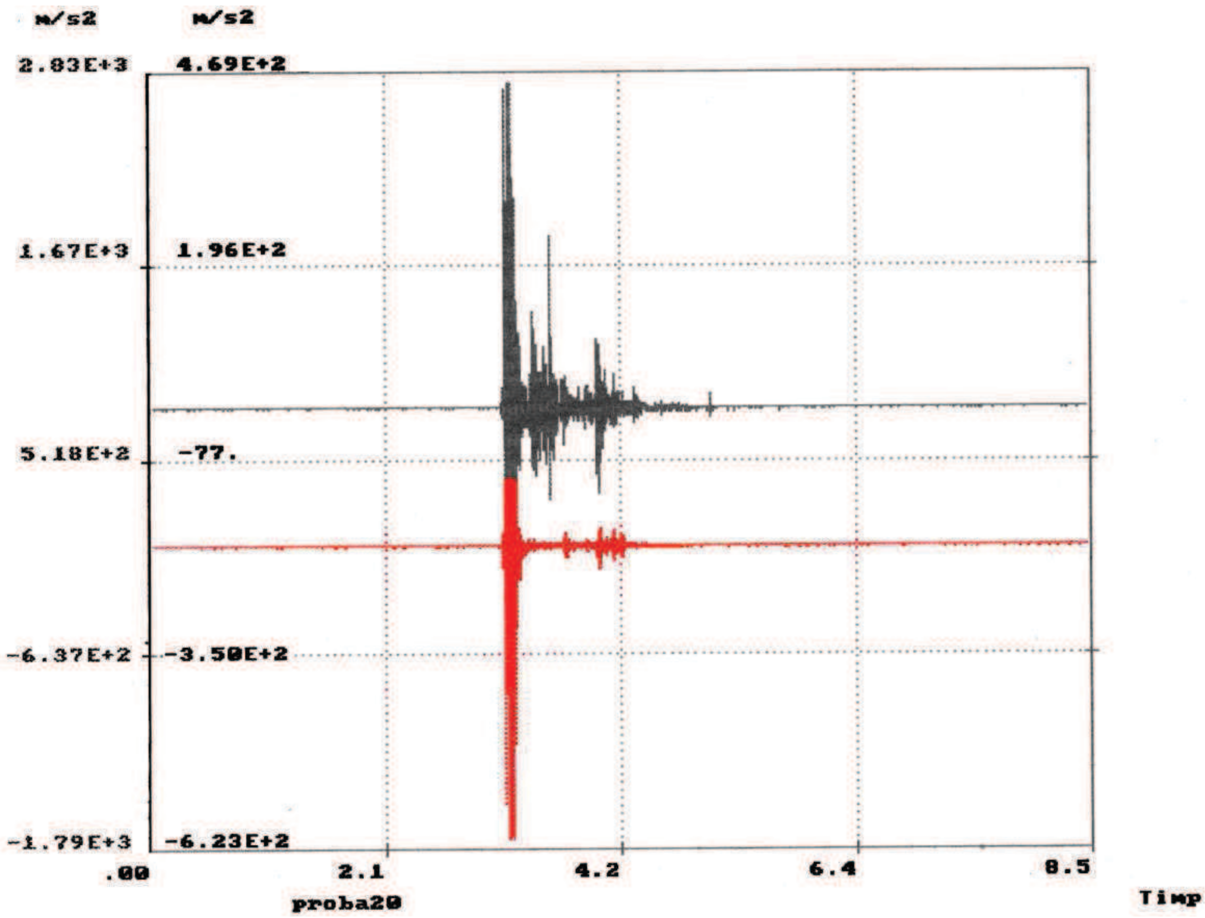



Figure 3. Diagram acceleration - time. Shooting angle 07-54

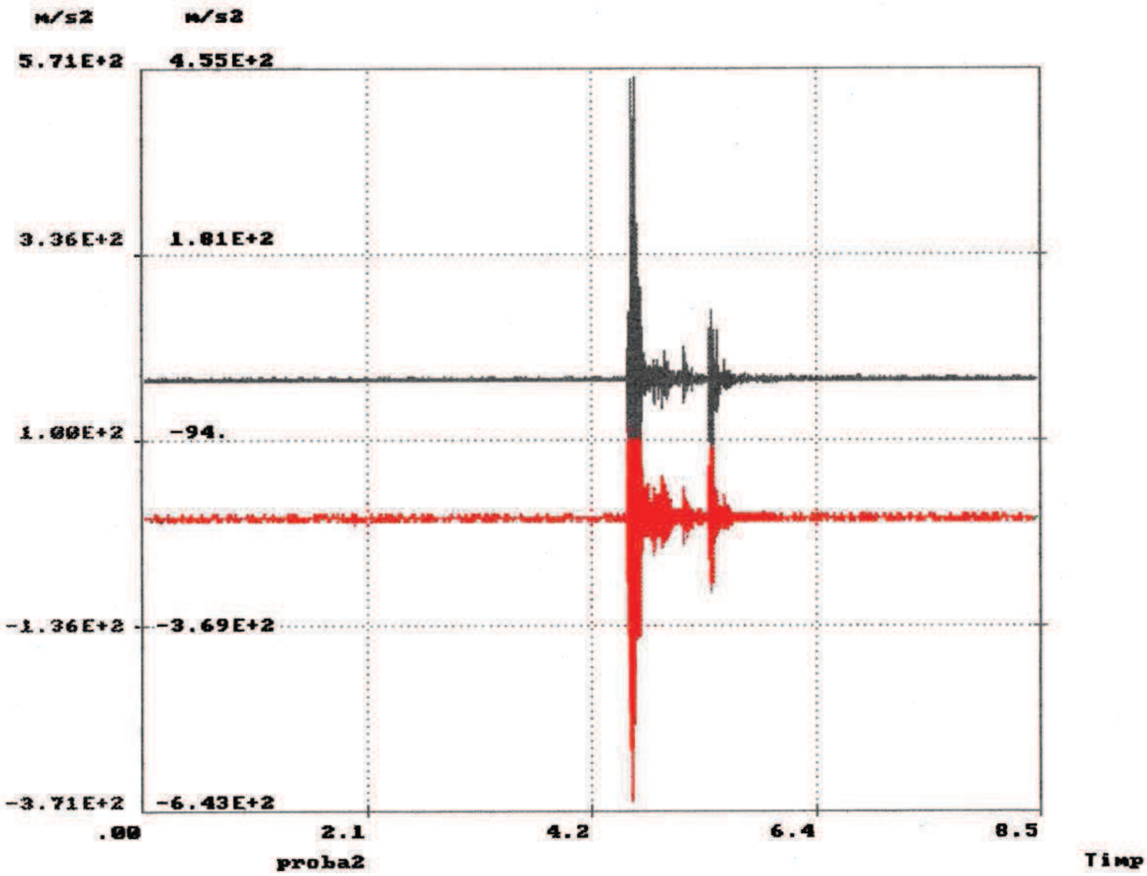



Figure 4. Diagram acceleration - time. Shooting angle 04-40

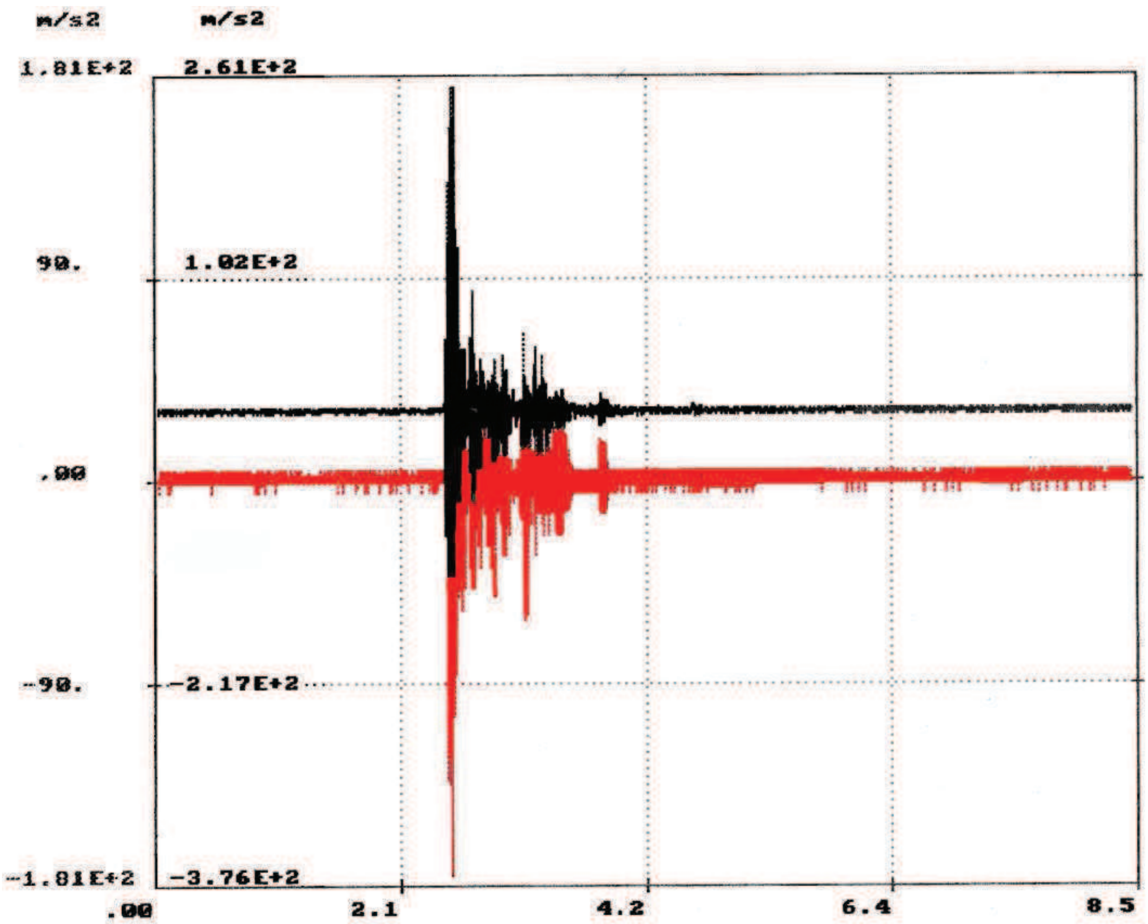



Figure 5. Diagram acceleration - time. Shooting angle 04-50

## 4. CONCLUSIONS

Excitation transmitted by proper shooting with a special naval and maritime product and the whole phenomenon arises affects the respective system.

Experimental determinations have implemented the existing theory for linear oscillating systems with impulse excitation disturbing factors having a great influence during the course of the phenomenon.

## 5. REFERENCES

[1] HAIRIS C.M., *Shock and vibration*, Technical Publishing, Bucharest, 1968
[2] KALMAN RE., *Dynamical systems theory*, Technical Publishing, Bucharest, 1975
[3] WALTERS R., *Hydraulic and Electro Hydraulic Servo Systems*, Iliffe Books LTD, London, 1984
[4] VLADU G.L., *Technical considerations in applying naval robotic arms*, Ph.D. thesis, Military Technical Academy, Bucharest, 2000.

# SECTION III

## ELECTRONICS, ELECTRONICAL ENGINEERING AND COMPUTER SCIENCE

# NOTES REGARDING ALGEBRAIC ANALYSIS OF P-TIMED PETRI NETS

[1]BORDEA GHEORGHE, [2]DINU SIMONA

*[1,2]Constanta Maritime University, Romania*

**ABSTRACT**

In this paper we present a modeling method for the P-timed Petri nets that can be applied only if each timing of the studied network can be expressed as a multiple of a basic unit of time. For such a network, an equivalent T-synchronized network shall be drawn. This can be studied using linear algebra, i.e. fundamental equation and incidence matrix based methods ([1], [2]).

**Keywords:** *Discrete Event System, Modeling, Petri Nets*

## 1. INTRODUCTION

For the study of the P-timed Petri nets, algebraic methods based on incidence matrix do not provide information regarding the timings of marks located in the network positions. For a P-timed Petri net in where every network timing can be expressed as a multiple of a basic unit of time, denoted by Δ in the paper, we will present a method that provides information on the timings of marks located in the network positions.

To do so, starting from the initial Petri net with different timings, we will build an equivalent Petri net in which all timings are equal to Δ. Is thus obtained a timed Petri net that may be considered a synchronized Petri net with a periodic external event, the period being equal to Δ.

## 2. THE P-TIMED PETRI NETS

A P-timed Petri net is a network of timed positions. For example, shall be considered the network in Fig. 1 that has three positions: $P_1$, $P_2$ and $P_3$ with timings 3Δ, Δ, and 2Δ respectively. Its transitions, $T_1$ and $T_2$ are not timed and are executed as soon as they become valid.

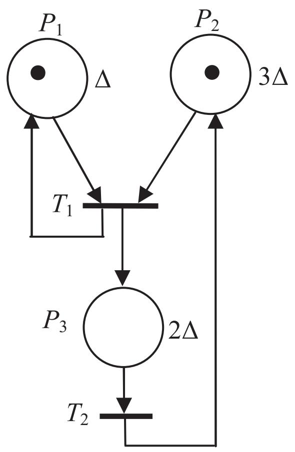



Fig. 1. A P-timed Petri net

A mark located in a timed position can participate in validation of a transition after a period at least equal to the position timing; the transition validation could be conditioned by the marks from other positions. For example, the mark from position $P_2$ becomes available after a time equal to Δ but it might wait for a mark from position $P_1$ where timing is 3Δ.

If the initial markings of the network positions are $M(P_1)=1$, $S(P_2)=1$, and $M(P_3)=0$, the initially marking of the network at the time t = 0, it follows:

$$M(0)=\begin{bmatrix} M(P_1) \\ M(P_2) \\ M(P_3) \end{bmatrix}=\begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} \tag{1}$$

The Evolution in time for the marking of the network in Fig. 1 is shown in Fig. 2. Thus, after a time equal to 3Δ, the transition $T_1$ is executed and the network marking will be:

$$M(3\Delta)=\begin{bmatrix} M(P_1) \\ M(P_2) \\ M(P_3) \end{bmatrix}=\begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} \tag{2}$$

After a time equal to 5Δ, we obtain the initially marking where the mark in position $P_2$ is available after a time equal to 3Δ and the mark from position $P_1$ is available after a time equal to Δ.

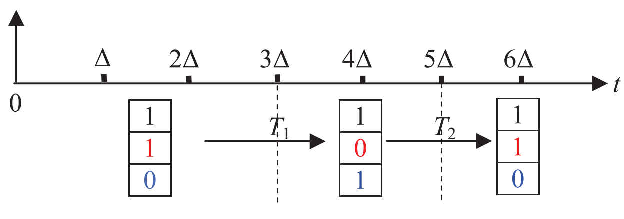



Fig. 2. The evolution of Petri net marking shown in Fig.1.

The analysis of network operation becomes more complicated if the position $P_3$ contains a mark, as well (Fig.3).

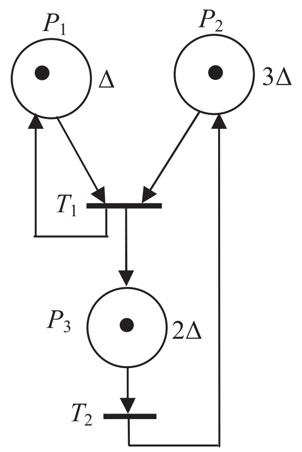


Fig. 3. Petri net in which all positions are marked.

The Evolution in time for the marking of the network in Fig. 3 is shown in Fig. 4.

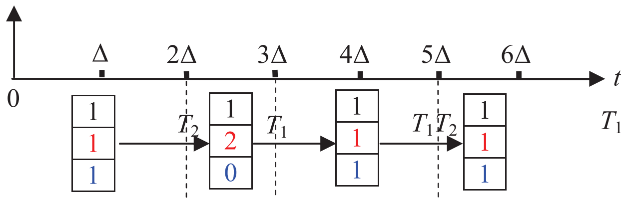


Fig. 4. The Evolution in time for the marking of the network shown in Fig. 3.

Thus, after a time equal to 2Δ, the transition $T_2$ is executed and the $P_2$ position marking will be given by two marks with different waiting times: a mark that is still reserved for a time equal to Δ, and a mark reserved for a time equal to 3Δ (Fig. 5):

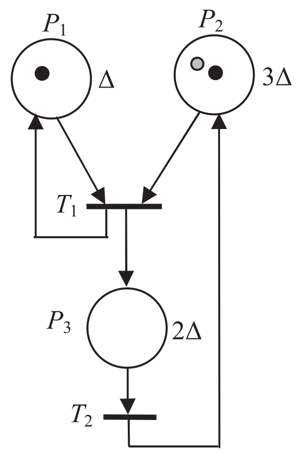


Fig. 5. Petri net with differently timed marks in position $P_2$.

After a time equal to 3Δ, transition $T_1$ is executed and the initial marking is obtained, only that the marks from positions $P_2$ and $P_3$ are available after a time equal to 2Δ, and the mark from position $P_1$ is available after a time equal to Δ.

After a time equal to 5Δ, both transitions $T_1$ and $T_2$ are executed and the initial marking is obtained. Within it, the mark in position $P_2$ is available after a time equal to 3Δ, the mark in position of $P_3$ is available after a time equal to 2Δ, and the mark in position $P_1$ is available after a time equal to Δ.

As can be seen from the analysis of Petri net shown in Figure 3, in the case of a more complex network, the network analysis is more complicated with this way of representation.

Through the equivalence of a P-timed Petri net with a synchronized Petri net, the evolution of the network will be easier to study using algebraic methods based on incidence matrix.

## 3. EQUIVALENT NETWORK

The P-timed Petri net shown in Fig. 3 can be equated to the synchronized Petri net shown in Fig. 6 in which the position $P_2$, with the timing 3Δ was equated with $P_{2a}$, $P_{2B}$ and $P_{2C}$ positions, connected by additional transitions $T_{2a}$ and $T_{2b}$ and position $P_3$ with 2Δ timing was equated with the positions $P_{3a}$ and $P_{3b}$ connected by the additional transition $T_{3a}$.

Thus, one obtains a Petri net (Fig. 6) in which all positions are timed by Δ:

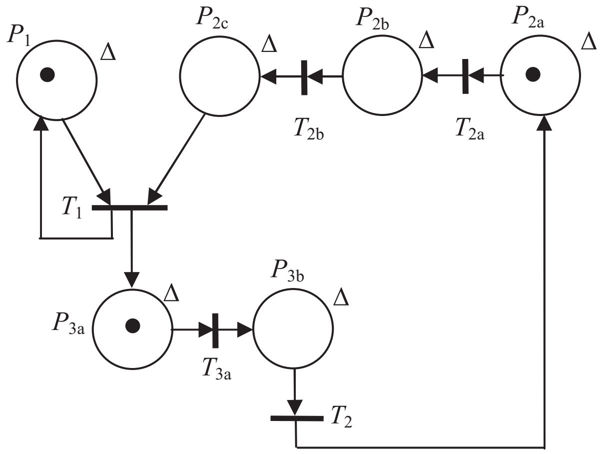


Fig. 6. A P-timed Petri net

**Remark 1**: The resulting network could be equated to a network in which all transitions are synchronized with the same external periodically event, E, of period Δ.

Thus, one obtains the P-synchronized Petri net shown in Fig. 7:

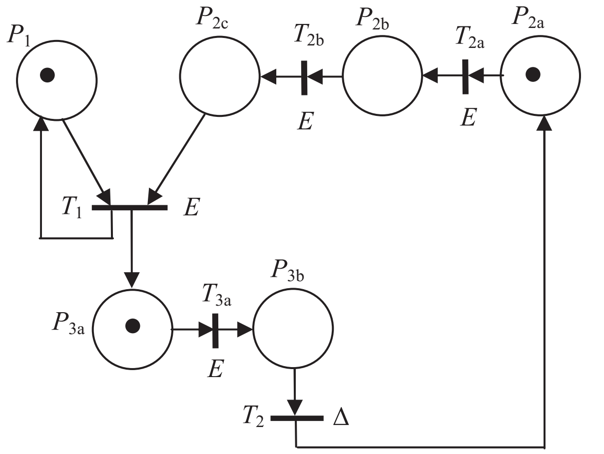


Fig. 7. A P-synchronized Petri net

In this case, the valid transitions will be executed only after the event E occurred, and the positions timing will be considered void.

If the initial markings for the positions of the network in Fig.3 at time t=0 are $M(P_1)=1$, $M(P_2)=1$ and $M(P_3)=1$, then the initial marking of the equivalent network in Fig. 7, at time t=0, will be:

$$M_{\mathrm{E}}(0)=\begin{bmatrix} M(P_1) \\ M(P_{2a}) \\ M(P_{2b}) \\ M(P_{2c}) \\ M(P_{3a}) \\ M(P_{3b}) \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix} \qquad (3)$$

Meaning of the positions markings $P_{2a}$, $P_{2b}$, $P_{2c}$, $P_{3b}$ and $P_{3b}$ is as follows:

- A mark in the position $P_{2a}$ is equivalent to a mark in the position $P_2$, timed by $3\Delta$;
- A mark in the position $P_{2b}$ is equivalent to a mark in the position $P_2$, timed by $2\Delta$;
- A mark in the position $P_{2c}$ is equivalent to a mark in the position $P_2$, timed by $\Delta$;
- A mark in the position $P_{3a}$ is equivalent to a mark in the position $P_3$, timed by $2\Delta$;
- A mark in the position $P_{3b}$ is equivalent to a mark in the position $P_3$, timed by $\Delta$;

Between the positions markings $P_2$ and $P_3$ of the network in Fig.3 and the positions markings $P_{2a}$, $P_{2b}$, $P_{2c}$, $P_{3a}$ and $P_{3b}$ in Fig.7 there are the following relationships:

$$M(P_2)= M(P_{2a})+ M(P_{2b})+ M(P_{2c}) \qquad (4)$$

$$M(P_3)= M(P_{3a})+ M(P_{3b}) \qquad (5)$$

For a time equal to $6\Delta$, the evolution of the Petri net marking in Fig. 7 is shown in Fig. 8. At times $2\Delta$, $3\Delta$, $4\Delta$ and $5\Delta$ two transitions are executed.

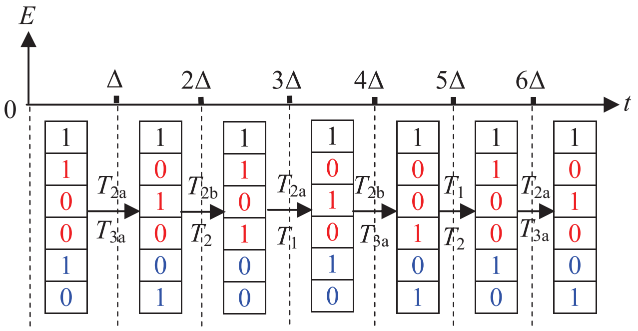



Fig. 8. The evolution of the Petri net marking in Fig. 7

## 4. RELATIONSHIPS BETWEEN THE INCIDENCE MATRICES

For the equivalent Petri network (Fig. 6), the following input incidence matrix results:

$$W_{\mathrm{E}} = \begin{array}{c} \\ \\ \\ \\ \\ \\ \end{array}\begin{array}{c} \begin{array}{ccccc} T_1 & T_{2a} & T_{2b} & T_{3a} & T_2 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \end{array} \begin{array}{c} \\ P_1 \\ P_{2a} \\ P_{2b} \\ P_{2c} \\ P_{3a} \\ P_{3b} \end{array} \qquad (6)$$

After the equivalence of the Petri net in Fig. 5 with the network in Fig. 6, the position $P_2$ was equated with the group of positions $P_{2a}$, $P_{2b}$ and $P_{2c}$, where $P_{2a}$ is the input position in group, and $P_{2c}$ is the output position in group. Similarly, the position $P_3$ was equated with the group of positions $P_{3a}$ and $P_{3b}$, where $P_{3a}$ is the input position in group, and $P_{3b}$ is the output position in group.

**Remark 2:** If in matrix $W_{\mathrm{E}}$ the lines associated to positions $P_{2a}$, $P_{2b}$ and$P_{3a}$ and the columns associated to additional transitions $T_{2a}$, $T_{2b}$ and $T_{3a}$ are deleted, one obtains the input incidence matrix $W$, for the initial network shown in Fig. 5, where in the matrix $W_{\mathrm{E}}$, the lines associated to the output positions in group, $P_{2c}$ and $P_{3b}$, have been associated to position $P_2$, and $P_3$ respectively.

$$W = \begin{array}{c} \begin{array}{cc} T_1 & T_2 \end{array} \\ \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \end{array} \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \qquad (7)$$

For the equivalent network (Fig. 6), the output incidence matrix is:

$$W^{+}_{\mathrm{E}} = \begin{array}{c} \begin{array}{ccccc} T_1 & T_{2a} & T_{2b} & T_{3a} & T_2 \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix} \end{array} \begin{array}{c} \\ P_1 \\ P_{2a} \\ P_{2b} \\ P_{2c} \\ P_{3a} \\ P_{3b} \end{array} \qquad (8)$$

**Remark 3:** If in matrix $W^{+}_{\mathrm{E}}$ the lines associated to positions $P_{2b}$, $P_{2c}$ and $P_{3b}$ and the columns associated to additional transitions $T_{2a}$, $T_{2b}$ and $T_{3a}$ are deleted, one obtains the output incidence matrix $W^{+}$, for the initial network shown in Fig. 5, where in the matrix $W^{+}_{\mathrm{E}}$ , the lines associated to the input positions in group, $P_{2a}$ and $P_{3a}$, have been associated to position $P_2$, and $P_3$ respectively.

$$W^{+} = \begin{array}{c} \begin{array}{cc} T_1 & T_2 \end{array} \\ \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \end{bmatrix} \end{array} \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \qquad (9)$$

As the incidence matrices associated to networks are given by the relations:

$$W = W^{+} - W \qquad (10)$$

$$W_{\mathrm{E}} = W^{+}_{\mathrm{E}} - W_{\mathrm{E}} \qquad (11)$$

it follows:

$$W = \begin{array}{c} \begin{array}{cc} T_1 & T_2 \end{array} \\ \begin{bmatrix} 0 & 0 \\ -1 & 1 \\ 1 & -1 \end{bmatrix} \end{array} \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \qquad (12)$$

$$W_{\mathrm{E}} = \begin{array}{c} \begin{array}{ccccc} T_1 & T_{2a} & T_{2b} & T_{3a} & T_2 \end{array} \\ \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 1 \\ 0 & 1 & -1 & 0 & 0 \\ -1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & -1 \end{bmatrix} \end{array} \begin{array}{c} \\ P_1 \\ P_{2a} \\ P_{2b} \\ P_{2c} \\ P_{3a} \\ P_{3b} \end{array} \qquad (13)$$

**Remark 4:** If in matrix $W_E$ the columns associated to additional transitions $T_{2a}$, $T_{2b}$ and $T_{3a}$ are deleted, the lines associated to positions $P_{2a}$, $P_{2b}$ and $P_{2c}$ are summed up forming a single line that is associated to position $P_2$ and the lines associated to positions $P_{3a}$ and $P_{3b}$ are summed up forming a single line that is associated to position $P_3$, the incidence matrix $W$ is obtained.

## 5. THE MARKING DETERMINATION

In the case of a Petri net, for a given initial marking $M_0$, after the execution of a sequence $s$ characterized by the characteristic vector $S$, the marking $M$ of the network can be determined with the fundamental equation:

$$M = M_0 + W\,S \tag{14}$$

For the network in Fig. 3, the initial marking is

$$M_0 = \begin{bmatrix} M(P_1) \\ M(P_2) \\ M(P_3) \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \tag{15}$$

and for a given sequence $s$, the characteristic vector $S$ is:

$$S = \begin{bmatrix} n(T_1) \\ n(T_2) \end{bmatrix} \tag{16}$$

where $n(T_1)$ and $n(T_2)$ represent the number of occurrences of transitions $T_1$, respectively $T_2$ within the sequence $s$.

For example, if $s = T_2\,T_1\,T_1$, the resulting vector is:

$$S = \begin{bmatrix} 2 \\ 1 \end{bmatrix} \tag{17}$$

and the resulting marking is:

$$M = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ -1 & 1 \\ 1 & -1 \end{bmatrix} \times \begin{bmatrix} 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix} \tag{18}$$

This modeling method does not provide information regarding the timing of marks located in the network positions after the execution of sequence $s = T_2\,T_1\,T_1$.

Starting from the associated equivalent network, the initial marking is given by equation (3):

$$M_{E0} = \begin{bmatrix} 1 \\ 1 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix} \tag{19}$$

For the sequence $s_E = T_{2a}T_{3a}T_{2b}\boldsymbol{T_2T_1}T_{2a}T_{3a}T_{2b}\boldsymbol{T_1}$, the resulting characteristic vector is:

$$S_E = \begin{bmatrix} n(T_1) \\ n(T_{2a}) \\ n(T_{2b}) \\ n(T_{3a}) \\ n(T_2) \end{bmatrix} = \begin{bmatrix} 2 \\ 2 \\ 2 \\ 2 \\ 1 \end{bmatrix} \tag{20}$$

and according to the fundamental equation, it follows:

$$M_E = M_{E0} + W_E\,S_E \tag{21}$$

namely:

$$M_E = \begin{bmatrix} 1 \\ 1 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 1 \\ 0 & 1 & -1 & 0 & 0 \\ -1 & 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 & -1 \end{bmatrix} \times \begin{bmatrix} 2 \\ 2 \\ 2 \\ 2 \\ 1 \end{bmatrix} \tag{22}$$

After performing computations, the final marking is obtained:

$$M_E = \begin{bmatrix} M(P_1) \\ M(P_{2a}) \\ M(P_{2b}) \\ M(P_{2c}) \\ M(P_{3a}) \\ M(P_{3b}) \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \end{bmatrix} \tag{23}$$

from which results the final marking of position $P_1$:

$$M(P_1) = 1 \tag{24}$$

and with the relationships (4) and (5) the final markings of the positions $P_2$ and $P_3$ shall be deducted:

$$M(P_2) = M(P_{2a}) + M(P_{2b}) + M(P_{2c}) = 0 \tag{25}$$

$$M(P_3) = M(P_{3a}) + M(P_{3b}) = 2 \tag{26}$$

Thus, for the initial network in Fig. 3, the final marking also achieved with the equation (18) is obtained:

$$M = \begin{bmatrix} 1 \\ 0 \\ 2 \end{bmatrix} \tag{27}$$

Unlike the marking given by (27), the marking given by (23) provides information on the timings of marks located in the network positions, after the execution of sequence $s = T_2\,T_1\,T_1$. For example, the timings of the two marks located in position $P_3$ are equal to $2\Delta$ because from equation (23) they are in position $P_{3a}$, therefore are marks timed by $2\Delta$.

## 6. CONCLUSIONS

Reducerea unei rețele Petri permite determinarea unor proprietăți ale rețelei.

By the equivalence of a P-timed Petri net with a T-synchronized Petri net, the analysis of the equivalent network, using methods based on incidence matrix and the fundamental equation, provides information on the timings of marks located in the network positions, after the execution of a sequence.

## 7. REFERENCES


[1] David R., Alla H.-*Du Grafcet aux reseaux Petri,* Edition Hermes, Paris, 1989;

[2] David R., Alla H.-*Discrete, Continuous and Hybrid Petri Nets,* Springer Edition, 2005.

# APPLICATION CONSIDERATIONS — CVT ELECTRICAL CHARACTERISTICS DURING LINEAR AND NONLINEAR LOADING

[1]CIUCUR VIOLETA-VALI, [2]KULIMANOVA MARZHANGUL

*[1]Constanta Maritime University, Romania [2]Caspian State University of Technologies and Engineering named after Shahmardan Esenovici Esenov, Kazakhstan*

**ABSTRACT**

The objective of this application was to characterize the CVT as a load while the CVT supplied a simple linear load and while it supplied a complex nonlinear load [11]. In the following tests, the CVT was connected first to a simple linear load and then to a complex nonlinear load. An electric-service supply source with an average total harmonic distortion in the voltage of 3% supplied power to the CVT during all tests.

**Keywords:** *low loading, load-current distortion, electric-service supply.*

## 1. INTRODUCTION - PERFORMANCE: LINE CURRENT DISTORTION

A resistive linear load consisting of incandescent lamps was connected to the output of the CVT. The load was increased in ten equal increments from 0 to 8.3 A (output current rating of the CVT). Next, a bridge rectifier (such as the type that might be used in electric-vehicle battery chargers) was connected to the CVT. The rectifier and its resistive load (incandescent lamps) were the complex nonlinear load of the CVT. By adding lamps, this complex load was increased in ten equal increments from approximately 0.4 A (rectifier with no lamps connected) to 8.3 A. Figure 1 and Figure 2 show the line-current distortion during these tests compared with the line-current distortion for the same loads connected directly to the electric-service supply. At no load, the power consumption of the CVT was approximately 120 W (core losses only). With the full linear load, total losses increased to approximately 134 W (core losses plus load losses); with the full nonlinear load, total losses dropped to approximately 110 W.

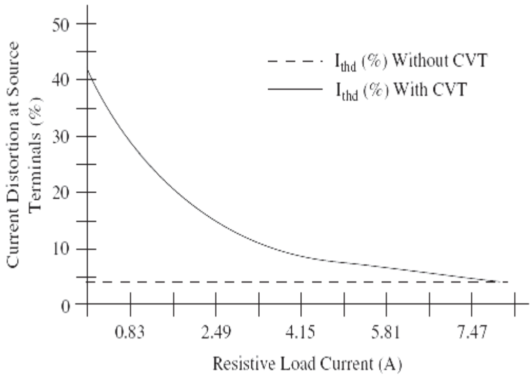



Figure 1 Line-current distortions for a linear load.

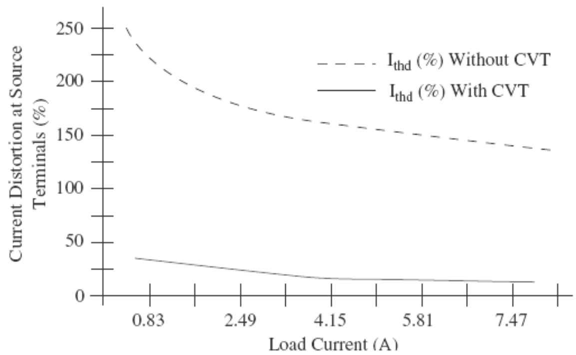



Figure 2 Line-current distortions for a nonlinear load.

Notice in Figure 1 and Figure 2 that, while the y-axis current-distortion magnitudes are significantly different, the absolute current-distortion values of the CVT's input current with either linear or nonlinear load is nearly identical. Current distortion at the CVT's input terminals was practically independent of the type of load connected to the output (approximately 40% at no loading to approximately 5% at full loading). When a linear, low-distortion load was connected to the CVT output, the CVT contributed to the current distortion at its input terminals from the electric-service power source, particularly during low loading. When a nonlinear, high-distortion load was connected, the CVT substantially reduced load-current distortion. When fully loaded, the CVT had relatively small power consumption and an efficiency of 85% to 90%. As opposed to most voltage regulators, the losses of the CVT decreased as the nonlinear load increased. The CVT also significantly affected the power factor of the load.

## 2. PERFORMANCE: POWER FACTOR

For both linear and nonlinear loads, the size of the load affected the input power factor of the CVT. While the CVT was loaded at less than 40% of its output power rating (approximately 3.3 A), the power factor ranged from 0.65 to 0.95. While the CVT was loaded at greater than 40%, the power factor was greater than 0.95 for the linear load and greater than 0.90 for the nonlinear load.

For the linear load, the power factor crossed from lagging to leading at approximately 60% load (approximately 5 A). Figure 3and
Figure 4 show the power factors for the linear and nonlinear load (without and with the CVT), respectively.

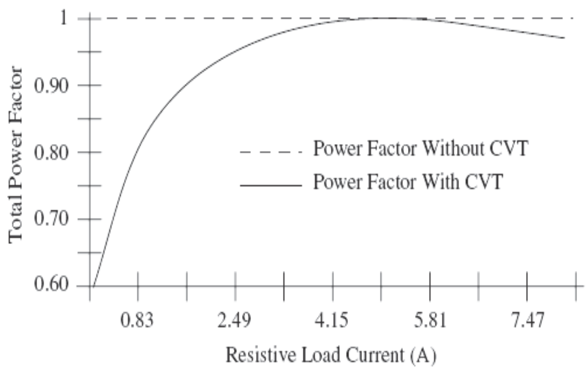



Figure 3 Power factor for a linear load.

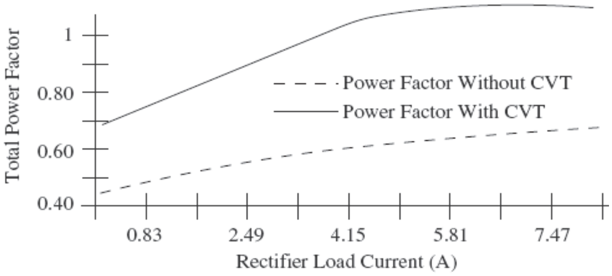



Figure 4 Power factor for a nonlinear load.

The CVT significantly affected the power factor of the load. At low loading, the nonlinear load without the CVT had a power factor as low as 0.44. With the CVT, the total power factor of the nonlinear load ranged from 0.61 to near unity. However, when loaded at less than 50%, the CVT significantly reduced the power factor for the linear, resistive load, which normally has a unity power factor.

Note that in most CVT applications, the aggregate facility loading is significantly small, so it would not be prudent to attempt any power-factor correction at individual CVT operating loads. Power-factor correction initiatives should be accomplished at the electric service meter of the facility.

## 3. APPLICATION CONSIDERATIONS-USING THREE-PHASE INPUT

One of the drawbacks of using a CVT is its inability to protect equipment from voltage interruptions. A traditional CVT can protect equipment down to approximately 40% of nominal voltage. A company in the midwestern U.S. has introduced a prototype CVT that protects equipment from deep voltage sags and brief power interruptions.

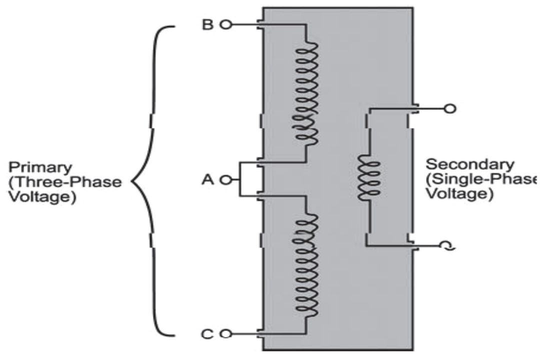



Figure 5 Schematic of a ride-through transformer.

As shown in Figure 5, the ride-through transformer (RTT) is designed to protect single-phase process controls. Unlike traditional CVTs, the RTT uses all three phases of supply voltage as its input. This enables the RTT to access energy in unsagged phases of the supply voltage during one- or two-phase voltage sags and interruptions.

EPRI PEAC tested the prototype, 1-kV, 480-V RTT [12] to determine its ability to protect process controls during single-phase, two-phase, and three-phase voltage sags and interruptions. The particular prototype acquired for testing was connected to a load bank that consisted of a mixture of 12 industrial control components: ice-cube relays, motor starters, contactors, a programmable logic controller, a linear dc power supply, and a switch-mode power supply.

Figure 6a and Figure 6b show the response of an RTT to phase-to-neutral and phase-to-phase sags.

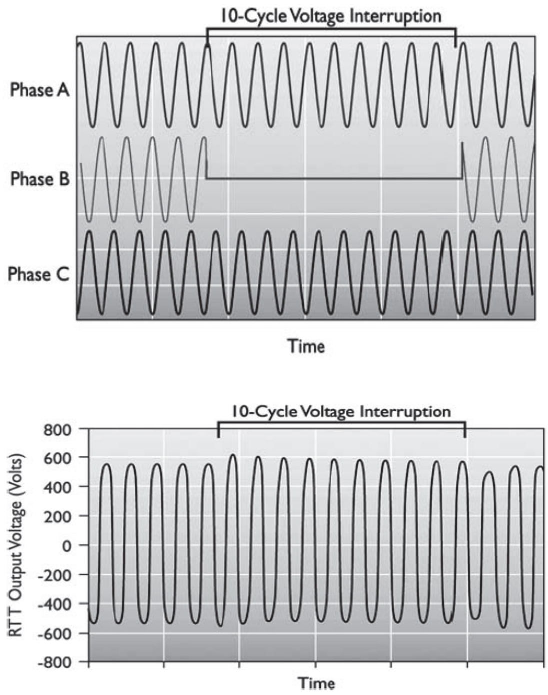



Figure 6 Performance of a ride-through transformer (RTT) during a ten-cycle voltage interruption and voltage sag. Voltage regulation of an RTT during a single-phase voltage interruption (top: input; bottom: output).

To get the most out of a CVT with a three-phase input, the most trouble-free voltage phases of the electric-service supply will have to be determined. For example, if most voltage sags occur on phase A or B, then the centres tap on the transformer primary should be connected to phase C. Although this prototype transformer promises to retail at a price substantially higher than the price of a traditional, single-phase CVT, the price differential can be greatly reduced by a reduction in size. Because the performance of a traditional CVT greatly depends upon loading, CVTs are often oversized for the connected load. A smaller but more loaded RTT should be able to perform as well as the dated, traditional CVT.

## 4. CONCLUSIONS

The test results revealed that the prototype RTT protected the connected process controls from most of the applied voltage sags and interruptions. Besides, it was observed that RTT performance greatly depended on the phase configuration (that is, single-, two-, or three-phase) of the voltage sags or interruption and, to a much lesser extent, on the loading of the RTT output. It was observed that the RTT performed like a typical CVT during three-phase voltage sags

## 5. REFERENCES

[1]. *Sola/Hevi-Duty Corp., About Sola/Hevi-Duty, www.sola-hevi-duty.com/about/solahist.html, October 18, 2002.*

[2]. *Advance Galatrek, CVT Background Data, http://www.aelgroup.co.uk/hb/hb003.htm, October 18, 2002.*

[3]. *EPRI, System Compatibility Projects to Characterize Electronic Equipment Performance under Varying Electric Service Supply Conditions, EPRI PEAC, Knoxville, TN, May 1993.*

[4]. *Godfrey, S., Ferroresonance, http://www.physics.carleton.ca/courses/75.364/mp1html/node7.html,October 18, 2002.*

[5]. *Cadicorp, Ferro-Resonance, Technical Bulletin 004a, www.cadicorp.com, October 18, 2002.*

[6]. *Groupe Schneider, Ferroresonance, No. 190, www.schneiderelectric.com, October 19, 2002.*

[7]. *IEEE, Standard for Ferroresonant Voltage Regulators, IEEE Std. 449-1998, Institute of Electrical and Electronics Engineers, Piscataway, NJ, 1998.*

[8]. *EPRI, Sizing Constant-Voltage Transformers to Maximize Voltage Regulation for Process Control Devices, PQTN Application No. 10, EPRI PEAC, Knoxville, TN, October 1997.*

[9]. *EPRI, Ferro-Resonant Transformer Output Performance under Varying Supply Conditions, PQTN Brief No. 13, EPRI PEAC, Knoxville, TN, May 1993.*

[10].*EPRI, Ferro-Resonant Transformer Output Performance under Dynamic Supply Conditions, PQTN Brief No. 14, EPRI PEAC, Knoxville, TN, January 1994.*

[11].*EPRI, Ferro-Resonant Transformer Input Electrical Characteristics during Linear and Nonlinear Loading, PQTN Brief No. 16, EPRI PEAC, Knoxville, TN, February 1994.*

*EPRI, Testing a Prototype Ferro-Resonant Transformer, EPRI PEAC, Knoxville, TN, unpublished.*

# HARMONIC FREQUENCIES MANAGEMENT

[1]DORDEA STEFAN, [2]ZBURLEA ELENA

[1,2]*Constanta Maritime University, Romania*

**ABSTRACT**

Harmonic effects must be considered, and managed, in order to avoid deterioration and malfunction of equipment, and to meet the rules and regulations' requirement for harmonic distortion levels. There are certain engineering aspects that may be used to obtain these objectives, discussed in the following.

**Keywords:** *harmonic effects, Frequency Converter*

## 1. INTRODUCTION

In a vessel with diesel electric propulsion, the frequency converters may constitute up to 80-90% of the actual load of the generators. Harmonic effects must be considered, and managed, in order to avoid deterioration and malfunction of equipment, and to meet the rules and regulations' requirement for harmonic distortion levels.

There are certain engineering aspects that may be used to obtain these objectives, discussed in the following.

## 2. GENERATOR IMPEDANCE

The harmonic currents injected to the power distribution system will mainly follow the lowest impedance routes, which normally are the generators.

For the frequencies of interest in the harmonic analysis, the generator sub-transient impedance is used. The d- and q-axis sub-transient inductance (Fig.1) are normally different, especially in a generator with salient poles (Fig.2), and the average of these, $X_d$'' and $X_q$'' are normally used, alternatively the negative sequence impedance, *X*-.

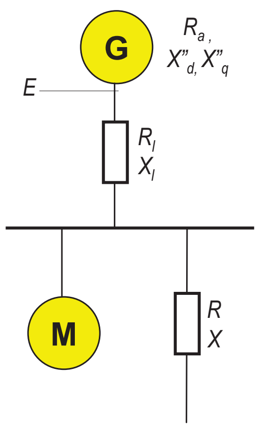



Fig.1 The d- and q-axis sub-transient inductances ($X_d$'', $X_q$'')

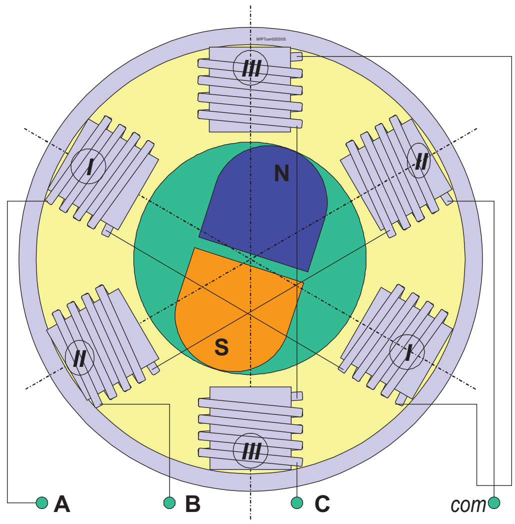



Fig.2 Synchronous generator with salient poles

A generator with low sub-transient inductance is normally larger than one with larger sub-transients. Normally, the value is about 20%, while it is relatively achievable to reduce this to 15% or even lower.

Another effect of lowering the sub-transient inductance is that the short circuit current level increases. One must therefore always make a trade-off with what is desired from harmonic distortion point of view, the equipment rating for short circuit currents, and the associated overall costs.

## 3. CONVERTER TOPOLOGY

The different converter topologies give different harmonic distortion. Normally the power rating and application determine the selection, but when possible, a converter with lower harmonic distortion should be selected to manage the overall distortion levels.

Increasing the rectifier's pulse numbers (fig.3 – 5) also give a lowering of the harmonic distortion, but must be trade-off by the associated costs of transformers and converter.

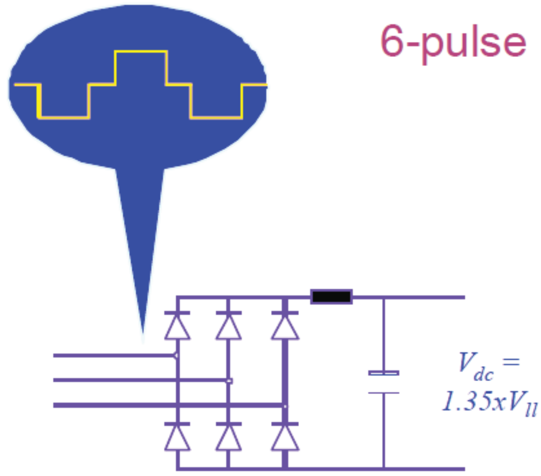



Fig.3 6-pulses diode rectifier

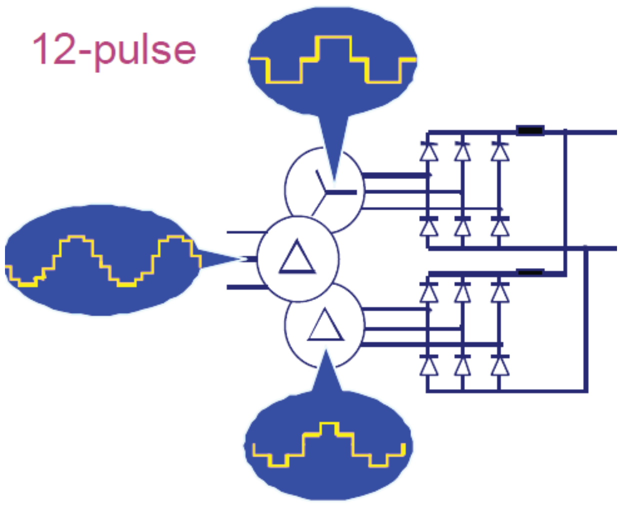



Fig.4 12-pulses diode rectifier
Parallel configuration

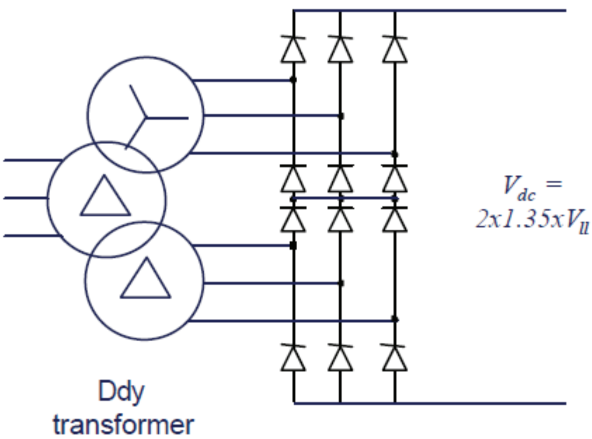



Fig.5 12-pulses diode rectifier
Series configuration

Normally, a VSI type inverter (fig.6) gives the lowest distortion in electric propulsion applications.

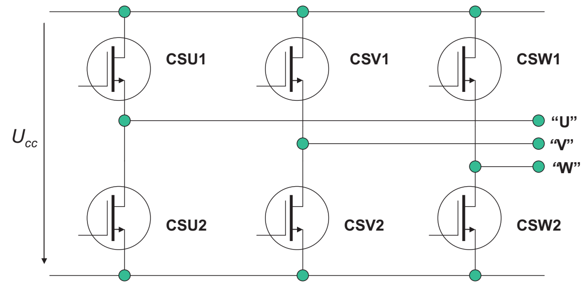



Fig.6 Power stage of a PWM inverter

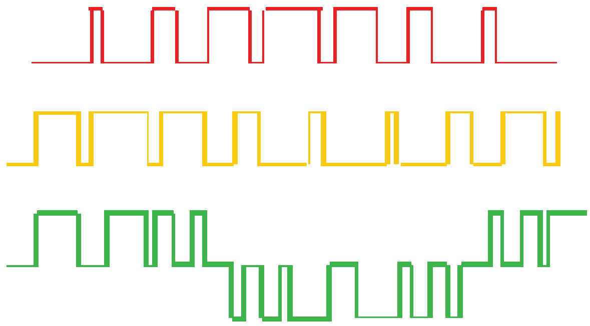


Fig.7 Generation of switching pulses to the PWM inverter

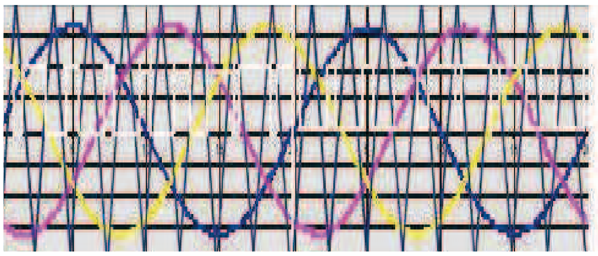


Fig.8 Wave forms of a PWM inverter

There are also converters with an active front end, constituted by switching elements instead of diodes. These kinds of converters give a much more sinusoidal current shape towards the network, similar as to the motor. However, the costs of these products are much higher than with diode rectifiers.

The cycloconverter (Cyclo) is a direct converter without a DC link (Fig.9). The motor AC voltage is constructed by selecting phase segments of the supply voltage by controlling the anti-parallel thyristor bridge. A 12-pulse configuration with reduced line harmonic is drawn, but the cyclo can also be supplied in a 6-pulse configuration. In 6- pulse configuration, the feeding transformers can be substituted with reactors when the supply voltage matches the inverter voltage.

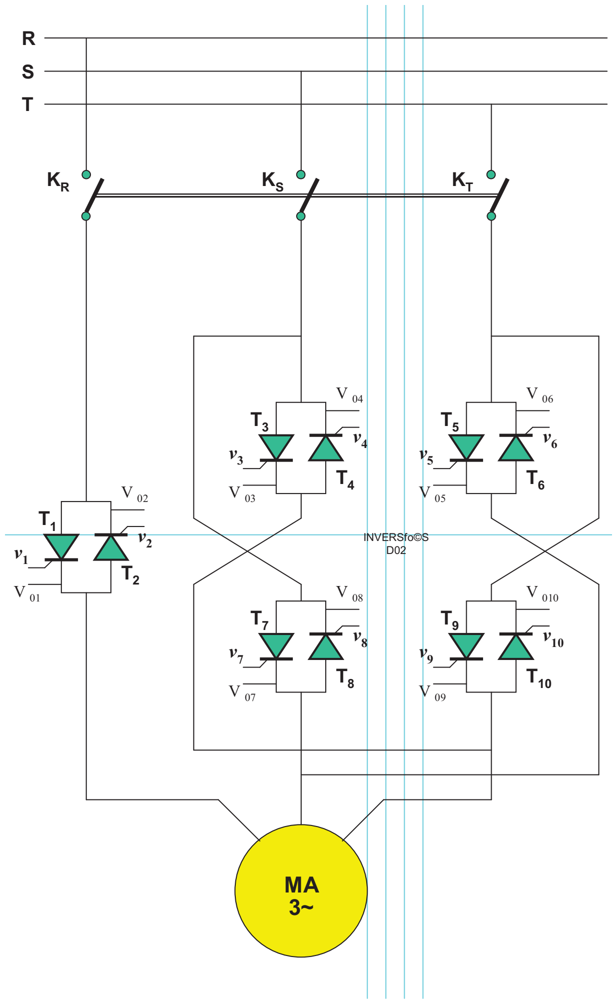



Fig.9 Cycloconverter drive

The motor voltage is controllable up to about one third of the supply frequency (about 20 Hz); thus it is most applicable in direct shaft drives without gear. It has been used for main propulsion systems, including podded propulsion.

The motor voltage contains a lower level of harmonics than the CSI, and the motor power factor may be kept high (unity in synchronous motor drives).

The supply power factor is motor voltage-dependent and is about 0.76 in the field weakening range. The content of line harmonic s is speed-dependent and must be carefully regarded in system design when the motor drive is large compared with the installed power.

The operation boundaries are similar to those found in the CSI type of synchronous motor drives, except that the low speed limitations are not present, since the commutation takes place towards the network voltages and not the motor voltages.

The cyclo converter has hence been preferred in applications where low speed operation and performance is essential, especially in ice breaking or ice going systems, but also in DP and passenger vessel applications where low speed / maneuvering performance is essential.

The Cyclo is available in a power range of 2-22MW per drive motor.

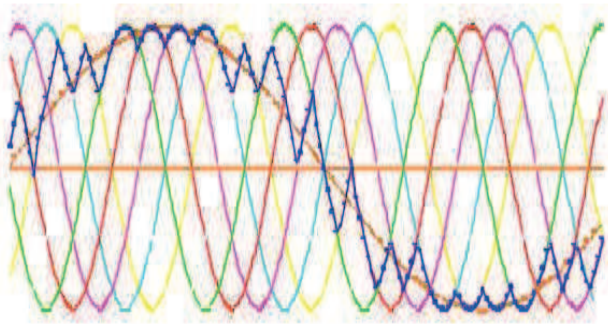


Fig.10 Input and fundamental output waveforms of a Cycloconverter drive

## 4. DESIGN OF SUPPLY TRANSFORMER

When a transformer feeds the converter, the transformer's short circuit impedance should be selected high to smoothen the load current and reduce the harmonic content. It must not be selected so high that the voltage drop over the transformer at full load reduces the power capability of the converter below the specified rating.

Normally, the short circuit impedance will be selected between 5 and 8%. A typical distribution transformer will rarely exceed 4%.

Also, the transformer should be equipped with a conductive sheet between the primary and secondary windings (Fig.11), grounded with an efficient high-frequency ground strap. This will not influence the lower harmonic transfer from secondary to primary windings, since these are magnetically coupled. For the very high frequencies, typically above MHz range, the coupling is more capacitive, and the grounded sheet will act as a screen for capacitive currents, leading them to ground instead of to the primary. Such screens are normally required to fulfill EMC (Electro-Magnetic Compatibility) regulations, and will also aid as a protection against flashover from a high voltage primary to the low voltage secondary if the insulation should fail.

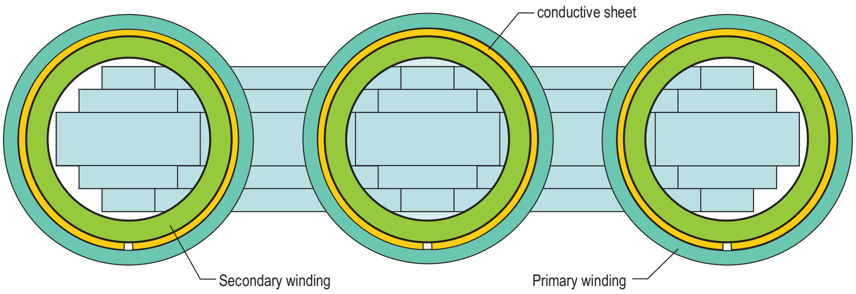



Fig.1 13-phased driving transformer of a Cycloconverter

## 6. REFERENCES


[1] **Dordea, Şt**., **Zburlea**, **E**., *Harmonic Distortion of 6 and 12 pulses Converters*, Constanta Maritime University Annals, Year XIII, 18th issue, Constanta, 2012, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSIS)

[2] **Dordea, Şt**., **Zburlea**, **E**., *Calculating harmonic distortion*, Constanta Maritime University Annals, Year XIII, 18th issue, Constanta, 2012, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSIS)

[3] **Dordea, Şt**., **Zburlea**, **E**., *Active steering by 4 electric thrusters*, Constanta Maritime University Annals, Year XII, 15th issue, Constanta, 2011, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[4] **Dordea, Şt**., **Zburlea**, **E**., *Electric propulsion with turbo generators*, Constanta Maritime University Annals, Year XII, 15th issue, Constanta, 2011, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[5] **Dordea, Şt**., **Zburlea**, **E**., *Active steering – Electric thrusters*, Constanta Maritime University Annals, Year XI, 14th issue, Constanta, 2010, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[6] **Dordea, Şt**., **Zburlea**, **E**., *Electric drives for azimuth propulsors*, Constanta Maritime University Annals, Year XI, 14th issue, Constanta, 2010, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[7] **Dordea, Şt**., **Zburlea**, **E**., *Proportional steering system*, Constanta Maritime University Annals, Year XI, 13th issue, Constanta, 2010, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[8] **Dordea, Şt**., **Zburlea**, **E**., *Anti-hunt control system*, Constanta Maritime University Annals, Year XI, 13th issue, Constanta, 2010, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[9] **Dordea, Şt.,** *Acționări electrice cu undă sintetică*, autor unic, Ed. Muntenia, ISBN (10) 973-692-153-0, ISBN (13) 978-973-692-153-7, 155 pag, Constanta, 2006.

[10] **Dordea, Şt.,** *Repartiția secvențială a sarcinii în acționarea electronică a motoarelor asincrone trifazate*, A IX-a Sesiune de comunicări științifice cu participare internațională „Ştiința și învățământul, fundamente ale secolului al XXI-lea", Ştiințe tehnice, vol.I, ISBN 973 – 7809 – 04 – 1, ISBN 973 – 7809 – 03 – 3, Academia Forțelor Terestre „Nicolae Bălcescu", pp. 49 – 53, 5 pg, Sibiu, 2004.

[11] **Dordea, Şt**., *Transferul de energie în sistemele electrohidraulice de guvernare navale*, Teză de doctorat, Universitatea „Dunărea de Jos" din Galați, 2002

[12] **Dordea, Şt.**, *Sisteme de guvernare cu acțiune continuă și comandă digitală* - Referat doctorat, Universitatea "Dunărea de Jos", Galați, 1998

[13] **Dordea, Şt.**, *Contribuții la transferul de energie în sistemele electrohidraulice de Guvernare Navale* – Referat doctorat, Universitatea "Dunărea de Jos", Galați, 1998

[14] **Dordea, Şt.**, *Stadiul actual în domeniul sistemelor de guvernare navale* – Referat doctorat, Universitatea "Dunărea de Jos", Galați, 1997

[15] **Dordea, Şt.,** *Steering Controls*, TCW Report, Anschutz, Kiel, 1989.

# LOWER HARMONIC DISTORTIONS BY USING TUNED FILTERS

[1]DORDEA STEFAN, [2]ZBURLEA ELENA

[1,2]*Constanta Maritime University, Romania*

**ABSTRACT**

Adding filters to the network will alter the load current waveforms of the converters, and the filter design will always be an iterative approach before finding the final design.

**Keywords:** *passive filter, Frequency Converter*

## 1. INTRODUCTION

Filters may be an efficient way to reduce harmonic distortion. The design may be difficult, especially if the network is complicated, in the meaning of many possible configuration alternatives.

## 2. PASSIVE FILTERS

A passive filter consists of inductances and capacitances, and sometimes also a resistance.

Fig. 1 shows the circuit diagram for a first order LC filter. The impedance in one of these branches for a certain frequency *f* is, where *w=2.p .f*:

$$Z_{filter}(\omega) = j\omega L + \frac{1}{j\omega C} = j\omega L\left(1 - \frac{1}{\omega^2 LC}\right)$$

As seen, the impedance has a series resonance, i.e. a zero impedance frequency, for

$$\omega = \sqrt{\frac{1}{LC}}$$

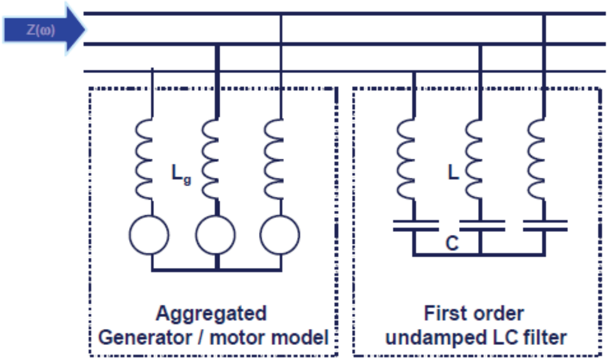



Fig.1 Circuit diagram of a passive filter in a network with a generator

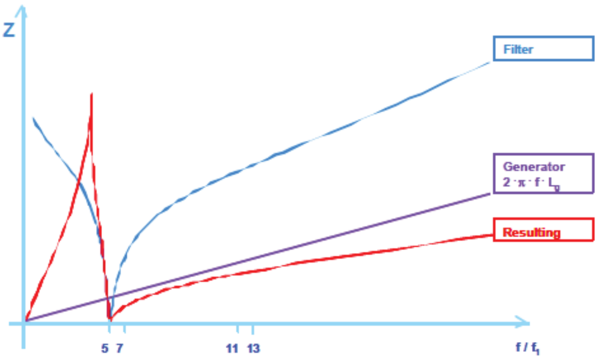



Fig. 2 Frequency response of a passive filter in a network with a generator

For currents with this frequency the impedance through the passive filter approaches zero, and the filter will ideally draw all currents of this frequency from the network without distortion. When tuned to the most significant harmonic frequency, the voltage distortion will thereby be reduced.

If there are several harmonics with significant value, it might be used several parallel connected filters, each tuned for one harmonic frequency.

Connecting the filter to the network, its impedance will come in parallel to the generator impedance. The resulting network impedance will then be a paralleling of the generator impedance and filter impedance:

$$Z\ (\omega) = Z_{gen}(\omega) \,\Big|\, \Big| Z_{filter}(\omega) = \frac{j\omega L_g \cdot j\omega L\left(1 - \frac{1}{\omega^2 LC}\right)}{j\omega L_g + j\omega L\left(1 - \frac{1}{\omega^2 LC}\right)}$$

In addition to the series resonance with a zero impedance at

$$\omega = \sqrt{\frac{1}{LC}}$$

this also have a parallel resonance with at

$$\omega = \sqrt{\frac{1}{\left(\frac{L_g}{L} + 1\right)LC}}$$

meaning that the impedance of harmonics with this frequency approaches infinite high values. If this network is injected by harmonic currents of this particular frequency, the result can be excessive harmonic distortion and deterioration of equipment. Parallel resonance will always occur when passive filters are applied, the objective is to ensure that not any harmonic current will excite it.

In practice, both the series and the parallel resonance approach finite values due to damping effects from resistive components in the network impedance. Fig. 2 shows a typical impedance curve for a network with generators and a passive filter tuned to the 5th harmonic. As seen, the zero impedance coincides with the 5th harmonic, but also have some reducing effects on the 7th and higher harmonics due to its paralleling of the inductance with the generator.

Also, it is seen that a series resonance occurs at about 3rd harmonic. This may cause problems if one expects that the network is subject to third harmonic currents, e.g from transformer inrush. This resonance frequency can be shifted by adding a 3rd harmonic filter to the network in parallel to the 5th harmonic network as shown in Fig. 3, with resulting frequency as shown in Fig. 4.

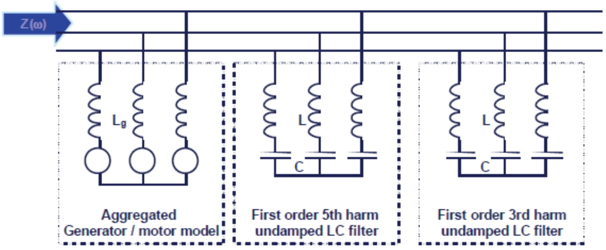



Fig.3 Circuit diagram of a passive filter in a network with a generator

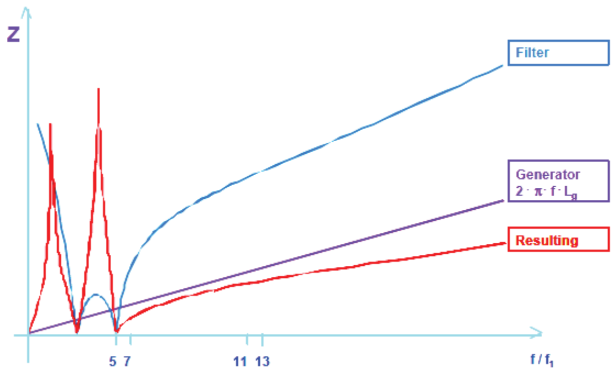



Fig.4 Frequency response of a passive filter in a network with a generato r

Passive filters may be an efficient way to reduce harmonic distortion. The design may be difficult, especially if the network is complicated, in the meaning of many possible configuration alternatives. Paralleling of filter units, min and max generator configurations, max capacitive loadings of the generators, etc. are important aspects in the design. Also, adding filters to the network will alter the load current waveforms of the converters, and the filter design will always be an iterative approach before finding the final design.

## 3. ACTIVE FILTERS

An active filter is a power electronic unit connected to the power distribution (Fig. 5) with switching components, such as MOS-FETs, similar to the inverter stage of a motor drive (Fig. 6).

By use of the switching elements, one can define a shape of the currents which shall flow from the active filter towards the network. If measuring the load current of a nonlinear load, e.g. a motor drive, the active filter can then be used to compensate for the harmonics of the non-linear load, such that the resulting current of the nonlinear load and the active filter becomes sinusoidal. Due to the switching of the power semiconductors, a high frequency filter is necessary to remove high frequent noise.

Active filtering is an efficient way of removing harmonic distortion. However, the rating of the filter is relatively high compared to the non-linear load it is supposed to filter, and the cost tends to be higher than many other alternatives.

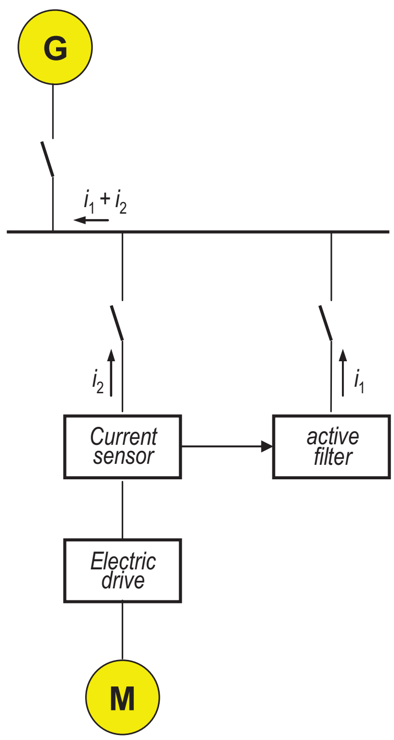



Fig.5 Active filter connected to the power distribution

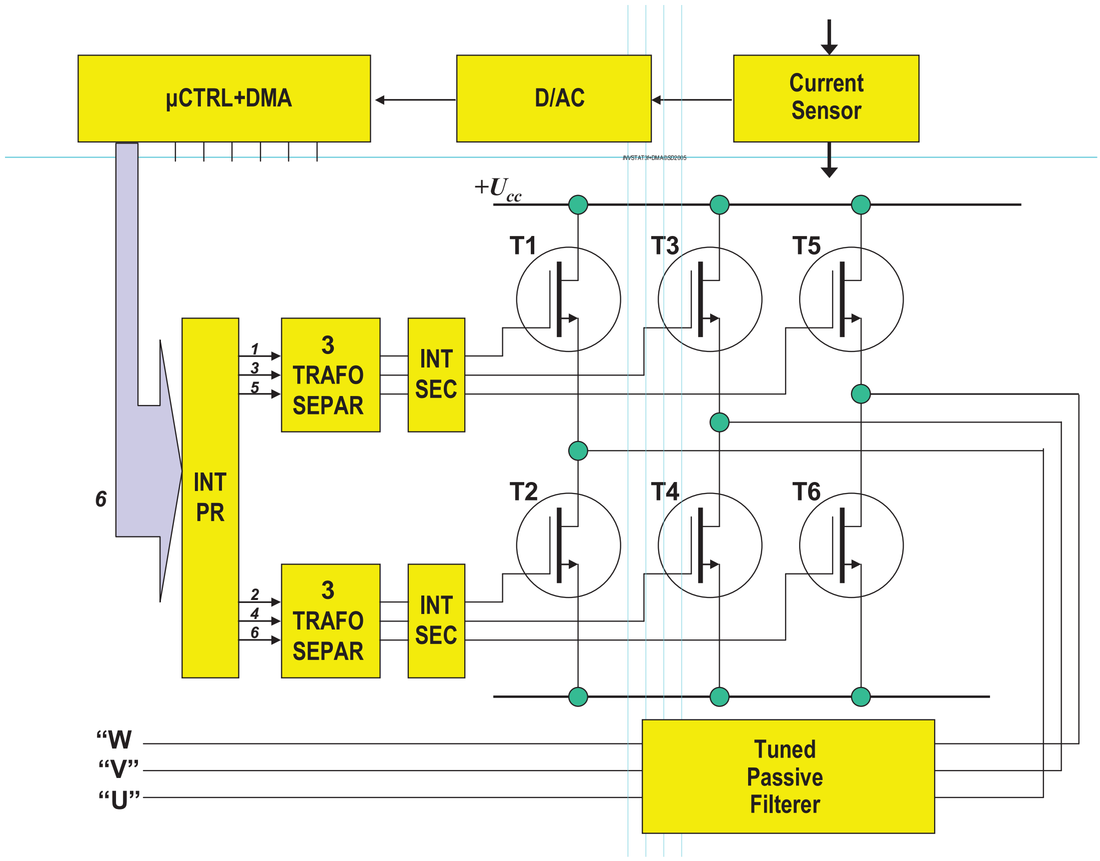



Fig.6 Active filter is a power electronic unit connected to the power distribution with switching components, such as MOS-FETs, similar to the inverter stage of a motor drive

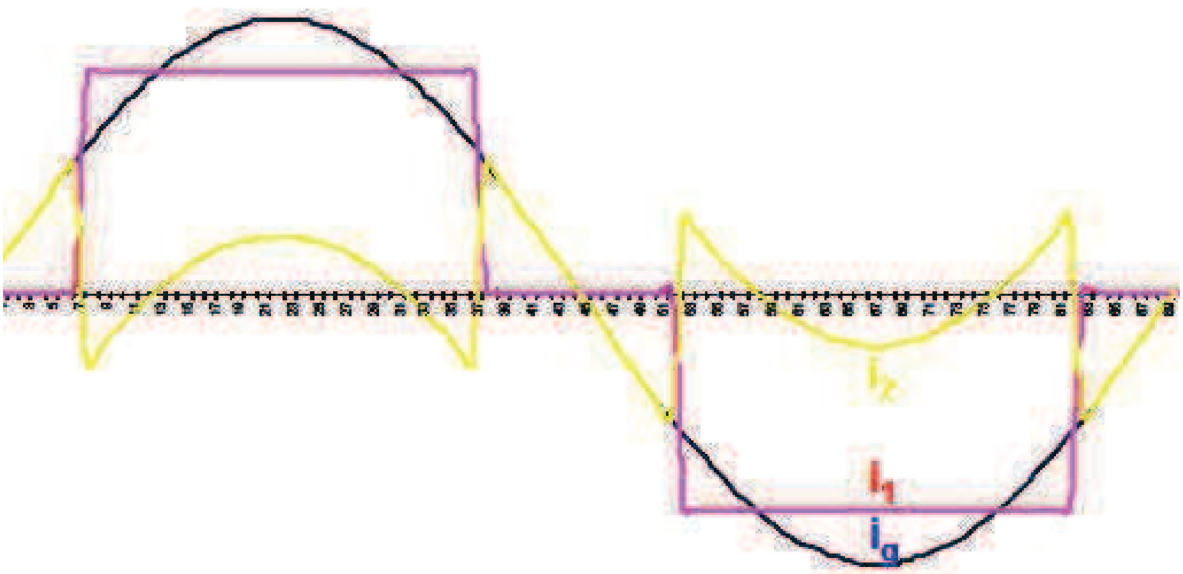



Fig.7 The active filter can be used to compensate the harmonics of a motor drive currents and so it becomes sinusoidal

## 6. REFERENCES


[1] **Dordea, Şt**., **Zburlea**, **E**., *Harmonic Distortion of 6 and 12 pulses Converters*, Constanta Maritime University Annals, Year XIII, 18th issue, Constanta, 2012, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSIS)

[2] **Dordea, Şt**., **Zburlea**, **E**., *Calculating harmonic distortion*, Constanta Maritime University Annals, Year XIII, 18th issue, Constanta, 2012, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSIS)

[3] **Dordea, Şt**., **Zburlea**, **E**., *Active steering by 4 electric thrusters*, Constanta Maritime University Annals, Year XII, 15th issue, Constanta, 2011, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[4] **Dordea, Şt**., **Zburlea**, **E**., *Electric propulsion with turbo generators*, Constanta Maritime University Annals, Year XII, 15th issue, Constanta, 2011, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[5] **Dordea, Şt**., **Zburlea**, **E**., *Active steering – Electric thrusters*, Constanta Maritime University Annals, Year XI, 14th issue, Constanta, 2010, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[6] **Dordea, Şt**., **Zburlea**, **E**., *Electric drives for azimuth propulsors*, Constanta Maritime University Annals, Year XI, 14th issue, Constanta, 2010, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[7] **Dordea, Şt**., **Zburlea**, **E**., *Proportional steering system*, Constanta Maritime University Annals, Year XI, 13th issue, Constanta, 2010, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[8] **Dordea, Şt**., **Zburlea**, **E**., *Anti-hunt control system*, Constanta Maritime University Annals, Year XI, 13th issue, Constanta, 2010, Editura Nautica, ISSN 1582 - 3601 (cotat *B*+ în sistemul CNCSS)

[9] **Dordea, Şt.,** *Acţionări electrice cu undă sintetică*, autor unic, Ed. Muntenia, ISBN (10) 973-692-153-0, ISBN (13) 978-973-692-153-7, 155 pag, Constanta, 2006.

[10] **Dordea, Şt.,** *Repartiţia secvenţială a sarcinii în acţionarea electronică a motoarelor asincrone trifazate*, A IX-a Sesiune de comunicări ştiinţifice cu participare internaţională „Ştiinţa şi învăţământul, fundamente ale secolului al XXI-lea", Ştiinţe tehnice, vol.I, ISBN 973 – 7809 – 04 – 1, ISBN 973 – 7809 – 03 – 3, Academia Forţelor Terestre „Nicolae Bălcescu", pp. 49 – 53, 5 pg, Sibiu, 2004.

[11] **Dordea, Şt**., *Transferul de energie în sistemele electrohidraulice de guvernare navale*, Teză de doctorat, Universitatea „Dunărea de Jos" din Galaţi, 2002

[12] **Dordea, Şt.**, *Sisteme de guvernare cu acţiune continuă şi comandă digitală* - Referat doctorat, Universitatea "Dunărea de Jos", Galaţi, 1998

[13] **Dordea, Şt.**, *Contribuţii la transferul de energie în sistemele electrohidraulice de Guvernare Navale* – Referat doctorat, Universitatea "Dunărea de Jos", Galaţi, 1998

[14] **Dordea, Şt.**, *Stadiul actual în domeniul sistemelor de guvernare navale* – Referat doctorat, Universitatea "Dunărea de Jos", Galaţi, 1997

[15] **Dordea, Şt.,** *Steering Controls*, TCW Report, Anschutz, Kiel, 1989.

# ANTENNA ANALYSER

[1]GRIGORESCU LUIZA, [2]DIACONESCU IOANA

*[1,2]Engineering Faculty of Braila, [1,2]"Dunarea de Jos" University of Galati, Romania*

**ABSTRACT**

The paper's aim is to allow a complete analysis of an antenna. In the same time we propose the calculus an also the way which allow to precisely determinate an antenna's impedance active and reactive components and in the same time the resonance frequency.

**Keywords:** *Antenna, frequencies, calibration.*

## 1. INTRODUCTION

The device presented below, in Figure 1, details a construction offered by F6BQU [1] and improved from the original construction as follows:

a. The value of the antenna's impedance with its two components, active and reactive (the latter may be inductive or capacitive);
b. The resonance frequency of the antenna;

Advantages: the cost is insignificant.
Disadvantages: It only performs direct measurements for the active component of impedance (resistance), the reactants have to be worked out from (very simple) calculations for which we are going to provide the formulae.

We tested the original version, which only measures the active component of reactance and shows that the antenna could have inductive or capacitative reactances, without providing their values or any data to enable calculation (there is a calibration only for the scale of rheostat P, there is none for the variable capacitor $C_v$), and we brought several improvements which make it more practical while keeping it equally simple. These result from the development of the calculation model above, from which other constructive versions may be derived.

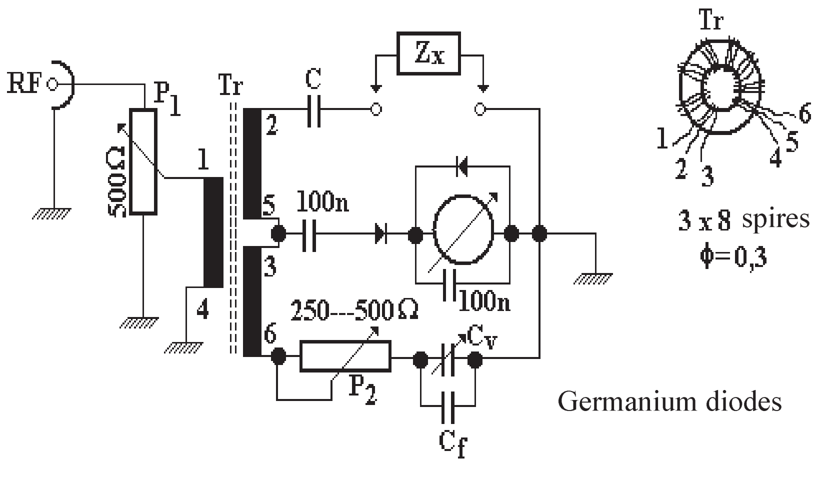



Figure 1 Antenna analyzer

## 2. CALCULATION MODEL

Figure 2 shows the circuit that underlies the calculation model. The two secondary inductances of the $T_r$ transformer appear in the circuit as E radiofrequency voltage forces with internal inductive reactance represented by the L inductance. We overlook the ohmic resistance of the conductor from the inductances and the L inductance includes both its own inductance and the mutual inductances which come up due to the very tight coupling of any inductance with the other two. Through construction these inductances are equal and, since they eventually disappear from the calculations, they do not have to be detailed. By building a compact device, with very short conductors, we can also overlook the reactance of the connecting conductors.

The measurements are done using the principle of balancing the AC bridge, respectively, minimizing or canceling current in its diagonal, namely the current marked in the scheme with $I_0$. Beside $I_0$ there also appear as unknown the $I_1$, $I_2$ currents, so to find them we have to use all the relations that can result from the Kirckhhoff laws.

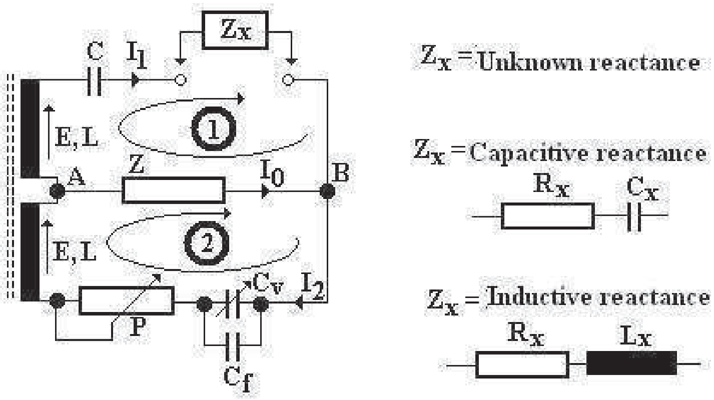



Figure 2 Calculation scheme

In general the unknown reactance may have a capacitive character or an inductive character, the purely resistive character appears with a highly reduced probability. For the purpose of simplifying writing we will mark the equivalent value of the group $C_f + C_v$ with $C_v$, since this group has variable capacity. For the case in which the unknown reactance has a capacitive character the calculation relations according to Kirckhhoff's laws are:

$$\begin{cases} \left(j\omega L + \dfrac{1}{j\omega C} + R_x + \dfrac{1}{j\omega C_x}\right) I_1 - I_0 Z = E \\ \left(\dfrac{1}{j\omega C_v} + P + j\omega L\right) I_2 + I_0 Z = E \\ I_2 = I_1 + I_0 \end{cases} \tag{1}$$

If the unknown reactance has an inductive character, the calculation relations become:

$$\begin{cases} \left(j\omega L + \dfrac{1}{j\omega C} + R_x + j\omega L_x\right) I_1 - I_0 Z = E \\ \left(\dfrac{1}{j\omega C_v} + P + j\omega L\right) I_2 + I_0 Z = E \\ I_2 = I_1 + I_0 \end{cases} \tag{2}$$

Where $\omega = 2\pi f$, f=frequency

As follows we get:

$$\begin{cases} I_2 = \dfrac{E - I_0 Z}{\dfrac{1}{j\omega C_v} + P + j\omega L} \\ I_1 = I_2 - I_0 = \dfrac{E}{\dfrac{1}{j\omega C_v} + P + j\omega L} - \left(\dfrac{Z}{\dfrac{1}{j\omega C_v} + P + j\omega L} + 1\right) I_0 \end{cases} \tag{3}$$

The first equation from (1) becomes, after replacing $I_1$

$$\begin{aligned} &\left(j\omega L + \frac{1}{j\omega C} + R_x + \frac{1}{j\omega C_x}\right) \frac{E}{\dfrac{1}{j\omega C_v} + P + j\omega L} - \\ &-\left(j\omega L + \frac{1}{j\omega C} + R_x + \frac{1}{j\omega C_x}\right)\left(\frac{Z}{\dfrac{1}{j\omega C_v} + P + j\omega L} + 1\right) I_0 - I_0 Z = E \end{aligned} \tag{4}$$

In order to have $I_0 = 0$, from (4) we get:

$$E-\left(j\omega L+\frac{1}{j\omega C}+R_x+\frac{1}{j\omega C_x}\right)\frac{E}{\frac{1}{j\omega C_v}+P+j\omega L}=0 \tag{5}$$

Namely

$$\frac{1}{j\omega C_v}+P+\cancel{j\omega L}=\cancel{j\omega L}+\frac{1}{j\omega C}+R_x+\frac{1}{j\omega C_x}$$

Or the equilibrium conditions of the bridge:

$$\begin{cases} P=R_x \\ C_v=\dfrac{C_x C}{C_x+C} \end{cases} \tag{6}$$

If the capacitive reactance $\dfrac{1}{j\omega C_x}$ is replaced by the inductive reactance $j\omega L_x$ we get

$$\frac{1}{j\omega C_v}+P+\cancel{j\omega L}=\cancel{j\omega L}+\frac{1}{j\omega C}+R_x+j\omega L_x \tag{7}$$

and

$$\begin{cases} P=R_x \\ C_v=\dfrac{C}{1-\omega^2 C L_x} \end{cases} \tag{8}$$

Relations (6) and (8) show that if $C_x=\infty$ or $L_x=0$ then $C_v=C$, this position for $C_v$ being preferable at the middle of the distance. It is also easy to see from (6) that $C_v\le C$ if the capacitive reactances are measured and from (8) that $C_v\ge C$ if the inductive reactances are measured.
From (6) and (8) we can see that the value of the unknown capacity $C_x$

$$C_x=\frac{C_v C}{C-C_v} \tag{9}$$

Is independent of the frequency, while the value of the unknown inductance $L_x$

$$L_x=\frac{C_v-C}{\omega^2 C C_v} \tag{10}$$

Strongly depends on frequency.
It results from (9) and (10) that the most frequent practical values of $C_x$ capacity (big values, which lead to very small reactances) or inductance $L_x$ (small values which lead to small reactances) appear for values of the variable capacitor $C_v$ which are close to the values of *C,* namely $C_v$ has to have a parallel trimmer in order to increase precision or to use a fixed capacitor $C_f$ paralleled with a variable capacitor of small capacity, up to maximum 20---25 pF, so that

$$C_f+\frac{C_v}{2}=C \tag{11}$$

The effective values of the reactances that the antenna may have are determined through calculations with

$$\begin{cases} X_C=\dfrac{1}{2\pi fC_x}=10^9\dfrac{C-C_v}{2\pi fCC_v} \\ X_L=2\pi fL_x=10^9\dfrac{C_v-C}{2\pi fCC_v} \end{cases} \tag{12}$$

Where *f*=frequency in kHz, capacities in pF, $C_v$=the readable value on the scale of the variable capacitor, which represents the added values of the fixed capacitor $C_f$ and $C_v$, reactance resulted in Ω.
The expressions from (12) show once again that small values of reactances (tenths, hundreds of Ω, at most) require small differences between *C* and the value indicated by $C_v$ at equilibrium.

## 3. WORKING METHOD

The measurement is done using the balanced bridge principle.
The terminal of the $T_r$ transformer is supplied with voltage by the RF hub (the voltage is preferable to allowed to vary between 2-30 MHz). This voltage may be taken, as a cheap solution, directly from the transmitter, set at the mínimum power on CW, a solution which has the disadvantage of not being able to supply a continuous range of frequencies. Ideally, instead of signal from the transmitter it can supply the analyser with signal from its own oscillator, with a continuous domain of frequencies on a large range, equipped with a frequency-meter, to know the exact frequency at which the measurement is done (very important). From $P_1$ (liniary), the level at which the bridge is supplied is adjusted, in order to set the desired sensitivity.
The secondary inductances 2-5 and 3-6, together with the fixed capacitor C, the unknown $Z_x$ impedance, the $P_2$ (liniary) potentiometer and the $C_v$, $C_f$ group, form a bridge, to whose diagonal the measuring instrument is placed. The bridge can be balanced at the minimum value of the measuring instrument, either from $P_2$, or $C_v$, or, alternatively, from the frequency modification, since every time we get a different type of information.
The group that contains the variable and the fixed capacitors $C_v$ and $C_f$, is dimensioned according to the máximum values of the reactants (reactive components) of the impedances which are to be measured. For

presumed values of tenths, maximum hundreds of Ω we will choose $C_v$=max.50---60pF and $C_f$ so that it will (even approximately) comply with the (11) equality.

Adopting $C$=200pF and $C_{v\max}$=50pF we get $C_f$=175pF. It is possible that such a combination of values may be difficult to find for $C, C_v, C_f$, but other combinations may be chosen in the interval 180---220pF for $C$, so that the (11) equality above be complied with, with a maximum error of 5---6pF.

In order to get correct measurements, the scales $P_2$ and the variable capacitor $C_v$ have to be calibrated first.

## 4. CALIBRATING THE SCALES

The scale of the potentiometer $P_2$ can be calibrated with an ohm meter or using resistances of known values. For the latter case we can proceed as follows:

- The fixed capacitor $C$ and the group $C_v$, $C_f$ are shunteded;
- Resistances of known value are coupled instead of $Z_x$;
- The antenna analyser is supplied with radiofrequency of any value, say 3650KHz.
- $P_2$ is set so that the device indicates a minimum (the bridge is balanced);
- The values of the measured resistances are marked on the $P_2$ scale;
- The shunts on the capacitors are eliminated;

After these calibrations, with known values, we can perform verification with an ohm meter to see if the bridge has been constructed symmetrically or not. For short connections and a well made threefold transformer we get a good electrical symmetry. By rechecking the calibration on other frequencies we only see if the device is symmetrical from an electrical point of view, thus being able to operate the necessary changes if need arises. At different frequencies, errors of up to 5% are usual.

The scale of the variable capacitor is calibrated approximately the same:

- $P_2$ is fixed at a minimum (or is shunted);
- We eliminate the shunts on the capacitors;
- We shunt the coils which measure the $Z_x$ impedance;
- We supply the RF bridge, as above;

When the variable capacitor is set the minimum value shown by the device the bridge will be in balance as $C_v + C_f = C$. This position will be marked on the scale with a special control line (red, thicker, etc) next to which we will write the value that $C$ has. This marker will play a very important role in measurements and its corresponding position will bare the name of **middle position**. This position must be found at the middle of $C_v$'s position, or as close as possible. Relation (11) is based on this considerent and a deviation from the equality given by (11) will only place the **middle position** asimetrically. An asimetrical position is also obtained if $C_v$ does not have a capacitative variation which is proportional with the rotation angle (liniary characteristic), but this thing does not fatally affect measurements.

- We verify if the middle position calibration is maintained on other frequencies too, here we could get the most obvious constructive deviations from the electrical symmetry, but, if they cannot be cancelled, they should at least be reduced as much as possible so that the device can be used.
- We shunt the capacitor C;
- We eliminate the shunt from $Z_x$ 's terminals;
- Instead of $Z_x$ we place capacitors of known value in the interval $C_f \cdots C_f + C_v$ and we balance the bridge from the variable capacitor each time; we mark it on the respective scale of values;
- The shunts on the capacitors $C$ are eliminated;
- We eliminate the shunt on $P$ (if it was done).

It is worth remembering that the scale of the variable capacitor will be marked in values of the equivalent capacity $C_v + C_f$ and not just the ones belonging to $C_v$.

## 5. MEASURING THE UNKNOWN $Z_x$ IMPEDANCES

The unknown $Z_x$ impedance (antenna or another type of user) is made up of an active component $R_x$ and a rective one $X_x$. $Z_x$ is directly connected to the coils shown in the Figure. Supposing we do not know for which work band the antenna was built, or if we know, supposing we made a significant mistake in constructing it, here it what should be done:

- We supply the device with the frequency we suppose to be the working frequency of the antenna (e.g. 3650kHz);

The variable capacitor $C_v$ will be placed on the middle position described above.

- From $P_2$ we balance the bridge, adjusting the radiofrequency voltage level from $P_1$, therefore the sensitivity of the bridge. $P_2$ will indicate the active component of the antenna's impedance, according to

$$R_x = P_2 \tag{14}$$

- Maintaining $P_2$ on this position we will subsequently try to balance the bridge from the variable capacitor $C_v$, respectively, to find another mínimum which is even smaller, with the device. We may obtain it here (balanced bridge) in the value range of $C_v$, or we may not be able to obtain this minimum in the adjusting field of $C_v$.

**If the bridge is balanced between the value range of $C_v$ there are two situations**:

a) On the $C_v$ scale, at bridge balance, we will read smaller values tan the middle position. This means that the antenna presents capacitive reactance, namely, it is too short for the frequency at which the measurement is carried out. The value of this reactance is given by the first equation in (12).

Example. The bridge has *C*=200pF, we measure at a frequency of 3650 kHz and rea don the scale the value $C_v$=180pF. From (3) we get $X_C = 24{,}22\ \Omega$.

b) On the $C_v$ scale we read, at bridge balance, values which are bigger tan the **middle position**. This means that the antenna presents inductive reactance, namely, it is too long for the frequency at which the measurement is done. The value of this reactance is given by the second equation in (12).

**If the bridge is not balanced amongst the value range of $C_v$.**

In this case we should notice on which side of the $C_v$ variable capacitor scale the bridge tends to become balanced. If the indications of the measuring instrument drop when setting the variable capacitor towards large values of the capacity without going through a minimum, it means that the frequency at which the measurement is performed is too big and measurements should be carried out at smaller frequencies.

If balance is not reached and $C_v$ is at the end of the scale with values that are unde the middle position, it means that the frequency at which the measurement is done is too small and that the measurements should be performed at higher frequencies.

If the bridge is supplied with radiofrequency voltage from the transmitter, therefore on fairly reduced adjusting intervals, we cannot choose the exact value of the frequency at which the measurement must be done. Nevertheless, by noticing towards which values $C_v$ moves in order to achieve balance, we can conclude that the antenna has either inductive or capacitive behaviour, namely it is too long or too short. By adjusting its size it can be brought to normal dimensions.

In case the antenna can't be modified so as to adjust its reactances, the measured values of these reactances show the value that the compensation element's reactance must have (the antenna adapter). If the antenna presents an inductive reactance (it is too long) this should be compensated with a capacity of the same reactance, and vice-versa, in case it has a capacitive reactance.

## 6. MEASURING THE FREQUENCY RESONANCE OF THE ANTENNA

In order to do this it is compulsory to supply the bridge with radiofrequency voltage, continuously adjusted on a large interval of values which goes beyond the range of values offered by each of the transmitter's bands. If the antenna shows small construction errors, compared to its correct dimensions, the range of values offered by the transmitter may be enough for us to figure out in which of the band's areas the resonance is produced.

By setting a particular value for the measuring frequency (it does not matter which) and $C_v$ on the middle position, we balance the bridge from $P_2$. Then the frequency is continuously modified until the instrument indicates the lowest minimum, also adjusting from $P_1$ for sensitivity. The frequency for which the device goes through minimum is the frequency at which the measured reactance on the bridge is null, $C_v = C$ and the relations from (12), at which the antenna, thus, resonates.

Similarly, we may find the resonance frequency of any circuit which contains reactive components, by connecting it as directly as possible to the measuring terminals of the bridge.

## 7. EXPLANATIONS AND CONCLUSIONS

The variable capacitor $C_v$ may also have bigger values, of up to 500pF, in which case, the fixed capacitor $C_f$ is no longer necessary, ensuring thus a larger adjusting range. However, checking the (12) formulae, it can be seen that the reactance depends on the value difference between $C$ and $C_v$. If this difference were too big, for example for $C_v$=500pF and *C*=200pF we could have measured, at the scale's end and at a frequency of 3650 kHz, an inductive reactance of 130Ω, far over the radiation resistance of an antenna, we get, thus, a useless piece of information. If with a bridge of *C*=200pF and *f*=3650KHz we should have measured the inductive reactances closer to reality, for example 10Ω or 20Ω, the scale of the variable capacitor $C_v$ should have shown capacities of 209pF, respectively, 220pF. The landmarks of such values would have been much too close together amongst them, as well as to the middle position of 200pF on a scale with the maximum value of 500pF, which would have affected the reading accuracy, respectively, the measuring accuracy, exactly where it is needed most, namely, at small values, the aim being to obtain a null reactance, as accurately as possible. A variable capacitor of large capacity would have also balanced the bridge at large values of the antennae's reactances (where the antennas shouldn't actually function), but it wouldn't have offered precision at small values. This is why we chose the compromise from the circuit, with a group of fixed capacitors and a variable capacitor with a reduced range of variation capacity.

A different solution would be to commute the $C$ and $C_v$ capacitors (or only $C_v$) on different values, for different reading precisions, but the interconnecting conductors at a commuter can affect the electrical symmetry of the bridge. In this respect the most advantageous solution can be chosen.

## 8. REFERENCES

[1] Orfanidis S.J. *Electromagnetic Waves & Antennas*, www.ece.rutgers.edu/~orfanidi/ewa 21 June 2004

[2] Rothammel Karl. *Antennenbuch*. Deutscher Militaerverlag, Berlin 1969.

[3] Smirenin B.A. *Radiotechnics coursebook, vol. I*. Editura Energetică de Stat, 1953

[4] Smirenin B.A. *Radiotechnics coursebook, vol. II*. Editura Energetică de Stat, 1954

[5] Stutzman W. L., Thiele G. A. *Antenna Theory and Design*, Second Edition, John Wiley & Sons Inc. ISBN 0-471-02590-9, 1998

[6]*** *The ARRL Handbook for Radio Communications*. 86$^{th}$ Edition, editor K1RO, Newington, CT 06111 USA, 2009

# CONTRIBUTION TO TREATMENT SYSTEM DEFORMED HIGHLIGHTED A NETWORK CONNECTION POINT OF MEDIUM AND HIGH VOLTAGE

MARZHANGUL RAKHASHOVNA KULIMANOVA

*Caspian State University of Technology and Engineering named after Sh.Yessenov, Aktau, Republic of Kazakhstan*

**ABSTRACT**

Always considered directly, an indicator of nonsinusoidal load, deforming residue is used to determine the periodic wave distortion, harmonic. Is normal for certain types of equipment, it is natural to be considered however as a separate indicator.

**Keywords:**. order of harmonics, Fourier series, parameters of distortion.

## 1. INTRODUCTION

Distorting regime is a permanent working AC networks, wherein at least one of the time variations of voltage or current is not sinusoidal. If voltage is sinusoidal, distorting regime appears only exists receiving non-linear (distorted), such as limiters, inductance, receivers flaming arc, discharge lamps gas or metal vapor, etc. If the voltage is harmonic, such as the saturated magnetic circuit transformers, distorting regime may be increased by the presence of capacitors in the circuit, which, with small reactance at high frequencies, can lead to significant current harmonics and can create resonant circuits capacitor-network. The study for distorting regime is done by decomposing the harmonics voltage and current in periodic non-sinusoidal Fourier series. In the distorting regime, besides active power, reactive power and apparent power interferes distorting power.

Distorting regime has the following negative effects on power system:

-Show of voltage and current distortion at all levels between generators and receivers

Distortion coefficient, showing regular size deviation from the sinusoidal shape is defined as the ratio between $U_{def}$ deforming residue and nominal voltage $U_n$.

$$\delta_U = \frac{U_{def}}{U_n} \tag{1}$$

the residue distorted has an expression

$$U_{def} = \sqrt{\sum_{i=2}^{n} U_i^2}, \tag{2}$$

where $U_i$ is the real value of harmonic i.

Practical, for $\delta_U \leq 5\%$ the size can be considered sinusoidal.

-The many power losses and energy in networks and electric machines due to increased apparent power because power distorting.

- Resonance overvoltages caused by capacitor reactive power compensation and harmonic due to overheating of these capacitors.
- Couples parasitic at motors produced by harmonics 5, 7, 11, 13 etc..
- Additional measurement error of power measurement devices (up to 3%) and energy (up to 14%) due to different value under power factor deforming than sinusoidal, the same reactive power. The harmonics limitation do using filters with discharge or absorption. Pressing filter designed to avoid resonance between the network and existing capacitors to improve power factor using reactors in air (tuning coils) in series with the batteries.

In AC traction substations, capacitor banks are used in series with resistors, connected to bars that connect the substation to supply leaders contact wire, amending LC parameters of the contact line in order to avoid occurrence of resonance for any of superior traction current harmonics produced by the locomotive rectifiers (resonant frequency falls below 50 Hz). Absorbent filter consisting of capacitors connected in series with the air reactors so calculated as to provide resonance for higher harmonics (5, 7, ...) present in consumer bars distorted in this way, the filter will absorb all current harmonics for which it was granted. Calculation of these filters is based on the current or voltage harmonic analysis, performed using oscillograms.

## 2. INDICATORS OF THE HARMONICS

The AC wave form ideal voltage or current is sinusoidal, and dc is the ideal constant pressure to be perfect. Causes distortions can be found in some extent the producer or supplier of electricity, but more often they are consumers, especially those who are receivers and linear elements. Basically, distortion current and voltage waves would qualify as deviations from the ideal form, together with voltage pulses, but while distortions are periodic, non-periodic pulses usually are.

Deviations from ideal shape can be characterized on the basis of harmonic analysis, by highlighting harmonic oscillations with periods of full submultiples of the fundamental period, highlighted the real wave period.

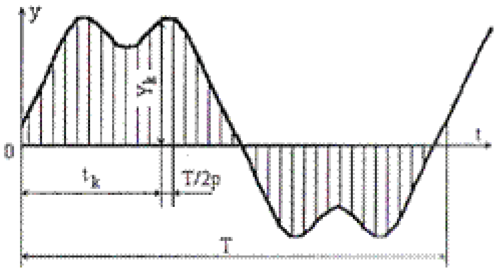



Fig. 1. The division for a period nonsinusoidal wave periodic in order to the harmonic analyze

Harmonic analysis of real wave voltage or current, obtained experimentally by with an oscillograph or registration involves identifying fundamental period T and divider it into equal parts 2p, so p parts on a half-period, as shown in Figure 1.

Of course, the number of divisions is limited below the maximum order of harmonics that must be identified: if it looking for p harmonics, the division must be at minimum 2p parties. Upper limiting the number of divisions is due to the possibilities of "reading" the function values analysis.

Where is noted by z (t) voltage or current wave subject to harmonic analysis, Fourier coefficients expressions known as:

$$A_N = \frac{1}{p}\sum_{k=1}^{2p} Y_k \cdot \sin Nk\frac{\pi}{p},\ \ N \geq 1$$
$$B_N = \frac{1}{p}\sum_{k=1}^{2p} Y_k \cdot \cos Nk\frac{\pi}{p},\ \ N \geq 1 \quad (3)$$

and continuous component is calculated by the formula:

$$Y_0 = \frac{1}{2p}\sum_{k=1}^{2p} Y_k \quad (4)$$

where:
- $Y_k$, $k=1\ldots2p$, consecutive ordinates wave is analyzed as practiced divisions;
- $N$ –Order harmonics, already stressed that. $Np$.
Fourier development wave z (t) is presented first form:

$$y(t) = Y_0 + \sum_{N=1}^{p}(A_N \sin N\omega t + B_N \cos N\omega t) \quad (5)$$

or condensed expression of:

$$y(t) = Y_0 + \sum_{N=1}^{p} Y_N \sin(N\omega t - \varphi_N) \quad (6)$$

the harmonic amplitude and phase are determined, respectively, by the relations:

$$Y_N = \sqrt{A_N^2 + B_N^2} \quad (7)$$

$$\varphi_N = arctg\left(\frac{-B_N}{A_N}\right) \quad (8)$$

And $\omega = 2\pi / T$ is the angular frequency corresponding to the fundamental.

Number of divisions (2p) is important not only for maximum harmonic order that can determine but the accuracy each harmonic and for resultant wave y. If the number of divisions is too small, appears especially errors in the phases of harmonics. For an acceptable harmonic analysis is recommended sampling of voltage and current waves for a period of 80ms, so for four periods, with a minimum number of divisions for a period 2p = 64.

A harmonic analysis relevant and fast can be obtained as follows:
- the correction phase $\varphi_N$ given by (8), the size

$$\Delta\varphi_N = \frac{\pi N}{p} \quad (9)$$

correction is of the form

$$\varphi_N' = \varphi_N - \Delta\varphi_N \quad (10)$$

where φ 'N are considered correct phase, which will be introduced in relation (6), instead $\varphi_N$ phase affected by the error in calculating the relations (3), which approximates the integral relations;
- calculated by summing harmonic wave and comparison with the results analyzed.
- By stopping calculating when the standard deviation of the values of the two waves, above, is minimal.

Establishing indicators for deviations wave characteristics from the ideal form, sine allowable values are based on either current or voltage harmonics of either the synthetic parameters of distortion. There is tend to include the consequences of the harmonics characteristic sizes of telecommunications equipment, electromagnetic compatibility therefore, the deforming regime indicators. If some indicators can be determined for both voltages and currents, there are indicators that make sense only for wave power.

*a) The harmonics of order N*

Is defined as the ratio, expressed as a percentage, between the $Y_{eN}$ effective value harmonic and $Y_e$ effective value wave:

$$\gamma_N = \frac{Y_{eN}}{Y_e} \cdot 100, [\%] \quad (11)$$

Where $Y_{eN}$ obtains by ratio with $\sqrt{2}$ *on* $Y_N$ amplitude, calculated with relation (7) and effective value $Y_e$ for the analized wave can calculated from array by *2p* values with relation:

$$Y_e = \sqrt{\frac{1}{2p}\sum_{k=1}^{2p} Y_k^2} \quad (12)$$

and using the result of a complete Fourier analysis

$$Y_e = \sqrt{\sum_{N=0}^{p} Y_N^2} \quad (13)$$

Sometimes, in the relation (11), instead of the effective use of $Y_e$ effective value of the fundamental $Y_{e1}$.

*b) distorting residue*

Is defined by the expression:

$$Y_{def} = \sqrt{\sum_{N=2}^{p} Y_{eN}^2} \quad (14)$$

can be easily calculated with the equation

$$Ydef = \sqrt{Y_e^2 - (Y_e^2 + Y_{e1}^2)} \quad (15)$$

since the three values involved are already determined.

Without always considered directly, an indicator of nonsinusoidal load, deforming residue is used to determine the periodic wave distortion, harmonic. Is normal for certain types of equipment, it is natural to be considered however as a separate indicator.

*c) distortion factor (the total Harminic Distortion - THD) of a wave harmonic*

Is defined as the ratio, expressed as a percentage of the residue deforming and effective value of the fundamental

$$\delta_Y = \frac{Y_{def}}{Y_{e1}} \cdot 100, [\%] \quad (16)$$

Regime is now distorting aspect which is the largest breakdown limit values of indicators in regulations and standards. Factors are specified for the harmonic distortion for both input voltages and currents.

Internal rules limiting distortion factor of the voltage curves as follows:

$$\delta_u \le 8\%$$

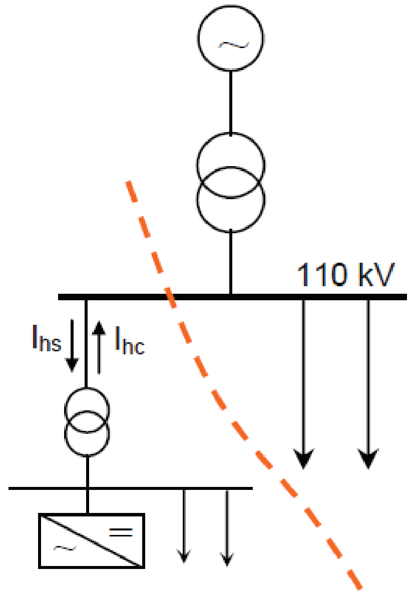
for low and medium voltage networks

$\delta_u \le 3\%$ high voltage networks

Measured current (I) at the point of connection (PC) is the sum of harmonic current injected the actual consumer network (IHC) and from the mains (IHS).

To determine whether the consumer meets the harmonic emission regulations or standards necessary to separate the total current measured by the injected fuel system.

In general, the actual consumer injected current is predominantly but not always, in some cases from the current system can be important due to resonance phenomena that can appear in the modification of network parameters that occurs during such incidents short circuits.




Harmonic voltage can be described by the relations:

$$\underline{V}_h(i) = \underline{Z}_s \cdot (\underline{J}_s - \underline{I}_h(i)) \quad (1)$$
$$\underline{V}_h(i) = \underline{Z}_c \cdot (\underline{J}_c - \underline{I}_h(i)) \quad (2)$$

where $J_s$ and $J_c$ is harmonic current from the source and the consumer, $\overline{Z}_s$ and $\overline{Z}_c$ is equivalent harmonic impedance on the source and the consumer.

One of the methods used to estimate the real part mark total harmonic impedance *Real* $\frac{\Delta V_h}{\Delta I_h}$ which will provide impedance value $\overline{Z}_s$ if the report is positive or value $\overline{Z}_c$ if the report is negative.

## 3. QUALITY CONDITIONS IN THE SUPPLY OF ELECTRICITY TO CONSUMERS

For proper operation of receivers, power supply must meet a number of conditions related to frequency, voltage, power and continuity. Detailed presentation of these conditions is systematizes below.

a) constant frequency voltage is a major challenge for both receivers functioning, maintenance precision measuring instruments and working machines driven by AC motors. Frequency variations can be caused by variation in load or severe damage to the system, such cases can be originated and electricity consumers.

Constant industrial frequency (50 Hz) is a system-level energy problem is related to the power reserve of power plant efficiency and dispatch system. In some cases, the possibility of generating electricity in power are limited, the supply tells consumers (killing distributors) in order to maintain the system frequency.

Maximum permissible deviations by frequency are ± 0.5 Hz (1%).

b) constant voltage, the amount and form, is a precondition for any type of receivers.

It is recommended that the voltage across the receiver is constant and equal to the nominal or possible variations should be within the limits specified for each handset. In operation voltage electrical installations are variations caused by consuming due to changes in load or short circuits.

## 4. CONCLUSIONS

Periodic variations can be slow due to load changes while receivers, and fast, also called fluctuations caused by rapid changes in pregnancy (eg arc furnaces, welding machines, rolling mills, compressors, machinery and others pulsating torque ), including those due to connection - disconnection of receivers.

A permanent reduction in value voltage may result to go down in value for the conductors sections, a situation with negative consequences such as: electrical insulation damage, malfunction and over-heating equipment and piping receivers. Voltages higher than nominal causes overload operation of receivers reduce the life force and light receivers. Voltage decrease under nominal value attracts heat density, operation at lower parameters, or the receivers not working.

As indicated voltage unilateral variation of voltage are drop-away voltage or overpotential of short duration. Is used as drop-away voltage for any decrease in voltage electrical network, with an amplitude in the range (0.2 ÷ 0.9) for nominal voltage and a duration of maximum 3 s.

Of receivers and sensitive installations drop-away voltage, the following:
- Motors and synchronous compensators;
- Asynchronous Motors (depending on torque resistant feature);
- Electronic equipment, including controlled rectifiers;
- Contactors of 0.4 kV and secondary circuits;
- Automatic or protecting circuits bottlenecks and technological adjustments.

The problem arises form the voltage shaped if DC powered receivers and if the supplied AC.

DC voltage across the DC receivers can have a series of harmonics, especially if the power supply is a rectifier ordered. Harmonic content is restricted according to their effects on the receiver, specifying permissible distortion coefficient.

Deviation from the sinusoidal voltage wave form determines receivers AC operation under distorted. While some receivers, such as induction ovens, wave voltage harmonics in mind not to others - including electric motors - voltage harmonics also be limited by specifying the allowed distortion coefficient.

## 5. REFERENCES

[1]*** *Testing and measurement techniques*. *Power Quality Measurement Methods*, CEI 61000-4-30/2000.

[2]*** Golovanov Carmen ş.a., *Metode moderne de măsurare în electroenergetică*, Editura tehnică, Bucureşti, 2002.

[3]*** *IEEE Trial-use Standard Definitions for the Measurement of Electric Power Quantities Under Sinusoidal, Nonsinusoidal, Balanced, or Unbalanced Conditions*, IEEE 1459/2000.

[4]*** *Guide to Quality of electrical supply for industrial installations*. Part 4. *Voltage Unbalance*. Working group WG 2 “Power Quality” 1998.

[5]*** *Power Quality in European Electricity Networks*, Eurelectric, February, 2002.

# BACKUP COMMUNICATION SYSTEM FOR EMERGENCY SITUATIONS IN ELECTRICAL ENERGY DISTRIBUTION NETWORKS

[1]SUSNEA IOAN, [2]VASILIU GRIGORE

[1,2]*University "Dunarea de Jos" of Galati, Romania*

**ABSTRACT**

The most common solution for remote monitoring and control of the protection relays used in modern electrical energy distribution systems relies on GSM/GPRS communication. In practice, however, the emergency situations in energy distribution systems usually occur in special weather conditions (storms, massive snowfalls, etc.), or in crisis situations (natural disasters, armed conflicts, etc.), when the GSM communication system is also disrupted. Thus, the fault localization and repair is often delayed, which results in significant losses for the electricity companies, and major discomfort for thousands of subscribers.

This paper explores the technical feasibility of creating an alternative communication system, based on the Wireless Sensor Networks (WSN) technology, able to substitute the GSM communication for monitoring the reclosers deployed along the energy distribution lines. This preliminary study suggests that the existing WSN devices and protocols allow the implementation of an emergency communication system capable to route relatively small amounts of data over wide geographic areas. Such a system is, in principle, capable to ensure backup communication for emergency fault diagnosis in electrical energy distribution systems.

**Keywords:** *Wireless Sensor Networks, Communication protocols, Energy distribution systems, Emergency situations*

## 1. INTRODUCTION. THE AIM OF THIS PAPER

The recent advances in Wireless Sensor Networks technology WSN ([1],[2]), determined by the emergence of new microcontrollers and novel radio communication devices with low cost and extremely low power requirements recommend this research domain as one of the most promising in what concerns the diversity and practical importance of the possible applications.

Despite the many applications described in the literature (see references [3..7]), there are still a few intrinsic limitations of the WSN technology, deriving from the limited energy available for the sensors (which results in reduced operation areas), and the low computing power of the microcontrollers used for the implementation of the network nodes.

The research described in this paper attempts to outline possible solutions for both the above mentioned drawbacks.

In what concerns the reduced operation area of the WSN systems, we propose a solution for creating an alternative communication system for monitoring the electrical energy distribution systems in emergency situations.

The current solution for remote fault diagnosis in modern electrical energy distribution systems relies on GSM/GPRS communication ([8]). In practice, however, the emergency situations in energy distribution systems usually occur in special weather conditions (storms, massive snowfalls, etc.), or in crisis circumstances (natural disasters, armed conflicts, etc.), when the GSM communication is also disrupted. Thus, the fault localization and repair is delayed, sometimes for several days, which results in significant financial losses for the electricity companies, and major discomfort for thousands of subscribers.

Considering this, we suggest that the existing WSN technology may be used for routing small amounts of digital data over extended distances (tens or hundreds of kilometers). The resulting communication network could, in principle, be used as a backup for the current GSM communication for fault diagnosis in electrical power distribution systems.

In what concerns possible solutions to overcome the limitation deriving from the reduced computing power of the microcontrollers commonly used for the implementation of the WSN nodes, we demonstrated in [9] that it is possible to implement generic artificial neural networks (ANN) over the physical layer of a WSN, by means of a special design of the communication protocol between the WSN nodes. A direct application of this idea is presented in the patent application [10], however the research in this direction is still in an early stage.

Beyond this introduction, this paper is structured as follows:

Section 2 is a brief review of the vast literature dedicated to wireless sensor networks;

Section 3 contains a description of proposed solution to implement a backup communication system for use in emergency situations in electrical power distribution networks;

Finally, section 4 presents the conclusions and future research directions

## 2. BRIEF REVIEW OF THE STATE OF THE ART IN WIRELESS SENSOR NETWORKS

In the past few years, there has been a great deal of interest in the WSN domain. A variety of research papers (see [3-7]) describe applications ranging from environment monitoring ([6]), traffic control ([5]), to military applications ([7]).

Other studies focus on using WSN in smart grids ([11]), healthcare ([12]), or in agriculture ([13]).

A comprehensive survey of the research directions and applications of WSN is available in [14], and [15].

Despite the exceptional interest of the researchers in WSN, which manifests itself in a very large number of publications on these topics (for example, a search in Google Scholar with the key „wireless sensor networks" returns over 200,000 hits, most of them quite recent), there are at least two characteristics of WSN that limit the sphere of possible applications ([16]).

First, the limited amount of (usually non-regenereable) energy available leads to a short lifetime of the battery operated nodes, and also limits the geographical area where sensors can be deployed from several hundred meters to a few kilometers.

Current solutions for extending the lifespan of the WSN nodes include either designing nodes with extremely low power consumption (e.g. [17], [18]), or creating the means for the nodes to „harvest" energy from the environment ([19], [20]), but the results reported in this last direction are somewhat singular and hard to reproduce on a large scale. Many other solutions focus on finding optimal routes for the data packets transmitted between nodes and the Base Station (BS) in multi-hop networks (see figure 1).

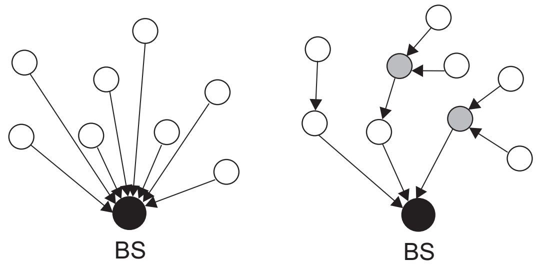



Figure 1 Basic WSN topologies

The problem of extending the operation range has been solved either by increasing the RF power of the radio transmitters ([21]) up to the limits imposed by the regulations of FCC and ETSI for the ISM bands, or by designing „gateways" ([22]) to other network technologies (e.g. IEEE-802.11, GSM).

In what concerns the problem of the limited computing power and storage capacity, the obvious solution is to design WSN nodes (also called „motes") equipped with more powerful, but relatively expensive processors (e.g. the SunSPOT mote, described in [23], uses a 32 bit processor, running at 180MHz, priced at around $200 per unit). Another, more interesting, solution is to distribute the computation tasks among a plurality of processors in a multi-agent systems approach ([10],[24],[25]).

## 3. USING THE WSN TECHNOLOGY FOR COMMUNICATION OVER EXTENDED DISTANCES

The security and integrity of the power grid is crucial in modern society, and especially in emergency or crisis situations. Extended power failures dramatically disrupt communication systems, thus hindering the process of fault localization and repair of the energy distribution systems themselves. Events from recent history (e.g. the North American blackout in August 13, 2003) show the even the most advanced technological societies are still vulnerable to such accidents.

Considering this, we conducted a preliminary research aimed to explore the feasibility of the idea of using the WSN technology for creating an alternative, backup communication system for monitoring and fault diagnosis in electrical energy distribution systems.

This leads to a WSN topology as shown in figure 2, wherein the communication nodes follow the power lines.

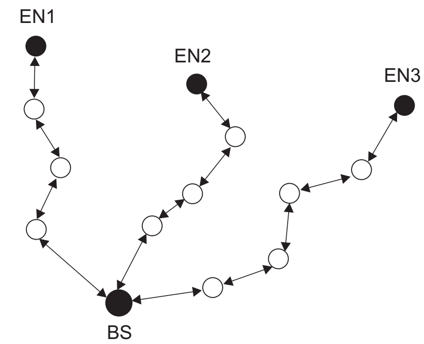



Figure 2 Multi hop communication between a Base Station (BS) and a number of Endnodes (EN)

Such a structure has several distinctive features:

- For operational reasons, the communication nodes must be placed on or near the electricity poles of the energy distribution network. In the medium voltage (20KV) distribution networks, the distance between successive poles is about 200m, which falls in the communication range of many wireless devices (e.g. IEEE802.15.4);
- Unlike in "conventional" WSNs, where the communication is unidirectional, from the sensing nodes to a base station (BS), in this case the communication is bidirectional between the base station and a number of endnodes (EN), located in the vicinity of the protection relays placed in key locations of the distribution network;
- Due to the low spatial density of WSN nodes, and the chain topology (see figure 2), each node can only communicate with a very limited number of adjacent nodes. Therefore, the routing options are also very limited. This leads to an implicit clusterization of the network, as shown in figure 3;
- The structure of the WSN nodes required for this application is simpler compared to the "classic" structure of a node, depicted in figure 4. The reduced node structure only contains a microcontroller and the communication transceiver is presented in figure 5. A simplified hardware for the nodes leads to lower power consumption, which is an obvious advantage for any battery operated device.

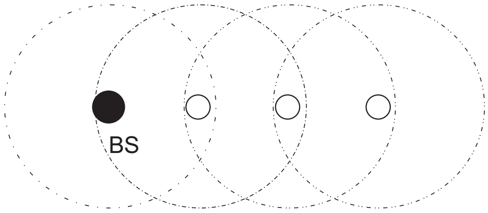



Figure 3 Implicit clusterization of the nodes in the chain topology

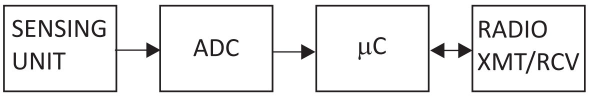



Figure 4 Structure of a typical WSN node

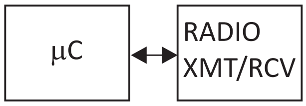



Figure 5 Hardware structure of the reduced node

Note that the node placement versus communication range presented in figure 3 is idealized. A more realistic representation, which also has increased robustness against failure of individual nodes, is shown in figure 6.

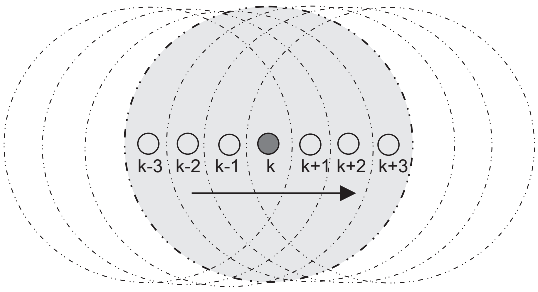



Figure 6 Alternative node clusterization

At any time, the radio signal transmitted by the node k, is received by 2 or 3 adjacent nodes ahead and behind the location of node k.

Starting from the above considerations, the problem of transmitting data over relatively long distances using low power transceivers can be solved by designing a communication protocol capable to route data packets between the nodes of the network, according to a multi-hop algorithm, with minimum costs in what concerns energy consumption and time delays. To do this, we have conducted an experiment using five "motes" consisting in a small, general purpose, microcontroller module (Atmel ATMega128), and an off-the-shelf low-cost radio modem, operating in the ISM bands (100mW RF power, 500m operating range, 2.4GHz). The hardware components used are shown in figure 7.

The data packets were structured as shown in figure 8, and the significance of the notations is as follows:

ORG – indicates the message originator (a one byte code indicating either the Base Station, or one of the end nodes)

NID – Node ID. The nodes are sequentially numbered, so that the node closest to the base station has NID=1, and the end node has the largest ID code.

OPC – OPCODE, a one byte code indicating the type of message.

SEQ – Sequence number. This is a message identifier, used to detect missing packets.

DATA – this is a variable length field containing the actual data payload of the packet.

CRC – a 16 bit checksum for error detection.

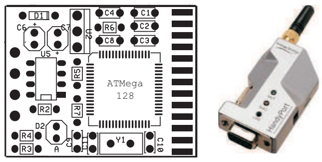



Figure 7 The hardware used in the experiment

| ORG | NID | OPC | SEQ | DATA | CRC |
|---|---|---|---|---|---|

Figure 8 The structure of the data frames

The messages are delimited by a header (the sequence 0x10-0x02), and a trailer (0x10-0x03). To avoid false end-of-frame detections, all the DLE characters (0x10) in the body of the message are transmitted twice (DLE stuffing). Duplicate DLEs are filtered at the receiver (DLE stripping).

The access of the nodes to the common communication medium is governed by a TDMA (Time Division Multiple Access) scheme (see figure 9).

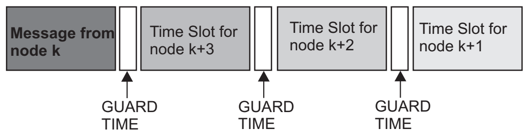



Figure 9 The TDMA medium access scheme

The time interval after the transmission of a message from node k is divided into 3 predefined time slots reserved respectively for nodes (k+3), (k+2), (k+1). The slot times are calculated to cover the length of the maximum size message (256 bytes). Guard times (about 5ms in our experiments) are needed to allow some wake-up time for modems and node CPUs.

All the receiving nodes having own_NID<packet_NID remain idle.

If node (k+3) receives the message from node (k) correctly (CRC OK), it uses the first time slot to re-send the message, after replacing NID with its own ID. In this case, nodes (k+1) and (k+2) remain idle. In node (k+3) is too far, and did not receive the message correctly, then the first time slot remains empty, but node (k+2) has the opportunity to use the second time slot to repeat the message. If node (k+2) is also unable to receive the message correctly, then node (k+1), which is closer to node (k), can use the third time slot to re-transmit the packet. In all cases, node (k) receives the repeated message, and interprets it as an acknowledge to re-enter sleep mode.

## 4. CONCULSIONS AND FUTURE WORK

This simple experiment demonstrates that, in principle, it is possible to create a backup communication system, based on the WSN technology, for emergency fault diagnosis in energy distribution systems.

Further research is needed to select hardware components for the nodes (the microcontroller unit and the radio transceivers) capable to operate for several years with the energy of a single low-cost battery. ZigBee (IEEE 802.15.4) seems promising since the latest products have about 1Km operation range, and very low power requirements. Considering the fact that the system has a very low duty cycle (0.1% or less), we believe that it is possible to develop a commercial solution for this system in a matter of months.

## 5. REFERENCES


[1] ILYAS, Mohammad; MAHGOUB, Imad (ed.). *Handbook of sensor networks: compact wireless and wired sensing systems*. CRC press, 2004.

[2] DARGIE, Waltenegus; POELLABAUER, Christian. *Fundamentals of wireless sensor networks: theory and practice*. Wiley, 2010.

[3] VIEIRA, Marcos Augusto M., et al. Survey on wireless sensor network devices. In: *Emerging Technologies and Factory Automation, 2003. Proceedings. ETFA'03. IEEE Conference*. IEEE, 2003. p. 537-544.

[4] XU, Ning. A survey of sensor network applications. *IEEE Communications Magazine*, 2002, 40.8: 102-114.

[5] WEN, Y.; PAN, J. L.; LE, J. F. Survey on application of wireless sensor networks for traffic monitoring. In: *First International Conference on Transportation*. 2007. p. 2079-2084.

[6] BARRENETXEA, Guillermo, et al. Sensorscope: Out-of-the-box environmental monitoring. In: *Information Processing in Sensor Networks, 2008. IPSN'08. International Conference on*. IEEE, 2008. p. 332-343.

[7] DUAN, Qi; AL-HAJ, Saeed; AL-SHAER, Ehab. Provable configuration planning for wireless sensor networks. In: *Network and Service Management (CNSM), 2012 8th International Conference on*. IEEE, 2012. p. 316-321.

[8]http://www.ipa.ro/galati/produse/electrica.htm Remote monitoring and control for the POLARR relays via GSM

[9] SUSNEA, Ioan. Distributed Neural Networks Microcontroller Implementation and Applications. *Studies in Informatics and Control*, 2012, 21.2: 166.

[10] SUSNEA, Ioan; VASILIU, Grigore "Sistem de reglare a temperaturii in cladiri – Temperature Control System for Buildings", Patent application nr. A01074/26.10.2011, National Patent Office OSIM, Romania.

[11] GUNGOR, Vehbi C.; LU, Bin; HANCKE, Gerhard P. Opportunities and challenges of wireless sensor networks in smart grid. *Industrial Electronics, IEEE Transactions on*, 2010, 57.10: 3557-3564.

[12] KO, JeongGil, et al. Wireless sensor networks for healthcare. *Proceedings of the IEEE*, 2010, 98.11: 1947-1960.

[13] LI, Xuemei; DENG, Yuyan; DING, Lixing. Study on precision agriculture monitoring framework based on WSN. In: *Anti-counterfeiting, Security and Identification, 2008. ASID 2008. 2nd International Conference on*. IEEE, 2008. p. 182-185.

[14] GARCÍA-HERNÁNDEZ, Carlos F., et al. Wireless sensor networks and applications: a survey. *IJCSNS International Journal of Computer Science and Network Security*, 2007, 7.3: 264-273.

[15] YICK, Jennifer; MUKHERJEE, Biswanath; GHOSAL, Dipak. Wireless sensor network survey. *Computer networks*, 2008, 52.12: 2292-2330.

[16] AKYILDIZ, Ian F.; KASIMOGLU, Ismail H. Wireless sensor and actor networks: research challenges. *Ad hoc networks*, 2004, 2.4: 351-367.

[17] POLASTRE, Joseph; SZEWCZYK, Robert; CULLER, David. Telos: enabling ultra-low power wireless research. In: *Information Processing in Sensor Networks, 2005. IPSN 2005. Fourth International Symposium on*. IEEE, 2005. p. 364-369.

[18] PARK, Chulsung; LIU, Jinfeng; CHOU, Pai H. Eco: an ultra-compact low-power wireless sensor node for real-time motion monitoring. In: *Information Processing in Sensor Networks, 2005. IPSN 2005. Fourth International Symposium on*. IEEE, 2005. p. 398-403.

[19] PENELLA, M. T.; GASULLA, M. A review of commercial energy harvesters for autonomous sensors. In: *Instrumentation and Measurement Technology Conference Proceedings, 2007. IMTC 2007. IEEE*. IEEE, 2007. p. 1-5.

[20] SUDEVALAYAM, Sujesha; KULKARNI, Purushottam. Energy harvesting sensor nodes: Survey and implications. *Communications Surveys & Tutorials, IEEE*, 2011, 13.3: 443-461.

[21] YADAV, SG Shiva Prasad; CHITRA, Dr A. Wireless Sensor Networks-Architectures, Protocols, Simulators and Applications: a Survey. *International Journal of Electronics and Computer Science Engineering (IJECSE, ISSN: 2277-1956)*, 2012, 1.04: 1941-1953.

[22] ZENNARO, Marco; BAGULA, Antoine B. Design of a flexible and robust gateway to collect sensor data in intermittent power environments. *International Journal of Sensor Networks*, 2010, 8.3: 172-181.

[23] JOHNSON, Michael, et al. A comparative review of wireless sensor network mote technologies. In: *Sensors, 2009 IEEE*. IEEE, 2009. p. 1439-1442.

[24] ZUNGERU, Adamu Murtala; ANG, Li-Minn; SENG, Kah Phooi. Classical and Swarm Intelligence Routing Protocols for Wireless Sensor Networks: A Survey and Comparison. *Journal of Network and Computer Applications*, 2012.

[25] VINYALS, Meritxell; RODRIGUEZ-AGUILAR, Juan A.; CERQUIDES, Jesus. A survey on sensor networks from a multiagent perspective. *The Computer Journal*, 2011, 54.3: 455-470.

# SECTION IV
## MATHEMATICAL SCIENCES AND PHYSICS

# OPTIMIZED DETECTION OF AMPHETAMINES BASED ON PRINCIPAL COMPONENT ANALYSIS

[1]CIOCHINA STEFANUT, [2]PRAISLER MIRELA

[1,2]*"Dunarea de Jos" University of Galati, Department of Chemistry, Physics and Environment, Romania*

**ABSTRACT**

In this paper we are presenting the results of a multivariate analysis applied in order to optimize the automated detection of illicit amphetamines. The study was conducted based on Principal Component Analysis (PCA). We have used as input for this unsupervised pattern recognition method a spectral database containing the GC-FTIR spectra of the main prohibited amphetamines, their precursors or derivatives. The spectra were preprocessed by using a function that is selectively amplifying the absorptions found as important from the point of view of the modeling and of the discrimination power. The results show that amphetamine analogues form distinct clusters according to their biological activity and associated toxic (stimulant or hallucinogenic) effects. The use of the selective amplifier leads to a significant improvement of the efficiency of the class identity assignment to unknown compounds.

**Keywords:** *amphetamine, principal component analysis, detection optimization*.

## 1. INTRODUCTION

The basic chemical structure of amphetamines contains an aromatic ring linked by an aliphatic side chain to one (1-phenylethylamine) or two (2-phenylethylamine) carbon atoms of amino group [1]. Their illegal use is determined by their hallucinogenic effect and / or because they are stimulants of the central nervous system [2]. Given the correlation between the substitution degree of the aromatic ring and the biological effect, we have assigned to the stimulant amphetamine the class code M (see Figure 1a) and to the hallucinogenic amphetamines the class code T (see Figure 1b).

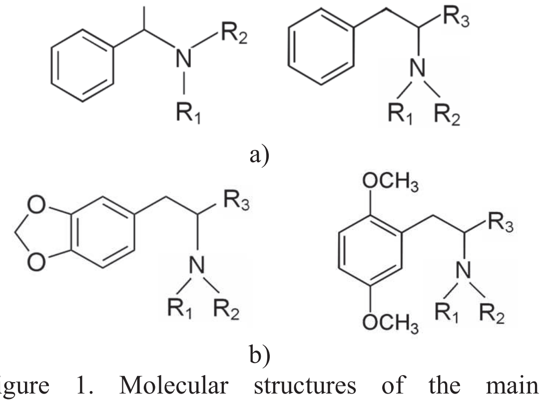



Figure 1. Molecular structures of the main amphetamine analogues: a) stimulant amphetamines (class M); b) hallucinogenic amphetamines (class T).

The use of GC-FTIR spectra allows the determination of the molecular structure, identity, purity and the dosage of chemical compounds. This is possible because the GC-FTIR spectrum is a typical and unique feature of molecules. GC-FTIR spectroscopy has become one of the major analytical techniques applied for the detection of drugs, especially due to its effectiveness.

The optimization of the detection of illicit drugs encountered on the illicit market is particularly important in the continuous fight of specialized authorities against clandestine laboratories, who keep on producing new types of recreational drugs. In this paper we are presenting a method that is optimizing the results obtained in the automatic detection and discrimination of the main amphetamine analogues. The detection is performed by an unsupervised pattern recognition technique, namely Principal Component Analysis (PCA). The optimization consisted of pre-processing the GC-FTIR spectra with a function that identifies the modeling and / or discrimination power of each variable (wave number) and increases the intensity of the measured absorptions accordingly.

The results indicate that spectra preprocessing increases the efficiency of the detection system. Although no information about the biological activity or toxicity of amphetamines was introduced in the input database, the illicit amphetamines are detected and classified (by class identity assignment) according to their primary (stimulant or hallucinogenic) biological activity. This result is generated by the correlation between the biological effect of amphetamines and the substitution pattern of the aromatic ring present in their molecular skeleton, the information about the latter structural feature being maintained by the GC-FTIR spectra. The proposed optimization method increases the impact of the specific absorptions associated to the molecular skeleton characteristic to each of the two classes of amphetamines (M and T). As a result, it minimizes the likelihood of erroneous classifications of unknown compounds. Consequently, the proposed method is a contribution to the overall effort of increasing the accuracy of the analytical methods that can be applied to detect, as fast and efficiently as possible, new illicit substances similar to amphetamines and their key precursors.

## 2. EXPERIMENTAL PART

A Perkin Elmer (Buckinghamshire, UK) Autosystem

GC was interfaced with a light pipe GC-IR System 2000 and connected to a FTIR System 2000 with a mid-infrared source and a medium band, liquid nitrogen-cooled mercury cadmium telluride (MCT) detector. Temperature-programmed separations were carried out on a Hewlett-Packard (Palo Alto, CA, USA) Ultra-1 methylsilicone capillary column (25m $\times$ 0,32 $\mu$m i.d., 0,52 $\mu$m film thickness). The carrier gas was helium at a flow rate of 1,8 ml min$^{-1}$. The analytical column outlet stretched into the light pipe inlet. Helium carrier gas was added as make-up gas at a flow rate of 1,8 ml min$^{-1}$ at the connection between the capillary column and the light pipe. The gold-coated light pipe (12 cm$\times$ 1mm i.d.) was heated at a constant temperature of 270$^0$ C. Real time spectra were obtained by addition of two scans, with a spectral resolution of 8 cm$^{-1}$ and 32 background scans. The scan range was from 4000 to 600 cm$^{-1}$. Chromatograms were calculated by the Gram-Schmidt vector orthogonalization method [3].

Methanolic stock solutions (1,0 mg ml$^{-1}$ ) of the reference standards were injected into the GC-FTIR system. The concentration of the stock solutions was chosen at 1,0 mg ml$^{-1}$ because after sample preparation, the methanolic extracts of the street samples are in the same concentration range. Gram–Schmidt reconstruction was performed using 10 basis vectors throughout the run. Baseline correction was performed on the reconstructed Gram–Schmidt chromatogram (GS) and low-noise vapor-phase FTIR spectra were generated after co-addition. The obtained reference vapor-phase FTIR spectra were stored in a computer-based library after normalization. The normalization procedure involves scaling each spectrum so that peak absorbance of the most intense band is set to unity. The spectral data were stored in the database at 5 cm$^{-1}$ intervals. The same GC-FTIR based analytical procedure was used for the analysis of suspect powders and tablets from judicial origin [3].

The database used as input for PCA contains 30 spectra, belonging to 7 stimulant amphetamines (class code M), 6 hallucinogenic amphetamines (class code T) and 17 non-amphetamine substances of toxicological interest (class code N). The stimulant amphetamines included in the spectral database are: amphetamine, β-phenylethylamine, methamphetamine, N-ethylamphetamine, N-n-propylamphetamine, α-phenylethylamine and N-methyl-α-phenylethylamine. The hallucinogenic amphetamines (class code T) are: 3,4-methylendioxyamphetamine, 3,4-methylenedioxy-N-ethylamphetamine, 1 - (3,4-methylenedioxyphenyl)-2-butanamine, 3,4-methylenedioxymethamphetamine, N-methyl-1-(3,4-methylenedioxyphenyl)-2-butanamine, and 3,4 -methylenedioxy-N-hydroxyamphetamine. The other 17 substances are negatives (class code N) of forensic interest: codeine-PFPA, γ-hydroxybutyric acid (TMS), caffeine, γ-valerolactone, γ-butyrolactone, cadaverine, piracetam, bemegride, β-butyrolactone, γ-hydroxyvaleric acid (TMS), cocaine I.S., γ-butyrolactone artifact 1 (thermal degradation product generated during the chromatographic separation of γ-butyrolactone), nicotamide, cadaverine - HFBA, dextromoramide, prolintane and putrescine [3]. The analyzed spectra were recorded between 4000 and 600 cm$^{-1}$, and the absorbance was measured every 5 cm$^{-1}$. Thus, each spectrum is a vector with 681 variables. Consequently, the spectral database used as input for PCA is a matrix with 30 $\times$ 681 entries [3,4].

## 3. RESULTS AND DISCUSSIONS

### *3.1. Spectra processing*

In order to optimize the amphetamines detection, the GC-FTIR spectral database was divided into two distinct classes. Class I contains the spectra of the positives (class code M and T). Class II contains the spectra of the negatives (class code N).

Then the spectra were preprocessed with a discriminating function defined as follows [3,4]:

$$w_k = \frac{\sum \frac{A_I^2}{N_I} + \sum \frac{A_{II}^2}{N_{II}} - 2\sum\sum \frac{A_I A_{II}}{N_I N_{II}}}{\sum \frac{\left(A_I - \overline{A_I}\right)^2}{N_I} + \sum \frac{\left(A_{II} - \overline{A_{II}}\right)^2}{N_{II}}} \qquad (1)$$

where $A_I$ and $A_{II}$ represent the absorptions in the GC-FTIR spectra corresponding to the samples of class I and II, $N_I$ and $N_{II}$ are the number of samples in class I and II.

Function *w* (see Figure 2) acts as a selective amplifier, as it increases the intensity of the absorptions ($w > 1$) measured at the wave numbers found as important by taking into account their modeling or discrimination power, and leaves unchanged the absorption intensity for the irrelevant wave numbers, for which $w = 1$.

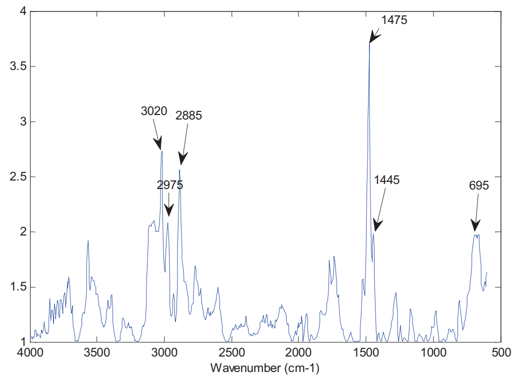
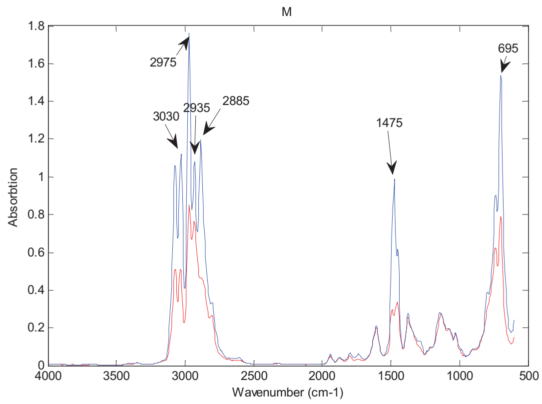
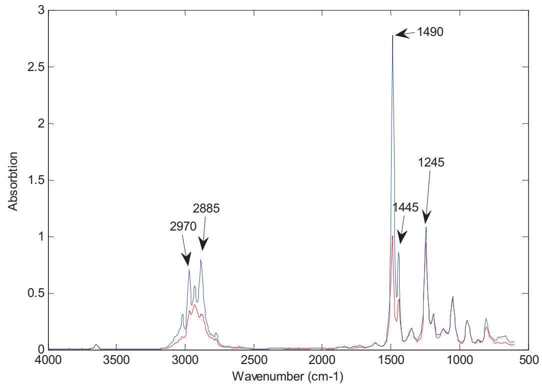



Figure 2. Selective amplifier *w* used for the preprocessing of the GC - FTIR spectra of amphetamines and other compounds of forensic interest

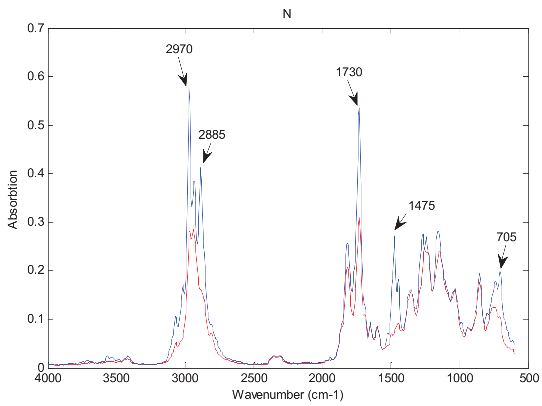
The effect of spectra preprocessing with the *w* selective amplifier is illustrated in Figure 3, which presents the mean spectra of the compounds included in classes M, T and N in comparison with the mean spectra calculated with the same spectra preprocessed with the *w* selective amplifier. A first remark is that, unlike the original spectra, the preprocessed spectra are no longer normalized. Secondly, the strongest enhancement of the absorption intensity takes place in the 1535 - 1405 cm$^{-1}$ and 3080 - 2800 cm$^{-1}$ spectral windows.




a)




b)




c)

Figure 3. Mean GC - FTIR spectra calculated with the unprocessed spectra (___) and with those processed with the *w* selective amplifier (___) for: a) stimulant amphetamines (class M); b) hallucinogenic amphetamines (class T); c) non-amphetamine (class N).

In the case of stimulant amphetamines (M) the *w* selective amplifier increases especially the intensity of the absorption found in the 2830-3030 $cm^{-1}$ domain specific to symmetric and asymmetric stretching vibrations of the methyl ($-CH_3$) and methylene ($-CH_2$) groups (see Figure 3a). The bands associated to the asymmetric stretching vibrations of $-CH_3$ and $-CH_2$ are found at 2975 and 2935 $cm^{-1}$ and are very strong [1].

Other absorptions that are significantly enhanced by the selective amplifier are the 1475 $cm^{-1}$ and 695 $cm^{-1}$ absorption bands. The first is associated to the stretching vibrations of the C = C bond present in the monosubstituted aromatic cycle, and the second to the $\Phi CC$ out-of-plane bending vibration of the benzene ring.

In the case of hallucinogenic amphetamines (see Figure 3b), the *w* selective amplifier increases the intensity of the absorption bands found at 2925 $cm^{-1}$ (associated to the stretching vibration of the aliphatic C-H bond), 1490 $cm^{-1}$ (corresponding to the breathing vibration of disubstituted aromatic rings) and 1245 $cm^{-1}$ (generated by the stretching vibration of the C-O bond) [1].

### *3.2. Determination of the number of principal components for PCA based on w preprocessed spectra*

Principal components analysis (PCA) was performed by using the *2012a MATLAB* software application [5]. In order to determine the number of principal components (PC) by means of which it is useful to perform PCA, the dynamics of the cumulative explained variance was examined. Figure 4 shows that it is rapidly increasing and then it reaches a plateau where it has almost a constant value. Table 1 shows that the first 10 PC lead to a very good cumulative explained variance, i.e. 95,9%. Therefore, we have considered useful to perform PCA with this number of PCs, the contribution of 4,1% of the remaining PCs to the cumulative explained variance being negligible [2]. The same number of PCs was found useful in the case of PCA performed with unprocessed GC-FTIR spectra. In other words, in both cases, the original 681-dimensional hyperspace was compressed to only 10 independent variables.

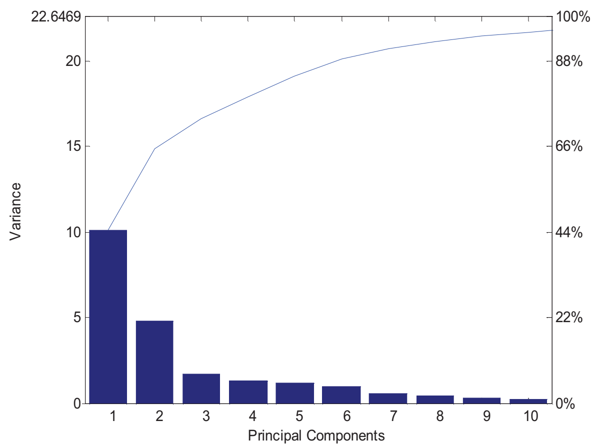



Figure 4. Explained variance of the principal components for the spectra processed with the *w* selective amplifier.

Table 2. Cumulative explained variance for PCA based on spectra preprocessed with the *w* selective amplifier.

| Principal component | PC1 (%) | PC2 (%) | PC3 (%) | PC4 (%) | PC5 (%) | PC6 (%) | PC7 (%) | PC8 (%) | PC9 (%) | PC10 (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Explained variance | 44,6 | 21,3 | 7,7 | 5,7 | 5,3 | 4,4 | 2,6 | 1,8 | 1,4 | 1,1 |
| Cumulative variance | 44,6 | 65,9 | **73,6** | 79,3 | 84,6 | 89,0 | 91,6 | 93,4 | 94,8 | **95,9** |

The analysis of the score plots associated to the unprocessed GC-FTIR spectra (see Figure 5) has been presented in detail in previous studies [6]. The visual inspection of the score plots for the *w* preprocessed spectra indicates that the best discrimination of the clusters associated to amphetamines (according to their biological activity) and to negatives is obtained with the score plots corresponding to the first three PC (see Figure 6). The same situation is encountered in the case of PCA applied to unprocessed spectra. This may be explained by the fact that these PCs are characterized by the largest explained variances in both cases (see Table 1). In conclusion, a first confirmation of the positive effect of the *w* selective amplifier is the fact that spectra preprocessing leads to a better cumulative explained variance (95,9% versus 93,8% for unprocessed spectra). In addition, the cumulative explained variance of the first three PCs is 73,6% for PCA performed with the *w* preprocessed spectra, as compared to 63,3% in the case of unprocessed spectra.

### *3.3. Cluster analysis*

The score plots associated to the unprocessed GC-FTIR spectra (see Figure 5) and to the *w* preprocessed spectra (see Figure 6) were analyzed in the multidimensional space defined by the first 10 PCs, in order to evaluate the quality of the clusters and the corresponding performances of the detection system. The score plots indicate that, in both cases, the compounds cluster in three relatively distinct clusters, specific to stimulant amphetamines (class M), hallucinogenic amphetamines (class T) and to non-amphetamines (class N).

The hallucinogenic amphetamines (T class) form the best defined cluster, being the only compounds with high positive PC2 scores (see Figures 5a, 5c, 6a and 6c). In the case of unprocessed spectra, some negative compounds have their associated points relatively close to the cluster of hallucinogenic amphetamines (they have positive PC2 scores). In the case of the preprocessed spectra, there is only one negative (codeine-PFPA, N30) characterized by a positive PC2 score, but it has a much lower value than the PC2 scores of hallucinogens. It is worth noting that in the case of preprocessed spectra, the PC2 scores of hallucinogens differ by almost 4 units from the those of other substances (see Figure 6a), while in the case of unprocessed spectra the smallest difference is slightly greater than one unit (see Figure 5a). In other words, preprocessing the spectra with the *w* selective amplifier considerably increases (4 times) the discrimination power of the system from the point of view of the hallucinogens.

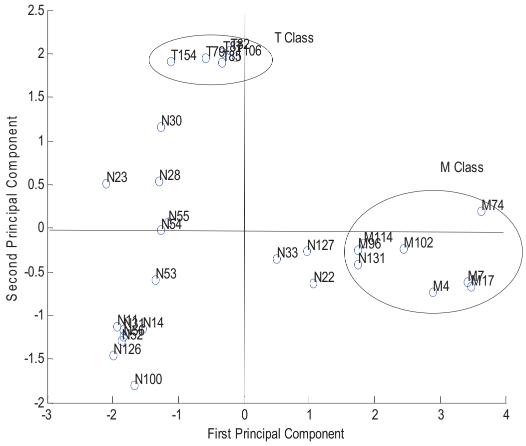
In the case of unprocessed spectra, the M and N clusters are not so well defined. The same happens in the case of the preprocessed spectra of these classes of compounds. The stimulant amphetamines (class M) are the only compounds having positive PC1 scores and negative PC2 scores, except for the negatives N22-cadaverine, N33-dextromoramide, N127-prolintane and N131-putrescine (see Figures 5 and 6). Still, the PC1 scores of these four substances are significantly smaller than those of stimulant amphetamines (class M). The closeness of the points associated to these four compounds to the cluster of stimulant amphetamines can be explained by the similarities between their molecular structures and the molecular skeleton of stimulant amphetamines, which are also reflected in similar FTIR absorption.

Nevertheless, we must emphasize that in the case of spectra processed with *w* selective amplifier, the distance between the cluster of the M class and the points associated to these negatives is significantly larger than in the case of unprocessed spectra (see Figures 5a and 6a). If in the latter case putrescine (N131) can be considered a false M positive, in the case of processed spectra all the above mentioned negatives have their associated points clearly placed outside the M cluster (their positive PC1 scores are significantly smaller than those of stimulant amphetamines). In the case of spectra preprocessing, the PC1 score of putrescine differs by almost 2 units from the PC1 score of the nearest stimulant amphetamine (M96 N -ethylamphetamine, EAMP). In other words, the optimization method leads also to an improved selectivity of the cluster of stimulant amphetamines.

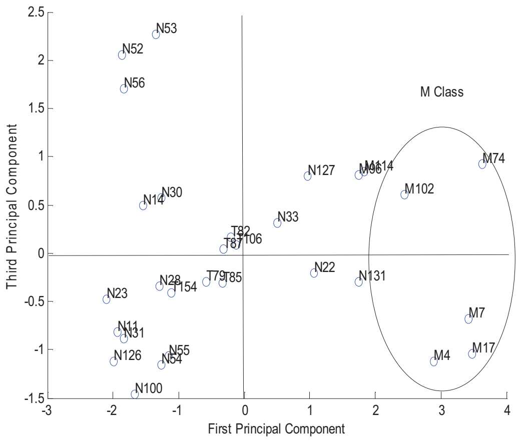
The structural analysis of the negatives with positive PC1 scores can provide important information about the nature of the compounds that may become potential false M positives if the proposed method is used to detect amphetamines by assigning the class identity to an unknown sample. For example, both cadaverine and putrescine have an amino group in their molecular structure, linked to an aliphatic chain similar to the side chain present in the structure of stimulant amphetamines (see Figure 7a and 7b). On the other hand, these substances have a very different biological activity from that of amphetamines.

Cadaverine is a foul-smelling compound produced by protein hydrolysis during animal tissue putrefaction. Putrescine is a colorless, foul-smelling ptomaine, produced in animal tissue during the decomposition of ornithine by decarboxylation [7, 8].

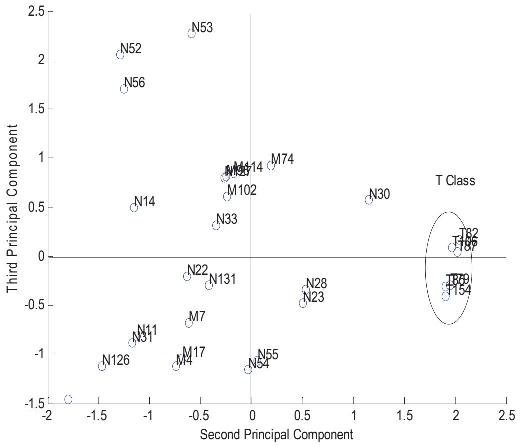
Prolintane contains an aromatic ring linked by an aliphatic chain to a heterocycle containing a nitrogen atom, instead of the amino group found in the molecular skeleton of amphetamines (see Figure 7c). Prolintane is used in legitimate pharmaceutical products for its antidepressant effect [9].




a)

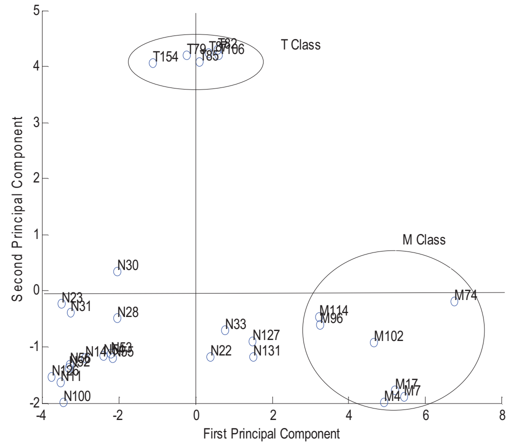



b)

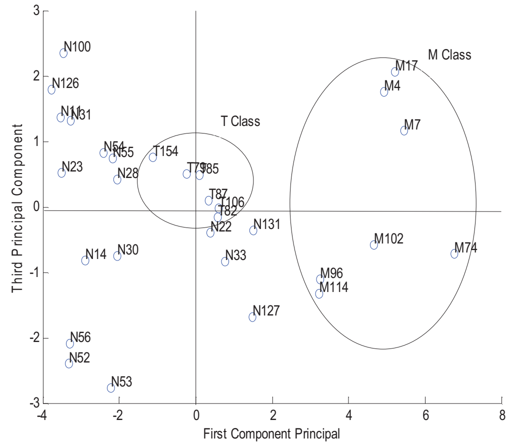



c)

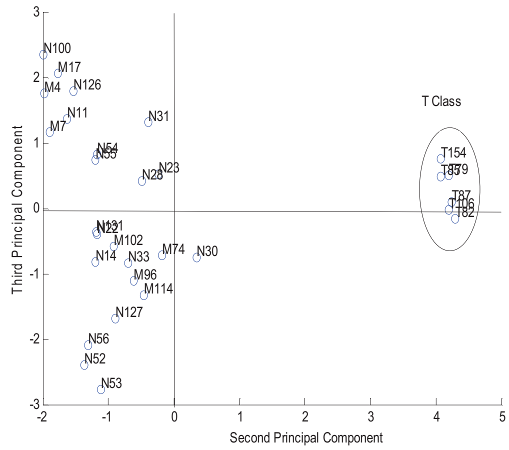
Figure 5. Score plots associated to the spectra of stimulant amphetamines (class M), hallucinogens (class T) and negatives (class N):
a) PC1 vs. PC2; b) PC1 vs. PC3; c) PC2 vs. PC3.




a)




b)




c)

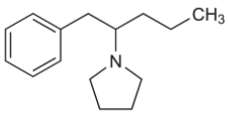
Figure 6. Score plots associated to the spectra of stimulant amphetamines (class M), hallucinogens (class T) and negatives (class N) preprocessed with the *w* selective amplifier:
a) PC1 vs. PC2; b) PC1 vs. PC3; c) PC2 vs. PC3.

Dextroramide has in its molecular structure two aromatic rings and two heterocycles linked to a side chain (see Figure 7d). This compound is an analgesic opioid with a remarkable bioavailability, being almost three times more potent than morphine. Its analgesic effect occurs very rapidly, and tolerance to the analgesic effect is generated relatively slowly as compared to most opioids with rapid effect [10].

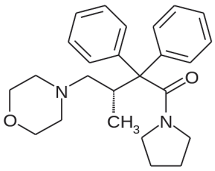
In the case of unprocessed spectra, the class of non-amphetamines (N) forms a relatively diffuse cloud (see Figure 5) in any combination of PCs used for the score plots. Preprocessing the spectra with the *w* selective amplifier leads to a significant reduction in the dispersion of the points associated to the negatives (see Figures 6a and 6c). In this case, the negatives are mostly concentrated in quadrant III of the PC1 vs. PC2 score plot, being characterized by negative PC2 scores (except for N30 - codeine-PFPA) and most of them have negative PC1 scores. In conclusion, spectra preprocessing also leads to an increased sensitivity of the detection method in terms of the recognition of non-amphetamines.


a)


b)




c)



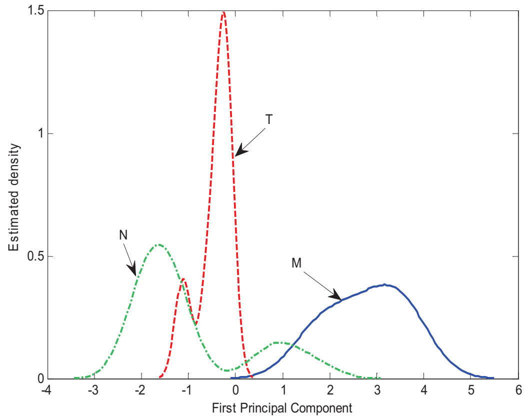

d)

Figure 7. Molecular structure of potential false M positives: a) putrescine b) cadaverine c) prolintane; d) dextromoramide.

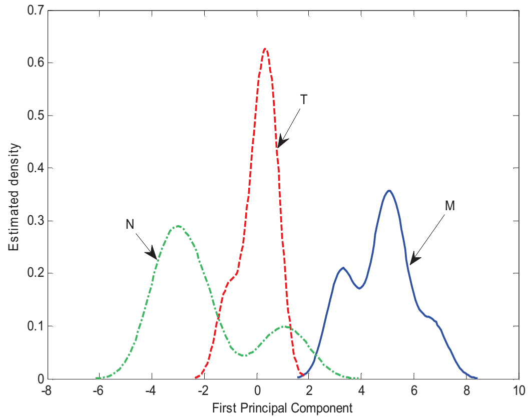
The modeling and discrimination capacity of the PCA detection system has also been assessed by using the estimated density distribution of the scores associated with GC-FTIR spectra. The estimated density distribution gives important information about the predictive capacity of the system. The results presented in Figures 8 and 9 confirm that the best cluster discrimination is obtained by using the PC1 vs. PC2 score plots. The density was estimated with a normal kernel function evaluated at 100 equidistant points $x_i$. The $x_i$ points cover the whole range of scores for each separate class of the modeled compounds. The kernel estimator used to calculate the estimated density function f is [11]:

$$f(x) = \frac{1}{nh} \sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right) \qquad (2)$$

where $h$ is the smoothing leveling parameter, $n$ = 100, and $K$ is the kernel function.




a)



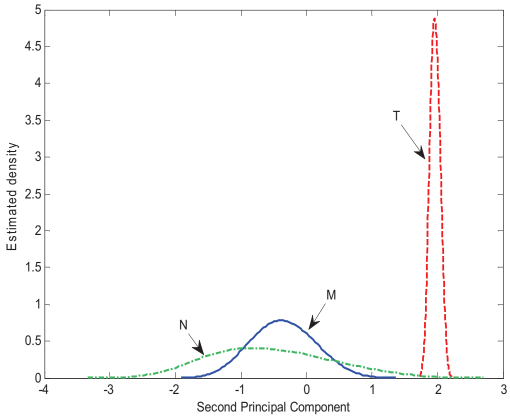

b)

Figure 8. Estimated density distributions calculated with the PC1 scores associated to the stimulant amphetamines (class M), hallucinogens (class T) and negatives (class N) in the case of:
a) unprocessed spectra
b) spectra preprocessed with the *w* selective amplifier.

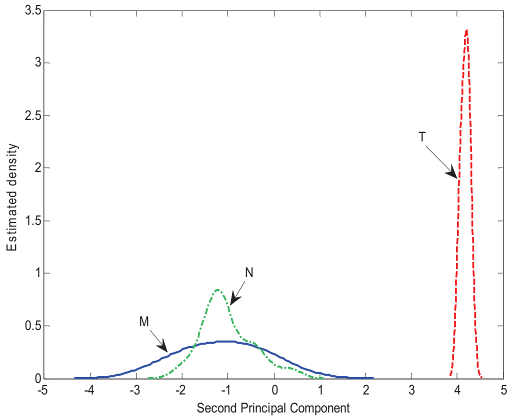
The estimated density distribution for PC1 (see Figure 8) indicates that the *w* selective amplifier leads to a significantly better clustering. The cluster of hallucinogenic amphetamines (class T) condenses so that the local maximum PC1 = -1.111 appearing in the T-class estimated density distribution calculated for the unprocessed spectra becomes a shoulder of the distribution calculated for the scores associated with the preprocessed spectra. The *w* selective amplifier also generates a much better delimitation of the cluster of the stimulant amphetamines (class M) from the cluster of the negatives (class N): the estimated density distributions of the two clusters overlap much less in the case of preprocessed spectra.

Figure 9a shows that if unprocessed spectra are used, some negatives have associated PC2 scores close to those of hallucinogenic amphetamines. In the case of *w* preprocessed spectra, the hallucinogenic amphetamines form the best defined cluster (see Figure 9b). The T class compounds are the only substances with high positive PC2 scores, these scores being substantially larger than those of any other compounds.

The vast majority of non-amphetamines (N) have negative PC2 scores for the *w* preprocessed spectra and thus, the detection system has a significantly better discrimination power from the point of view of the hallucinogenic amphetamines.



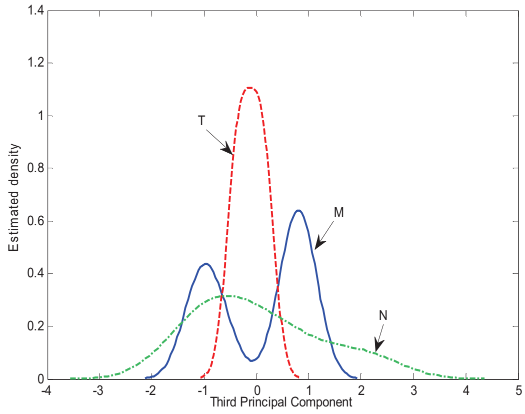

a)



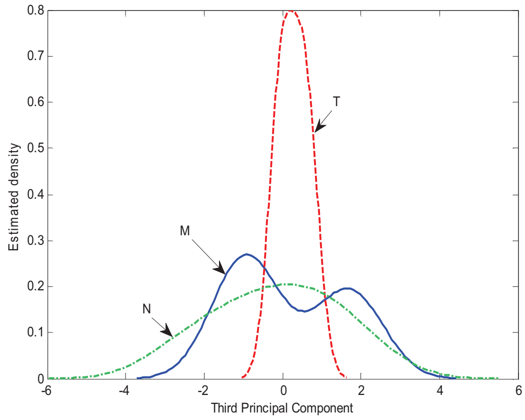

b)

Figure 9. Estimated density distributions calculated with the PC2 scores associated to the stimulant amphetamines (class M), hallucinogens (class T) and negatives (class N) in the case of:
a) unprocessed spectra
b) spectra preprocessed with the *w* selective amplifier.

In the case of unprocessed spectra, as well as for the *w* preprocessed spectra, the estimated density distribution (see Figure 10) outlines that PC3 explains a relatively small amount of variance. Consequently, the estimated density distributions calculated for this PC are virtually overlapped. Figure 10 shows also that the overlap is not improved by spectra preprocessing. As a result, we may conclude that the best detection can be achieved with the first two principal components.




a)




b)

Figure 10. Estimated density distributions calculated with the PC3 scores associated to the stimulant amphetamines
(class M), hallucinogens (class T) and negatives
(class N) in the case of:
a) unprocessed spectra
b) spectra preprocessed with the *w* selective amplifier.

Ideally, the optimization of the detection system should lead to clusters situated as far apart as possible in the multidimensional space (larger distances between their centers) and to a condensation of the clusters (smaller cluster radii). On the other hand, the comparative analysis of the estimated densities calculated for the first three PCs (see Figures 8, 9 and 10) shows that in some cases the maxima of the estimated density distributions corresponding to the *w* preprocessed spectra have smaller values than those of the densities estimated for the unprocessed spectra. For example, this situation is encountered for the estimated density distribution associated to the hallucinogenic amphetamines (class T) for the first three PCs. In other words, preprocessing the spectra with the *w* selective amplifier increases the distance between the centers of clusters M and N, but also leads to a relative dispersion of the T cluster. However, this behavior does not affect the positive effect of the selective amplifier, because the latter cluster remains the best defined even under these conditions.

The estimated density distributions calculated for classes M and N do not have the same behavior as in the case of class T. For example, spectra preprocessing virtually leaves unchanged the maximum value of the estimated density for stimulant amphetamines (M) in the case of PC1 (see Figure 8).

The positive effect of the selective amplifier is best manifested in the case of negatives. In the case of the N compounds, the maximum of the estimated density distribution for PC2 is significantly larger in the case of preprocessed spectra than for the unprocessed compounds (see Figure 9). This behavior explains the improved results obtained for the spectra preprocessed with the *w* selective amplifier regarding the modeling of amphetamines and their discrimination from non-amphetamines (see Figure 6a).

## 5. CONCLUSIONS

Classical methods of spectral database searching for the identification of an unknown compound is based on the calculation of the Euclidean distance between the spectrum of the unknown and each spectrum present in the database. However, this method is effective only when the database contains the spectrum of the analyzed substance (the spectrum of the tested compound is identical to one of the spectra in the database). The detection method proposed in this study has the particular advantage that it can assign the class identity to any unknown having a molecular structure similar (not only identical) to those of the modeled classes. Testing the spectrum of a new compound by the proposed method indicates not only the similarity of its molecular structure to one of the targeted classes of illicit amphetamines, but also the biological activity it is most likely to have. The major advantage of this method is that it allows the recognition of the class identity of an unknown, even if its spectrum is *not* in the training spectral database.

The best results in the detection of amphetamines and their PCA based classification are obtained by using the PC1 vs. PC2 score plots. The class identity assignment is significantly improved by preprocessing the input GC-FTIR spectra with the *w* selective amplifier. The selective amplification of the absorption intensity, depending on the modeling and / or discrimination power of each variable (wave number), leads to a better delineation of the clusters formed by the classes of modeled substances and to increased distances between clusters.

Consequently, the use of the *w* selective amplifier leads to an improved selectivity in assigning the class identity for positive compounds (T hallucinogenic and M stimulant amphetamines) and to a better sensitivity in recognizing the negatives (N non-amphetamines). Under these conditions, the probability of misclassifications (assigning one of the M or T class identities to a negative compound) is much smaller. In other words, preprocessing the GC-FTIR spectra with the *w* selective amplifier decreases the number of false positives and increases the number of correctly classified negatives.

The cumulative explained variance analysis indicated that, in the case of processed spectra, 95,9% of the information contained in 681-dimensional space defined by the initial spectral database can be concentrated into a new hyperspace defined by only 10 independent latent variables (PCs). This result is also very important, indicating that combining PCA with the preprocessing of the GC-FTIR spectra with the *w* selective amplifier generates a detection system requiring considerably less computer resources.

## 6. ACKNOWLEDGEMENTS

This results presented in this paper were obtained within the SOP HRD - TOP ACADEMIC 76822 project. The authors are grateful for the financial support from the European Union, the Romanian government and the "Dunarea de Jos" University of Galati.

## 7. REFERENCES

[1] S. Gosav. *Studii privind identificarea amfetaminelor ilicite prin metode spectrale si de inteligenta artificiala,* Ed. Tehnopress, 2008.

[2] S. Gosav, M. Praisler, *Identificarea automata a amfetaminelor cu retele neuronale artificiale – studiu comparativ*, Buletinul AGIR, XIII - 3 (2008) 12-16.

[3] M. Praisler, I. Dirinck, J. Van Bocxlaer, A. De Leenheer, D.L. Massart, *Exploratory Analysis for the Automated Identification of Amphetamines from Vapour-Phase FTIR Spectra*, Analytica Chimica Acta 404 (2000) 303- 317.

[4] M. Praisler, J. Van Bocxlaer, A. De Leenheer, D.L. Massart, *Automated recognition of ergogenic aids using Soft Independent Modeling of Class Analogy (SIMCA)*, Turkish Journal of Chemistry, 26-1 (2002) 45-58.

[5] Statistics Toolbox 7 User's Guide, 2010

[6] Ş. Ciochină, M. Praisler, *Studiu de fezabilitate privind detecţia şi discriminarea amfetaminelor pe baza spectrelor vibraţionale,* Sesiunea Ştiinţifică Internatională "Uniunea Europeană – Spaţiu de libertate, Securitate şi Justiţie", Bucuresti, 23 mai 2013.

[7] R.A. Lewis, *Lewis' Dictionary of Toxicology*, 1998, CRC Press. pp. 212. ISBN 1-56670-223-2.

[8] E. Kamhi, *Alternative Medicine Magazine's Definitive Guide to Weight Loss*, 2007, Celestial Arts. pp. 14. ISBN 1-58761-259-3.

[9] T. Kuitunen, S. Kärkkäinen, P. Ylitalo, *Comparison of the acute physical and mental effects of ephedrine, fenfluramine, phentermine and prolintane*, Methods and Findings in Experimental and Clinical Pharmacology 6-5 (1984) 265–270.

[10] T.E. Jones, R.G. Morris, N.C. Saccoia, D. Thorne, *Dextromoramide pharmacokinetics following sublingual administration, Palliative Medicine* 10-4 (1996) 313-317.

[11] C. Rose, M.D. Smith, *Mathematical statistics with Mathematica*, Springer-Verlay, 2002.

# SELECTIVE AMPLIFIER USED FOR THE EFFICIENT DETECTION OF AMPHETAMINES

[1]PRAISLER MIRELA, [2]CIOCHINA STEFANUT

[1,2]*"Dunarea de Jos" University of Galati, Department of Chemistry, Physics and Environment, Romania*

**ABSTRACT**

In this article we are presenting the optimization of the selectivity of a multivariate system designed to detect the illicit amphetamines. The input database consists of the GC-FTIR spectra of a selection of relevant compounds, which were preprocessed with a function that selectively amplifies the absorptions with high discrimination and / or modeling power. The analysis of variable loadings determined by Principal Component Analysis (PCA) enabled the identification of the infrared absorptions responsible for the discrimination of well defined clusters and the detection of a large variety of forensic compounds according to their biological (stimulant and / or hallucinogenic) effect. The improvement of the detection results generated by the use of the selective amplifier is discussed in detail.

**Keywords:** *Principal Component Analysis, selective amplifier, amphetamines, loading plots.*

## 1. INTRODUCTION

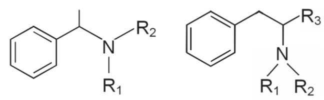
The amphetamines are the most popular synthetic drugs, being consumed for their stimulant effect upon the central nervous system. The chemical structure of amphetamines and many of their physico-chemical characteristics are very similar, as small changes in their molecular structures do not affect significantly their biological effect (see Figure 1) [1]. These similarities provide many opportunities to clandestine laboratories to circumvent the law.

As illicit amphetamines are generally volatile substances, GC-FTIR spectroscopy has become one of the most effective techniques for their identification and detection. The IR spectra allow not only the identification of a particular functional group, but also provide information about its location within the molecular structure [2].

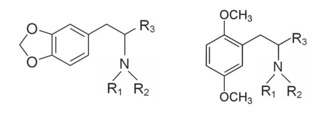
The main objective of this study is to optimize the multivariate detection of new compounds having a similar (not just identical) structure to that of prohibited amphetamines currently encountered on the illegal drug market. The detection is performed by Principal Component Analysis (PCA). The proposed optimization consists of preprocessing the infrared spectra in the training database with a function that acts as a selective amplifier.

## 2. EXPERIMENTAL PART

The database used in this study consists of 30 spectra, 7 of which belong to illicit stimulant amphetamines (see Figure 1a) and 6 belong to hallucinogenic amphetamines (see Figure 1b). The assessment of the importance of each measured absorption in their vibrational spectra was performed by PCA. The stimulant amphetamines included in the input database are: amphetamine, β-phenylethylamine, methamphetamine, N-ethylamphetamine, N-n-propylamphetamine, α-phenylethylamine and N-methyl-α-phenylethylamine (class code M). The modeled hallucinogenic amphetamines are: 3,4-methylendioxyamphetamine, 3,4-methylenedioxy-N-ethylamphetamine, 1-(3,4-methylenedioxyphenyl)-2-butanamine, 3,4-methylenedioxymethamphetamine, N-methyl-1-(3,4-methylenedioxyphenyl)-2-butanamine and 3,4-methylenedioxy-N-hydroxyamphetamine (class code T).




AMP: $R_1$= H; $R_2$=H; $R_3$= $-CH_3$
BPEA: $R_1$= H; $R_2$=H; $R_3$=H
MAMP: $R_1$= H; $R_2$=$-CH_3$; $R_3$= $-CH_3$
EAMP: $R_1$= H; $R_2$=$-CH_2-CH_3$; $R_3$= $-CH_3$
PAMP: $R_1$= H; $R_2$=$-(CH_2)_2-CH_3$; $R_3$= $-CH_3$
APEA: $R_1$= H; $R_2$=H;
MAPEA: $R_1$= H; $R_2$=$-CH_3$;
a)




MDA: $R_1$= H; $R_2$=H; $R_3$= $-CH_3$
MDEA: $R_1$= $-CH_2-CH_3$; $R_2$=H; $R_3$= $-CH_3$
BDB: $R_1$= H; $R_2$=H; $R_3$= $-CH_2-CH_3$
MDMA: $R_1$= $-CH_3$; $R_2$=H; $R_3$= $-CH_3$
MBDB: $R_1$= $-CH_3$; $R_2$=H; $R_3$= $-CH_2-CH_3$
N-OH-MDEA: $R_1$= -OH; $R_2$=H; $R_3$= $-CH_3$
b)

Figure 1. The molecular structures of the main amphetamine analogues included in the database.
a) stimulant amphetamines (class code M);
b) hallucinogenic amphetamines (class code T).

The experimental conditions used for recording the spectra have been presented in detail in previous studies [3,4]. The spectral database also contains the spectra of 17 non-amphetamine compounds of toxicological interest (class code N) were also included, i.e. codeine-PFPA, γ-hydroxybutyric acid (TMS), caffeine, γ-valerolactone, γ-butyrolactone, cadaverine, piracetam, bemegride, β-butyrolactone, γ-hydroxyvaleric acid (TMS), cocaine I.S., γ-butyrolactone artifact 1 (thermal degradation product generated during the chromatographic separation of γ-butyrolactone), nicotamide, cadaverine-HFBA, dextromoramide, prolintane and putrescine.

## 3. RESULTS AND DISCUSSIONS

### *3.1. Preprocessing of experimental spectra*

In order to optimize the PCA detection of amphetamines, the spectra were preprocessed by using a *w* function that amplifies the absorbance measured at those wave numbers that are identified as having a high modeling and / or discrimination power. The aim was to obtain separate clusters that are as well defined as possible for the modeled classes.

In order to define the selective amplifier *w*, the spectra contained in the database were grouped in two classes as follows: class I, which includes the spectra of positive compounds (M, T) and class II, which includes the spectra of the non-amphetamine compounds. The values of the selective amplifier *w* were calculated for each wave number as follows [3,4]:

$$w_k = \frac{\sum \frac{A_I^2}{N_I} + \sum \frac{A_{II}^2}{N_{II}} - 2\sum\sum \frac{A_I A_{II}}{N_I N_{II}}}{\sum \frac{\left(A_I - \overline{A_I}\right)^2}{N_I} + \sum \frac{\left(A_{II} - \overline{A_{II}}\right)^2}{N_{II}}} \quad (1)$$

where $A_I$ and $A_{II}$ are the absorptions in GC-FTIR spectra corresponding to the samples of classes I and II, $N_I$ and $N_{II}$ are the number of samples included in classes I and II.

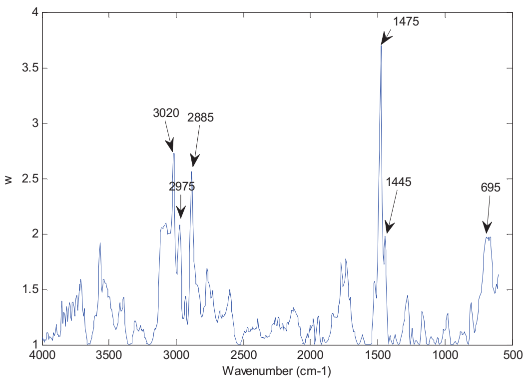



Figure 2. The selective amplifier *w* used for preprocessing the GC - FTIR spectra

Function *w* (see Figure 2) acts as a selective amplifier, as it amplifies the absorbances measured at the wave numbers identified as having a high modeling and/or discrimination power (for which $w > 1$) and leaves unchanged the absorption intensity for the unimportant wave numbers (for which $w = 1$).

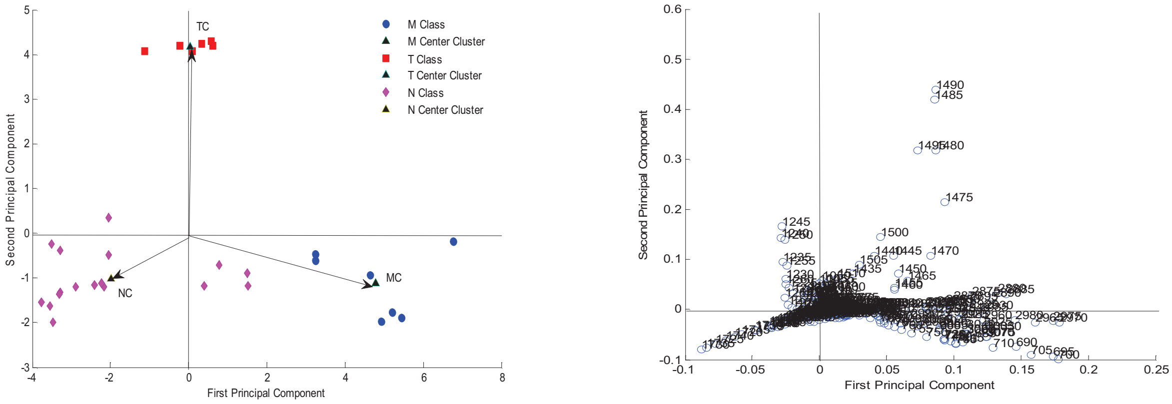
The comparative analysis of the score plots indicated that the class identity assignment is improved by preprocessing the GC-FTIR spectra with the selective amplifier *w* [5], which yields better defined clusters associated with the modeled classes of compounds (see Figure 3, 4 and 5). The significant increase of the distance between the centers of the clusters has led to improved selectivity in assigning the class identity of positive compounds (M and T), as well as to a very good sensitivity in recognizing the negatives (N). The improved selectivity decreases the probability of misclassification, i.e. assigning one of the class identities of the positives M or T to a negative compound. Consequently, we have performed the analysis of the loading plots in order to determine which absorptions were identified by the selective amplifier as having high modeling and / or discrimination power and correlate these absorptions with the various chemical groups present in the molecular structure of the modeled compounds.

### *3.2. Analysis of the PCA loading plots obtained with the spectra preprocessed with the w selective amplifier*

PCA was performed by using the *MATLAB 2012a* software [6]. The optimal number of principal components (PC) by means of which it is useful to perform PCA was determined by evaluating the cumulative explained variance, which shows that the first 10 PC lead to a cumulative explained variance of 95,9% [5].

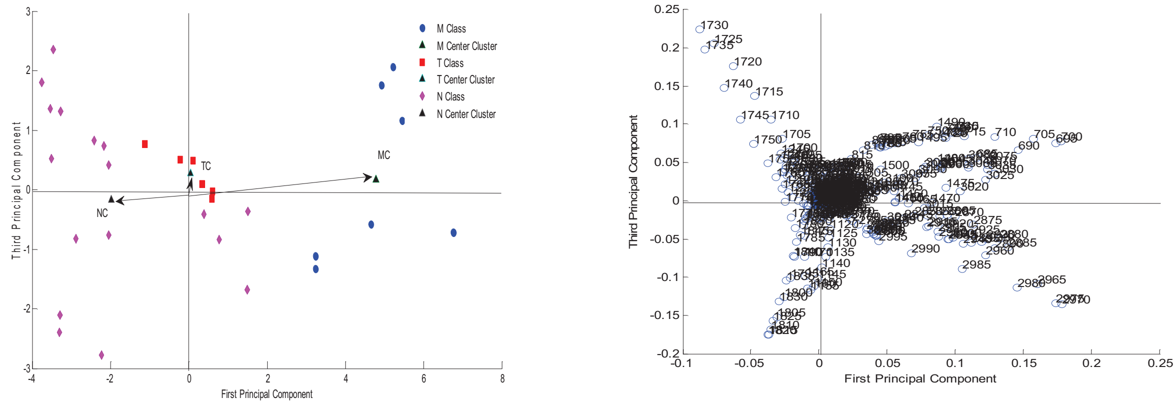
The analysis of the score plots indicated that in the case of the spectra preprocessed with the *w* selective amplifier, the most appropriate representations for observing the clusters formed by the modeled classes are those obtained by combining the first three PCs (see Figures 3a, 4a and 5a). This was predictable, as the first three PCs yield a cumulative explained variance of 73,6% [5]. The scores analysis reveals the formation of two well defined clusters that are modeling the amphetamines analogues according to their biological effect (stimulants – class M and hallucinogenic amphetamines – class T). In order to identify which are the main absorptions contributing to the formation of these clusters, we have performed the analysis of the associated loading plots.

The variables having the most important contribution in shaping a cluster have position vectors in the loading plots pointed towards the direction of the position vector of the cluster's center defined in the score plots. These variables are positively correlated. From these variables, those characterized by the highest loadings have also the most significant modeling power for the respective cluster. The variables having the position vectors pointing in the opposite direction are negatively correlated with the variables mentioned above. From these, the variables characterized by the highest loadings have the most important discriminating power for the cluster in question. The variables whose position vectors are perpendicular to the axis of correlated variables are independent, i.e. they have no contribution to the



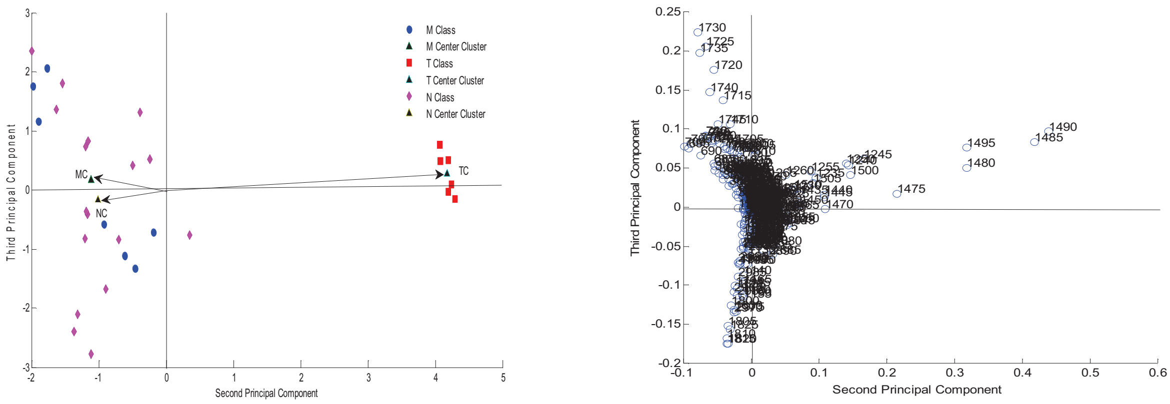

a) b)

Figure 3. Representation of PC1 vs. PC2 for the database spectra processed with the *w* selective amplifier: a) score plots and position vectors of each cluster center; b) loading plots.




a) b)

Figure 4. Representation of PC1 vs. PC3 for the database spectra processed with the *w* selective amplifier: a) score plots and position vectors of each cluster center; b) loading plots.




a) b)

Figure 5. Representation of PC2 vs. PC3 for the database spectra processed with the *w* selective amplifier: a) score plots and position vectors of each cluster center; b) loading plots.

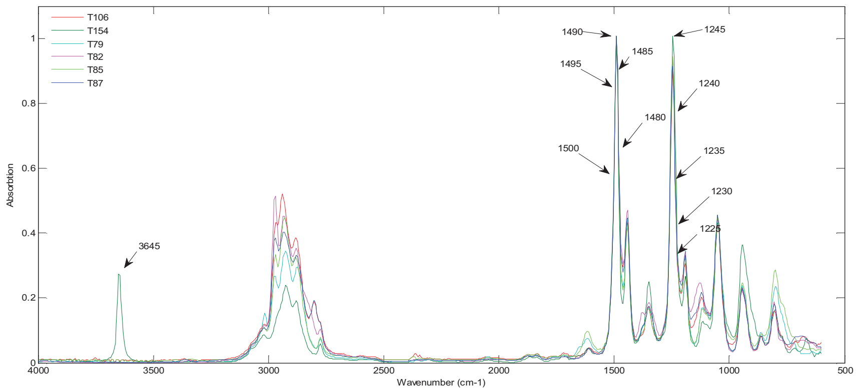



Figure 6. The GC-FTIR spectra of the main hallucinogenic amphetamines (class code T).

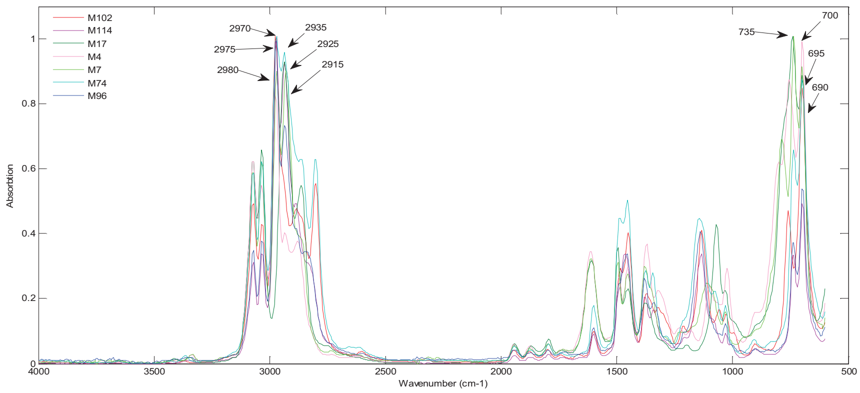



Figure 7. The GC-FTIR spectra of the main stimulant amphetamines (class code M)

modeling or to the discrimination of the compounds forming the analyzed cluster. The absorptions characterized by small loadings have a small contribution to cluster modeling or discrimination.

In order to increase the objectivity in the identification of the variables responsible for the formation of each cluster, the positions of their centers were determined by using the scores associated to the spectra of the compounds that belong to each separate cluster. The coordinates ($x_c$, $y_c$) of the center of a cluster was calculated as [7]:

$$x_c = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad y_c = \frac{1}{n}\sum_{i=1}^{n} y_i \qquad (2)$$

where $n$ is the number of compounds that form the cluster, $x_i$ their scores associated to the PC represented on the abscissa and $y_i$ their scores associated to the PC represented on the ordinate (see Figure 3a, 4a and 5a).

The analysis of the score plots has shown that the best cluster discrimination occurs in the representation of PC1 vs. PC2 scores (see Figure 2a, 3a and 4a). The PC1 vs. PC2 loading plot (Figure 2b) indicates the existence of two sets of variables that ensure the remarkable specificity in detecting the hallucinogenic amphetamines (class T). The first set consists of those absorptions whose position vectors make the smallest angles with the position vector of the center of the T cluster and have the highest PC2 loadings, i.e. 1470, 1475, 1480, 1485, 1490, 1495 and 1500 $cm^{-1}$. At these wave numbers, the spectra of hallucinogens show a very stable absorption band associated to the vibrations of the trisubstituted aromatic ring present in their molecular skeleton (see Figure 6) [8].

The second set of consists of the wave numbers 1235, 1240, 1245, 1250 and 1255 $cm^{-1}$ , which define the envelope of the 1245 $cm^{-1}$ absorption band, associated to the stretching vibration of the C-O group in the *para* and *ortho* position of the heterocycle present in the molecular structure of hallucinogens. As shown in Figure 6, this band is also very stable in position and shape, being virtually insensitive to small changes in the substitution pattern of the amino group present in the side chain of the hallucinogens. A difference can only be seen for 3,4-methylenedioxy-N-hydroxyamphetamine (T154), in whose spectrum the 1245 $cm^{-1}$ band has a stronger intensity due to the additional absorption generated by the O-H out-of-plane deformation vibrations [8].

Figure 3b also indicates the variables with no influence on the T cluster formation, whose position vectors are perpendicular to the position vector of the center of the T cluster. The independent variables are in the range 2970 - 3030 $cm^{-1}$. This region contains the spectral window 3000 - 3015 $cm^{-1}$ specific to the absorption bands associated to the C-H stretching vibrations of the trisubstituted aromatic ring. In this region most hallucinogens have weak absorption bands (see Figure 6). This is due to the fact that the aromatic ring is trisubstituted, and therefore the number of C-H bonds present in the heterocycle structure is small [8]. The absorption bands in the region 2970 - 2980 $cm^{-1}$ are specific to the aliphatic side chain of the hallucinogens. In this case also, the hallucinogenic amphetamines have medium or weak absorption bands (see Figure 6). These absorptions are irrelevant for modeling the T cluster because all these chemical groups are also present in the molecular structure of stimulant amphetamines (M). Instead, they are important for defining the M and N clusters.

The variables with the greatest influence in generating the cluster of the stimulant amphetamines (class M) are the absorptions that have the largest positive PC1 loadings and the position vectors oriented approximately in the same direction as the position vector of the center of cluster M. These are the absorptions ranging from 695 to 735 $cm^{-1}$ and from 2900 to 2990 $cm^{-1}$ (see Figure 3b and 4b). The absorptions in the first spectral range (see Figure 7) characterize the substitution pattern of the aromatic ring. In particular, the absorptions showing in the 695-735 $cm^{-1}$ region in the spectra of stimulant amphetamines are associated to the vibrations of their monosubstituted aromatic ring. The second set of absorptions are due to the absorption bands showing between 2975 $cm^{-1}$ and 2935 $cm^{-1}$, associated to the asymmetric stretching vibrations of the $–CH_3$ and $–CH_2$ groups present in the amphetamines aliphatic side chain [8].

The independent variables for class M belong to the 1475 - 1500 $cm^{-1}$ region. This spectral window (see Figure 7) contains the absorption band showing at 1495 $cm^{-1}$ for the compounds M7, M4, M114, M96, M17 and at 1485 $cm^{-1}$ for the compounds M74, M102, which are associated to the degenerated stretching vibration of the C - C bond present in the monosubstituted aromatic ring [8]. The position and particularly the intensity of this band vary depending on the nature of the side chain of the molecular structure of stimulant (M) amphetamines. The lack of significance of these absorptions for the modeling of this cluster is explained by the fact that the most stable absorption band specific to hallucinogens shows also in this region (see Figure 6).

## 5. CONCLUSIONS

The proposed artificial intelligence method carries out the detection of amphetamines according to their biological activity, which is associated to the substitution pattern of the aromatic ring present in the amphetamines molecular skeleton. The proposed optimization method, i.e. the preprocessing of the GC-FTIR spectra with the *w* selective amplifier, leads to a more efficient recognition of the amphetamines.

The *w* selective amplifier generated an improved detection of the hallucinogenic amphetamines, as the presented method is both selective and sensitive in detecting these compounds. In the case of stimulant amphetamines, the optimization preserves the sensitivity of the detection method, and significantly improves its selectivity.

The impact of each FTIR absorption on the efficiency of the proposed detection method (PCA) was assessed by identifying the absorptions with the most important modeling and / or discrimination power, as well as the molecular units that are generating these bands. The objectivity of this process was enhanced by selecting the variables according to their orientation of the position vectors in the loading plots, as compared to the position vector of the center of each cluster in the score plot. The analysis of the loading plots allowed the identification of the main absorptions contributing to the modeling and discrimination of amphetamines according to their biological activity, i.e. stimulants (class M) and hallucinogens (class T).

But maybe the most important result of the variables' selection is that the important absorptions appear at consecutive wave numbers. In other words, the performance achieved in defining the clusters is secured by taking into consideration the *shape* of the important absorption bands, not only the absorptions measured at various individual wave numbers.

## 6. ACKNOWLEDGEMENTS

The results presented in this paper were obtained within the SOP HRD - TOP ACADEMIC 76822 project. The authors are grateful for the financial support from the European Union, the Romanian government and the "Dunarea de Jos" University of Galati.

## 7. REFERENCES

[1] F.P. Smith, *Handbook of Forensic Drug Analysis,* Elsevier Inc, 2005.

[2] M. Praisler, J. Van Bocxlaer, A. De Leenheer, D.L. Massart, *Chemometric detection of thermally degraded samples in the analysis of drugs of abuse with GC-FTIR spectroscopy*, Journal of Chromatography A, 962 (2002) 161-173.

[3] M. Praisler, I. Dirinck, J. Van Bocxlaer, A. De Leenbeer, D. L. Massart, *Exploratory analysis for the automated identification of amphetamines from vapour – phase FTIR spectra*, Analytica Chemica Acta, 404 (2000) 303- 317.

[4] M. Praisler, J. Van Bocxlaer, A. De Leenbeer, D. L. Massart, *Automated Recognition of Ergogenic Aids Using Soft Independent Modeling of Class Analogy (SIMCA)*, Turkish Journal of Chemistry, 26-1 (2002) 45-58.

[5] S. Ciochină, M. Praisler, *Optimized detection of amphetamines based on principal component analysis,* submitted for publication, Annals of Constanta Maritime University, 2013.

[6] Statistics Toolbox 7 User's Guide, 2010

[7] B.G.M. Vandeginste, *Handbook of Chemometrics and Qualimetrics, PartB (vol. 20B),* Elsevier, 1998.

[8] S. Gosav, *Studii privind identificarea amfetaminelor ilicite prin metode spectrale si de inteligenta artificiala,* Ed. Tehnopress, 2008.

# SECTION V
## ENGLISH FOR SPECIFIC PURPOSES

# INSIGHTS INTO SPECIALIZED TRANSLATION. THE CASE OF MARITIME TEXTS

COJOCARU OLGA

*University of Galati, Romania*

**ABSTRACT**

The paper intends to raise awareness on the important role played by globalization in our production and perception of language, as well as the changes brought to the status of English as an international *lingua franca*. The emergence of the new branch of Translation Studies, namely LSP translation, draws attention towards an imminent search for standardization of terminology and for this purpose, the corpus-based approach suggested in the paper attempts to highlight the recurrent problems encountered at a lexical and terminological level in different stages of a translation project involving an institutional text.

**Keywords:** *Globalization, Language for Special Purposes, Specialized Translation.*

## 1. INTRODUCTION

Closely following the imminent changes occurring to language in today's globalized world as well as the impact of recent advances in technology, the paper sets to highlight the most important lexical and terminological issues encountered in the translation process, when working with institutional texts.

The corpus-based approach draws on Boris Pritchard's study regarding the lexical aspects of translating specialized texts [1]. Taking the official issue of Standard Marine Communication Phrases (IMO SMCP 2001) published by the International Maritime Organization, in English (2002) as source language text (SLT), Pritchard deals with its translation into Croatian as the target language text (TLT). However, for the purpose of our research, we shall focus only on the lexical aspects applicable to all translations.

In an attempt to outline the three major aspects and problems involved in the translation of institutional texts, we will discuss: the nature of the translation project, the textual features of the IMO SMCP 2001 phrasebook and, most importantly, the lexical/terminological issues encountered in the process.

## 2. THE POSITION OF ENGLISH IN THE GLOBAL CONTEXT

The concept of globalisation falls into the category of dominant "buzz words" in the social sciences debates and in the media today [2]. Christina Schäffner [3] rightfully considers it as influential in all social, political and economic aspects of life and attributes this influence to the undergoing developments in the world of today. The results can be seen in the rise of multinational companies, in the attempts undertaken by companies to expand into international markets and in the contribution the Internet has as a digital marketplace.

The way information travels: instantly, in unlimited quantities and via numerous channels, redefined the way we produce and perceive language. Considering this advances in technology, Snell-Hornby [4] makes a threefold classification of the areas that radically changed in the last years: the nature of the material the consumer has to process, the language in which it is presented and the concept of text.

In the context of global discourse the status of English as an international *lingua franca* (a language widely used in some region for communication among people speaking a variety of languages [5]) becomes essential. There are two main reasons for this development: the first is the world-wide domination of North-American technology and culture, and the second is related to the easily accessible grammar and core vocabulary in everyday conversation [6]. The official language of 52 countries, with a total population of more than 170 million, English holds the key position as the language spoken in the leading economic power of the world: the United States [7]. Despite its shared dominance within the European context (alongside German, French and Italian), its status within the European Union as one of the chief means of communication led Snell-Hornby to conclude that the world language English can be seen as:

*'the free-floating lingua franca ('International English') that has largely lost track of its original cultural identity, its idioms, its hidden connotations, its grammatical subtleties, and has become a reduced standardized form of language for supra-cultural communication'* [8].

## 3. INTRODUCING LANGUAGE FOR SPECIAL PURPOSES

A significant aspect of the new globalized society regards dealing with more than one language, especially within professional settings. Emphasis is now placed on the process of localization of products and services, and translation is now put on an inferior level, in the case of multilingual text production. [9]

In this context, we draw on Reiss and Vermeer's definition of a specific branch of translation studies, called the LSP translation, where LSP stands for Languages for Special Purposes. They consider any text as an "offer of information" [10] and the receiver is the one who chooses what he/she considers important or useful to his purposes. The translator is a special type of receiver, having power to construct a new text for the target culture, based on his opinion of what elements are important and need to be transferred into the target text. This is regarded as the *Skopos* rule, explained by Vermeer as follows:

*Each text is produced for a given purpose and should serve this purpose. The Skopos rule thus reads as follows: translate/interpret/write in a way that enables your text/translation to function in the situation in which it is used and with the people who want to use it and precisely in the way they want it to function.* [11]

Drawing on the above presentation, Sandrini considers the LSP translation:

"*the exteriorization of specialized knowledge systems and cognitive processes weighed and selected from an information offer (interiorisation) with the objective of disseminating them in another linguistic (interlingual) and cultural context (transcultural) governed by skopos"* [12]

In an attempt to establish a framework for LSP translation, it is utterly important to consider the recent developments in technology and the role they play in the translation process. LSP has come to assume, according to Christopher Taylor, the meaning of subject-based texts in areas such as chemistry, law, medicine and even politics. While this categorization reflects the meaning of "special", Taylor [13] describes the meaning of the word "purpose" as the writer's motivations, his own way of defining, classifying, describing, not only applying the norms and characteristics of the subject.

We live in the age of globalization, therefore we need to seek an international standardization of terminology in order to deal with the immensity of specialist terms coming from different linguistic and cultural systems. For this purpose the European Union created sophisticated database systems and efficient translation programmes to deal with the task of specialized translation. Moreover, the search for standardization created some unexpected consequences. Hartley/Paris [14] point out the production of the so-called "controlled languages": computer driven creations in which a text is limited to a specific number of effective items, controlled by the text producers. Due to financial and commercial reasons, the development of "controlled languages" is imminent and together with various translation memory tools and machine-assisted translation have established themselves as essential tools in today's world.

## 4. WORKING WITH SPECIALIZED TEXTS: A CORPUS-BASED APPROACH.

### *4.1. The Translation Project*

This section of our paper takes up the institutional text Standard Marine Communication Phrases (IMO SMCP 2001) as source language text and its translation into Croatian as the target language text (TLT), and goes on discussing the main features of the translation project. [15] Importantly, the assignment follows the recommendations of the International Maritime Organization concerning the translation of the original English text of IMO SMCP 2001, where IMO is an UN sub-organisation responsible for safety at sea and protection of the marine environment, into the national languages of the member states.

Due to its status of lingua franca, English is part of the official languages and the recommended working language of the sea, not to mention in international navigation and maritime industry for a century. Furthermore, a team of non-professional translators[1] jointed the project with the goal to put together a list of mandatory phrases for an easier sea communication in safety conditions. Functional as an official document since 2002 (although adopted by IMO in 2001) the list is referred to as the IMO SMCP 2001[2] and falls into the category of 'restricted languages' [16] and 'controlled languages' [17], regulated by simplistic rules for lexis and grammar. As mentioned above, English is the official language for safety-related communication in the maritime world, but national versions of IMO SMCP 2001 are also available.

The objective of the translation project discussed here is to find a middle ground between Newmark's semantic equivalence [18], where the position of institutional text allows a SLT-oriented translation where the content of the message requires complete and precise preservation, and Vermeer's 'functional equivalence' found in its *Skopos Theorie* [19] explained above. Finally, the main function of the IMP SMCP 2001 is to provide necessary linguistic competence for the safety of navigation and protection of the maritime environment, not only for the business of shipping but also for yacht and pleasure boat skippers in general.

### *4.2. Textual features of institutional texts*

The source text analysis reveals key points regarding the aims, features and the use of the IMO Standard Maritime Communication Phrases (IMO SMCP 2001). Firstly, the threefold classification regarding their purpose implies assisting the grater safety of navigation, standardizing used language in communication for navigation at sea, and supporting the maritime training institutions in order to meet the previously mentioned objectives. Secondly, due to its status of restricted and controlled language, the IMO SMCP 2001 is regulated by the following communicative features: basic knowledge of English, including simplistic rules for lexis and grammar, a simplified version of maritime English, and standardized structures to reduce misunderstanding. Interestingly, the above mentioned textual features determine the pragmatic value of the phrases as well as the requirements of the translation. [20]

[1] Seafaring experts, ship`s officers- members of the Nautical Department of the Faculty of Maritime Studies of the University of Rijeka, guided by the author of the text as the translation coordinator or the editor in chief and by the Head of the Nautical Department as chief consultant or assistant editor.

[2] First introduced in 1977 as SMNV (Standard Marine Navigational Vocabulary), amended in 1985, adopted by IMO in 2001 and published in 2002 under the name of Standard Marine Communication Phrases.(better known in the international maritime world and quoted as IMP SMCP 2001).

The phrases are essential in emergency situations occurring under pressure and stress, therefore attention is paid to the receiver's needs. In order to achieve communicative competence and efficiency, the functional words (i.e. articles or auxiliary verbs) are omitted, obtaining elliptical and truncated sentences. An important aspect is also the mode of the phrases - primarily intended to be spoken, not written. [21]

Another important feature of the IMO SMCP 2001 is its structure. On the one hand, the list is divided according to its application into External Communication Phrases (ship-to-ship, ship-to shore, shore to-ship) and On-board Communication Phrases; and on the other hand, according to status into Part A – an official idiom for mandatory use at sea, in spoken and written communication alike; and Part B- that deals with other on-board standard safety-related phrases, and can prove useful for maritime English instruction, despite its non-mandatory use. Moreover, the legal document contains a preamble, citations, recitals, enacting formula, and enacting terms (main and final provisions), while the glossary list the principal terms and their definitions. [22]

In an attempt to define and describe the phrasebook, Pritchard considers it as *a thematically arranged list of phrases dealing with a number of selected maritime topics and representing the dominant speech acts and moves in maritime communications* [23] and separates it from 'general' English due to the linguistic traits typical cu maritime discourse, while Perego (2004) sees them as following *'a clearly codified, widely accepted pattern depending on the standard methodological framework of the discipline in question'*.[24]

A summary of other communicative features for the IMP SMCP 2001 implies the avoidance of synonyms and contracted verbal forms, at the same time providing complete and alternative answers to simple questions, as well as a phrase for each event, and finally structuring phrases according to the principle theme. [25]

*4.3. Lexical and terminological issues*

The purpose of our study is to focus on the body of the IMO SMCP 2001 phrases in order to determine some lexical and terminological issues encountered in the different stages of the translation project. Therefore, attention is paid to the lexis and terminology of Maritime English and we start with a brief outline of the characteristics that such texts encounter, keeping in mind their restricted use of languages [26]: monoreferentiality, reduction of ambiguity, conciseness or semantic uniqueness, and specialization of meaning of words found in general language. Moreover, the texts are empty of any emotional tone. [27] In this context, we understand how the general terminological requirements are partially met, but we also agree to Pritchard's example of ambiguous phrases (e.g. casualty, line, cable) and semantically unstable phrases (for instance, neologisms in either source language text of target language text).[28]

With regard to the terminology used in Maritime English, most studies [29] share the idea that technical vocabulary alone is not sufficient for any ESP study, due to distinctive topics, text format, style and rhetoric etc. found in any specialized discourse. Drawing on Pritchard (2005) we distinguish five types of lexical units in Maritime English terminology:

1. Firstly, the low number of strictly technical terms specific only to nautical use (e.g. general nautical terms or, terms referring to ship design, construction, cargo work ship handling etc.).
2. Secondly, a set of semi-specific, highly polysemous, general vocabulary items adapted in the maritime context: at the verb level (haul, steer), in the case of descriptive adjectives (clear, clean, heavy) and semi-lexical nouns (line, position, time, situation).
3. Thirdly, the multi-word lexical units (MWLU) are lexical combinations and associations ever-present in Maritime English: compounds (e.g. shipping forecast), collocations (draw up), collocations with verbs such as: let, make, set, get; that are considered the most productive means of lexicalizing the new concepts in the maritime world.
4. Fourthly, the use of idiomatic phrases (either prepositional or adverbial) in sip handling operations (e.g. for mooring or anchoring: heave in/on/up/to/away).
5. Finally, discourse connectors and markers are typical in maritime communication and in written maritime discourse. [30]

A discussion regarding the most suitable translation procedures for the study of English (SL) and Croatian (TL), led to some interesting findings, applicable if you will, to most translations. Following an eclectic approach in order to secure translation equivalence, the subject experts considered borrowing and loan translation the most suitable solutions for the transfer of new or uncommon concepts, while professional translators chose neologisms or the invention of completely new terms by semantic translation for the process. Oppositely, modification and adaptation were barely suggested as methods. The corpus-based analysis revealed aspects of transposition (a shift from phrases to single verbal in translation) as well as a shift in grammatical mood (indicative vs. imperative). The less lexicalized terms in the target language are translated using paraphrase. [31]

Frequent translation problems arise at the level of multi-word lexical units (compounds and collocations), due to the syntactic difference of the two languages, as well as different in word formation and composition. For instance, the corpus-based analysis revealed a simple rendition of collocations of the type 'adj+noun', while the translation equivalents for English compounds of 'noun+noun' type raised several issues at a syntactic and semantic level. [32]

Moreover, the use of highly specialized compounds may also cause difficulties in translation, because the member-elements of multi-word lexical units are sometimes semantically deceiving. For instance, in the term 'damage control', the word *damage* does not refer to its dominant sense (`harm impairing the function and condition of a thing'[3]), hence the translation must take into consideration the new meaning of the compound as

[3] *Collins Internet-connected Dictionary* 2004, Harper Collins Publishers.

a single lexical unit within the maritime/naval context. If we consider the lexical combination 'damage control team' we encounter misleading elements due to the ambiguous nature of the words *damage* and *control* even in specialized technical contexts (e.g. 'physical harm' vs. 'remuneration/compensation for damage' for the first term, and 'management' vs. 'supervision/a means of checking' for the second term), as well as the sociolinguistic issues raised by the third terms *team.* In this case, literal translation is not advised. A solution could be to look for linguistic traits in order to distinguish the contextual meaning of the word *damage* and here, the IMP SMCP 2001 proves to be a powerful tool in establishing concordance lines at a syntactic and semantic level. Analyzing the data, the phrasebook establishes a frame of reference for the compound and shows how the individual element *damage,* gained a totally new meaning, corresponding to the definition found in the Glossary of IMO SMCP 2001: 'A group of crew members trained for fighting flooding in the vessel'. There are other multi-word lexical units that fit the same category as the above term, i.e. difficulties in translation, but due to lack of space we mention only a few: tidal stream, lifeboat station, bridge team management, etc. The above presented typology of maritime terminology shows us how ambiguity has come to be considered one of the main problems in the translation of specialized discourse text, therefore the specialized translator must succeed in providing a correct semantic and pragmatic interpretation of the term in the target language. [33]

Other translation issues arise when dealing with verbal phrases. In this case, the analysis of *stand by* shows a lexical representation of a number of speech acts of great importance in maritime safety. For this reason, the IMO SMCP 2001 Glossary provides a twofold definition for the verbal phrase: 'to be in readiness or prepared to execute an order' and 'to be readily available', as in *Stand by lifeboats/liferafts*; uncommon in an institutional text that presents rules on safety communications. [34]

For lexical sets, we encounter difficulties in all stages of the translation process and that call for special attention. Typical of specialized discourse, lexical sets are the result of cognitive processes, therefore are unable to map the extralinguistic reality in an appropriate manner. There are various types of lexical texts that raise issues in maritime text translation, but we focus mainly on the ones found in the IMO SMCP 2001 phrasebook. Thus, especially difficult to translate were lexical sets: describing actions (action, measures, steps, activities), indicating degrees of danger at sea (incident, accident, emergency, etc.) and terms describing groups of people involved in maritime operation (centre, unit, group, team, etc.). [35]

The translation of organization names, authorities, objects, etc. also raises great concern within the project. The phrasebook contains names of institutions (IMO), conventions (STCW), codes (IMDG code), authorities (VTS), systems (Global Positioning System/GPS), ship team units (fire-fighting team), procedures (COW) etc., that prove difficult cu to understand if addressed outside the maritime public or if they are not in their original English language. The result is in most cases an unintelligible reading of the original name and due the loan translation procedure they sound strange even to maritime professionals. Moreover, within the English language conventions the important concepts are written in capital letters, baring a close resemblance to proper names and due to their abbreviations and acronyms, the situation becomes even more complicated. Here, we mention the most frequent and completely lexicalized concepts/names in maritime English: Vessel Traffic Service (VTS); Global Maritime Distress and Safety System (GMDSS) and Maritime Rescue Co-ordination Centre (MRCC). These terms are often replaced by their abbreviated SL form and the most frequent translation procedure for them is by lexical code-switching, while their explanation is found in footnotes. [36]

Last, but not least, this type of translation brings forth the issue of lexical choice: the dilemma of using a foreign or a domestic word, in most cases by means of loan translation, for both English and imported terms. Technical texts created for legal purposes reject the use of doublets therefore they adopt the domestic option despite the flaws in real communication.[37]

## 5. CONCLUSIONS

After paying close attention to the new contexts for translation, characterised by globalization, specialization and digitization, we have to acknowledge the fact that the recent advances in technology and the internationalization of markets led to an increased interest in the process of translating, especially in the field of Language for Special Purposes. For this reason the first part of our paper focused on providing a context and a definition for LSP translation in today's global context.

The hands-on approach text dealt with the main issues that arise when embarking on a project of translating any institutional text. We starting with a source-text analysis where elements of layout, structure and discourse markets were discussed, and then we focused on the lexical, especially terminological issues encountered: dealing with borrowings and loan translation, ambiguity, multi-word lexical units, lexical sets and dealing with names and abbreviations, etc. Finally, an overview of procedures adopted for this type of texts includes: literal translation, especially in the initial stage of translation, word-class transposition (e.g. verb to noun), and only on rare occasions the translator chooses free translation.

We have seen how institutional and, in this case, maritime texts raise important issues in translation and due to their high status in assuring safety at sea and protection of the marine environment, it is essential to establish accurate maritime terminological norms in the target languages.

## 6. REFERENCES

[1][15][19][20][21][22][23][28][31][32][33][34][35][36] [37] PRITCHARD, B., Some Lexical Aspects of Translating Specialized Texts*,* in Gotti, M. & Šarčević

S., (eds) *Insights into Specialized Translation*, Bern: Peter Lang, 2006: 261-288.
[2][3] SCHÄFFNER, C., *Translation in the Global Village,* Clevedon/Buffalo/Toronto/Sydney: Multilingual Matters Ltd., 2000.
[4] [6] [8] SNELL-HORNBY, M., Communicating in the Global Village: On Language, Translation and Cultural Identity, in Schäffner, C. (ed.) *Translation in the Global Village.* Clevedon/Buffalo/Toronto/Sydney: Multilingual Matters Ltd., 2000: 11-28.
[5] TRASK, R. L., *Key Concepts in Language and Linguistics*, London/New York: Routledge, 1999:11.
[7] NAVARRO, F., *Which is the world's most important language?* Lebende Sprachen XLII, 1997: 5-10.
[9][12] SANDRINI, P., *LSP Translation and Globalization*. In Gotti, M., Šarčević , S. (eds.) *Insights into Specialized Translation*. Bern: Peter Lang, 2006: 107- 120.
[10] REISS, K./VERMEER, H., *Grundlegung einer allegemeinen Translations-theorie.* Tübingen: Niemeyer, 1984: 72.
[11] Nord, C., *Translating as a Purposeful Activity*. Manchester: St. Jerome, 1997: 29.
[13] TAYLOR, C.., *Linguaggi settoriali; linguistica testuale e nuovi 'tipi' di testo*. In Cortese (ed.) 1996: 281-92.
[14] Hartley, A. / Paris, C., Translation, Controlled Languagues, Generation. In Steiner, E./ Yallop, C. (eds.). *Exploring Translation and Multilingual Text Production: Beyond Content.* Berlin: Mouton de Gruyter, 2001: 307-326.
[16][26] GOTTI, M. *Specialized Discourse, Linguistic Features and Changing Conventions.* Bern: Peter Lang, 2003.
[17] STOLZE, R., Die Fachübersetzung, Eine Einfürung, Tübingen: Gunter Narr. 1999: 141-3.
[18] NEWMARK, P., *A textbook of Translation*. New York: Prentice Hall. 1988.
[19] VERMEER, H.J., *Skopos and Translation Commision- Aufsätze*, Heidelberg: Universität, 1989.
[24] PEREGO, E., Review of Gotti (2003). TESL-EJ 8/1, R-10, 2004.
[25] TRENKER, P., Maritime English: An Attempt of an Imperfect Definition. In *Proceedings of the Workshop on Maritime English (WOME 2A)* Dalian: Dalian Maritime University & International Maritime Lecturers Association, 2000: 1-8.
[27] SCARPA, F. (2001). *La traduzione specializzata..* Milan: Hoepli. *Standard Marine Communication Phrases* (IMO SMCP 2001), London: 2002; *Standard Marine Navigational Vocabulary* (SMNV 1977/1985) London: 2001: 57
[29] SAGER J.C./DUNGWORTH D./MCDONALD, P.F. English Special Languages. Wiesbaden: Brandstetter. 1980: 23.
[30] PRITCHARD, B. Multi-word Lexical Units. In Doria, M. (ed.) Comunicação e Globalização. Lisboa: ILTEC, 2005 178-91

# ANTAGONISTIC TERMS FOUND ON LAND AND OFFSHORE

GEORGESCU MIRCEA

*Constanta Maritime University, Romania*

**ABSTRACT**

There are words and phrases that contradict themselves. In other words, by some freak of language evolution, they are their own antonyms, or homonyms with opposite meanings, or antonyms with the same lexical form (or phonetic). The English language has its generous share of words, although some think "they are not a ton of them" [3; 1], that can mean the opposite of themselves, and sometimes they are included in 'let's have fun with words' chapter. And yet, studying a language is not a joke and these contradictory terms should be given more consideration. And even more so when we meet them in a metalanguage such as maritime English (from now on named offshore words and phrases).

The contronyms are divided into words, phrasal verbs, and expressions that meet the definition, and a lot of the most difficult are followed by examples to throw more light on them, i.e. to make them more user friendly.

I also tried to identify a number of words used in the seafaring adventure as they have never been mentioned in the literature.

**Keywords:** *contronyms,paradoxes, context, on- and off-shore use,*

## 1. INTRODUCTION

About sixty years ago, the columnist Sydney J. Harris was the first to notice a strange category of words and started compiling a Dictionary of Pharisaical Phrases -expressions that mean the opposite of what they say. "Whenever people want to hurt others, and gratify themselves," Harris observed, "they begin with a mealy-mouthed phrase." [5; 2]

The work of exploring the antagonistic terms continued and soon they began to go by many names, such as Janus word, contronym, contranym, antagonym, auto-antonym, self-antonym, enantiodrome and antilogy.

There are two ways that contronyms come about. [8; 1] Firstly, two different words that are already opposites can become more similar in spelling over time. This is what happened with "cleave," where the "to split" side was *cleofan* and the "to adhere" side was *clifian*, and they grew together.

The other, more common way is for one word to develop two opposite meanings over time. That may seem like an odd thing for a word to do, but words are in a constant state of change. People tend to think of words as having strict borders around their definitions, but they're more like big balls of wibbly wobbly stuff.

Let's consider the verb *unravel* which means to unknot, unscramble, or untangle. It's only logical to assume that *ravel* must mean the opposite - to tangle or complicate. Well, *ravel* is both an antonym and a synonym for *unravel*. Derived from the Dutch word for "a loose thread," *ravel* can mean either to tangle or untangle, to complicate or clarify. That makes *ravel* an example of a word which has opposite or contradictory meanings. One should not be surprised that *ravel* is so rarely used: you never know if it's coming together or falling apart. [4; 2]

Another contronym is the verb *peruse*. Since the Middle Ages, *peruse* has meant to read or examine carefully. When *perusing* a document, you are studying it with great care. Later on, some people starting using *peruse* as a synonym for "skim" or "scan", which is to read quickly - the opposite of its traditional meaning.

But we have to keep an eye on the dictionary, for they follow the winding tracks of the language evolution. If a large number of people continue to "stretch" the meaning of a word, the inverted definition may eventually supplant the traditional one.

## 2. ANTAGONISTIC WORDS

### *2.1 Onshore use*

- Anxious**:** Full of mental distress because of apprehension of danger or misfortune, vs. eager or looking forward to
- Apology: A statement of contrition for an action, or a defense of one
- Apparent(ly)**:** Not clear or certain (For now, he is the apparent winner of the contest.), or obvious (The solution to the problem was apparent to all.)
- Assume**:** To actually have (To assume office), or to hope to have (He assumed he would be elected.)
- Awful**:** Extremely unpleasant, ugly *vs.* Awe-inspiring [typically, a feeling of admiration]
- Bill: A payment, or an invoice for payment
- Bolt: To secure, or to flee
- Buckle: To connect, or to break or collapse (buckle under pressure)
- Cleave: To adhere, or to separate
- Clip: To fasten, or detach
- Consult: To offer advice, or to obtain it
- Continue: To keep doing an action, or to suspend an action
- Cool**:** positive sense (cool web-sites) *vs.* negative sense (cool reception).
- Custom: A common practice, or a special treatment
- Dike: A wall to prevent flooding, or a ditch
- Discursive: Moving in an orderly fashion among topics, or proceeding aimlessly in a discussion

- Dollop: A large amount (British English), or a small amount
- Dust: To add fine particles, or to remove them
- Effectively: in effect (doing the equivalent of the action but not the real thing) *vs.* with effect (doing the action and doing it well)
- Enjoin: To impose, or to prohibit
- Fearful: Causing fear *vs.* being afraid
- Fine: Excellent/acceptable or not allowed (a roadside sign that read "Fine for Littering" was quickly removed after a few days) [3; 2]
- Finished: Completed, or ended or destroyed
- First degree: Most severe in the case of a murder charge, or least severe in reference to a burn
- Fix: To repair, or to castrate
- Flog: To promote persistently, or to criticize or beat
- Garnish: To furnish, as with food preparation, or to take away, as with wages
- Go: To proceed or succeed, or to weaken or fail
- Grade: A degree of slope, or a horizontal line or position
- Handicap: An advantage provided to ensure equality, or a disadvantage that prevents equal achievement
- Help: To assist, or to prevent or (in negative constructions) restrain
- Hysterical: Being overwhelmed with fear *vs.* being funny
- Inflammable: Burns easily *vs.* does not burn (the incorrect assumption by many that the prefix *in-* means *non*). Only the first definition is correct; the risk of confusion has removed this word from gasoline trucks! [3; 4]
- Last: Just prior *vs.* final
- Lease: To offer property for rent, or to hold such property
- Left: Remained, or departed
- Let: Allowed, or hindered
- Literally: Actually, or virtually
- Mad: carried away by enthusiasm or desire *vs.* carried away by hatred or anger
- Mean: Average or stingy, or excellent
- Model: An example for imitation, or a usually miniature representation
- Nonplussed: disturbed or perplexed, or undisturbed or indifferent.
- Off: Deactivated, or activated, as an alarm
- Out: Visible, as with stars showing in the sky, or invisible, in reference to lights
- Out of: Outside, or inside, as in working out of a specific office
- Overlook: To supervise, or to neglect
- Oversight: Monitoring, or failing to oversee
- Peer: A person of the nobility, or an equal
- Policy: Required activity without exception (company policy) *vs.* an optional course of action
- Practiced: Experienced, expert vs. inexperienced effort (The child practiced coloring.)
- Presently: Now, or soon
- Puzzle: A problem, or to solve one
- Quite: Rather (as a qualifying modifier), or completely
- Ravel: To entangle, or to disentangle
- Refrain: To desist from doing something, or to repeat
- Rent: To purchase use of something, or to sell use
- Riot: Violent disorder *vs.* revelry (noisy partying)
- Rocky: Firm, steadfast *vs.* tending to sway (a rocky shelf)
- Sanction: To approve, or to boycott
- Sanguine: Confidently cheerful, or bloodthirsty
- Scan: To peruse, or to glance
- Screen: To present, or to conceal
- Seed: To sow seeds, or to shed or remove them
- Shelled: Having the shell removed *vs.* enclosed in a shell
- Shop: To patronize a business in order to purchase something, or to sell something
- Skinned: Covered with skin, or with the skin removed
- Splice: To join, or to separate
- Stakeholder: One who has a stake in an enterprise, or a bystander who holds the stake for those placing a bet
- Strike: To hit, or to miss in an attempt to hit
- Table: To propose (in British English), or to set aside
- Temper: To soften, or to strengthen
- Transparent: Invisible, or obvious
- Trip: A journey, or a stumble
- Unbending: Rigid, or relaxing
- Variety: A particular type, or many types
- Wear: To endure, or to deteriorate
- Weather: To withstand, or to wear away
- With: Alongside, or against

### *2.2 Offshore use*

As only one of the meanings is used offshore, the examples will refer to the latter.
- Bound: Restrained from movement or heading to a destination, e.g. His ship is bound for Amsterdam.
- Fast: Moving rapidly, or fixed in position, e.g. The lines are (made) fast.
- Trim: When you trim a manuscript, you strip it of excess verbiage, but if you trim a ship, you are adding to some part of it, e.g. The ship is trimmed by the stern.

### *2.3 Slang meaning*

- Bad: There is the normal meaning and the slang meaning of "good" (sometimes pronounced *baad* for emphasis).
- Goods: good things, or bad things, e.g. I have the goods from the warehouse robbery, but I'm worried the police have the goods on me.
- Sick: Unpleasant (A sick joke), or wonderful (That sportscar is really sick! - slang)
- Reside: to stay put, or to change places (the latter implies a phonetical change).

## 3. ANTAGONISTIC PHRASAL VERBS

Phrasal verbs are mostly known as highly polysemous, but some have contradictory meanings.
- Give out: To provide (Can you give the drinks out?), *vs.* to stop because of a lack of supply (After two hours the bosun's patience gave out).
- Give up: To devote (oneself) completely (She gave herself up to her work.) *vs.* to cease to do or perform (They gave up the search.)

- Hold up: To support (The beam holds up the roof), or to impede (They tried to hold up the ship in the yard for another week)
- Put out: Extinguish, or produce smth.
- Strike out: An ending *vs.* a beginning
- Take care of: Look out for and nurture *vs.* get rid of or kill
- Wind up: To end (If you behave like this you'll wind up without any friends), or to start up (Could you wind up the window, please?)

## 4. ANTAGONISTIC PHRASES

### *4.1 Onshore use*

These are several phrases that (probably through corruption) have come to mean the opposite of what they should mean if taken literally. [6; 2]

- All downhill from here: Things are going to get better *vs.* things are going to get worse.
- could care less: (Used as if it were synonymous with "could *not* care less.") One has no interest at all.
- Everybody knows that . . . means ‘everybody who happens to agree with the prejudices and preconceptions of the speaker’.
- For your own good . . . means "for the pleasure it affords me in telling you something you won't like to hear."
- fought with: Fought on the same or opposite sides (The Finns fought with the Germans in WW II.)
- I don't like to boast . . . means "try to top this one."
- I don't mean to be critical . . . means the speaker now feels he has *carte blanche* to find fault with whatever you have done, or have not done, because his motives are so laudably sympathetic.
- I don't need to tell you . . . means the speaker feels he *has* to tell you, at great length, what you may already be presumed to know.
- If I don't, somebody else will . . . means that the speaker has adopted the creed of the oldest profession in the world to justify his unethical conduct.
- I have nothing against him, but . . ." means the speaker is about to slip a butter-knife between someone's shoulder blades.
- I know you won't mind . . . means the speaker is about to push his way in line ahead of you.
- I'm all for progress . . ." means the speaker is pedaling backwards as fast as his intellectual rear-view mirror will permit him.
- I'm sure you won't mind if . . ." means that the speaker hopes that the other person is politer than he is, and is fully prepared to take advantage of this civility.
- In the brief time allotted me . . ." means the speaker has nothing to say and will take as long as possible to say it.
- It really isn't any of my business . . ." means that the speaker is convinced it *is* his (or her) business, and enthusiastically informs you how you ought to run your business or conduct your personal affairs.
- Let us be realistic . . ." means all who disagree with the speaker are wild-eyed idealists, and probably subversive crackpots.
- like never before: totally amateurish vs. with great skill (She's dancing like she's never danced before.)
- Not to change the subject, but . . ." means the speaker intends to change the subject as promptly and forcibly as possible.
- Of course, I'm not an authority . . ." means the speaker has unshakable faith that he alone has the very last word on the subject under discussion.
- Restrict access to … mean to allow access only to *vs.* to disallow access to (To restrict access to adult movies, please contact the front desk.)
- Tell me about it: I want to know more *vs.* I already know.
- To be perfectly honest about it . . ." means the speaker is preparing to disguise his rudeness as candor.
- We must look at the facts . . ." means the speaker has carefully arranged a set of facts that meet with his complete approval, and any contradictory evidence is mere "theory" which no reasonable person could believe.
- We must see each other again soon . . . means "As long as we can keep it this vague, there's little chance of our meeting soon, which is fine with me."
- You can't mix business and friendship . . ." means that the speaker is immediately going to sacrifice friendship to business, and never the other way around.
- You only live once … means "Then why not do what I know I shouldn't do?"

### *4.2 Offshore use*

- Near miss: A hit close enough to achieve the effect *vs.* narrowly falling short of the objective (It was a near miss although the OOW altered course and increased speed);
- Throw out an idea: you present it for consideration, or you discard it (The captain threw out the idea of going for shelter).
- Watch out for**:** A positive statement meaning "try to find or partake" of *vs.* a negative statement meaning "avoid" (Watch out for the pirates.)

## 5. ANTAGONISTIC PHRASES THAT HAVE THE SAME MEANING

- burned up, burned down: (Both mean "destroyed")
- fat chance; slim chance: (Both mean "not too likely")
- cool; hot: (Both mean "wonderful" [Slang], e.g., when applied to a car) [2; 2]

## 6. DOUBLE CONTRONYMS

We have dealt so far with a pseudo-antagonym (see *inflammable*), and lots of antagonyms. It is no doubt that the cherry on the cake is "pitch", a DOUBLE contronym.

"Pitch" can mean to actively promote or encourage acceptance of (I pitched my screenplay to the producer.), or to discard (That toner cartridge is empty. You should pitch it.) Pitch can also mean a level surface (The soccer players have come out onto the pitch.), or a steep incline (The roofer charged me extra due to the steep pitch of my roof.) [7; 2]

## 7. CONFUSING WORDS

The following examples made Elis suggest a new word, confusionyms. [2; 2]

**-** Biweekly (bimonthly, biyearly): twice a week (month, year) *vs.* every two weeks (month, years);
- Daily**:** 5 days a week *vs.* 6 days a week *vs.* 7 days a week (for example, the "daily" newspaper);
- Every day**:** As in "daily" above, one often hears on the radio "Listen to our morning show every day" to mean Monday through Friday.

## 8. CONCLUSIONS

A close view of the contronyms clearly indicates that they are paradoxical cases which give colour to the language and reflect the contradictory nature of the universe. The fact that they have double senses can make for confusion.

They apparently (?!) can give us quite (?!) a lot of trouble if we aren't careful enough, 'so it pays to watch out for their skulking presence in the language.' [1; 1] If you use them, be sure that the context will make the meaning clear.

## 9. REFERENCES

[1] CARILLO, J., "English Plain and Simple", (2008) in The Manila Times, Saturday, August 16, 2008 issue © by the Manila Times Publishing Corp.
[2] ELIS, C., *Antagonyms*, (1996) in http://www - personal.umich.edu/ ~cellis /antagonym.html
[3] FOGARTY, M, *Janus Words: "Sanction" and "Cleave"*, (2012) in http://grammar.quickanddirtytips.com/sanction-cleave.aspx
[4] NICHOL, M., *75 Contronyms*, (2011) in http://www.dailywritingtips.com/75-contronyms /
[5] NORDQUIST, R., *A Dictionary of Phony Words* (2009), in http://grammar.about.com/od/words/a/ A-Dictionary-Of-Phony-Phrases.htm
[6] *The American Heritage Dictionary of the English Language*, 4th edition, (2000), Houghton Mifflin Company, , ISBN-13: 9780395825174
[7]http://www.fluther.com/1004/what-are-some-examples -of-contranyms/
[8] http://theleagueofnerds.wordpress.com/tag/controny

# CHARACTERISTICS OF THE LANGUAGE USED IN NAVAL ARCHITECTURE ADVERTISING

[1]TRISCA ANCA (IONESCU), [2]CROITORU ELENA

[1,2]*"Dunarea de Jos" University of Galati, Romania*

**ABSTRACT**

Nowadays advertising in naval architecture is meant to persuade a client to purchase products, ideas, services etc. The main function of advertisements is to create desires, emotions, feelings, values, attitudes towards the products in its viewers (possible customers). This paper gives an overall analysis of the advertisement in naval architecture from the aspects of language levels (graphological, lexical, syntactic, grammatical, and semantic) and textual analysis (the layout and the paragraph).This paper can help readers better understand and appreciate the language of naval architecture advertisements.

**Keywords:** *advertising, naval architecture; lexical, syntactic, grammatical, semantic features*

## 1. INTRODUCTION

The advertisement is a medium of communication and expression and it effectively accomplishes the set goals. A successful advertisement is expected to achieve five goals such as attracting attention, commanding interest, creating desire, inspiring conviction and provoking action. All these five functions are inter-related and in concert serve to promote the selling power of the product advertised.

Today, we see a notable influence of advertising in every human life because of its ways of communication. While defining the concept, a well-known advertising copywriter John Kennedy remarks that advertising is "salesmanship in print". This indicates that the ultimate objective of advertising is to encourage the sell.

With the development of globalization and industrialization, more and more shipyards and naval architecture firms develop types of ships ,services are produced ; as a consequence , advertisement plays a key role in selling products. Even if the technical field is highly professional, advertising in naval architecture is an art. Its function is to "attract attention, arouse interest, stimulate desire, create conviction and get action.". Magazines and catalogues are designed to persuade clients. Most ship exhibitions offer them for possible buyers. They have become one of the most effective ways of providing information. Language plays an important role in advertising not only because there are so many shipyards, but due to the high costs that building a ship imply .How companies advertise such expensive devices are presented in the following lines. We shall present the language devices with relevant examples from catalogues (DAMEN SHIPYARDS GROUP, BAYLINER, ABU DHABI SHIP BUILDING) offered at The Maritime Exhibition in Dubai (2013).

## THE CHARACTERISTICS OF THE LANGUAGE OF ADVERTISING

## 2. THE GRAPHOLOGICAL LEVEL

Graphological arrangement in advertisements plays a very important role in drawing people's attention, making it outstanding among other product advertisements. Generally, larger, capital and bold letters are used in the headline in order to draw people's attention and make them curious about what this advertisement mainly says and thus leads the readers to go on reading unconsciously and arouse their curiosity and desire to know more about this product and finally reaches its goal to persuade the readers to buy it. Full capitalization is used to emphasize the message as well as different fronts to underline key features of the company. The examples below are taken from Damen Shipyards Group catalogue (pages 3-7, 2013):

(a) Standardisation key to success our standards;
(b) Wide range in stock standard hulls;
(c) Research &development Damen's backbone;
(d) Through the entire lifecycle sustainability;
(e) Founded in the Netherlands global presence

The subtitles are followed by a short description and a brief presentation (the fronts decrease gradually).The short paragraph which illustrates the features uses smaller fonts, and describes how the company achieved the features presented. The main arguments used are decades of experience and the Dutch quality (an important supplier of ships with an impressive experience in sailing and shipbuilding):

*"STANDARDISATION KEY TO SUCCESS OUR STANDARDS*

*Damen's focus on standardization in undoubtedly one of our fundamental corporate values. When Kommer Damen took the helm in 1969,the modular building concept was one of the first initiatives he introduced after listening carefully to client feedback.*

Four decades ago the standardization concept was totally new in the shipbuilding industry and even today it is still unique.

Damen has developed standard ranges in each of our niche markets, from tugs to luxury yachts. These standard vessels can be equipped with a large range of options. *The design can also be modified to meet customer wishes or we can start from scratch to design and build your unique dedicated vessel."* (DAMEN available at www.**damen**.nl )

As it can be noticed in the paragraph above there is an italic word *"your"* which makes it more conspicuous among those words. The presence of "your" makes the more like the face-to-face conversation and the advertiser speaks to the readers in a tender tone, making the advertisement more reliable and the readers are more likely to go on reading in a happy and curious mood, feeling that the firm addresses every need they might have.

At the same time, the advertisement uses smaller-than-headline-and- larger-than-body-copy letters for the subtitle. This subtitle is well-designed and attractive. It provides more information about the product and furthermore shows the arguments behind the key features presented. The different fonts have a sharp graphological contrast, making this message eye-catching, clear and in good order.

## 3. THE LEXICAL LEVEL

### *3.1 COMMON USES OF FIRST AND SECOND PERSON PRONOUNS "WE", "US" "YOU"*

The use of second person pronoun "you" tends to shorten the distance between the product or the producer and consumers, as if the producer or the ad is speaking to you face to face, making sincere promises, honest recommendations. In so doing, the ad slogans stand a better chance to move the receiver or customers to action, because the receiver feels that (s)he is being thought of and taken care of and he/she is the centre point of the producers.

The example below is illustrative in this respect:

"Damen Technical Cooperation enables you to build your Damen vessel locally, anywhere in the world. We provide you with a prefabricated shipbuilding kit and can, on request, combine this with expert assistance, training and backup. "

The use of first person pronoun "we" is the most direct way to tell the receiver what the company stands for, his idea, his view, and his credit. It can be regarded as a self-introduction to the potential customers to let them know you, recognize you, believe you and trust you:

"We believe that our range of products helps our customers achieve their goals in terms of availability, reliability and lifecycle costs. Customers may benefit by using one of our services or a strategic combination of several products." (DAMEN, available at www.damen.nl )

The use of personal pronouns obviously sounds like face-to-face talk, making the conversation warmer, more friendly and trustable in tone, and finally strengthens the appeal to the readers. Those reading the advertisement may probably be persuaded and stimulated and finally agree with what the advertisement says with strong desire for purchasing.

### *3.2. USE OF UNQUALIFIED COMPARISON*

Companies have to abide by the code of commercial practice and stick to the rules of advertising. They should not advertise their product at the expense of others. They cannot say: *"Brand X is better than brand Y."* Otherwise, unpleasant lawsuits will inevitably occur. Thus, they resort to unqualified comparison to avoid defaming other products. (XUE Hangrong 2003:189) such as for instance:

*"Some boat builders incorporate all the latest frills and throw in extraneous items just like sprinkles that add calories but hardly any taste (a very catchy simile), leading to a vessel that's cluttered and hard to figure out. With fewer over-the-top additions, each Bayliner Cruiser is streamlined and precise-an incredible creature of stealth, speed and utility."* (Bayliner available at http://global.bayliner.com/ )

### *3.3. USE OF "EVERY" "ALWAYS", ETC.*

These words are often used in ads to indicate the universal application of the product or to include as many potential customers as possible or to achieve the emphasis of the product's utility or the company's unswerving commitment.

For example:

*"When doing business with the Damen Shipyards Group, you can always rely on a single point of contact."*

### *3.4. USE OF "NO", "NOTHING", ETC.*

Negatives tend to be used very sparingly because the purpose of all ad slogans is to strengthen the positive side. But when negatives do occur, they are usually placed in an emphatic position to highlight the special positive side.

For example:

*"no structure is misaligned; nothing is wasted."(Bayliner)*

### *3.5. SPECIFIC TERMINOLOGY*

We observe shipbuilding specific terms, and specific processes, for instance (cf. Maci 2010):

• Acronyms :"The impact of various hull forms on resistance, reducing hull resistance using air lubrication and examining alternative fuels such as LNG are typical examples.", ROV support, GL Class notation, "The JSS fulfils the operational requirements of the Royal Netherlands Navy for a robust multi-functional platform(…)"(DAMEN)

• Abbreviations: STD (standard), ECT (Emission Control Technology), HP (horse power).

• Blending (campsite = camping site);

• Specialization of words from general language: in-console storage, sunlounge, cockpit.

### *3.6. CREATIVE USE OF IDIOMS OR PROVERBS*

Idioms and proverbs are familiar to most potential customers in a society and have no difficulty to be popularized. The creative use of the idioms and proverbs can give them new meaning while making them memorable.

For example:

*"They say looks aren't everything. A good personality is what really matters. Well, luckily for the all-new 185 Bowrider, it's been blessed with both."(*BAYLINER)

*"Some boat brands don't get this balance right .They maximize floor space but provide nowhere for you to put your gear-so you're always stepping around it or sliding it over to catch a seat. Other boats compromise usable space with badly designed storage or furniture components. Bayliner knows you can't have the yin without the yang."(*BAYLINER)

*"The more the merrier. Big crews and fun-loving families, rejoice: Bayliner's brand-new deck boards have the capacity for just about everything you want of your time on the water."* (BAYLINER)

## 4. THE MORPHOLOGICAL LEVEL

### *4.1. USE OF SUPERLATIVES AND HYPERBOLE*

Abundant use is made of **superlatives** and **hyperbole** in characterizing the product, with often indirect reference to rival products.

For example:

*"All of our standard designs are worked out to the smallest detail."*(DAMEN)

*"This results is an efficient delivery process at the best price-quality ratio."* (DAMEN)

Thus, the language of advertisement with the different devices becomes 'a loaded language' like the fragrance of the flower and helps to spread the intended message more effectively.

### *4.2. USE OF PRESENT TENSE*

The present tense is commonly used in the advertisements. The use of present tense tends to indicate the good quality of the products and its long-lasting and ever-lasting effect. At the same time, it makes the advertisement easier to understand without transferring from other kinds of tenses.

For instance:

"*Up to 150 vessels are manufactured annually ,at one of our 35 owned shipyards or at numerous partner yards."(DAMEN)*

*"This Bayliner is everyman's cruiser."(Bayliner)*

*"ADSB is focused on providing customer satisfaction thorough world-class workmanship, innovation ,integrity ,honesty and service to society."(ABU DHABI SHIP BUILDING)*

### *4.3. USE OF MODALS*

Uses of modal verb can which conveys the idea of "possibility" and "certainty":

*"The shipyard can construct vessels using steel, aluminum or composite materials".* (ABU DHABI SHIP BUILDING)

*"Damen can supply all workboats needed for the wide variety of tasks in ports and harbors*. (DAMEN)

*"(...)crews can rest assured that the vessels are entirely fit for purpose, offering unrivalled seakeeping behavior, speed and reliability".(*DAMEN)

### *4.4. USE OF FIRST AND SECOND PERSONAL PRONOUNS*

Pronouns of the first and second person: "we", "I" and "you" outnumber the other pronouns in advertisements. It is because that these pronouns help create a friend-like intimate atmosphere to move and persuade the audience.

Advertisements with lots of pronouns of the first and second person are called gossip advertisements. Advertisements that go like talking with friends closely link the advertisement and the audience. The audience will easily accept a product, a service or an idea as if a good friend recommended them: *"Damen Technical Cooperation enables you to build your Damen vessel locally, anywhere in the world. We provide you with a prefabricated shipbuilding kit and can, on request, combine this with expert assistance, training and backup. "(DAMEN)*

## 5. THE SYNTACTIC LEVEL

### *5.1. USE OF SHORT SIMPLE SENTENCES*

Short simple sentences are easy to remember, while one main aim of an ad slogan is to be memorable and recited. For example:

*"Get the most of your boat"(*PROGRESSIVE)

*"Get on a board*." (BAYLINER)

*"Help never looked like this before*."(Sea Tow App)

### *5.2. USE OF EVERYDAY SENTENCES*

Every day sentences tend to be overly used in day life, but it can be very forceful when used in an ad slogan. These sentences travel very fast, because anyone can remember it without any effort. It can just hang upon people's lips. It's something popularized without much publicity.

For example,

*"Bayliner gives you the best value for your dollar*."(BAYLINER)

*"Each model has dedicated storage built in for the necessities like fenders, PFDs and cockpit tables. But that just scratches the surface. Bayliner are made for play and entertaining, so all of your toys and guests' gear are accommodated, too. Go ahead, bring it on! "*(BAYLINER)

### *5.3. USE OF QUESTIONS*

In ad headlines questions are often used to attract attention by mentioning the matter that concerns the customers most. They help to arouse the curiosity of the customers and entice them to read on to find the solution to the problem. Many slogans (also called themeline or tagline) begin as successful headlines. (Arens & Courtland 1994: .289)

For example:

*"Who doesn't dream of someday owning their own island?(...)It's fun to dream ,of course, but having a private island to call our own is, for most of us, the stuff*

*of pure fantasy. Well, maybe not. Bayliner has been busy working the problem, and just may have found a way-three ways, in fact to turn this into reality. The solution : a completely relaunched lineup of Bayliner Deck Boats."(*BAYLINER)

*5.4. USE OF IMPERATIVE SENTENCES*

In an ad, the slogan is the last few words said. Although it's just a few words, the admen don't let it go at that. They use every opportunity to exhort the potential customers to act, to buy and to consume. The slogan is their last battle field to get people moved. It is not surprising that they would use imperative sentences to make a slogan while this kind of sentence is the most direct way to achieve the ideal effect.

For example:

*"Get the most of your boat"(*PROGRESSIVE)

*"Get on a board*." (BAYLINER)

*5.5. USE OF NEGATIVE SENTENCES*

The negative sentences are seldom used in the advertisements. The next example shows that negative words are not used to deny the product but to show a contrast with the product.

For instance:

*"Having less of something doesn't always seem like a good thing-especially when it comes to a boat."(*BAYLINER)

## 6. THE SEMANTIC LEVEL.RHETORICAL DEVICES

Advertisers always endeavor to use the vast rhetorical devices to persuade the target audience to take a desired action because advertisers deliberately set out to attract its audience, and it's obvious that every element in an advertisement is carefully selected and placed for maximum effect. The following are some of the frequently used devices in advertisement.

*6.1. METAPHOR*

Metaphor compares two different things by speaking of one in terms of the other. Unlike a simile, metaphor asserts that one thing is another thing, not just which one is like another. However, metaphor is a profoundly important and useful device like simile.

For example:

*"The roadmap to happiness has no road."(*BAYLINER)

*"Flash of brilliance (...) Until you're in the pitch black and need a light ,you don't really appreciate a spotlight." (*BAYLINER)

*"Bayliner Deck Boats are a breath of fresh air in a stale market." (*BAYLINER)

*6.2. PERSONIFICATION*

Personification represents an animal or inanimate object as having human attributes- of form, character, feelings, behavior, and so on. Ideas and abstractions can also be personified and can be brought to life through personification and objects can be given greater interest.

For example:

*"Amels has become the established leader in premium, semi custom-built superyachts*. (DAMEN)

## 7. CONCLUSIONS

This advertisement in naval architecture makes use of many devices at all levels of language. By the use of these devices, the producer can better communicate with the costumers and make the product more appealing among the possible buyers.

## 8. REFERENCES


[1] ***http://global.bayliner.com/

[2] ***http://ojs.academypublisher.com/index.php/tpls/article/view/tpls0302275284

[3] ***http://www.adsb.ae/

[4] ***http://www.isrj.net/UploadedData/643.pdf

[5] ***www.ccsenet.org/journal

[6] ***www.damen.nl

[7] ANGELA,Goddard.*The language of Advertising*[M]. London and New York: Routledge, 1998

[8] ARENS,W.& C.Bovée. *Contemporary Advertisement*[M]. Massachusetts:Irwin Incorporation, 1994

[9] CRYSTAL, David. *'The First Dictionary of Linguistics and Phonetics'* a. Select Book Service Syndicate: New Delhi, 1985

[10] DAVIS P. M. et al.*) 'The Effective Use of Advertising* Media' Random House: London,1996

[11] LEECH, G) *'English in Advertising'* Longman: London, 1966

[12] LEECH, G *'Principles of Pragmatics'* Longman: London, 1985

[13] LEVINSON, S. C. '*Pragmatics*' Cambridge University Press, Cambridge, 1983

[14] WU Zhiming,HU Zhiwei. *Selection of English Advertisement* Language[M]. Beijing:Beijing University Press, 1999.

[15] XUE Hangrong. *Introduction to English Styles*[M].Xi'an:Xi'an Jiaotong University Press, 2003

[16] YANG Rongqi,CHEN Yuhong. *Appreciation of English Advertisement Style*[M]. Wuhan:Huazhong Science and Technical University Press, 1995

[17] MACi, Stefania M. *The Language of Tourism*. Bergamo: CELSB, 2010

# ON NOMINALIZATION IN MARITIME DISCOURSE

VISAN IOANA RALUCA

*Constanta Maritime University, Romania*

**ABSTRACT**

A very common syntactic phenomenon of specialized discourse is nominalization. Reliance on nominalization can be explained as a search for greater conciseness of expression, the information conveyed in a concise, direct, condensed form having a greater impact upon the reader. Thus, in maritime discourse a great amount of semantic and syntactic information is compressed into a highly compact form, i.e. nominal compounds, compound nominal phrases or complex nominal groups. The purpose of the present approach is to enlarge upon the concept of nominalization and its productivity in maritime discourse.

**Keywords:** *nominal compounds*, *translation, lexical density, maritime texts*

## 1. INTRODUCTION

As many linguists have pointed out (Berwick 2001; McKenna 1997) but perhaps most notably Quirk, Greenbaum, Leech, & Svartvik (1980: 84) "[S]cientific writing differs greatly from other styles in having a distinctly higher proportion of noun phrases with complexity". More recently, Godby (2002) clearly demonstrates the significance of noun phrases in the specific context of engineering writing.

Among the difficulties that scientific English poses both to learners and professional researchers, Halliday (2004:162) mentions syntactic ambiguity. Nominalization is one of the grammar structures causing a higher degree of ambiguity in maritime texts. When nominalizing, semantic information is usually left out, which increases the degree of ambiguity and the difficulty in correctly decoding the sentence. Thus, the difficulty of maritime language is not limited to the lexical level but it also applies to a range of specific grammar structures that characterize maritime discourse.

Maritime written discourse is characterized by a high lexical density "[..] measured in the number of lexical items per clause and a strong tendency to encode this lexical content in a nominal form [..]" (Halliday 1985b: 75).

## 2. FEATURES OF NOMINALIZATION

Maritime discourse makes frequent use of long noun groups ( i.e. *slow speed diesel engine → motor diesel cu turație mică; specialized heavy lift vessel → navă specializată de transport al mărfurilor agabaritice; emergency position indicating radio beacons → radiobaliză de indicare a poziției în caz de sinistru,* etc.) which call for a high degree of formality, a strategy used to obtain certain stylistic effects and syntactic compression. Technicalization can be one of the most important factors that can give rise to compound difficulty. To clarify, communicating a new idea or concept in maritime written discourse may often require the employment of a multi-word construction, especially if the meaning is complex as in *high deck bending stresses*, *mooring line breaking strength, rough breast line restraint determination, high holding power anchors*. Hallyday (1985a) considers that spoken language is essentially verbal in nature, while written language is essentially nominal. He claims that spoken and written discourse are two different modes of representing experience, two alternative ways of language creations. Thus, in written discourse "the text is created as an object and perceived by the reader as an object it exists" (Hallyday 1985a: 49a) while in spoken discourse "the text is created, and is perceived by the listener, as a process" (id. ibid.). Maritime texts make frequent use of nominalization because verbal nouns seem to reflect the parallel process whereby results are inferred from experiments and objects from their construction process. These abstract nouns can carry the Latin ending *–ion* (i.e. *containerization, embarkation, ignition, immersion, palletization,* etc.) or they can take the form of gerunds and infinitives. In maritime discourse, nouns ending in *-ing* (i.e. *mooring*, *lashing, winding, anchoring, towing, dragging, yawing, rolling, pitching, trimming* etc.) or nouns retaining the infinitive form (i.e. *berth, buoy, ship, anchor, dock, lock, warp, trim,* etc.) are related to the internal and external shipboard activities, to the ship's motions or vessel's operations. According to Ulrych (1992: 135) the distinction between a form in *–ing* and the infinitive is that the former has more of an iterative meaning, while the latter tends to foreground the singulative aspect of the action or event. Another important category of verb-derived nouns specific to seamanship texts and maritime legal texts are the nouns ending in *-age* (i.e. *anchorage, buoyage*, *cordage, leakage, stowage, salvage, storage,* etc.).

## 3. NOMINAL COMPOUNDS

According to Trimble (1985: 130), "[N]oun compounds, also called noun strings can be defined as two or more nouns plus necessary adjectives (and less often verbs and adverbs) that together make up a single concept; that is, expresses a single noun idea". Nominal compounds, also termed complex nominals, compound nominal phrases, noun strings or complex lexical items have a considerably higher occurrence in maritime language. They are used for compressing semantic and syntactic information into a highly compact form. Nominal compounds normally encapsulate condensed information in short structures; or they hold maximum information in minimum linguistic structures. The idea has been shared that nominal compounds are frequently used in the realization of scientific registers for reasons of impersonality, to avoid finite verbs and participles and to set the writing as being specialized and technical.

*Nominal adjectivation*, as Gotti (2008: 73) puts it, is one distinctive aspect of the right-hand-pattern and "involves the use of a noun to specify another with an adjectival function". Therefore, while Romanian relies on left-to-right pattern, in English the right-to-left construction can be easily adopted in order to make the sentences shorter and the noun phrase denser

The noun phrase *a partly submerged vessel* contains a premodifying past participle, which in turn, it is premodified by an adverb. This noun phrase is expressed in maritime Romanian by means of a defining relative clause: *o navă care este parțial în imersiune*. *Adjectiviation* generally takes on complex syntactic values because it often stems not only from the evolution of noun phrases but also from phrases containing adjectives and present and past participles: (i.e. *an all around flashing yellow light → lumină galbenă cu sclipiri vizibile pe întreg orizontul*). Sometimes nominal compounds can lead to a loss of conceptual clarity due to their being too dense. For this reason, a strategy for a better understanding of denser compounds in maritime texts is decoding them by means of a relative clause. Thus, the nominal compound *cargo oil pumps control board* which translates into Romanian as *pupitru de comandă a pompelor de încărcare* can be paraphrased by the relative clause *a board which controls cargo in oil pumps*.

## 4. MARITIME COMPOUND PATTERNS AND SEMANTIC RELATIONSHIPS

A model of the complex noun phrase in technical English is offered by Croitoru (1996: 83). In her schemata nominal and adjectival premodifiers indicate permanent characteristics while *–ing* and *–ed* premodifiers signal temporary characteristics (i.e. *man-made fibre cordage stopper → boț de parâmă; two-legged swinging mooring → ancorare giratorie cu două ancore*). Salager (1985: 58) holds the idea that compound nominal phrases are more numerous in EST than in common core English, and the more specialized the text is, the longer and more numerous the compounds. The greater amount and complexity of these compounds contribute a great deal to the fuzziness of the non professional translator and therefore, this is the reason why he/she needs a close collaboration with a domain specialist. By taking up Trimble's model of compounds classification (1985: 133), we can argue that compounds in maritime English texts can be categorized as follows:

A) Simple: *anchor chain = a chain used in anchoring; bulk cargo = cargo that is carried in bulk; berthing place = a place for berthing a ship*

B) Complex: *cargo handling gear = a gear used to handle cargo; life saving equipment = equipment used to save life*

C) More Complex: *rated winch brake capacity, non-dimensional wind yaw moment coefficient*.

English syntactic rules allow several adjectival uses of phrasal elements. It has to be pointed out that nominalization in maritime texts is the link with textual construction. By favouring the reintroduction of concepts in thematic position, nominalization also allows for an easier flow of information from new to given, therefore facilitating text development (Gotti 2008). By thematizing information through nominalization, a maritime text also allows far greater cohesion. The pervasiveness of nominalization leads to loss of verbal value, and as a result the verb is weakened and often functions as copula, a link between increasingly noun phrases. The verb *to be* is often used as linkage between nominal or adjectival phrases, which in turn derive from syntactic transformation of verbs with a strong semantic content. The following sentences illustrate that non-copulative verbs are replaced by adjectival forms which are then joined to their corresponding noun phrases by a copulative verb: *This cargo is a ten-ton load → The load weighs ten tons; The bulk carrier is a multi-deck vessel → The bulk carrier has a multitude of decks.*

In the examples below, several compounds consisting of two short nouns are merged into a single term. At first the two nouns are hyphenated and then they become one word. Thus, in maritime English the pattern N + N can cover such features as:

**Functions on board**: *helmsman → timonier; donkeyman → mecanic auxiliar; storekeeper → magazioner; pumpman → pompagiu; boatswain → nostrom; seaman → marinar*;

**Different types of vessels**: *bulk carrier → vrachier; container ship → navă portcontainer; icebreaker → spărgător de gheață; warship → navă de razboi; fisherman → pescador; lightship → navă far; tugboat → remorcher; firefloat → navă de stins incendiul; salvage vessel → navă de salvare; buoyage vessel → navă de balizare; supply boat → navă de aprovizionare; survey vessel → navă de cercetare marina; pilot tender → pilotină;*

**Onboard devices, installations and machinery**: *windlass → vinci de ancoră; anchor chain → lanț de ancoră; anchor cable → lanț de ancoră; cable chain → lanț; breast line → traversă; bow line → parâmă prova; stern line → parâmă pupa; head rope → parâmă prova; bow spring → șpring prova; stern spring → șpring pupa.*

**Onboard spaces and separations**: *bulkhead → perete etanș; starboard → tribord; weather deck → punte principala; tanktop → puntea dublului fund; chain locker → puț al lanțului de ancoră; wing tank → tanc lateral; engine room → camera motoarelor; cofferdam → coferdam; messroom → sală de mese; wheelhouse → timonerie; chartroom → camera harților; quarterdeck → punte pupa; gangway → scară de acces.*

Maritime compounds also display the following common semantic relationships (Blakey 1987:146):

| | |
|---|---|
| B of A | e.g.*cylinder cover*, *hatchway* |
| B with/has A | e.g. *salt water, ship owner* |
| B contains A | e.g. *wheelhouse, engine room* |
| B is made of/from A | e.g. *manila rope, copper wire, air-cushion* |
| B in/on/at A | e.g. *port operations, after peak tank* |
| B operated by A | e.g. *hand pump, steam engine* |
| B uses A | e.g. *water plant* |
| B shaped like A | e.g. *needle valve, I-beam* |
| B invented by A | e.g. *Hall anchor*, *Beaufort wind scale* |

Moreover, compounding also involves the use of adjectives (*deep tank, double bottom, forecastle, parallel middle body, strong beam, main deck),* nominalised adjectives (*deck longitudinals*), ordinal numbers *(first mate, third engineer),* prepositions *('tween deck, overhauling*), proper nouns turned into common nouns (*disel engine*, *jackstaff, jacob's ladder, samson post*), onymic units in the form of eponyms (or names of inventors to describe a product: i.e. *Hall anchor,, Plimsoll mark, Williamson turn*) or toponyms (place names and geographical names, i.e. *York-Antwerp Convention, North Atlantic freeboard mark*, *North Atlantic loadline*), the names of seasons (*summer load line*) and metaphors (*cat's walk*, *dog watch, crow's nest, donkeyman).* Reverse combinations (*breadth moulded, length overall),* adjectival compounds (*watertight*, *oil tight*), poly-words created by connecting words with prepositions (*round of deck, turn of the bilge, men-of-war, length between perpendiculars*) or by using the genitive case (*bosun's locker, Ship's Cook*) can also be detected. All these multi-word units do not only condense information and create new meanings different from the one of the parts making up a combination, they are a way of creating 'unique' meanings. In fact, in most cases, they are the only acceptable referential forms available to point to areas of experience shared by the target maritime community. They do not serve other frames of reference and there exist no other words to point to the concepts they represent. These multi word units have stable relationships having frozen or fixed forms and are to be considered as single words though written with hyphens or with spaces in between. They can be seen as extreme forms of fixed collocation (Schmitt and McCarthy 1997:43). Another important aspect to be considered is that in maritime Romanian the equivalents for some of these compounds may be one word only, or they can be expressed by means of the following sequences: *noun + noun* as in *parâmă prova; noun + prep.+ noun* as in *navă de cercetare; noun +adj.noun + noun* as in *puntea dublului fund; noun + adj.* as in *tanc lateral*.

The purpose of *nominal adjectivation* is to make exposition denser and attach semantic weight to the compound. Maritime English texts also reveal instances of compounds comprising three items and taking on the following patterns:

- **N + Present Part. + N**: *cargo handling gears → dispozitive de manipulare a mărfii; cargo handling equipment → echipament de manipulare a mărfii; fire-retarding doors → uşi cu calitate ignifugă; sound-signalling appliances → dispozitive de semnalizare sonoră.*
- **Adj. + N + N**: *controllable pitch propeller → elice cu pas reglabil; wet bulk cargo → marfă lichidă* *n vrac; dry bulk cargo → marfă uscată* *n vrac.*
- **N + N + N:** *deck-beam brackets; fire-detection equipment; mine clearance operations → operaţiuni de dragare a minelor; cargo stowage factor → indice de stivuire; rudder head shaft → ax al cârmei*
- **Past Part. + N + N***: balanced spade rudder → cârmă compensată;*
- **Present Part. + N +** N: *swinging derrick system → instalaţie de* *ncărcare cu braţ turnat;*
- **Adj. + Present Part. + N:** *steady turning radius → rază statică de* *ntoarcere*
- **N + Past Part. + N**: *power driven vessel → navă cu propulsie mecanică*

A method for a better understanding of denser compounds is paraphrasing them by means of a relative clause as the following examples illustrate: *radio direction finding station* can be paraphrased by *a station which finds the direction by means of radio waves* and translates into maritime Romanian as *staţie de radiogoniometrare*. Similarly, *propeller pitch control system* can be paraphrased by the relative clause *a system which controls the propeller pitch* and translates into Romanian as *mecanism de schimbare a pasului elicei*.

## 5. IMPLICATIONS FOR NOMINAL COMPOUNDS TRANSLATION

Both complex and more complex compounds, let alone the highly complex ones, raise a lot of problems in translation. This may be due to the challenge posed by the order in which the premodifiers are located and the lack of an explicit specification of the semantic relations among the different elements. In addition, the translation of premodified noun phrases into Romanian offers numerous possibilities to make such relations explicit through postmodification. Coseriu (1973: 11) considers that nominal compounds do not cause any translation difficulty, holding the idea that when dealing with noun phrases one is not dealing with transposition of meanings, but merely with replacing signifiers on a one-to-one basis. Along the same line of thought, Calonge (1995: 184-185 qtd. in Quiroz 2006: 370) argues that "phrases representing specialized meanings [...], are in general easy to translate and only calque should be avoided". We refute the above mentioned arguments and consider that terminological phrases do cause significant problems to translation, including those nominal phrases that seem to be relatively simple. Thus, as suggested by Pritchard (2006: 273) the lexical combination *damage control* is semantically deceiving and its literal translation can produce false pairs in the target language. The word *damage* in the compound *damage control* does not refer to its dominant sense of "harm impairing the function or condition of a thing" (id.ibid.) and therefore, the translation into Romanian must render the maritime sense of the compound as a single lexical unit, that is, *control de avarie*.

We believe that with most of nominal compounds, the maritime translator needs the collaboration with a specialist. A large number of compounds cannot be translated by considering the meanings of the constituent lexical items separately (Croitoru 1996: 153). The translation difficulty of a nominal compound even if consisting of two nouns, is increased by the polysemy on the one hand and the grammatical behaviour of nouns on the other. The greater the amount of information, the more complex the nominal groups which can cause problems to translators.

## 6. CONCLUSIONS

To conclude, the use of nominalization is very productive with both maritime English and Romanian discourse. Nominal compounds can perform a range of functions rendered by the semantics of the words and their arrangement into the phrase-structure i.e. the system determination through pre-and post-modification which would indicate development of the discourse. Wells (1960: 217-218) also advocates the same kind of supremacy to nominalized structures since they provide ESP texts with at least three characteristics: a) impersonality; b) possible avoidance of finite verb forms; c) specialization and technicalization. Considering the fact that any given compound should convey its meaning unambiguously in a wide spectrum of contexts, it can be said that its translation should equally exhibit a similar degree of clarity if it figures in corresponding contexts. Meeting this requirement may be harder than what it first seems to be because complex nominal groups will often prove difficult.

## 7. REFERENCES


[1] BERWICK, R, C., *Language: From words to meaning.* 2001, Recitation given at MIT.Oct262001.Retrieved June14,2009 from: http://www.ai.mit.edu/projects/berwick/recitation7.pdf

[2] BLAKEY, T.N.. *English for Maritime Studies.* Cambridge: Prentice Hall International., 1987

[3] COSERIU, E., *Einführung in die strukturelle Betrachtung des Worschatzes*, Tübingen: Gunter Narr, 1973

[4] CROITORU, E., *Interpretation and Translation*, Porto Franco, Galați, 1996.

[5] GODBY, C.J., *A computational study of lexicalized noun phrases in English.* Doctoral dissertation, Ohio State University. USA, 2002

[6] GOTTI, M., *Investigating Specialized Discourse*, Bern: Peter Lang AG, European Academic Publishers, 2008

[7] HALLIDAY, M.A.K., *Spoken and Written Language*, Geelong, Victoria: Deakin University Press, 1985(a)

[8] HALLIDAY, M.A.K., *An introduction to functional grammar,*London: Edward Arnold, 1985(b)

[9] HALLIDAY, M. A. K., In Webster J. (Ed.), *The language of science*. London: Continuum, 2004

[10] MCKENNA, B., *How engineers write: an empirical study of engineering report writing*. Applied Linguistics, 18, (2), 189-211. England: Oxford University Press, 1997

[11] QUIRK R., GREENBAUM G., LEECH G. & SVARTVIK, J, *A grammar of contemporary English,* London: Longman, 1980

[12] QUIROZ, G., A., "Using an English- Spanish Parallel Corpus to Solve Complex Premodification in Noun Phrases", In Gotti, M., Šarčević , S. (eds.) *Insights into Specialized Translation*. Bern: Peter Lang, 2006: 367- 390.

[13] PRITCHARD, B., "Some Lexical Aspects of Translating Specialized Texts" Gotti, M. & Šarčević S., (eds) *Insights into Specialized Translation*, Bern: Peter Lang, 2006: 261-288.

[14] SALAGER, F., *Syntax and Semantics of Compound Nominal Phrases in Medical English Literature. A comparative Study with Spanish*,in ESP, Febr. 1985

[15] SCHMITT, N., MCCARTHY, N., *Vocabulary: Description, Acquisition and Pedagogy.* Cambridge: Cambridge University Press, 1997

[16] TRIMBLE, L. *English for Science and Technology.* Cambridge University Press, 1985

[17] ULRYCH, M., *Translating texts, from theory to practice*. Cideb Editrice,1992

[18] WELLS, R., *Nominal and Verbal Style*, in Sebeok 1960

# SECTION VI
## TRANSPORT ECONOMICS

# THE STRATEGIC ISSUES – STRUCTURAL ELEMENTS OF STRATEGIC MANAGEMENT

BALTA CORNELIU

*Wales University Romania*

**ABSTRACT**

The paper presents the most important concepts related to strategic management and the connection with strategic results as they are obtained after the main steps in strategic management are followed. The dynamics of the relationship between strategic issues and objectives is included.

**Keywords:** *strategic management, vision, mission, leadership.*

## 1. INTRODUCTION

Organizations having a solid strategic management component are characterized by values, vision, mission, strategic planning, budget, policies, procedures, issues, objectives, informational standards and organizational structure.

The specialized literature on strategy makes extensive uses of terms such as strategic vision and strategic objectives, while a concept such as strategic issues has been less and sometimes insufficiently[1] studied.

## 2. THE STRATEGIC ISSUES - SUPPORTING ELEMENTS FOR THE ORGANIZATION'S STRATEGIC MISSION AND VISION

Within our approach, the strategic issues are considered the main business strategies supporting the whole activity of the organization. Technically, they are structural elements of the strategic planning activity, in the sense that the organization's strategic vision is based on a series of strategic issues. The strategic issues are also called *„the pillars of excelence"*[2] in the specialized literature, and they define the organization's strategic reactions in its attempt to achieve its vision in its main domains, as follows:

- Financial
- Beneficiaries/Customers
- Internal processes
- Organizational capacity

That is why the development of the strategic issues is carried out in relationship with other strategic elements such as:

- The market challenges;
- The beneficiaries / customers' value level;
- The strategic results;

The strategic issues can be attached to a strategic result, the two possible situations being that more strategic issues support a single strategic result or only one strategic issue supports one strategic result. Generally, the relationship among strategic issues, strategic results, strategic vision and mission can be illustrated as shown in the following figure.

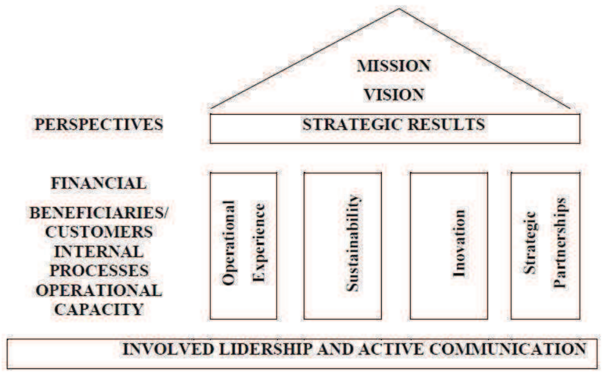



Figure no. 1. *The Relationship among strategic issues, strategic results, strategic mission and vision*

Most often, the strategic issues are similar in different organizations. Such similar strategic issues are: operational excellence, business development, excellence of customer service, sustainability, innovation or strategic partnerships[3]. Despite this resemblance, there are obvious differences among organizations in terms of strategic results, the specific characteristics of any organization being shaped by its specific strategic results.

## 3. THE RELATIONSHIP BETWEEN THE STRATEGIC ISSUES AND STRATEGIC RESULT

Within the strategic management process, each strategic theme can be de-composed in a series of strategic objectives corresponding to each important domain of the organization.

Thus, we may identify strategic objectives in the financial compartment, in the organization's relationship with its beneficiaries/customers, other strategic

[1] *** *STUDY BY ERNST & YOUNG:Performanța și capitalul, temele strategice pentru industria auto din acest an (Performance and Capital, This Year's Strategic Issues for the Car Industry*, Bursa newspaper, 08.March.2013.

[2] Ole Ingstrup, Paul Crookall, *Three Pillars of Public Management: Secrets of Sustained Success,* McGill-Queen's University Press, 1998, *passim*

[3] Mytelka, Lynn Krieger, ed. *Strategic partnerships: States, firms, and international competition*, Fairleigh Dickinson University Press, 1990. *passim*

objectives related to the organization's internal processess and not ultimately strategic objectives regarding the organizational capacity.

By grouping these objectives at the level of the whole organization, the management of the company defines strategic directions, limitations and parameteres for each strategic issue, according to the desired strategic result. An illustration of this process can be seen in the following figure.

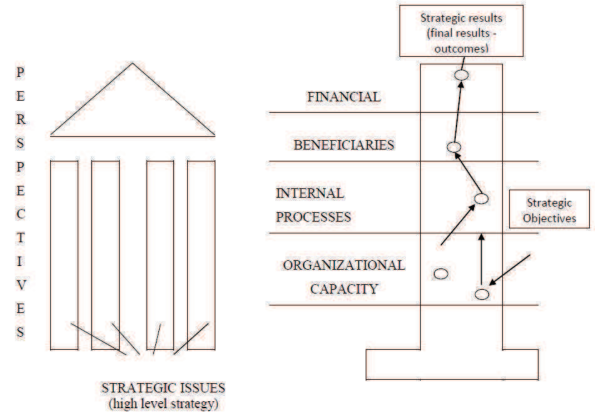



Figure no. 2. *The relationship between the strategic issue and the strategic result*

Therefore, a strong strategic issue includes an inter-conected set of strategic objectives, which is the very way in which the strategic issue contributes to the organization's strategic mission and vision, by constituting the basis for communicating the strategy in a consistent manner.

We will offer the example of innovation, treated as a strategic theme.[4] It will be differently interpreted according to the department it addresses. From a financial point of view, innovation can be defined as the permanent delivery of value towards the organization for investors, customers, etc. From the point of view of the organization's relationship with its beneficiaries, the innovation can be defined as the development and offer of new products and services or a business model that shall offer value to beneficiaries or clients. From the point of view of an organization's internal processes, innovation as a strategic theme can be represented by the creation and administration of an assessment process or of a process promoting new ideas. Concerning the organizational capacity, the strategic issue of innovation is based on a combination of leadership, culture, values and organizational structures that would allow the generation of new, valuable ideas for the organization.

## 4. THE EFFICIENT USE OF STRATEGIC ISSUES IN THE PROCESS OF STRATEGIC MANAGEMENT

Once all the strategic issues are developed in close relationship to each organizational domain and supporting the desired strategic results, they can be included in the organization's strategic planning. The reason for approaching each theme independently and only in a later stage integrating them in the final strategic planning is the desire to include all the aspects necessary for achieving the strategic result.

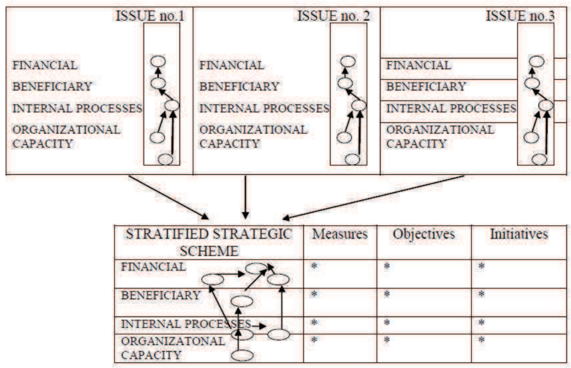



Figure no. 3. *The process of integrating the strategic issues within the strategic planning*

Leaving out this stage, especially beacuse of insufficient time is not desirable as major strategic objectives might be omitted, having a key role in the process of reaching the strategic results. Such a situation would lead to the impossibility of achieving the strategic result, and implicitely to the impossibility of achieving the organization's mission and vision.

Following the logic of these final statements we can come to the conclusion that strategic topics assure the structural integrity of the whole organizational system.

In order to demonstrate the way in which strategic objectives support the different strategic topics in the departments of the organizations we can de-construct in a detailed way the dynamic relationship among strategic objectives, issues and results within the broader framework of strategic planning.

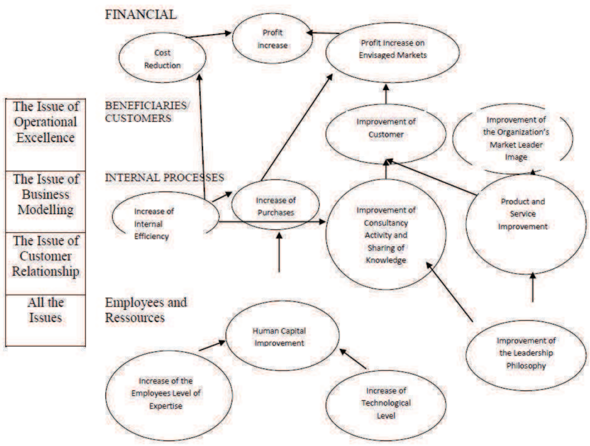



Figure no 4. *The dynamics of the relationship between strategic issues and objectives*

---

[4] Dan Montgomery, Gail Perry, *Build innovation in zour strategy,* Strategy Management Group, North Carolina 2011, pp. 1-4

## 5. CONCLUSIONS

The reality of the contemporary economic environment demonstrates that organizations need to adopt highly flexible attitudes in relationship to the market, to investors, business partners and even competition. Frequent re-evaluations of the strategy have become necessary, the key role belonging to the strategic management. By establishing, designing and integrating strategic issues within the general organizational strategy, that shall support strategic results, the leading staff of an organization will be able to correctly assess any change of the strategic direction and correctly decide on the changes necessary for assuring the organization's integrity and sustainability, the latter concept being defined as a set of structural changes influencing the organization's strategy[5] and performance.

## 6. REFERENCES

[1] JORGENSEN et al. "*Lean Maturity, Lean Sustainability*", Advances in Production Management Systems (2007)

[2] MAIER, A. M. et al. "*A review of maturity grids based approaches to assessing organizational capabilities*", Academy of Management Meeting, Anaheim, California, Academy of Management (2008)

[3] SRAI R. K. and NORTON D. P. *The Execution Premium* (Harvard Business School Press, 2008).

[4] SRAI R. K. and NORTON D.P. *The Strategy – Focused Organization* (Harvard Business School Press, 2001)

[5] SRAI J.S. "*Process Organization, Capabilities and Supply Networks-Enterprise organization and operation*", in Springer Handbook of Mechanical Engineering, Editors: Karl-Heinrich Grote, Erik K. Antonsson, Springer, Heidelberg. (2009)

[6] PORTER M. E. and KRAMER M. R. "*Strategy and Society –The Link Between Competitive Advantage and Social Responsibility*", Harvard Business Review, December 2006

[7] WILLARD B., "*The Next Sustainability Wave: Building Boardroom Buy"*, New Society Publishers, 2005

[5] Howard Rohm, Dan Montgomery, *Link Sustainability to Corporate Strategy Using the Balanced Scorecard,* Strategy Management Group, 2011, pp1-2

# QUALITY ASSESSMENT OF STRATEGIC MANAGEMENT IN ORGANIZATIONS – A MATURITY MODEL

BALTA CORNELIU, ROSIORU NICOLETA DIANA

*Wales University Romania*

**ABSTRACT**

The paper presents the actual main concepts related to assessment of quality management in organizations. Strategic management is analyzed taking into consideration the most important dimensions including leadership, culture and values, process improvement, etc. The five levels of maturity model of strategic management are described showing the connection with organizational development.

**Keywords:** *quality assessment, maturity model, performance measurement*

## 1. INTRODUCTION

The effects of the financial crisis characterizing the years 2008-2010 have led to major changes in the management of organizations, especially in the area of their strategic management[1].

Regardless of the type of organization, strategic management is the most important component of its managerial activity, as it sets up the organization's mission, vision and objectives. Starting from 2010, not only the top management of companies but also investors have focused on their organizations' place on the market, aiming at improving their strategic management. This need of organizations to assess the quality of their strategic management has led to the development of a *strategic management maturity model (SMMM)*.

## 2. THE STRATEGIC MANAGEMENT MATURITY MODEL (SMMM)

The strategic management maturity model has been born from the managers' need to have a rapid assessment of their organization's strategic management situation, to monitorize the progress of the strategic management improvement process and to allow rapid assessment methods for organizations and departments in order to identify their strengths and weaknesses.

Generally, the organization's management process starts from two basic questions:

- Are the organization's activities performed well?
- Are the organization's activities performed correctly?

The specialists in the field have established that the answer to the first question can be found in the area of operational management. A series of instruments have been developed that can improve the proper development of activities, such as TQM, Six Sigma or the re-design of business processes. To these the strategic management maturity model is added.

The strategic management maturity model starts from re-defining the concept of performance by adding its strategic management component, which is meant to answer the second question, regarding how correctly the organization's activities are carried out. As a starting point in the attempt to answer this second interrogation, it is necessary to state that the aspects relates to corectness are defined by the strategy established according to the vision of the organization's leading staff. It is also important to mention that the mere improvement of processes cannot guarantee an organization's success or the success of one of its missions. Both managerial components, the strategic and the operational one are necessary as they are complementary. Therefore, the process of assessing the quality of an organization's strategic management should take into account both the strategic and the operational management, in order to establish the organization's complete managerial capacity.

The assessment process by means of the strategic management maturity model means evaluating, measuring the strategic management dimensions on a scale of five SMMM specific levels. References to strategic management dimensions shall take into consideration the following dimensions of performance assessment:

- Leadership;
- Culture and values;
- Strategic thinking and planning;
- Direction;
- Performance measurement[2];
- Process improvement;
- Strategic management sustainability.

We will shortly characterize each of these dimensions in order to better understand the organization's maturity model.

---

[1] Martin Kunc, Rahul Bhandari, (2011) *Strategic development processes during economic and financial crisis,* Management Decision, Vol. 49 Iss: 8, pp.1343 - 1353

[2] Simons, Robert, Antonio Dávila, and Robert S. Kaplan. *Performance measurement & control systems for implementing strategy: text & cases*. Upper Saddle River, NJ: Prentice Hall, 2000, passim.

*Leadership*

An efficient strategic management will obviously start from the organization's leading staff, which are supposed to launch new hypotheses and find new sollutions for problems, thus building, creating the company's future vision. There are certain characteristics that the company's leading staff need to possess in order to perform these tasks, such as:

- The capacity to set up a clear and consistent vision regarding the future of the organization;
- The capacity to pro-actively prepare the organization for facing the challenges of the projected future;
- The capacity to get involved in turning the organization's vision into clear tasks for each employee;
- The capacity to be an example illustrating the organization's values, ethics and policies;
- The capacity to encourage employees to come up with new ideas which should finally lead to career advancement, as well as the capacity to encourage team work.

*Culture and values*

This dimension refers to the culture and values existing within the organization, both at the level of the management and of the employees. In a mature organization, the difference is made by the way culture and values are communicated, understood and practised at both levels mentioned above.

A mature labour force's culture and values are proven by the following:

- The principles and practices of change management are applied by the leading staff;
- The degree in which the organization's values and vision are internalized by the employees;
- The degree of participation in the process of modelling the organization's culture and work paterns;
- The level of trust, transparency and freedom of communication;
- The degree of flexibility and willingness to accept change as a necessary step for accomplishing the new strategic demands;
- The level of understanding and the consistency of sharing the organization's values and policies.

*Strategic planning and thinking*

The development of an organization's strategy is a complex and challenging process, the completion of its component tasks being based on strategic thinking.

Strategic thinking is, in its turn, based on a series of abilities:

- The ability to use consistent definitions of the terms used in the planning process and the capacity to make the difference among them;
- The capacity to understand the difference between projected and strategic planning;
- The capacity to understand the effects of the dynamics of the organization's systems such as delays or feedback;
- The ability to describe the items of the planning process to the necessary strategic amplitude;
- Openness to new ideas and the ability to encourage innovation and creativity;
- The ability to think of alternative strategies and scenarios;
- The ability to establish a relation between the organization's strategic planning and its budget;

*Direction*

This dimension refers to the strategic direction that can be defined as the degree in which an organization's human and material resources are oriented towards a projected strategy.

The absence of this dimension is synonym to chaos and it means that the organization's managers, programs and projects have different objectives translated into the lack of a common vision. Such a state of chaos leads to the waste of resources, to delays, conflicts and confusion.

The organizations that benefits from a strategic direction[3] are characterized by values, vision mision, strategic planning, budget, policies, procedures, tasks, objectives, informational standards and organizational structure.

Generally, the direction measures the extent to which:

- The human factor at all levels is motivated by a mutual strategy and vision;
- The employees understand that their support of the organization's strategy influences the way they work;
- The employees are self motivated and the motivation is not related to obeying rules.

*Performance measurement*

The measurement of strategic performance is related to strategic planning and to the way in which strategic results are integrated withing the organization's vision.

The characteristics to be identified in the assessment process of this dimension are the following:

- Measurements regarding not only the financial expenses, the accomplished tasks or the deliverables, but also the results;
- Measurements that use correct percentages and units of measure adapted to the best possible understanding of the situation;
- The frequency with which measurements are made and reported for supporting the decision making process;
- A balanced set of measurements that shall cover a series of different dimensions, from financial data to customer satisfaction, internal processess or organization capacity.

Performance measurement is also based on the assessment of the way technology is used in the process of handling the information on performance. The use of hard copies for documents may be adequate for

[3] Donaldson, Gordon, and Jay William Lorsch. *Decision making at the top: The shaping of strategic direction*. New York: Basic Books, 1983, pp. 111-112.

organizations of small dimensions but in larger, modern organizations the collection and dissemination of data on performance need advanced IT systems and networks. Thus, the extent to which final users have access to relevant data becomes an aspect mirroring the maturity of strategic management.

*Performance management*

The above mentioned data collection and dissemination do not achieve their goal if the data are not used efficiently. Performance management[4] is that very dimension of strategic management which defines the degree in which the data regarding the performance are used in the decision making process. The following aspects shall be taken into account:

- Recognition of the organization as a dynamic system;
- Use of feedback by the organization's management so that they might identify the results of their decisions;
- Placement of the organization, by its leading staff, in a learning environment so that it might validate its vision;

These aspects establish the extent to which an organization's managerial staff have access to the information necessary in order to make decisions, thus defining the level of performance management.

*Process improvement*

Broadly speaking, the role of the strategic manager is to identify the organization's processess that need improvement, an activity which is based on strategic imput in the sense that information is received regarding the use of resources for the improvement of the most strategic processess on the long and respectively the short term.

The improvement of the processess shall start from the assessment of the following aspects:

- Knowledge of the activity processess which are important from a strategic point of view;
- Abilities, practices and technologies used for improving the quality and the efficiency of the processes;
- Knowledge of the organization's competences and capacities and of the way they are involved in the carrying out of the processes;
- The extent to which the organization is aware of its customers' and beneficiaries' expectations;
- The existence of emergency plans in case of future risks, disasters, financial problems or change of the leading staff.

*Sustainability of strategic management*

This dimension is defined by the following aspects:

- Placement of the organization in the area of strategic vision, planning and initiative;[5]
- Existence of a reward and value recognition system that shall contribute to the effort of motivating employees;
- Presence of a strategic management cell that shall draw up the strategy and supervise the performance level.

The short description of these eight dimensions of strategic management is a key element in the analysis of the assessment process of an organization's strategic management based on the maturity model.

## 3. THE LEVELS OF THE MATURITY MODEL OF STRATEGIC MANAGEMENT

For each dimension previously analysed within the assessment model of the degree of maturity of an organization's strategic management we can identify five maturity levels, as follows:

- ad-hoc and static level;
- reactive level;
- structured and pro-active level;
- administered and oriented level;
- permanent improvement level.

According to the level within which the eight specific dimensions of strategic management can be placed, organizations fall under one of the five levels, of which the ad-hoc and static level is the lowest and the permanent improvement level is the highest. For a better understanding of our thesis, the following figure presents the assessment model of the degree of maturity of an organization's strategic management:

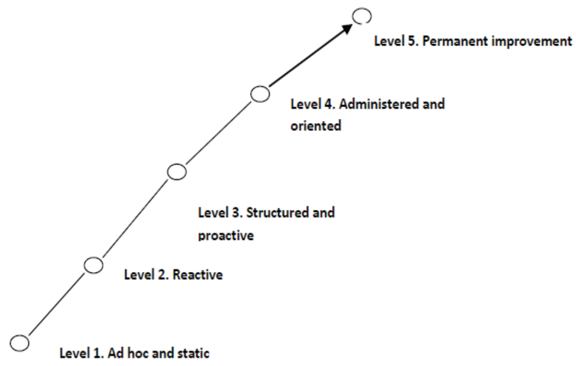



Figure 1 The maturity levels resulting from the assessment of the dimensions of an organization strategic manageme

## 4. CONCLUSIONS

The use of the maturity model in the assessment process of the organizations' strategic management is a

[4] Armstrong, Michael, and Angela Baron. *Performance management*. London: Kogan Page, 1994, p.5-16.

[5] Wheelen, Thomas L., and J. David Hunger. *Concepts in strategic management and business policy*. Pearson Education India, 2011, pp. 27-35

necessary tool, especially on the contemporary economic background, when organizations are subject to a long process of adaptation to the new characteristics of the economic-financial environment.

The identification, as a result of this type of evaluation, of an organization's degree of maturity offers its management, investors and customers reliable data on its situation on the market.

## 5. REFERENCES

[1] JORGENSEN et al. "Lean Maturity, Lean Sustainability", *Advances in Production Management Systems* (2007)

[2] MAIER, A. et al. "A review of maturity grids based approaches to assessing organisational capabilities", Academy of Management Meeting, Anaheim, California, Academy of Management (2008)

[3] SRAI R. K. and D. P. Norton, *The Execution Premium*, (Harvard Business School Press, 2008).

[4] SRAI R. K. and D. P. Norton, *The Strategy-Focused Organization*, (Harvard Business School Press, 2001).

[5] SRAI, J. S. "Process Organisation, Capabilities and Supply Networks-Enterprise organization and operation" in *Springer Handbook of Mechanical Engineering*, Editors: Karl-Heinrich Grote, Erik K. Antonsson, Springer, Heidelberg. (2009)

# IMPORTANCE OF STUDYING CHRONOLOGICAL SERIES FOR THE ANALYSIS OF TRANSPORT ACTIVITY

BRANZA GRATIELA

*Constanta Maritime University, Romania*

**ABSTRACT**

The knowledge of socio-economic phenomena on different time periods are based on the interpretation of time series. The purpose of the statistical analysis of time series is to determine the objective trend of a phenomenon development in the past, but also in present, extrapolating the past and present data to the future in order to determine the values of the forecast. This paper presents the possibilities of analysis and interpretation of a time series of data on transported goods in Romania in the period 2005-2010, with its specific system indicators. It combines theoretical issues with the applicative ones, highlighting the importance of statistical analysis of time series to capture objectively the evolution of the economic phenomenon that is the research subject in this paper.

**Keywords:** *chronological series, time series, indicators system, absolute indicators, relative indicators, average indicators, mode of transport, transported goods*

## 1. INTRODUCTION

Analysis of the evolution in time of various social and economic phenomena and processes requires systematization of data as chronological series. Chronological series, called dynamic or time series consists of two parallel rows of data, where the first row shows the variation of time characteristic and the second row the variation of the researched phenomenon or feature from one time unit to other.

Knowledge of phenomena in their historical evolution allows to lay assumptions about the evolution of those phenomena in future. Time series analysis is performed using tools and ways that discover the following: variation in time of economic phenomena and processes, the general trend and its quality, seasonal variation of economic phenomena, forecasts and future evolutions. Dynamic series properties are: variability and uniformity of terms, interdependence and frequency of terms.

Taking into account the properties of dynamic series, statistical analysis of time series has to be based on a system of indicators that characterize many quantitative relations of the series and throughout the period to which they relate. Consequently, time series analysis requires solving the following issues:

-Development of time series;

-Data processing and their presentation as a system of absolute, relative and average statistical indicators in order to characterize the series;

-Setting the trend of the evolution of phenomena in the series, using the methods of statistical adjustment;

-Determining the cyclical evolution of the phenomenon;

-Analyze seasonality through specific statistical methods for studying phenomena influenced by seasons;

-Statistical foundation of forecasting calculations, mainly by extrapolating time series.

## 2. INDICATORS SYSTEM OF TIME SERIES. CASE STUDY: TRANSPORTED GOODS BY MODE OF TRANSPORT IN ROMANIA

Depending on the expression of the indicators that make up the series we identify time series consisting of absolute indicators; series consisting of relative indicators and those formed by average indicators. Depending on the unit of time in which each of the levels characteristic refers to, we can distinguish: chronological series of intervals (flow series) and dynamic series of moments (stocks series). The indicators can be expressed in absolute or physical units (tonnes, pieces, etc.) and in relative values (percentages, coefficients).

In the table below it is presented a chronological series that include statistical data for transported goods by railway, road, inland waterways, maritime, air and petroleum pipelines transport in Romania during 2005-2010.

Table 1. Transported goods (thou tonnes) by mode of transport in Romania in the period 2005-2010

| Mode of transport/ Year | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Railway transport | 69175 | 68313 | 68772 | 66711 | 50596 | 52932 |
| Road transport | 306994 | 335327 | 356669 | 364605 | 293409 | 174551 |
| Inland waterways transport | 32845 | 29304 | 29425 | 30295 | 24743 | 32088 |
| Maritime transport | 47678 | 46709 | 48928 | 50449 | 36021 | 38118 |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Air transport | 20 | 23 | 22 | 27 | 24 | 26 |
| Transport via petroleum pipelines | 13378 | 12702 | 12310 | 12390 | 8520 | 6551 |

Source: Statistical Yearbook of Romania 2011. Time series 1990-2010, National Institute of Statistics, http://www.insse.ro

Regarding data processing for time series, it is useful the system of indicators made up of three subsystems. The first subsystem is represented by the *absolute indicators* and includes *absolute levels of series terms and absolute change.*

*Absolute change* expresses the increase or decrease of characteristic level and can be calculated either with fixed base or with the base chained, depending on the reference level chosen for the whole period analyzed, as follows:

$$\Delta_{t/1} = y_t - y_1 \tag{1}$$

$$\Delta_{t/t-1} = y_t - y_{t-1} \tag{2}$$

Relationships of passing from one base to another:

$$\sum_{t=2}^{n} \Delta_{t/t-1} = \Delta_{n/1} \tag{3}$$

$$\Delta_{t/1} - \Delta_{t-1/1} = \Delta_{t/t-1} \tag{4}$$

Table 2. Absolute change of transported goods by railway transport in Romania during 2005-2010

| Year | Transported goods (thou tonnes) | $\Delta_{t/1}$ (thou tonnes) | $\Delta_{t/t-1}$ (thou tonnes) |
|---|---|---|---|
| 2005 | 69175 | - | - |
| 2006 | 68313 | -862 | -862 |
| 2007 | 68772 | -403 | 459 |
| 2008 | 66711 | -2464 | -2061 |
| 2009 | 50596 | -18579 | -16115 |
| 2010 | 52932 | -16243 | 2336 |

Source: Author's calculation

Analyzing the amount of goods transported by rail with absolute change resulted in decreases in the value of this indicator both to the reference year 2005, and from one year to another, as we can see in table 2.

The second subsystem of time series indicators is composed of *relative indicators*, such as: *dynamic index* calculated with fixed based or with the base chained, *rate of increase (decrease)* calculated with fixed based or with the base chained and *the absolute value of a percentage of increase (decrease)* calculated with fixed based or with the base chained. Most used indicators are dynamic index and rate of increase (decrease).

$$I_{t/1} = \frac{y_t}{y_1} \cdot 100 \tag{5}$$

$$I_{t/t-1} = \frac{y_t}{y_{t-1}} \cdot 100 \tag{6}$$

Relationships of passing from one base to another:

$$\prod_{t=2}^{n} I_{t/t-1} = I_{n/1} \tag{7}$$

$$\frac{I_{t/1}}{I_{t-1/1}} = I_{t/t-1}. \tag{8}$$

In table 3 we can observe the results obtained by using dynamic index and rate of increase (decrease). For example, in 2008 the rate of increase of transported goods by road is 19% compared to the reference year 2005 and in 2010 the rate of decrease is 43% compared with the same reference year.

Table 3. Relative indicators of transported goods by road transport in Romania in the period 2005-2010

| Year | Transported goods (thou tonnes) | $I_{t/1}$ (%) | $I_{t/t-1}$ (%) | $R_{t/1}$ (%) | $R_{t/t-1}$ (%) |
|---|---|---|---|---|---|
| 2005 | 306994 | - | - | - | - |
| 2006 | 335327 | 109,0 | 109,0 | 9,0 | 9,0 |
| 2007 | 356669 | 116,0 | 106,0 | 16,0 | 6,0 |
| 2008 | 364605 | 119,0 | 102,0 | 19,0 | 2,0 |
| 2009 | 293409 | 96,0 | 80,0 | -4,0 | -20,0 |
| 2010 | 174551 | 57,0 | 59,0 | -43,0 | -41,0 |

Source: Author's calculation

The last subsystem comprises the *average indicators*, such as:

*The average level* of time series is calculated differently depending on the type series:

-For chronological series of intervals, the average level is an arithmetic average of the terms of the series:

$$\bar{y} = \frac{\sum_{t=1}^{n} y_t}{n}, t = \overline{2, n}; \tag{9}$$

- For chronological series of moments, the average level is determined by calculating:

a) simple chronological average, if the series is composed of equal time intervals:

$$\bar{y}_{cr} = \frac{\frac{y_1 + y_2}{2} + \frac{y_2 + y_3}{2} + \ldots + \frac{y_{n-1} + y_n}{2}}{n-1}, \tag{10}$$

b) weighted chronological average, if the series are formed of unequal time intervals:

$$\bar{y}_{cr} = \frac{y_1\left(\frac{t_1}{2}\right) + y_2\left(\frac{t_1 + t_2}{2}\right) + \ldots + y_n\left(\frac{t_{n-1}}{2}\right)}{\sum_{i=1}^{n-1} t_i}. \tag{11}$$

The annual medium quantity of transported goods via petroleum pipelines in Romania was 10.975 thou tonnes according to calculation in the period of study.

*The average level of the absolute change* (increase or decrease) can be calculated according to the formula:

$$\overline{\Delta}=\frac{\sum_{t=2}^{n}\Delta_{t/t-1}}{n-1} \quad \text{or} \quad \overline{\Delta}=\frac{y_n-y_1}{n-1}. \qquad (12)$$

The calculation of the average level of the absolute change shows that on average it has been recorded an annual decrease of 1.365 thou tonnes of goods transported via petroleum pipelines during 2005-2010.

*The average index of dynamics* is determined as:

$$\bar{I}=\sqrt[n-1]{\prod_{t=2}^{n} I_{t/t-1}} \quad \text{or} \quad \bar{I}=\sqrt[n-1]{\frac{y_n}{y_1}} \qquad (13)$$

*The average rate growth* is obtained using the following formula:

$$\overline{R}=\bar{I}_{(\%)}-100\% \quad (14)$$

Analyzing the transported goods by air transport in the period 2005-2010 with the use of average index of dynamics and the average rate growth, the results of calculations indicate an average modification of 3% annually in the goods quantity transported by air.

Here we can make an observation, the last three average indicators have some limitations, since they depend on the quality of extreme terms (first and last), without regard the variation within the series.

Outside the system of indicators, another important method to capture the evolution of an economic phenomena is the graphical representation, ie the *time charts* for chronological series (see figure 1).

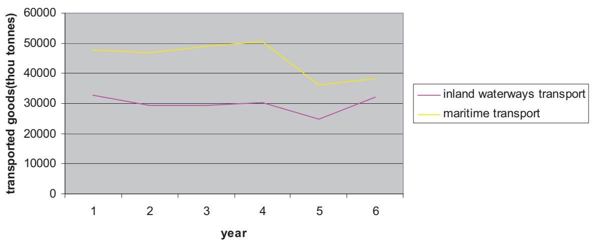



Figure 1. Evolution of transported goods by inland waterways transport and by maritime transport in Romania during 2005-2010

## 3. COMPONENTS OF A TIME SERIES AND ITS ADJUSTMENT

The evolution of a social and economic phenomenon is caused by the action of various factors essential or accidental that prints a certain regularity of that phenomenon development. These factors actually make the components of a chronological series. In time series analysis, their decomposition and statistical evaluation of component parts is a fundamental problem, which finds its resolution in statistical theory and practice through a number of methods.

*Trend* - is the main component of the development and the consequence of essential causes with long-term acting (technical progress, population growth). It is a systemic component.

*Seasonality* - is represented by the fluctuations (oscillations) according to the seasons, climatic factors, social factors, which influence the conduct of a phenomenon or process over a period of time.

*Cyclicality* - is determined by factors of diverse nature acting on the analyzed phenomenon.

*Residual variation* - is the part of the variance of a time series that is generated by unexpected, residual factors and manifests in the form of deviations from what is systematically in the evolution of the analyzed phenomenon.

To determine the general trend in the evolution of a phenomenon, the operation of adjusting the time series is extremely important because it eliminates seasonal fluctuations, cyclical and accidental oscilations.

More broadly, by adjusting the terms of a series of statistical data means replacement of real terms with theoretical terms and expresses lawfulness specify of objective development of phenomena that the data refer to.

Adjustment methods are various, but the most known and used methods are:

-Adjustment based on moving averages;
-Adjustment by graphic method;
-Adjustment based on the average level of the absolute change;
-Adjustment based on the average index of dynamics;
-Adjustment through the analytical methods of calculation based on the method of least squares.

Analytical adjustment take into account all terms of the time series, eliminating deficiencies of mechanical methods that consider only the extreme terms. The analytical methods are based on a mathematical model, in which the trend is expressed as a function of time: $y=f(t_i)$ , where t=the values of the independent variable (time); y=values of the dependent variable (the phenomena presented in chronological series).

Choosing the adjustment function that estimates best the trend is done either on the basis of the plot or on the base of calculation of absolute differences with the base chained. After choosing the adjustment function, using one of the above criteria, we must estimate the parameters of these functions using the method of least squares. This method aims at minimizing the sum of squared deviations of actual values from those adjusted:

$$\sum\left(y_i-Y_{t_i}\right)^2=\min,\ t=\overline{1,n}\ . \qquad (15)$$

Using calculation methods based on the method of least squares, adjustment and extrapolation are inseparable. The forecast calculations often use statistical extrapolation based on the average level of absolute change and on the average index of dynamics.

In order to distinguish between the terms adjusted (Yt) and the extrapolated ones (which are still considered theoretical terms), the extrapolated terms will be marked with $Y_t^{'}$ and time variable with t'. The calculation formulas to be used are as follows:

- To extrapolate on the base of average growth: $Y_t^{'}=y_0+t'\overline{\Delta}$ (16)
- To extrapolate on the base of the average index of dynamics : $Y_t^{'}=y_0\cdot\bar{I}^{t'}$ (17)

For statistical extrapolation based on analytical methods of calculation, the first condition is to determine the data is such manner that it does not alter the origin of time variation that is among time series and that $\sum t_i = 0$.

## 4. CONCLUSIONS

In conclusion, the analysis of time series have to consider the entire system of indicators resulting from their processing, enabling emphasizing the objective trend of the phenomena investigated development, removing what is accidental and insignificant in evolution. To this end, it is appropriate that for the study of phenomena dynamics to use complete data sets that consist of comparable indicators and consider an entire stage of development. Only a complete and accurate analysis of a statistical series can provide the real chronological forecasts. In other words, the statistical analysis of the trend with the interpretation of cyclical fluctuations and in particular, seasonal variation allows a thorough knowledge of the evolution of phenomena in order to develop a variety of "possible future" scientifically.

## 5. REFERENCES

[1] ANGHELACHE, C., *Theoretical and economic statistics, theory and applications*, Economic Publishing House, Bucharest, 2004

[2] ANGHELACHE, C., MANOLE, A., *Dynamic/Chronological (time) Series – theoretical presentation, structure, relationships between indices*, Statistical Review, no.10, National Institute of Statistics, Bucharest, 2012

[3] BIJI, M., BIJI, M.E., LILEA, E., ANGHELACHE, C., *Statistical Treaty,* Economic Publishing House, Bucharest, 2002

[4] BIJI, M.E., SECARA, M., BRANZA, G., *Statistics. Theory and applications,* Ex Ponto Publishing House, Constanta, 2010

[5] BRANZA G., *Statistics. Compendium, applications, tests,* Ex Ponto Publishing House, Constanta, 2008

[6] ***, *Statistical Yearbook of Romania 2011. Time series 1990-2010*, National Institute of Statistics, Bucharest, 2011

[7] ***http://www.insse.ro

# SUSTAINABLE TRANSPORT' S INDICATORS. COMPARATIVE STUDY: EU-27 AND ROMANIA

[1]BRANZA GRATIELA, [2]CRISTEA VIORELA-GEORGIANA

[1,2]*Constanta Maritime University, Romania*

**ABSTRACT**

Sustainable development is one of the most important target of the European Union. Between EU Sustainable Development Strategy's challenges, sustainable transport represents an essential aim. According to EU statements, "to ensure that our transport systems meet society's economic, social and environmental needs whilst minimizing their undesirable impacts on the economy, society and the environment". Our work is a comparative study between EU-27 and one of its member country (Romania) regarding the set of sustainable transport's indicators, as a statistical overview of progress towards the accomplishment of EU sustainable development strategy's goals in this sector of activity. As a result of our statistical analysis, we present some measures that can be taken to increase the sustainability of european transport, focusing on reducing the adverse effects of transport activities on the environment and promoting solutions in order to minimise the vehicle's emissions and costs and thus, to meet the sustainability objectives and to contribute to a sustainable quality of life.

**Keywords:** *sustainable transport, indicators, sustainable development, transport mode, EU-27, Romania, environment*

## 1. INTRODUCTION

Sustainable development is an essential goal of the European Union, focusing on the life quality increase and taking into account economic, social and environmental aspects.

An important part of European Union Sustainable Development Strategy is represented by the indicators that measure the progress towards the accomplishment of strategy's purposes. More than 100 indicators characterize sustainable development in European Union, but a global overview is given by headline indicators. Thus, in the field of transport, energy consumption of transport relative to GDP (gross domestic product) is the headline indicator used to evaluate sustainable transport. On level 2, we find two subthemes – Transport and mobility, Transport impacts – with specific indicators, such as: Modal split of passenger transport, Modal split of freight transport, Energy consumption by transport mode, Greenhouse gas emissions from transport, People killed in road accidents. [2]

## 2. ENERGY CONSUMPTION OF TRANSPORT RELATIVE TO GDP IN EU-27 AND ROMANIA

This indicator is defined as the ratio between the energy consumption of transport and GDP. The energy consumed by all types of transport (road, rail, inland navigation, aviation) is covered, including commercial, individual and public transport, with the exception of maritime and pipeline transport.

Table 1. Dynamics of Energy consumption of transport relative to GDP in EU-27 and Romania in the period 2000-2010 (%)

| Year | EU-27 | Romania |
|---|---|---|
| 2000 | 100 | 100 |
| 2001 | 98,7 | 113,9 |
| 2002 | 98,2 | 111,8 |
| 2003 | 98,3 | 112,0 |
| 2004 | 98,7 | 107,2 |
| 2005 | 97,8 | 96,2 |
| 2006 | 96,6 | 92,5 |
| 2007 | 95,0 | 92,7 |
| 2008 | 94,1 | 97,6 |
| 2009 | 95,7 | 105,1 |
| 2010 | 93,3 | 100,5 |

Source: Series of statistical data, [9]

While European Union recorded a decrease in the dynamics of this indicator in the period 2000-2010, in Romania its evolution is oscillating in the same period with successive increases and decreases. This fact is due to the instability of economic and social policies promoted. The lowest level of the indicator was recorded in the year before accession to the EU (92.5% in 2006).

## 3. TRANSPORT AND MOBILITY

### *3.1. Modal split of passenger transport*

Both in the EU and in Romania the largest share in the structure of passenger transport is held by vehicles, on the 2nd and 3rd places being the public means of transport (buses, coaches) and trains.

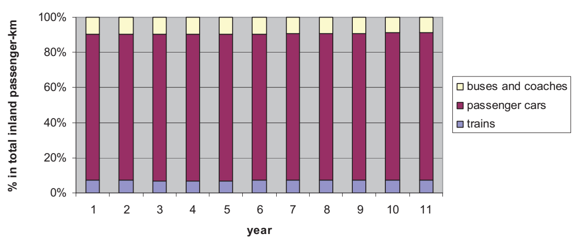



Figure 1. Structure of passenger transport in EU-27 in the period 2000-2010

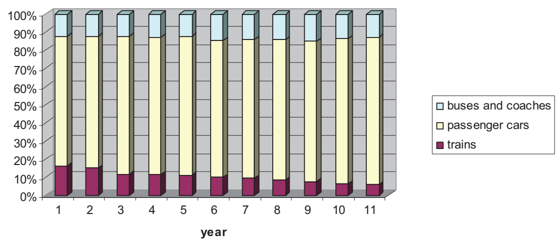



Figure 2. Structure of passenger transport in Romania in the period 2000-2010

*3.2. Modal split of freight transport*

At EU level we observed that in the structure of freight transport prevail road transport with all its shortcomings, especially in terms of effects on the environment. Compared with the structure presented in the EU-27, Romania has a surprisingly favorable situation. Even if freight transport by road has the main place in its structure, in recent years it is used more and more the inland waterways transport and the rail transport (see data from 2010 in table 2). National authorities are focusing on the growth of intermodal transport promotion as a solution for efficient transport activity in Romania.

Table 2. Modal split of freight transport in EU-27 and Romania in the period 2000-2010 (%)

| Year | Mode of transport | | | | | |
|---|---|---|---|---|---|---|
| | Railways | | Roads | | Inland waterways | |
| | EU27 | RO | EU27 | RO | EU27 | RO |
| 2000 | 19,7 | 49,1 | 73,7 | 42,9 | 6,5 | 7,9 |
| 2001 | 18,8 | 43,1 | 74,8 | 49,6 | 6,4 | 7,3 |
| 2002 | 16,5 | 34,4 | 77,2 | 57,3 | 6,4 | 8,2 |
| 2003 | 18,2 | 30,4 | 76,0 | 62,4 | 5,8 | 7,1 |
| 2004 | 17,9 | 27,8 | 76,1 | 60,8 | 5,9 | 11,4 |
| 2005 | 17,7 | 21,7 | 76,4 | 67,3 | 5,9 | 11,0 |
| 2006 | 18,0 | 19,4 | 76,3 | 70,5 | 5,7 | 10,0 |
| 2007 | 17,9 | 18,9 | 76,3 | 71,3 | 5,8 | 9,8 |
| 2008 | 17,8 | 19,0 | 76,3 | 70,2 | 5,9 | 10,8 |
| 2009 | 16,6 | 19,4 | 77,5 | 60,0 | 6,0 | 20,6 |
| 2010 | 17,1 | 23,5 | 76,4 | 49,2 | 6,5 | 27,2 |

Source: Series of statistical data, [9]

In terms of energy consumption by mode of transport (expressed in 1000 tonnes of oil) on the first place in the EU-27 and in Romania is road transport, followed by international air transport, railways, domestic aviation and domestic navigation, as it is shown in table 3 and table 4. For example, domestic navigation consumes 46 times less fuel than road transport in 2009.

Table 3. Energy consumption by transport mode in EU-27 in the period 2006-2011

| Year | Road | Rail | International Aviation | Domestic Aviation | Domestic Navigation |
|---|---|---|---|---|---|
| 2006 | 304775 | 7548 | 44957 | 6704 | 7306 |
| 2007 | 309035 | 7757 | 46099 | 7063 | 6788 |
| 2008 | 305481 | 7725 | 47257 | 6832 | 6809 |
| 2009 | 300245 | 7303 | 43763 | 6134 | 6417 |
| 2010 | 299744 | 7397 | 43160 | 6273 | 6093 |
| 2011 | 297576 | 7319 | 44489 | 6026 | 5926 |

Source: Series of statistical data, [9]

Considering statistical data presented in table 4, we observe the same ranking of transport mode by energy consumption in our country.

Table 4. Energy consumption by transport mode in Romania in the period 2006-2011

| Year | Road | Rail | International Aviation | Domestic Aviation | Domestic Navigation |
|---|---|---|---|---|---|
| 2006 | 3999 | 147 | 155 | 2 | 41 |
| 2007 | 4055 | 264 | 124 | 105 | 85 |
| 2008 | 4665 | 245 | 135 | 129 | 78 |
| 2009 | 4796 | 200 | 149 | 85 | 55 |
| 2010 | 4404 | 221 | 166 | 111 | 59 |
| 2011 | 4548 | 286 | 93 | 133 | 52 |

Source: Series of statistical data, [9]

## 4. TRANSPORT IMPACTS

The second category of sustainable transport indicators are those relating to the effects of transport activities on population and environment.

Referring to greenhouse gas emissions by transport mode, in the period 2000-2010, at EU-27 level we observe an oscillatory evolution, registering significant increases, in average 1.3% per year, until 2008 and then declines in 2008-2010 on the background of world economic crisis. For the same period, in Romania there are increases of carbon emissions' levels, less in 2005-2006 and 2009-2010, as we can see in figure below.

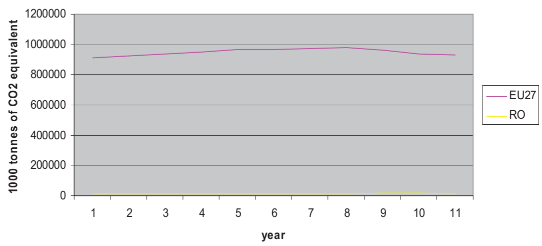



Figure 3. Greenhouse gas emissions by transport mode in EU-27 and Romania in the period 2000-2010

Regarding people killed in road accidents, Romania accounts 4.4% of the number of deaths in EU-27 due to road accidents in 2000 and in 2009 its share has doubled to 8.1%. In terms of number of deaths per million inhabitants, Romania's situation is worrying, because the values are approximately equal to those of the EU-27 in 2000-2003, and after 2003 they exceed them considerably (for example, in 2008 the number of deaths per million inhabitants in the EU-27 was 78 and in Romania 142). This is due to insufficient developed and modernized road infrastructure in our country and to the lack of investment in the transport sector.

Table 5. People killed in road accidents in EU-27 and Romania in the period 2000-2009

| Year | Number of killed people | | Number of deaths per million inhabitants | |
|---|---|---|---|---|
| | EU-27 | RO | EU-27 | RO |
| 2000 | 56427 | 2499 | 116 | 113 |
| 2001 | 54302 | 2461 | 111 | 112 |
| 2002 | 53342 | 2398 | 109 | 111 |
| 2003 | 50351 | 2235 | 102 | 103 |
| 2004 | 47290 | 2418 | 96 | 113 |
| 2005 | 45346 | 2461 | 92 | 121 |
| 2006 | 43104 | 2478 | 87 | 120 |
| 2007 | 42496 | 2800 | 86 | 130 |
| 2008 | 38875 | 3061 | 78 | 142 |
| 2009 | 34500 | 2796 | - | - |

Source: Series of statistical data, [9]

## 5. MEASURES TAKEN TO INCREASE THE SUSTAINABILITY OF EUROPEAN TRANSPORT

An important measure taken to support sustainable transport was represented by the "MoMo-model", a global transport spreadsheet model that includes all modes of transport and most vehicle types and covers 29 countries and regions.

It is based on the "ASIF" framework: **A**ctivity (passenger travel)***S**tructure (travel by mode, load factors)*Energy-**I**ntensity = **F**uel use.[4]

The model is used within the IEA (International Energy Agency) and it contains detailed by-mode, by-fuel and by-region historical data and projections to 2050 for the transport sector and its energy and greenhouse gas implications, based on hypotheses on GDP and population growth, fuel economy, costs, travel demand, vehicle and fuel market shares. It allows a comparison of marginal costs of technologies and total cost across all modes and regions for a given scenario. As we can see in figure below, due to this model, the sales are expected to triple by 2050 and the fuel economy target will be reached by 2020-2030. By 2050, plug-in vehicles will account for more than half of all sales, nearly 50% of energy is low-CO2 renewable in 2050.[7]

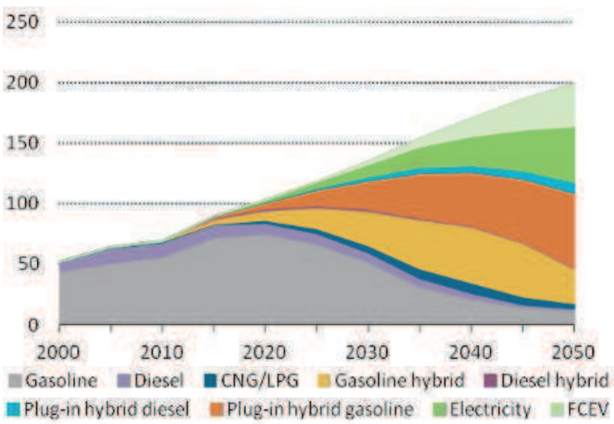



Figure 4. Improve case on fuel by 2050 due to "MoMo-model"

The White Paper on Transport, consider that a Single European Transport Area should ease the movements of citizens and freight, reduce costs and enhance the sustainability of European transport. Also it claims that there should be a "Single European Sky" (regarding the capacity and quality of airports), a "Single European Railway Area" (this includes the abolishment of technical, administrative and legal obstacles which still impede entry to national railway markets) and a "Blue Belt" (in the seas around Europe that shall simplify the formalities for ships travelling between EU ports).[3]

One of the most important forum which focuses on reducing the adverse effects of transport activities on the environment and contributing effectively to sustainable development is the UNECE Transport Division (division of The United Nations Economic Commission for Europe, a forum where the countries of Western, Central and Eastern Europe, Central Asia and North America, 56 countries in all, come together to forge the tools of their economic cooperation), that facilitates the international movement of persons and goods by inland transport modes.[5]

Each UNECE country recognized that transport is an important tool to help meet overall sustainability objectives, so it consider that specific goals for sustainable transport may include improved service quality and quality of access to goods and services, safety, improved air quality, noise reduction, improved water quality, protection of natural habitat and open space, historic preservation, reduced carbon emissions, increased social equity, economic development, and a satisfying quality of life, as well as local goals consistent with the overall objective.[6]

So the UNECE is playing a key role in some areas of sustainability, like international access, road traffic safety, environmentally friendly vehicles and intermodal transport.[6]

## 6. CONCLUSIONS

Due to the fact that transport system provides the individual with access to basic social services, such as health, food, education, employment and recreational activities, this requires the transport system to be safe to ensure that human health is not at risk, in brief to ensure the development of sustainable transport. So, in order to support sustainable transport many things were made:

-Further market opening has taken place in aviation, road and partly in rail transport;
-The safety and security of transport across all modes has increased;
-New rules on working conditions and on passenger rights have been adopted;
-Transeuropean transport networks (financed through TEN-T, Structural Funds and the Cohesion Fund) were created, contributing to territorial cohesion and the building of high-speed railway lines;
-International ties and cooperation have been strengthened.

To accomplish the objectives of sustainable transport, it is required that all aspects of sustainable development to be considered (the three pillars of sustainability- economic, social and environmental, that are closely linked) in relation with five inter-related transport areas: accessibility, affordability, safety, security and environment. Also the UNECE Transport Division states that sustainable transport policies can be financially beneficial, but it requires political commitment. [6]

In order to achive a high level of sustainable transport, future development must rely on a number of strands such as:

-Improving the energy efficiency performance of vehicles across all modes. Developing and deploying sustainable fuels and propulsion systems;

-Optimising the performance of multimodal logistic chains, including by making greater use of inherently more resource-efficient modes, where other technological innovations may be insufficient (e.g. long distance freight);

-Using transport and infrastructure more efficiently through use of improved traffic management and information, advanced logistic and market measures such as full development of an integrated European railway market, removal of restrictions on cabotage, abolition of barriers to short sea shipping or undistorted pricing.

Transport is one of the biggest contributors to climate change and poor air quality, yet it is also a vital part of our modern society and economy. Adopting sustainable transport technologies and behaviours allows us to balance our need for mobility with more sustainable lifestyles. Sustainable transport strives to identify solutions which reduce both vehicle emissions and costs.

## 7. REFERENCES

[1] Commission of the European Communities, COM(2009) 400 final, *Mainstreaming sustainable development into EU policies:2009 Review of the European Union Strategy for Sustainable Development,* Brussels, 2009

[2] Eurostat, *Sustainable development in the European Union, 2011 monitoring report of the EU sustainable development strategy,* Publications Office of the European Union, Luxembourg, 2011

[3] European Commission, *White Paper Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*, 2011

[4] Lew Fulton, François Cuenot, Alex Körner, *The IEA-International Energy Agency Mobility Model*, 2012

[5] OECD, *Transport Outlook 2010:The potential for innovation*, International Transport Forum, Germany, 2010

[6] UNECE Transport Division, *Transport for sustainable development in the ECE region,* 2011

[7] ***http://www.iea.org

[8] ***http://www.europa.eu/legislation

[9] ***http://epp.eurostat.ec.europa.eu

# ASSESSMENT OF STRUCTURAL INSTRUMENTS IMPACT UPON SUSTAINABLE DEVELOPMENT

CIOBANU CARMEN-LILIANA

*„Alexandru Ioan Cuza" University of Iasi, Romania*

**ABSTRACT**

In assessing the impact of pooling structural funds, macroeconomic models have great advantages in testing versions of financial resources allocation and in the opportunity of analyzing the trends that the economy follows and domains of interest.

The models offer perspective of estimation on long time horizons to justify political, economic or social decisions allowing the quantification of pertinent macro-economic impacts, from the analysis of a functional economic model, is simulated through projections the functioning of national economies.

**Keywords:** *cash flow, funding sources, impact.*

## 1. INTRODUCTION

For the period 2007-2013 there were three financial instruments known as Structural Funds including:

- The European Regional Development Fund (ERDF): support for SMEs, transport, environment, energy, education, health, tourism, research and development, territorial cooperation - aims at removing regional disparities on the principle of sustainable development.
- European Social Fund (ESF): aims to achieve the strategic objectives of employment in education and training, adaptability of workers and enterprises, social inclusion, increasing administrative efficiency.
- Cohesion Fund (CF): large infrastructure of transport and environment.

Regionalization is a solution to reducing development disparities while ensuring facilitating a better absorption of EU funds, it involves determining the number, profile, surfaces and residences of development regions.

Every seven years regional policy is reviewed by the EU institutions. Theories, concepts, models used, field specialists, procedures, participants, involved agencies, authorities, the degree of involvement in promoting programs, insufficient access to funds have created confusions leading to a decreased level regarding absorption of structural funds. Through accomplished studies, through reports, statistics, samples, case studies, questionnaires, the conclusion was - low absorption in terms of attracting structural funds in Romania.

## 2. MACROECONOMIC MODELS

Methods and techniques for assessing the impact of Structural Instruments:

- At the macro level: macroeconomic models
- At the micro level
  - Impact assessment based on the program theory
  - Cost-benefit analysis - calculates performance indicators of the project, and is based on a cost-profit method, forecast structured on a limited number of indicators, taking into account the influence of the time factor.

Net present value (NPV) – has to be positive and is calculated as follows:

$$VAN = \sum_{i=1}^{5} \frac{FN_i}{(1+r)^i} + \sum_{i=6}^{12} \frac{FN_i \, \mathrm{exp}lt}{(1+r)^i} - VI \quad (1)$$

Unde:

$FN_i$ = net cash flow from the first year;

$FN_i$ explt - operating cash flow in year i

VI = value of the investment;

The benefit / cost report is an additional indicator of VAN, comparing the present value of future benefits with that of future costs, including the value of the investment:

B/C = VP(I)0/VP(A)0(2)

Where:

VP (I) 0 = present value of financial inflows generated by the project in the analysed period

VP (O) 0 = present value of financial outflows generated by the project in the analysed period.

### 2.1 *Macroeconomic models of assessing the impact of Structural Instruments*

- The HERMIN model
- The HEROM model
- The QUEST model
- The Ecomod model

### 2.2 *The HERMIN model*

This multisectorial and dynamic model which is used by the majority of member states to assess the impact of structural funds upon national economies and to analyse comparative trends regarding financial transfers.

HERMIN model is annual and allows an overview of the current situation regarding current situation and for a time horizon, based on information retained, a forecast in two versions: with funds and without funds.

HERMIN includes four sectors: manufacturing, services, agriculture, governmental services and is structured on three main elements: offer for each sector, absorption and distribution of income.

### *2.3 The HEROM model*

The HEROM model represents the Romanian version of the HERMIN model. This model has been adapted taking into account macroeconomic indicators during the transition and pre-accession process, and from the need to align the economic policies of Romania to those of the European Union, at the same time facilitating the achievement of long time horizons forecasts.

### *2.4 The QUEST model*

The QUEST model is a neoclassic one - global macroeconomic Keynesist, being able to analyze the impact of cohesion policy over the European Union. This model is based on the same principles as the HERMIN model: financial management and appropriate investment plans. This model takes into account the assumption that public investments are as productive as private ones.

### *2.5 The ECOMOD model*

The ECOMODE computerized general equilibrium model is a multi-sectorial model. Using this model led to the conclusion that Member States which access higher community funding benefit of significant socio-economic positive effects.

## 3. THE ABSORBTION RATE OF STRUCTURAL FUNDS

The absorption measured is the external one, meaning the amount of payment requests submitted by Romania to the European Commission.

The absorption rate is calculated taking into account the EU contribution payments in relation to the 2007-2013 financial allocation, representing actual payments regarding projects with money given by the European Commission, excluding national contribution, and the amount of sums reimbursed from the European Commission in relation to the 2007-2013 U.E. allocation (amounts reimbursed by the Romanian state through the Ministry of Finance in each program).

One of the causes that explain the low absorption rate of a system is the lack of a motivation system for the officials involved, this leading to congestions and delays in the cycle of the project.

One solution would be motivating officials through an adequate salary system, attracting a body of field experts, outsourcing processes to private organizations to assess projects and requests for reimbursement.

Another issue might be the non-unitary interpretation of institutions, changing the rules during the game, changes, blurry procedures, generating delays and a negative impact upon projects.

Table 1. Ținte cumulative

| Program Operaț | Fond | Ținte cumulative | | | | |
|---|---|---|---|---|---|---|
| | | 2011 | 2012 | 2013 | 2014 | 2015 |
| POS T | Total | 403 | 1.781 | 3.054 | 3.768 | 4.566 |
| | FC | 291 | 1.316 | 2.235 | 2.685 | 3.277 |
| | FEDR | 112 | 465 | 819 | 1.083 | 1.289 |
| Mediu | Total | 355 | 836 | 2.202 | 3.317 | 4.513 |
| | FC | 330 | 664 | 1.659 | 2.357 | 3.276 |
| | FEDR | 25 | 172 | 543 | 960 | 1.237 |
| POR | FEDR | 678 | 1.275 | 2.164 | 3.078 | 3.726 |
| POS CCE | FEDR | 372 | 982 | 1.739 | 2.185 | 2.427 |
| POS DRU | FSE | 122 | 671 | 2.071 | 2.812 | 3.476 |
| PODCA | FSE | 21 | 80 | 154 | 182 | 208 |
| POAT | FEDR | 18 | 47 | 77 | 112 | 146 |
| Total | | 1.979 | 5.672 | 11.461 | 15.454 | 19.062 |
| Total net/an | | 1.979 | 3.693 | 5.789 | 3.993 | 3.608 |

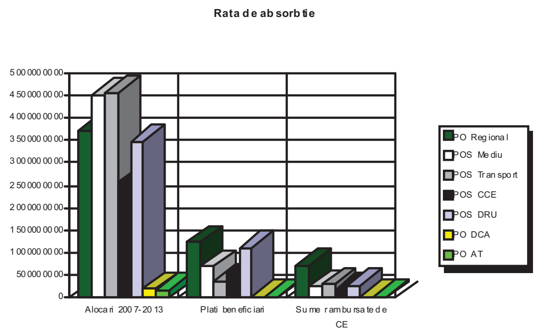



Figure 1 *Stadiul absorbției fondurilor structurale*

## 4. EUROPE 2020

Europe is going through a period of transformation. The crisis has wiped out years of economic and social progress and highlighted structural weaknesses in Europe's economy. Meanwhile, the world rapidly evolves and long-term challenges, (globalization, pressure on resources, aging) is increasing.

The EU must now handle its own future. The next round of programs will be launched in 2014.

An important challenge is drafting documents for the 2014-2020 programming horizon. MAEUR will manage the scheduling for all funds regarding the following horizon, including those for agriculture and fisheries. There is danger here: choked by immediate priorities, given the poor absorption with undersized institutional capacity, this formal developed programming might have disastrous long-term effects.

Europe 2020 puts forward three mutually reinforcing priorities:

- smart growth: developing an economy based on knowledge and innovation;
- sustainable growth: promoting a more efficient in terms of resource use, greener and more competitive;
- favourable inclusive growth: promoting an economy with a high rate of employment, being able to ensure social and territorial cohesion.

Regarding the implementation of the Commission's budget for 2014-2020, the Government's objective is to attract as many European funds amounting to over 21 billion euros available to Romania. The intention being that of launching a unique computer system (to provide transparency regarding European funds), whereby taxpayers know the situation of each project is taken separately.

For the 2014-2020 period, the emphasis is put on a more limited number of investment priorities in line with these objectives will be the centerpiece of the new partnership contracts, which member states will conclude with the European Commission. They will establish clear targets and will provide a financial performance reserve to reward regions that best meet their goals.

To ensure that EU investment impact on growth and employment is not undermined by unsound macro-economic policies or by weak administrative capacity, the Commission may ask to review programs or may suspend the funding if remedial measures are not taken.

The impact of funds will also be strengthened by simplifying and harmonizing the rules of different funds, including those related to rural development and maritime affairs and fisheries, making regulations and information transparent. A single set of rules will apply for five different funds. Also, a more integrated approach will ensure that various funds meet certain coherent objectives and mutually reinforce their effects.

The areas covered by the new strategy are: transport and infrastructure, environment and climate changes, energetic field, competitiveness and economic growth, education, employment and social inclusion, tourism, culture/cultural heritage, health and social services, regional development, rural development and agriculture, administration, territorial dimension (the role of cities, areas with specific geographical and demographic problems, border areas, EU macro-regional strategies).

The European Commission has adopted a draft legislative package which will provide a framework for the EU cohesion policy for 2014-2020.

The new proposals are designed to reinforce the strategic dimension of the policy and to ensure that EU investments are focused on long-term objectives regarding Europe's economical growth and jobs. ("Europe 2020"). Through the partnership contracts agreed with the Commission, member states will commit to reduce their range of investment priorities in line with these objectives.

There are 23 million unemployed and 113 million at the point of and below the poverty line in EU. The EU needs to define its evolvement direction by 2020. For this purpose, the commission proposes the following main aims for EU:

- 75% of the population aged between 20 and 64 should have a job;
- 3% of the EU's GDP should be invested in research and development (R & D);
- the "20/20/20" climate / energy targets should be met (including a reduction of emissions increased to 30% if the conditions are right to do so);
- the rate of early school leavers should be under 10% and min. 40% of the younger generation should have a tertiary degree
- the number of persons at risk of poverty would be reduced by 20 million.

Solutions, proposals and actions to achieve proposed goals, that ensure Romania's evolution from a social and economic point of view:

- Expertizing certain specialists in the regional development field, providing information channels
- Encouraging cooperation between institutions, universities, public administrations and economic agents
- Regular training of persons seeking access to European funds
- Removing bureaucracy
- Facilitating access to information for all business actors, of institutions
- Ensuring an updated database at a regional level to make real and concrete analyses

## 5. CONCLUSIONS

The low degree of absorption capacity is justified by poor information regarding the economic actors, poor management, corruption, bureaucracy, changes in necessary documentation along the way, of submission data "Failing to the Applicant Guides", lack of motivation of the personnel involved in performing structural funds, lack of standardized documents and uniform procedures for various management authorities (MA), public procurement procedures and the long period of evaluation of projects, which lead to delays.

Although these aspects have been identified and reported to the central decisional level, through the adoption of the National Strategy for Fighting Fraud to Protect the EU financial Interests in Romania, the obtained results are far below expectations.

The main challenge in the development of programming documents is that Romania has to have a coherent, real,that can be funded and enforceable strategy. In November 2010, the European Commission published its first ideas on the future of EU cohesion policy after the current programming period which ends in 2013.

## 6. REFERENCES


[1] OPRAN, Constantin; STAN, Sergiu; ABAZA, Bogdan; NASTASA, Steluta; *Managementul proiectelor;* Editura comunicare.ro; Bucuresti, Romania, 2002.

[2] ABDELGHANY, Alina; *Analiza economico – financiară aplicată în conducerea firmei*; Editura Europolis; Constanța; România, 2005

[3] Certificatul bancar european; *Clienți şi produse bancare*; Institutul Bancar Român, România, 2007

[4] IATAN, Elena; *Management financiar contabil*; Editura Europolis, Constanța, România, 2007

[5] BRATU, Alina; *Credit bănci;* Editura Ex Ponto; Constanța, România, 2005

[6] NICULESCU, Nicolae; GRECU, Iulia; *Previziune economica – Concepte si elemente fundamentale;* Editura Muntenia, Constanta, România, 2005

# THE PRICE SYSTEM IN ROMANIAN MARKET ECONOMY

DRAGAN CRISTIAN

*Constanta Maritime University, Romania*

**ABSTRACT**

The liberalization of the price in our country led in most cases to price increases because of significant causes: the supply is far bellow the demand, competition among producers can not manifest because of lack of supply and economic agents, companies do not work to production capacity, productivity is low and the costs are high. Obsolescence of technologies didn't allow a high production, price reduction of raw materials and energy at the world price level and subvention elimination.

**Keywords:** *price system, supply, demand, price analysis.*

## 1. INTRODUCTION

The main objectives of the pricing analysis and the cost reduction analysis are: eliminating unrealistic costs; the use of consumption norms for raw materials; materials shall be reviewed in accordance with the degree of processing, labor determination on labor standards, cost coverage is provided by analyzing the possibility of exploiting to a maximum the internal reserves and cost reflection of truly necessary spending; price documentation involves price offers that must be substantiated by detailed economic calculations; during the crisis period, when demand is weak and prices affect inflation, legal regulations are necessary concerning: control on real prices established by the producers, compliance with competition loyalty, efficient use of financial, human and material resources and ensuring market transparency.

The price system created in Romanian market economy has the specific features of a competitive economy. Currently, the price system includes:

- Free prices formed by the demand - supply mechanism, under competition conditions.
- Regulated prices set by national regulators or by the Ministry of Finance.

Free prices represent the rule, while the regulated prices represent the exception.

Inflation, as a monetary phenomenon, is an excess of monetary mass compared to the quantity of goods and services that provide its coverage.

Indicators that measure inflation are: the general price index as a result of rapid grow of prices, the degree of erosion of the national currency against the freely convertible currencies, and the ratio of monetary mass and gross domestic product.

## 2. PRICE LIBERALIZATION IN ROMANIA

One of the fundamental features of the market economy is the free price formation.

Price liberalization involves the following problems:

A. Dysfunctions elimination in the field of price:

- the administrative nature of pricing
- existence of monopoly producers which generate imbalances between supply and demand
- widespread shortages of goods
- grants implementation for some businesses
- dependence on world market economy

B. Removal of the anachronism created in the functioning of the price mechanism: prices reflected higher costs of raw materials, energy, labor, inefficient technologies, etc.

C. Reflecting the value process of formation and distribution of income in the economy through price expression, the connection between price and the financial system. There are prices with no connection to normal costs, rates of profitability without any connection to determining factors (capital, interest, etc.).

D. Connecting internal price developments in worldwide prices - the traditional Romanian Market Economy function involved the abrogation of price system inherited based on excessive planning mechanism and state monopoly.

Some concrete measures were taken and the most important are:

- Increasing and guaranteeing the shrinkage and purchase price movement of agricultural products directly from the manufacturers to the state fund;
- Changes in the tax system, tax regulations;
- Regulating the competition discipline and competitors loyalty;
- Preparation, organization, supervision and control of price formation in order to avoid tax evasion;
- Liberalization of wages

Price liberalization in our country led in most cases to price increases because:

- Supply is well below demand;
- Competition between producers can not occur because of lack of supply and economic agents
- The enterprise is not working on production capacity, productivity is low, and costs are high;
- Obsolescence of technology did not allow the realization of a high production
- Bringing the price of raw materials and energy to the world price and eliminating the subsidies.

Basic requirements for free prices functioning are:

1. increase and stabilization concerning production at such a level in order to ensure consumer needs and the balance between supply and demand;
2. restructuring and restricting producer monopoly, diversifying the economic agents
3. creating a monetary and financial mechanism to adjust the economic and monetary processes and prevent pressure on prices;
4. establishment of the RON exchange rate at a level in the economy
5. reduction of direct state intervention in the economy
6. generating a market mechanisms for goods and services, capital and labor and create conditions for their well-function.

The price system created in Romanian market economy has the specific features of a competitive economy. Currently, the price system includes:

- Free prices formed by the demand - supply mechanism, in competition conditions
- Regulated prices set by national regulators or by the Ministry of Finance.

Free prices represent the rule, while the regulated prices represent the exception.

There are two main structures:

- Prices for goods and services that include production factor prices;
- Special prices that include interest, wages, land prices, etc..

The following price categories are defined:

*1. Wholesale prices of industrial products, where:*

- price is determined by negotiation;
- price includes evolution of production costs and producer profit.

2. *Shrinkage price and the purchase price at which the agricultural products are both for the state fund provides cover production costs and a profit margin;*

*3. Selling price of agricultural products:*

- are prices that deliver agricultural products to economic agents from the state fund;
- include purchase price and commission for the companies from which they were acquired.

*4. Price of imported goods are set as such or formed on the external prices in foreign currency at the exchange rate in force, plus customs duties, excise duties, VAT and commission conducting import and export enterprise;*

*5. Prices for export products include expenses for the production, preparation and transportation to the border and the export company commission;*

*6. Estimate prices are used to determine the price of construction - installation and repair;*

*7. Retail price:*

- is used for selling products to the public;
- includes: wholesale price (purchase), negotiated trade margins (covers expenses and profit service for the business unit), the addition wholesaler, if goods are purchased at wholesale deposits, VAT;

*8. Rates: are prices for services provided by economic agents and fixed by general rules of price formation.*

On the whole the prices and tariffs of the price categories above can be represented as:

1. Market Prices:
- Are established by contracts between companies and are available for all displayed goods for sale;
- They represent the largest share of the price.

2. Fixed prices are set by the government or by the authorized bodies;

3. Limit prices are:

a. maximum prices

• applied to products of great importance for the public, the price is strictly correlated with the amount of people;

• attractive price capping subsidized by the state, these prices are below equilibrium price.

b. prices to the minimum:

• under these prices transactions pricing is not allowed;

• apply in countries where the government protects certain sectors in which the state is involved in the organization of markets;

• is above the equilibrium price.

Limit fixed prices appear as an exception to the general rule of pricing and covers the following situations:

1. prices of basic economic resources for which a policy of protection and rational use is promoted;
2. prices to some strategic products for the national economy;
3. prices and tariffs for production that are and temporarily subsidized by the state;
4. prices of those products that make the object of the delivery tasks set by the government or by the bodies empowered by negotiation with traders.

## 3. PRICE FORMATION MECHANISM - WHOLESALE PRICING FROM THE MANUFACTURER OR IMPORTER

Wholesale prices are prices set in the commercial transactions between economic agents. Those are free negotiable prices and their level and structure are formed in the context of legal regulations as follows:

a. basic raw materials, fuel, energy and major natural resources. Wholesale prices are established to the world prices level according to:

- The tendency during external price developments;
- Changes in the supply and demand structure, exchange rate, the results of negotiations with traders.

The Formula:

$$WP1 = WP2,$$

where:

WP1 is the wholesale price;

WP2 is world price.

b. raw materials, parts, equipment, installations for the production and prices of imported investment is calculated by the relation:

PR = [(PEFFR + CTA + CID + TV + MI] + VAT

PE = price-free external boundary – Romanian
CTA = external costs of transport and insurance
CID = expenditure loading – unloading
CV = exchange rate in USD or USD
TV = import duty
MI = margin business social import

c. for all categories of products, works and services prices are set by the equation:

1. if it has no excise duty:

PR = PP + VAT

where: PP is the producer price

2. if there are excises

PR = PP + Excise + VAT

## 4. MARKETING PRICING

The market prices contain two kinds of prices:

a. wholesale price that applys to selling goods in large quantities by specialized companies selling wholesale products and that is formed by the relationship (excluding VAT):

PG = PR + ACG + VAT
PG = wholesale price;
ACG = markup of the wholesaler;
PR = wholesale price

b retail price is formed:

- If business unit sourcing directly from wholesale companies excluding VAT:

PA = PG + ACA + VAT

PA = retail price;
WCA = commercial addition.

- If direct supply from the manufacturer:

PA = PR (excluding VAT) + ACA + VAT

- Trade margin appears as a separate item in the trading price and is free set by traders who establish the selling price.

Inflation, as a monetary phenomenon, is an excess of monetary mass compared to the quantity of goods and services that provide its coverage.

Indicators that measure inflation are: the general price index as a result of rapid grow of prices, the degree of erosion of the national currency against the freely convertible currencies, and the ratio of monetary mass and gross domestic product.

While money supply increases the volume of goods and services created remains unchanged or increases more slowly. This ratio is expressed through prices.

Indicators that measure inflation are:

- the general price index as a result of rapid grow of prices;
- the degree of erosion of the national currency against the freely convertible currencies, and the ratio of monetary mass and gross domestic product.

The national economy must be carried out by the following equality:

**National value = amount distributed income;**
**Goods and services = prices and tariffs.**

In the analysis of inflation one may see a price increase, without increases at the physical economic level nor at the purchase quantities. Also, an increase in goods prices and tariffs increases the national value of goods and services and namely the amount of revenues that are formed from different types of individuals and legal persons, even if the quantities of goods and services produced in a given period remains unchanged. This mutual concatenation of prices and income is called inflationary spiral. The following significant cases are distinguished:

- An increase in social tax obligations. This leads to higher prices;
- Growth of the import prices of raw materials also leads to costs increase. This activates the inflationary spiral;
- Excessive growth of the budget deficit or credit excess in the economy also activates the inflationary spiral.

In order to stop inflation the following four strategies are used:

1. Blocking the price:
- is suppressed by higher prices and inflation;
- can be a long process;
- may lead to price changes through the renewal of assortment in order to ensure earnings growth.
2. Blockage of revenue and expenditure, which means freezing wages and prices;
3. Currency blockage;
4. Blocking public spending by blocking taxes and social contributions.

To analyze inflation productivity envisaged the following prerequisites should be met:

- The price depends on the ratio between wages and labor productivity;
- An increase in labor productivity offsets wage as a cost element.

## 5. REFERENCES

[1] MOLDOVEANU G, DOBRIN C – Quality Management in public sector, A.S.E., 2007
[2] GARVIN, D. A. (1987), 'Competing on the eight dimensions of quality', *Harvard Business Review*
[3] Juran, J.M. (1979), 'Quality Improvement'
[4] *Quality Control Handbook*, third edition. Mc Graw-Hill: New York.
[5] Stanca, C., *Consideratii asupra masurarii performantelor portuare*, Analele Universitatii Maritime Constanta, Anul III, Volumul 3, pg.13-20, Constanta, 2002, ISSN 1582-3601
[6] Stanca, C., *Development of River Information Services for Logistic Actors through RISING Project*, Constantza Maritime University Annals, Year X, 15th Issue, Editura Nautica, Constanta, 2011, pg.111-115,ISSN 1852-3601

# THE TAX SYSTEM IN ROMANIA

DRAGAN CRISTIAN

*Constanta Maritime University, Romania*

**ABSTRACT**

Tax system as a set of principles, rules and method of organization is materialized in laws or regulations having the force of law. In Romania, the task of creating a tax system and fiscal strategy lays upon the legislature (Parliament) and the executive (the Government).

**Keywords:** *tax system, fiscal procedure code, profit tax, income tax.*

## 1. INTRODUCTION

The tax system is designed to meet the requirements of social and economic reform in full swing. Also, the tax system in Romania must have specific criteria and be a manifestation of the will from both parties, including the political will.

The tax reform that occurs in Romania tends to improve the tax structure by increasing the role (share) of indirect taxes, mainly by increasing the role of excise, value added tax and customs duties.

At the same time, the share of direct taxes will decrease (the profit tax, income tax, tax on dividends etc.) compared to indirect taxes. Tax reform aims to achieve an optimal tax structure, an application of the declarative principles in the detriment of taxation principles.

For this purpose, within the tax reform, the new tax system tends to allow efficient administration and should be understandable for taxpayers.

In developing tax policy the following should be pursued:

- efficiency criteria;
- opportunity cost of taxation;
- income of taxpayers and their protection;
- development taxes or other forms of levies and their stimulation;
- initial distribution of income, which should influence economic activity, investment and consumption.

A better tax administration is necessary towards tax system and its strategy which must be done by the Ministry of Finance (for state budget sources) and territorial administrative bodies (for local budgets sources ).

In order to increase the efficiency of tax administration, the Ministry of Finance has developed the Fiscal Code and the Fiscal Procedure Code.

Legislation on taxes and duties include:

- Tax Code;
- Fiscal Procedure Code;
- Methodological rules and orders of the Minister of Public Finance were developed and approved in accordance with the provisions of the Tax Code, regulations of local public administration due to the provisions of the Tax Code and treaties to which Romania is a party.

By its terms, the Tax Code provides a long-term stability of the taxes and duties system and tax payers will be able to follow and understand tax burden they have to bear and its importance to social development.

The transparency of the Fiscal Code allows tax management system to widespread in the system used by EU standards. Tax liabilities of individual taxpayers and legal entities should be made at unique terms and specialized accounts for better management of taxes.

In developing the Fiscal Code have been considered the following principles of taxation:

• tax neutrality is measured in relation to various categories of investors and shareholders ensuring equal conditions to Romanian investors and also to the foreign capital;

• certainty of taxation, by including clear legal rules that do not lead to arbitrary interpretation and timing, that can not lead to random interpretation, so that the timing, manner and amount of payment must be clear for each payer, so they can follow and understand the tax burden they bear, and can easily analyze their influence on financial management decisions over their tax burden;

• the individual tax fairness by imposing different income, depending on their size, so that the tax burden is equal;

• imposition of efficiency by providing long-term establishment of the Fiscal Code, so that such provisions can not cause adverse retroactive effect for companies reported to taxation law in force concerning their major investment decisions.

## 2. TAX CODE

Therefore, the Tax Code provides the legal framework and taxes that will apply in Romania, stating:

- people paying taxes;
- method of calculation and payment of taxes (Tax Code includes methodology for establishing and amending taxes applicable in Romania and will authorize the Ministry of Finance to develop methodological standards, guidelines and order in their application).

According to the Tax Code, applicable taxes in Romania are:

- profit tax;
- income tax;
- tax on dividends;
- microenterprises income tax;
- taxes on incomes obtained by Romania from non-residents;
- representations income tax;
- value added tax;
- excise duties;
- tax on oil and natural gas from domestic production;
- local taxes.

The Tax Code may be amended only by adopting a law that would amend the Code. Ministry of Finance is the central public authority which develops methodological standards, orders and instructions for the uniform application of the Tax Code.

Orders and instructions given by Ministry of Public Finance are published, mandatory in the Official Gazette of Romania, Part I.

## 3. FISCAL PROCEDURE CODE

Fiscal Procedure Code regulates all fiscal and legal relations in connection with taxes owed to the state and local budgets, regulated by the Tax Code. Managing taxes is governed by the Fiscal Procedure Code, Tax Code and normative acts adopted in application thereof.

According to the general principle of conduct in the administration of taxes, tax authorities apply uniform legislation, following the correct assessment of taxes owed, without being reduced, increased or established by law violations.

*Fiscal Procedure Code regulates:*

- The legal tax (fiscal substantive law report and procedural law report tax) and subjects of the legal tax (state administrative-territorial units, taxpayer and other persons who acquire rights and obligations in this report);

- legal obligations representatives that were appointed, representatives of individuals and legal entities and unincorporated associations shall fulfil their tax obligations;

- Defining the tax receivable (tax claims are entitled the charging tax or fee, entitled to a refund of tax liability on the right, the right to collect tax duties, entitled to the refund of tax or duty paid without legal basis), the birth and extinction of tax receivables;

- Rights and obligations of debtors and creditors;

- Fiscal domicile;

- The territorial and documents issued by tax authorities;

- Estimate the tax bases;

- Tax registration, tax and accounting records;

- Declaring taxes, tax returns form and content, deadlines, sanctions and penalties;

- determining the tax, decision imposing;

- Prescription right to assess taxes;

- Tax audit;

- Control procedures (competence, principles for selecting taxpayers taxpayer rights and obligations);

- Collecting tax debts (the debt, pay and compensation, debt extinguishment order);

- Interest and penalties owed by taxpayers for late deadlines tax obligations;

- Facilitate the payment of tax debt (rescheduling, deferred taxes and taxes, interest and / or penalties, exemptions and / or reductions of interest and / or delay penalties);

- Enforcement, enforcement arrangements;

- Ways of solving complaints.

## 4. STRUCTURE OF REVENUES

In Romania, revenue, according to the state budget structure, consist of:

I. Current income of which:

A. Income Tax

- direct taxes, including:
    - profit tax;
    - income tax;
    - other direct taxes, including:
    - tax on income derived by non-resident individuals and legal entities;
    - tax on profits from illicit commercial activities or of the Law on Consumer Protection;
    - tax on dividends from companies.
- indirect taxes, including:
    - value added tax;
    - excise and other indirect taxes;
    - customs duties to individuals and legal entities;
    - other indirect taxes of which:
    - delay penalties / interest, default interest and penalties on unpaid tax revenue in time;
    - fees and charges for the issuance of operating licenses and permits;
    - charge for the prospecting, exploration and exploitation of resources minerals;
    - judicial stamp duties, stamp duty for notaries activity, extra stamp duty (from 01.01.2003 in accordance with Ordinance no. 36/2002 on local taxes, these taxes are sources of local budgets);
    - judicial fines etc.

B. Non-tax revenues:

- payments from net income of public utilities;
- payments from public institutions (metrology taxes, charges for services rendered and to issue the international traffic, consular fees, taxes and other revenues from environmental protection, availability payments from public institutions and the self-financing activities);
- miscellaneous income (from the application of extinguishing limitation, revenues from fines and other sanctions, concession revenues, revenues from the sale of goods seized, abandoned and other amounts established along with confiscation).

II. Income from capital:

- income from asset public institutions;
- income capitalization stocks from national material reserves and mobilization.

III. Proceeds from repayment of loans

Budget revenues are financial resources that are due to public budgets, based on legal provisions, consisting of taxes, Contribute, other payments and other revenues.

Budget revenues are characterized individually by certain features of the way of establishment of origin, payment terms, etc.

Common elements of revenues are as follows:
- budgetary income;
- debtor or the subjects of taxation;
- taxable object or material;
- evaluation unit;
- assessment unit;
- how to place trim or income;
- collection (budget revenue collection);
- payment terms;
- duties, rights and obligations of debtors;
- responsible borrowers;
- budgetary income qualifications (local or central determining whether income).

## 5. THE CLASSIFICATION OF TAXES

After the substance and form features beyond the perception, distinguish the most important grouping of taxes:

a) direct taxes, which are set and levied directly on individuals or legal income or assets required by law, for example:
- profit tax;
- tax on dividends;
- income tax;
- tax income of non-resident individuals and legal entities;
- income tax or foreign economic organizations that have representations in Romania etc.

Coincide with the tax payer that supports tax.

b) indirect taxes, which are based on the sale of goods or services (entertainment, banking, transport, etc..) or execution of works. Generally, these taxes and fees are included in the price of goods, services or works, so be borne by consumers or beneficiaries, so the natural or legal persons other than the subject of taxation. In the category of indirect taxation, characterized in that the payer is different from one that supports tax or fee, enter:

- VAT;

Since specific direct tax (income tax, dividend tax, etc.) is the coincidence between the tax payer and the tax supports, that the main economic effect of direct taxation is to reduce nominal income. This is equivalent with reducing the money available to the individual by subtracting net income from wages effect in reducing personal consumption.

Also, the tax applied to profits made by companies leads to a lower net income, which has the effect of reducing investment opportunities through cash flow and dividends distributed.

Tax return direct taxation (ratio of expected revenues by introducing / increasing direct tax revenues actually collected by the introduction / increase that tax) is a decreasing linear function of the coefficient of direct taxation. The above relationship allows Laffer curve demonstrating efficacy (efficiency) of direct taxation.

Indirect tax acts, not directly on the incomes of economic agents, but through prices. Higher prices reduce the purchasing power of economic agents, but not by reducing revenues, but the more expensive goods and services.

The impact of indirect taxes on prices (prices upward) phenomenon there is an increase in inflation in the economy. This type of inflation is cost-push inflation because prices are rising not because of demand action, but because of supply action.

Indirect taxes are perceived by consumers through an increase of goods or service prices.

*Decrease in revenues is due to lower volume of taxes collected. Increased revenue from taxes can only increase under the tax base (which can only increase based on a real and solid growth, while reducing taxation and revenues through improved collection).*

## 6. REFERENCES:

[1]Manual on methodology for implementing internal control standards, “Risk Management” - Ministry of Finance, January 2007
[2] Minister of Public Finance Order no. 946/04.07.2005.
[3] http://www.riscuri.ro
[4] http://ebooks.unibuc.ro/StiinteADM/cornescu/cap5.htm
[5] Orange book – Risk Management – Principles and concepts, October 2004, Chapter 4, point. 4.3.
[6] Codul Fiscal.

# COMPUTER MANAGEMENT SYSTEMS IN MARITAIM ORGANIZATION

[1]GEORGESCU STEFAN; [2]MUNTEANU VALENTİNA

*[1]Constanta Maritime University, Romania; [2]Andrei Saguna University, Constanta, Romania*

**ABSTRACT**

Increasingly rapid changes in business environment and increase the complexity of activities within a shipping company needs to continuously adapt in a fast rithm that often challenging exercise capacity and human factor analysis. ERP systems (Enterprise Resource Planning) was created as the solution to these challenges, being able to process a high volume of data and aggregated information to optimize processes and efficiency.

The use of IT management solutions within an organization can optimize resources for multiple projects, you can remove failures created by the lack of centralized coordination of projects, can make project portfolio analysis to assess their performance and profitability An ERP is a complex multi-modular software application that integrates with the organization of economic processes to optimize and increase their efficiency.

In terms of functionality, an ERP software covers the following areas of interest of the organization: planning, procurement management, inventory management, interaction with suppliers, customer relationship management, order tracking, financial management, human resource management.

Starting from the premise of that the whole is greater than the sum of the parties, conducted an ERP integration organization and synchronization functions. It is an excellent means of integrating and ordering information, streamlining the exchange of data between departments.

**Keywords:** *Management, Enterprise Resource Planning, Organization, Software, Computer systems*

## 1. INTRODUCTION

For a computer systems management objectives to be operational in good condition and to use their normal parameters is required:

- knowledge of continuous quality of the services provided;
- proper management structure and systems and their components;
- achieving the transition from curative to preventive actions before the damage occurred does not substantially affect the performance of the system or its components;
- ensuring adapt easily and relatively quickly to developments in the field.

Structure management computer system contains technical and software elements which must provide:

- information redundancy suppression management;
- make easy dialogue between management applications;
- increase capacity and improve the system development (extensions, integration of machinery and new applications);
- obtain a high yield of the processing system ongoing hardware and software;
- execute in secret operations management at all levels of hierarchical military organization;
- make timely inspection and maintenance operations for all components.

## 2. COMPUTER SYSTEMS MANAGEMENT STRUCTURE

We can define five components of computer systems management:

- configuration management including: setup and system configuration changes, specifying its parameters, specific data collection;
- management failures which consists in detecting, diagnosing and correcting them;
- performance management aimed at gathering and statistical data on the state assessment systems and running applications;
- verifying security management: reliability, access control, system integrity, and data processed by it;
- metering and accounting management aimed at tracking resources and associated costs.

Configuration management means that all the activities and medium term to define, observe and collect data for monitoring physical, electrical and logical system components. Fault management includes activities to maintain a high quality dynamic services in the system. This process has the following objectives: detection of abnormal conditions caused by events that lead to system failures (errors) or abnormal, by collecting information about them, isolate the causes that have produced failure and analysis, correction of errors or abnormal operations leading to malfunction system.

Performance management activities is to assess (monitor) in real time to key performance indicators on the use of the hardware system, checking the levels of maintenance at a time and the potential. Monitoring consists of measuring performance and system testing facilities, monitoring performance and efficiency of computer applications and databases.

Safety management system aimed at protecting, seeking input into the system, access to applications, data transfer, protection management components, implementation of security measures.

## 3. IMPLEMENTING AN ERP SOFTWARE? (ENTERPRISE RESOURCE PLANNING) IN AN ORGANIZATION - NEED TO IMPLEMENT A COMPUTER SYSTEM

A potential customer should consider improving resource planning organization and then implement an application or computer system.

The need for improved resource planning organization comes more from the negative experience that has it in their daily work - with high costs distribution of information, slow retrieval of information, failure monitoring work carried out, ineffective communication, the existence of downtime / delays, increased costs of materials needed storage. After accepting the idea and awareness, an important step in forming belief implementation of such solutions is endorsed advice made by specialist advisors, consulting firms, etc.. accompanied by sound arguments and many examples to support optării for one or more parts of this vast field.

As a long term investment, consultancy work is useful in establishing a strategy together with the client to identify business process consultancy that require automation, build solutions, development, training, technical support. For the organization to derive maximum benefit from Project and solution to quick assimilation by users oragnizației personnel must be involved in all phases of implementation: associating the project to decision makers who can allocate the necessary resources to engage in proper conduct of its consisting of user key personnel who can provide information in the analysis stage, IT professionals who have a role in putting the technical infrastructure.

Implemented for the project to gain a higher value is recommended as Managing organization, an individual decision to participate actively in its entry in the "production". There are plenty of cases where implementation was technically outstanding, but use solution under the "production" has not made a decision without time by management. Resource planning applications do not require significant additional hardware.

Depending on the complexity of the project should take account of existing hardware resources, servers, communication lines, workstations. It seeks to develop solutions that take into account the technical resources of infrastructure and communication lines of different structures weaker military. The main advantage to a military structure is scalable solution - an implementation can begin building on the modest resources, increasing system performance with minimum cost escalation of hardware resources and staggered over time.

Often seeks the integration of existing systems with new solutions resource planning solutions that solve business problems other very well.

## 4. WHAT IS THE ERP SOFTWARE? (ENTERPRISE RESOURCE PLANNING)

An ERP is a complex multi-modular software application that integrates business process optimization and organization in order to increase their effectiveness. In terms of functionality, an ERP software covers the following areas of interest of the organization: planning, procurement management, inventory management, interaction with suppliers, customer relationship management, order tracking, financial management, human resource management.

Starting from the premise of that the whole is greater than the sum of the parties, conducted an ERP integration organization and synchronization functions. It is an excellent means of integrating and ordering information, streamlining the exchange of data between departments.

Increasingly rapid changes in business environment and increase the complexity of activities within a company needs to continuously adapt in a fast pace that often challenging exercise capacity and human factor analysis. Systems ERP (Enterprise Resource Planning) was created as a solution to these challenges, being able to process a large volume of data and aggregated information to optimize processes and efficiency.

## 5. IN SERVING AN ERP? JUSTIFICATION FOR INVESTMENT IN AN ERP SYSTEM

A computer system resource management organization may serve to:

- gather relationships with customers and suppliers through a chain efficiently;
- reduce production costs and stocks of resources;
- integrated planning organization;
- improve productivity;
- maximize overall profit by flexibility and responsiveness;

Why the growing market requirements to implement an ERP system in the organization we have? For the following figures speak for themselves about the benefits of ERP:

- stocks - 18%;
- reduce material costs - 5%;
- additional cost savings / salary - 8%;
- increase in sales and customer satisfaction - 12%;
- improve control Financial Accountant - 16%.

Purpose is the most important business process value chain in an organization and the quality and market competitiveness of products resulting from the processes is essential. To achieve these goals is essential to effective management information system activity. But implementing a software solution perfectly modeled on specific activities of the organization can ensure competitiveness on the premises.

What would justify the investment in a system palnificare resources:

- streamlining the organization's actions;
- standardization of processes within the organization;
- eliminate islands of information
- modularity and information islands open architecture that facilitates adoption of future technologies.

## 6. IMPLEMENTING AN ERP SYSTEM

Implementing an ERP system must have the purpose of streamlining business processes and organization, and their senior management. Military organizations have specific managerial and procedural flow of their work, which distinguishes them from other organizations. Their specificity is useful and even necessary in certain situations, consulting on specific activities regarding the implementation of an ERP system.

Assessment activity redesigning flows - where appropriate - and realistic estimate of the benefits of ERP implementation steps necessary for successful implementation of an integrated information system and complex as an ERP.

Good management of business operations and lead to increased productivity, compliance standards, reducing production costs incidental (unplanned), an efficiency of basic word organization.

Theory can not establish a set of standard tools (generally valid) to business management, tools such as system of rules, system methodologies, workflow (via which describes the conduct of processes), information flows, as these tools to become functional to be adapted to specific conditions of business: complexity of technological lines, existing equipment, preparedness of staff, absence of an integrated information system, or whether a less powerful.

What can be said with certainty and fact practice showed that value management organization is greatly increased by using an integrated ERP computer system. When it comes to using an ERP system performance, storage methodologies, workflow and information flows irrespective factor designed computer could process development and thus hamper the effective management of activities.

It is absolutely necessary if such methodologies, procedures and flows of their optimization, the optimization starts from the ERP system functionality and part of management consulting.

Ensuring successful implementation of ERP system is subject to:

- simplifying information flow restoration (where appropriate a) methodologies and working procedures;
- establishing product nomenclatures structure;
- identify measures to avoid sharp increase in risk of unfinished business;
- identifying risk factors (in terms of implementation) and reduce its effective;
- training on levels of competence of staff to use an ERP system;
- training staff to be able to establish new working methodologies and procedures using the ERP system.

## 7. HIGH PRESSURE REQUIRES A CHANGE

The public sector is in the midst of change required, first, the multiplicity of laws, initiatives and standards that have made their presence felt in recent years. All they have imposed on public sector reform in the hope that at the end they be able to speak about transparency, operational efficiency and on performance management.

The pressure felt by the public sector has its origins in growing demand great customer service oriented, the need for collaboration between public agencies, national security, optimizing resources, fiscal responsibility and visible performances.

Due to the spread of electronic commerce and electronic payments for various services, people began to become intolerant to red tape present in their relationship with government. In addition, media attention has brought many examples of ineffective or even illegal practices in the public sector, that transparency has become an imperative. In response to these accusations, the government is quick to implement an information system to support interaction with citizens .

However, to minimize risks of such critical initiatives, public sector would need a better approach to information architecture.

## 8. ORGANIZATION RESISTANCE TO CHANGE - HOW TO PROTECT OURSELVES WHEN IMPLEMENTING AN ERP?

Just as the human body reacts to detect a virus, so on, and an organization will react to the attempt to implement a new ERP system. Why? Firstly, because there is a change, and human resistance to change is one of the largest and most fierce.

One of the biggest risks of implementing a new computer system in an organization is that of acceptance. Clearly, however integrator and would try anything and would like the recipient, never can "customize" or customize an application in such a way that required a change in organization processes. In addition to this structural change, large or small, there will be an inherent difference in how the actual work and human interaction with the system.

Extremes of practice examples, where customers must evaluate and select a computer system are: an example in which the client says he has a distributed data processing so that each regional center shall perform all operations, then the only center Reporting aggregate - a situation where a provider immediately said that during the implementation period, estimated at nine months, will be migrated to a central processing because software is licensed per number of users defined in the version distributed system and the cost would be huge .

Of course it is unrealistic to expect the organization to change structurally in a relatively short time. Other extreme is the provider's representative says without blinking that the application will mold perfectly to the structure of the company, you really do not have basic information on processes and working methods used - as unrealistic. It is clear that implementation of a new computer system will induce a change in the organization - how this change is treated as provider and the beneficiary contributes fundamentally to success.

According to studies on the psychology of change and innovation adoption, there are two major reasons for this resistance to humans. The first and most important is accustomed to the current situation, acceptance and willingness to conserve "nothing." In fact, this custom refers to the way the man carries out certain activities, not necessarily refer to the outcome of these activities.

The current process is changing greatly and resistance will be higher - see rhetorical question in the title. For example, the five o'clock Saturday afternoon is the busiest at the supermarket? Because such people have become accustomed. Even if it stems from home exasperates, how many of them will come the next morning at 10? Only those who have the strength to change the habit.

This factor is of course dictated by the subconscious conservation, since there are usually logical reasons for this change. The second major reason for resistance to change is the perceived risk of producing a change in the current process. The perceived risk is greater, the resistance will be fierce, but in this case there are objective reasons, justifications that can give easily, sorry.

Even though in some cases this risk is low, the desire will be stronger conservation, and seek and invent arguments against.

As such, management strategies have emerged and induced change in organization development and continuing evolution of IT technologies.

A preliminary phase would be to review / assessment of individual users and groups of influence in the organization who would be affected, and who could resist change. Following this analysis, will be implemented effective change management strategy that can have three stages. User awareness through effective communication of concepts, technology and benefits the organization as a result of implementing an ERP.

This first phase refers to a communication within the organization.

The second stage could be a communication to the user groups, usually by direct manager and / or through workshops. This stage involves influencing emotional behavior of users on the new system, conveying the message that this change will have beneficial effects on this group and on each individual in the group. In this case, the message should be made other than the media and be tailored to the needs and expectations of each group.

The third stage of the strategy change management introduced the organization by a new computerized system would be to adopt - training the users and finding the most effective means of migration so accustomed to the previous situation to be channeled to the new system.

## 9. CONCLUSIONS

Performing organizations and institutions are put in a position to initiate, plan, propose and carry out activities and projects.

Computer assisted management helps managers to make project planning to introduce and organize all the details necessary to achieve the objectives acestora.Is also essential to ensure markets or gain, increase profits, reduce costs, increase product quality and service.

Risks must be assessed as well to have prepared alternative scenarios for further reduction of the time or resources consumed. Sometimes, however, is resource intensive risk assessment, risk evaluation costs exceed the costs that may arise.

How can managers provide this risk? Only experience and full use of software tools can help.

The use of IT management solutions within an organization can optimize resource allocation for multiple projects, you can eliminate failures created by the lack of centralized coordination of projects may be achieve project portfolio analysis to assess their performance and profitability.

## 10. REFERENCES

[1]. C. Bodea, „Handbook of Project – Based Management", Economic Publishing House, Bucharest, 2002

[2]. G. Maloş, D. Enache, „Methods to optimize the integrated management of defense procurement", Bucharest, 2004

[3]. C. Opran, S. Stan, „Planning, design and implementation of projects", Publisher comunicare.ro, Bucharest, 2003

[4]. V. Popa, „Applications of the reengineering project management techniques", NDU Publishing. Carol I, Bucharest, 2006

# COMMUNICATION'S MANAGEMENT IN CRISIS AND CONFLICT SITUATIONS. APPLICATION OF COMMUNICATION'S SKILLS IN MARITIME INDUSTRY

[1]IMASHOVA ZHULDZ, [2]KARZHAUBAYEVA ONAICHAN, [3]FELICIA SURUGIU, [4]SIMONA MINA

*[1,2]Caspian State University of Technologies and Engineering, Kazahstan,*
*[3]Maritime University of Constanta, [3]University Ovidius of Constanta, Romania*

**ABSTRACT**

Which are the purposes for Communication courses regarding the professional training in maritime industry? As such, here there are some certain hypotheses and objectives regarding the needs of communication skills in maritime domain.

Why do we need communication's skills?

One of the main objectives is to know our interlocutor: we need to relate in order to know our interlocutor within the first 5 minutes of relating. Eric Berne in "What do say after we say Good Afternoon (Hello), considers that the process finding out requires an analysis:

- Of the first 20 words (through the dynamic elements of expression: volume, tonality, rhythmus)
- The first 20 steps (walking is an expressive non-verbal element-we walk in certain manner when we are enthusiastic and in a different manner when we are under the pressure of the negative emotional stimuli: stress, anxiety, pain).
- The first 20 breaths (the control of breathing is a fundamental non-verbal communication's element in managing stress and anxiety; the success of our tasks, which involve crisis or unforeseen situations, is determined by this control)
- The first 20 looks: glances and looking are fundamental communication's vectors.

Up to the interpersonal communication's skills improving, the main objective of the paper is to establish correct labor and employee relations, within the shipping domain. The relations between managers and their employees must be handled legally and effectively. Employer and employee rights must be addressed. It is important to develop, communicate and update human resources policies and procedures so that managers and employees know what is expected of them.

**Keywords:** *managing, conflicts, communication skills, maritime industry.*

## 1. INTRODUCTION

There are some rules also applied in communication in shipping:

- Open and directly communication: keep the communication simple and to the point. This should be the basic style of communication. Considering the numerous emails from various receivers an average person reads daily, the simple and to the rule simply works.
- Not all the receivers of your message are the same. We have to identify their preferred channel of communication. We would rather forward a cargo claims to a lawyers's firm through mail instead of using the internet, having printed out all the necessary documents. We should also include an accompanying letter, explaining the situation and succinctly and directly explain the case.

➢ Another fundamental objective in the communication's process is represented by adaptability. The communication's skills are measured by a fundamental attribute: the adaptability to difficult, conflicting communication scenarios, adaptability to new and diverse situations. The human being is extremely comforted by what exists within the area of anterior experiences and in discomfort towards the new and different situations. What do we do when we notice differences: we try to transform them according to our own habitat and comfort…

➢ The communication's skills are necessary in order to make ourselves known to the interlocutor the way we want, and not in a manner that is expected by the interlocutor. Ever since entering a room, to the manner in which we activate the window of our hidden inner self and do not allow our interlocutors to identify our stress, pain and anxiety resources, or the manner in which we advertise ourselves during a job interview, are all part of the communication's process.

➢ Managing conflicts is another important objective in improving communication skills.

## 2. CONFLICTS IN MARITIME INDUSTRIES AND COMMUNICATION SKILLS

### *2.1 Human resources approaches in maritime industry*

Conflict has existed and it will always exist among people, either separate, or in different groups. Wherever people are, ideas, conjunctures, values, styles, standards, will exist, and they might determine conflicts. Generally conflict might be determined by the following:

- ✓ Objectives
- ✓ Purposes
- ✓ Aspirations

- ✓ Unconfirmed expectations
- ✓ Habits
- ✓ Prejudice
- ✓ Competition
- ✓ Sensitivity
- ✓ Especially aggressiveness – the most important of the conflicting presumptions.

In S. Deep's and L. Susman's opinion[1,p.120], three causes in perpetuating conflict can be identified:

- o We live in a world that is more complex and diverse, a world in which different people desire different things. Only a few things satisfy everybody, as well as the known fact that the human being is apprehensive of different or new situations.
- o Working with people means the existence of an ongoing source of conflict.
- o Incompatibilities, vanity, egos and egocentrism can only be presumed and/or potentially conflicting situation;
- o We live and work in a world that imposes certain limits regarding our resources. In this context, the organizational conflicts are determined by the organizational restrictions and to the same extent by the invariably limited resources.

The dynamics of the organizations, just like those of the groups, comprise a consensus as well as dialogue and conflict, because, just as R. Hall[2,pp.30-70] pointed out, "The conflict constitutes an inherent organizational process". In this context, the present scientific task's objective is to point out a few of the trigger conflict motivations within the work groups, as follows:

- ❖ The existence of dualism in the humans' relations with their peers: people need to get involved in something, as well as to stand on the side lines, according to their conformation needs, as well as to revolt; furthermore, they need to be part of something noteworthy, as well as being independent from the collectivity. This type of dualism of attitudes is capable of generating intrapersonal, interpersonal and group conflicts;
- ❖ The great responsibility of every manager "to push" the organization from the chaotic tendency – the individual's own influence -, towards performance; the leadership of the whole (organizational objectives and values), by the concentrated force of the divisions, becomes fundamental. Experience has demonstrated that in any organization, usually, the individual interests are paramount in comparison to the general interests. In this context, the human resources will be coordinated, in their activity, by personal interests.

The management's role is to minimize the gap between the individual interest and the organizational interests. Otherwise, the organizational conflict is inherent.

Regardless of the number of people that agree to the outlined objectives at the organizational level, they will have diverging opinions regarding the manner in which they are carried out; moreover, due to the fundamental characteristic itself of the human nature (individuality/difference), the individuals have different opinions. If we include to the aforementioned criteria the fact that people have different values and/or convictions, standards of behaviour, manners, priorities, personalities and different levels of the sense of humour, the explanations for the interpersonal and group conflicts are easily identifiable.

Due to the inevitable character of conflicts, the outcome is that managing the human resources is one of the most important activities, and the management of conflict is considered by a greater number of specialists in the field, as being just as important as all of the other human resources management's functions.

In an individual opinion, the conflict is generated by the intentional requirement on behalf of an individual and/or a group in an effort to realize the objectives of another group. Given that the objectives of both sides are in many occasions, incompatible, the realization of the object by one of the sides makes its realization by the other side, impossible.

There are several points of view regarding the role that the conflicts have within the organizational life. On one hand, conflicts are abnormal dispositions within the activity, having a profound dysfunctional character.

On the other hand, conflicts are usual aspects of existence and evolution of business, and from a functional point of view, it has a positive result.

The classics of managerial science present conflict as a "bad" thing, determined by the lack of understanding among people and the profoundly poor interpersonal relations. The characteristics of the organizational sector, as the main guide of the human behaviour, are considered to be "guilty" for the presence of conflicts. In order to avoid the conflicting coordinates, the organizations will focus on developing a harmonious cooperation between the management and the employees. The organizations that practice this type of policy promote harmony, the family spirit and helping one another, are considered to be paternal organizations. In their framework, the united team will not accept unwanted interferences that might disturb the organization's life. In dealing with employee engagement, satisfaction and motivation, ship management has to improve one's own leadership and self -development skills. Such practices may include daily activities such as journal writing: creating to do lists leads individuals to much clearer actions. Keeping a record about what is to be done and need to be completed during the day ensures that no tasks are left unattended. Is an important way of involve employees, of managing time and planning some other activities.

Another concept, in opposition to the traditional one, called behaviour driven, accepts the existence of conflict as an inevitable, and even a desirable fact. According to this concept the presence of conflict is not caused by the organizational sector, instead it is caused by different personal interests, purposes and/or objectives. It is not beneficial accepting conflict, when the purpose is to follow one's personal interests to fulfil unproductive purposes. However, in the absence of conflicts, apathy might occur, immobility and the organizations' inability to adapt to the challenges of change.

Conflicts are inevitable. In this regard, a recent study carried out by The American Management Association points out that "…..The managers spend approximately 20% of their time with conflicts and consider that the ability to negotiate has become very important in the last 10 years".

In the management of conflict, the capability to solve conflicting situations is considered to be at the same level and sometimes even more important than planning, communicating, motivating and decision taking. Among the potentially organizational conflict generating sources, are the following: misunderstandings, inadequate communication, different values, and personality dissimilarities, etc. Managing conflicts in a place of diversity as maritime industry is, could be consider a challenge.

The managers are confronted on a daily basis with internal as well as external conflicts. What causes these conflicts? The researchers have discovered six conflict generating areas, as follows: managerial authority; the belief and system of values utilized; proposed purposes.

In my opinion, aside from the above mentioned causes, we can include as being potentially conflict generating causes within the organizations, the following: the inadequate responsibility of employees; the noninvolvement or different participation of the employees in adopting decisions, the absence of the managerial support, rising standards and the level of performances, rapid technological changes, different managerial styles, organizational environment, age difference and prejudice.

The processing model, elaborated by Pondy, starts from the premise that the only way to understand a conflict is to identify it as being a dynamic process, rather than stable or static.

*The latent conflict* is determined by the consequences of certain anterior conflicting episodes. Among them, we can mention the following: the lack of resources, the aspiration for having a lot more autonomy, the differences between the personal objectives and the organization's objectives. The external environment itself, influences the latent conflict;

*The comprehended* conflict emerges simultaneously with the awareness of existence of certain latent conditions. The divergent objectives and/or the purposes do not determine conflict as long as it is not obvious. Conflict is maintained in a latent state, the ones involved consider it insignificant. It transforms into a perceptible conflict only when we direct our attention towards it. Therefore, there can be present a great number of conflicts, more than we can manage, and as such, the comprehended conflict does not necessarily have to become a perceptible conflict.

*The manifested conflict* it is expressed through behavior, the most frequent reactions being, apathy, dramatic attitude, open hostility, and/or aggressiveness. Using the mechanisms that they possess, the managers can anticipate and take measures before the conflicts are manifested openly. There are a few theoretical conflict models. Thomas considers that the conflict models describe either the process, or the structure of a certain conflicting situation.

If a conflict has been resolved, the involved sides can move towards cooperation; if it hasn't been resolved the conflict will increase its intensity, encompassing parts or problems that haven't been, implicated, initially.

In order to solve conflicting situations, we can outline as a starting point a few basic criteria, in establishing a conflicts' pattern: the essence of conflicts, the subjects involved in the conflict, the position taken by the actors involved, the degree of intensity, shape, duration, evolution and the effects generated by the conflicts, respectively.

Special attention must be provided to the asymmetries within the organizations. A flawed developed union life, the centralism of the human resources policies, are the causes for asymmetrical, power struggle conflicts, which unfortunately the employer-employee rapport will end in a win –lose situation with the triumph of the employees, they are part of a special status group.

The position taken by the actors involved in the conflict allows the symmetrical and asymmetrical differentiation of conflicts. In this context, the conflicts frequently arise among the sides that have a different predominance, such as the majority and the minority, a legitimate government and a rebel group, an owner and its employees, etc.

These types of conflicts are asymmetrical, and their genesis is not found in the typical problems or aspects that might divide the sides, it is found in the structure that constitutes the sides. It seems that no structure given by the role and/or relations cannot be changed, without the emergence of a conflict. In the asymmetrical conflicts the structure is constituted in such a manner, that "the big fish always gulps the smaller fish". The only solution is to change the structure; however this is not always in the interest of the "big fish". As such, there are no win-win results, and the third party can only join forces with the "smaller fish", in order to reach a solution. If this doesn't take place, the "big fishes" will try to maintain their power and keep under control the "smaller fishes".

Depending on the degree of intensity, the conflicting states can be manifested through discomfort, incidents, misunderstanding, tensions and crisis. The discomfort is the intuitive feeling that things are not normal, even though the conflicting state cannot be precisely defined. The incident is a nuisance over time and is the basis of more intense conflicts, and that is why they are not forgotten. An incident can be just a simple problem, but when it is misunderstood, it can escalate in tension. Misunderstanding is a form of conflict caused by erroneous perceptions, by the lack of connection among the sides and/or inadequate communication. Finally, tension and crisis are two extreme forms of conflict – people "go overboard" and let themselves be dominated by feeling.

*2.2 Employee and labour relations in maritime industry*

The human behaviours are governed by two main systems: a reward and penalty system. Our behaviours that are followed by positive results tend to develop. Opposite that, the behaviours that are followed by negative results tend to diminish. The research in the field of neurosciences and psychology has allowed establishing the biological basis of the reward system and the identification in the brain of certain nervous structures around the hypothalamus, called "the center of pleasure". According to Patrick Legeron [4, p.56, Apud

Routtenberg, “The reward system of the brain”, Scientific American, 1978, 239, pp. 154-164)) in the case of the animal’s experience it is well known that a rat will learn not only to press a handle, but continues to regularly do it if it gets, what psychologists call “an incentive”. This incentive might turn into a more consistent reward (food reward), but it can be obtained by stimulating the rat’s electric centre of pleasure as well. Once more, in animals, a diminishing or even the suppression of certain behaviours by employing “punishment procedures”: the rat receives an electric shock every time it moves on the other side of the cage. It will avoid moving fast in that direction.

What is usually neglected is the fact that the rewards extremely activate the intense emotions such as, pleasure (with reward) and fear, aggressiveness, conflicting states (with punishment) and it determines motivation. In the work field it can be noticed a higher rise of the unpleasant consequences, what we in general might call frustrations. The frustrations, are less and less rewarded, and constitute permanent sources of organizational conflicts.

Material frustrations and psychological frustrations can be distinguished, because the rat feeds itself basically with “material incentives”, with pieces of meat, the human being needs (according to the theories regarding the human needs), recognition, attention and/or affection just the same. The two aspects – material and psychological, are essential for the proper function and emotional balance.

The native organizations where the material motivations are inadequate, especially in the public sector, not only do they not provide the human resources’ emotional stability but are conflict generators as well. The material motivations can be intrinsic and/or extrinsic. The intrinsic motivation is the one that commences from the direct relation between the task and worker and usually is self-applied [3, p.152]. Extrinsic motivation is the one that commences from the task’s external work environment, and is almost invariably applied by the managerial system. The obvious fundamentals for the human needs are the material motivations (extrinsic). The specialists consider that the third millennium wages can in most positive cases satisfy our escalading needs. Why do people work? In great part is to earn money. Therefore, this fact, even though it seems ordinary, it confirms the fact that today’s material needs are greater: advertisements’ pressure, a consumer society, the ideology of to have and to be, everything is orchestrated in such a manner that it is not possible not to have the latest phone and the latest computer software. “There is no wage increase, and that diminishes the enthusiasm. We are required to have more and more qualifications, to study computers, English…….but the salary doesn’t change. It should be that the relations be different, the *I give to myself; you give me” type”*. Affective gratitude is an aspect; however, it is incomparable to the financial aspect…”[Legeron,op.cit.]. It is obvious that a human resource that thinks in this manner will generate conflicts in their rapport with the other employees, especially with the higher ranked employees, responsible with the evaluation of the professional performance and establishing work motivation. For the native public management, the evaluation graphs that lack objectivity, egalitarian, egalitarianism motivation, based not on the performances of the employees, but according to the seniority criteria, don’t do anything else except to perpetuate the conflicting conditions.

After the people were asked to do their jobs well – that is the natural thing to do, invariably even the efficiency evaluation generates frustrations and/or conflicting conditions – after they’ve been asked to surpass themselves and tend to do more, at this moment we are witnessing the emergence of a new tendency, initiated by the management, for the sole purpose of managing conflicts. Today, it is asked of the individual to be more affectively involved in his/her work: it is desired that he/she love their work, to get a sense of satisfaction out of it and to dedicate themselves, body and soul.

Successful performance of the employees requires more than possession of certain skills. New employees have to be familiarized with the environment through orientation, their introduction to their job and organization as a whole.

## 3. CONCLUSIONS

Considering the above, it is clear that the role of human resources has changed over the years. In the past, strategies were designed based only on a company’s needs, developing procedures and safety standards by assuming that their personnel were essentially alike.

With the understanding that individuals are unique, having different capabilities, skills, knowledge, just as they have different aspiration levels and attitudes towards work, strategies can now be formulated in such a way as to take advantage of the company’s personnel core competencies.

Human resource managers in shipping no longer view employees as dispensable individuals who can be replaced by other applicants in an instant. Instead, they invest in their development and continuous training, taking into consideration their individual characteristics.

However, the biggest challenge in human resources management as applied in shipping is not just to recognize these individual characteristics and skills, but to create a successfully mix of people who will be able to carry out their collective duties successfully, both on board a ship and in a department of the ship management company-and make these teams work together in synergy.

As the 2010 Manila Amendments to the STCW stress, management, leadership and teamwork are much sought after qualities, to promote not only safety after and security on board but also effectiveness, efficiency, motivation and self- respect to professionals and overall benefits for the shipping management company. As shipping is such an international business, human resources management have to include talent management, executive and leadership development, performance management, compensation and labour relations [5]. Developing a global mind-set in human resources in shipping means effectively evaluating the global competitive environment and its impact in managing people: effective locate, attract, engage and retain competent employees, both on shore and on board with a view to achieve the company's strategic objectives and goals.

## 4. REFERENCES

[1] DEEP, S., SUSSMAN, L., *The secret in succeed: make inteligent actions!,* Polimark Edition, 1996

[2]HALL,R.,*Organizations. Structures, Processes and Outcomes*, Prentice-Hall International.Inc., 1996

[3]JOHNS, G., *Organizational behaviour*, Economics Edition, 2001

[4] LEGERON, P., *How to avoid stress*, Economics Edition, 2004

[5]JACKSON, M.,R., *Human resource managemen*t, 13-th Edition, South Western Cengage Learning

# SUPPLY CHAIN MANAGEMENT IN SHIPPING

[1]IORDANOAIA FLORIN, [2]IMASHOVA ZHULDUZ, [3]KARZHAUBAYEVA ONAIKHAN

*[1]Constanta Maritime University, Romania,[2,3]Caspian State University of Technologies and Engineering, Kazahstan*

**ABSTRACT**

Supply chain management strategies began to be used in shipping for a short time. They will change the traditional concepts of liner or tramp, which are limited only to transport goods and less on what kind of opportunities they represent. The transition to this new concept will not be easy because the maritime market has a certain specific; the shipping companies are more interested in the price of a larger transport, in the cost reduction of the ships than in the direct affiliation to a supply chain. Some shipping companies are part of supply chains, even without involving in the strategies of the partners in the chain, having only transportation contractual relationship. In this paper, it will be presented and analyzed a number of situations in which the maritime shipping companies are. It will be presented a number of solutions for integrating maritime shipping companies in international organizations that require the existence of supply chains.

***Key words****: maritime transport, ship, costs, logistics, supply chain. JEL Classification: F23, L91.*

## 1. INTRODUCTION

The global economic crisis has seriously affected many shipping companies because of the lack of goods for transport. Some companies have failed, others have sold some of the ships for scrap or "second hand" to get liquid and resist on the market. Other companies have managed to resist and to continue investing using a management adapted to the crisis on the maritime market. Searching and finding goods for transport became so important that maritime shipping companies are in constant search for them. For this reason, they use the most modern methods and techniques of management, marketing and communications to find the goods owners, senders and international buyers. In this context, each owner seeks to permanently preserve relationships with partners, even after a single contract of transport. In certain situations in order to keep the partners, they make voyages thus:

-With a very small profit.

-No profit.

-Even with a certain loss on a voyage or more made in a year.

A number of experts believe that the shipping offer is "slow and weighted" as a response to changes in demand, due to the fact that transport ships should require a long period of time for their construction, and this fact introduces a delay period in supply answer on demand,(Branch, 1998). After the ship was built, it has an operating duration from 15 years to 30 years, so it responds to a "falling demand" and hence an "endless" business, especially if there is a great surplus to be replaced. Over time, ship offer was controlled or influenced by four groups of people who are making the decisions as follows:

-Owners (ship owners).

-Charterers (goods owners).

-Bankers who finance navigation.

-Various national public authorities, trade unions and international organizations, which make the rules for ship and crew safety, environmental protection, profit distribution, etc.

In recent years it appeared and became very important nowadays a new category called "ship managers". These are the companies that take over or rent ships from owners, through a management contract and then use them to transport goods. This situation arose because "Ship-managers" have direct links and partnerships with charterers. They have succeeded in the past 10 years to attract the smaller owners, with a few ships, which are more vulnerable to changes in the maritime market compared to large companies with many ships. Another aspect which influences the maritime transport is the productivity ships and commercial fleets. Merchant fleet is defined by its size and the productivity of the ships used adds an element of flexibility. Specialists in the field carry out the research of merchant fleet according to (Branch, 1998):

-the number of ships,

-their size or capacity charge

-productivity with which ships are operated.

Over time studies carried out by various research institutes showed that ship productivity is variable (Nautical Institute, 1994). Analyzing the situation of oil tankers it was observed that the peak productivity was of 44,000 tons miles / dwt in 1972, but until 1985 it fell to 24,000 tons miles / dwt. It means that productivity decreased to half the initial value, followed by a 40% increase, to 33,000 tons miles/dwt. Productivity of bulk transport ships was much more stable at around 20,000-25,000 tones miles/dwt. The analysis of the nature of productivity changes for oil tankers revealed the following situations:

-Operating time: 137 days (37,53%).

-Navigation ballast: 111 days (30,41%).

-Landing and departure maneuvers: 40 days (10,9%).

-Other activities: 77 days (21,09%), which are represented by:

- -repairs
- -supply,
- -short or long term storage,

-navigation accidents,
-waiting time in harbor or berth,
-port authorities controls, etc.

The detailed analysis of ships activities helped to draw conclusions invaluable for ship owners and charterers. Thus, it was found that some of them are caused by physical and technical performance of the ships, but also by factors operating on the maritime market. The indicator to measure the productivity of merchant fleet is ton miles/t "dead weight" [Dead weight = weight, "dead" weight that is without freight (money) or total carrying capacity of the ship]. Thus productivity depends on four important factors: speed of the ships; residence time in port; tonnage used fully or partially; travel time or travel days at sea.

At present, maritime shipping companies are seeking solutions to withstand the fluctuations on the maritime market. One solution is represented by the integration in a supply chain, where ships are engaged in permanent (line) contracts. Further in this paper it is made an analysis of the general situation of shipping companies in the context of overall strategies of supply chain management, following the value chain situation in shipping, forming strategic alliances in the shipping industry, distribution channel in this area, how establishing partnerships within the distribution channel and finally it is presented an overview of how to obtain financial performance.

To facilitate the understanding of supply chain management in shipping we carried out two studies.
The first study was at a maritime shipping company that understood the role of supply chain and invested in this area. The second study, at a Romanian shipping company, but which has ships registered in another country, with the flag of convenience. The Romanian company does not belong to any supply chain. Scientific research in this field in Romania is still at an early stage. Even though there are many specialized works which seek what is happening in the international and European maritime transport and logistics, though they cover only a small part of situations and existing problems. Some more information and technical and economic papers have emerged in management and port logistics.

## 2. SUPPLY CHAIN MANAGEMENT STRATEGIES IN SHIPPING

After studying the situation on the sea, looking at what is happening in maritime shipping companies, it appears that at least a part of supply chain management strategies are currently being used. The need and the reasons of their use are known to specialists in economics, but the executives of the shipping companies are not based on management or marketing economic studies. They are usually naval officers who previously had leading positions as a ship captain or a chief engineer. This situation has some negative influences on how there are perceived the new ideas that appear in the specific doctrine, where they do not have access very often or they learn about them too late. This is the so-called "conservatism" of the managers of the maritime shipping companies, which still manifests at present, even with negative consequences. The leaders of large, strong, solid and proactive maritime shipping companies managed to understand the importance of supply chain management. And those from smaller companies have noticed what the large companies were doing, have copied some of the measures taken by them and adapted on the go or tried to adapt, to resist. But it is still not come to understand what "supply chain management" is globally or the world fleet management. Following the evolution of the concepts of this type of management, except that "supply chain management" is not a stand-alone strategy, that it must be an integral part of overall strategies of the company and especially of "the individual strategies which involve business partners of the companies "(Porter, 1980), maritime shipping company executives must understand the peculiarities of the strategies because:

-They generate competitive advantages for integrating the shipping companies and coordinating the flows of information

-It comprises a variety of specific activities, especially those that involve successful completion of the command, i.e. the ship reaching the port of destination. This should be considered as part of the company's strategies.

-It uses a number of elements and specific ways, suitable to achieve the level of quality of service, at which the managers at least "adhere and aspire" through the implementation of the International Safety Management Code and international quality standards from the ISO series (International Organization for Standardization), to fit between the company's strategic activities.

## 3. THE CURRENT SITUATION IN SHIPPING

First of all, maritime shipping companies are interested in aspects of cost reduction, and then in value chain analysis, strategic alliances, distribution channels and obtaining profits.

A).Costs reduction. Over the last few years there have been noticed a number of measures that have been adopted by the management of shipping companies to reduce costs thus, (Iordanoaia, 2008):

-Changing organizational structure.
-Reducing staffing.
-Outsourcing of some services to certain specialized companies.
-Reflagging by registration in a country with lower taxes (tax heavens).
-Renting the ships to a maritime management company.
-Introduction of computer performance, modern communication technologies.
-Reducing consumption of materials and spare parts.
-Reduce consumption of fuels and lubricants by reducing ship speed by half.
-Postpone the processing of material costs, etc.

But most problems are related to ships and here there have been, are and will be in future the toughest problems related to costs. In the past 20 years companies have adopted a series of measures, some of them being very drastic, for cost reduction and over this period there were many conflicting situations because of this. The first measure was to reduce the number of crew members. Thus, there were significant reductions from approx. 40-50 people in the early 80s, to 15-20 people now, their number varying according to the type of the ship (Teodor, 1998). The second measure was that the crew on board should take over a greater number of tasks, to increase their number, even with the risk of decreased safety of the ship (Stan, 2003). All the times, there have been disputes between owners, authorities and trade unions due to the increasing number of tasks of the crew on board. A very important measure was the introduction of modern computers, reducing the time of writing official documents issued by the ship, (Iordanoaia, 2006). Another important moment was that the modernization of communications between the parties as follows: ship and company management, ship and agents, ship and brokers, ship and port authorities, the company and third parties.

B).Value chain analysis in shipping. Value chain analysis in this area is different from that of the production of goods or provision of services in mainland due to the following reasons, (Iordanoaia, 2006):

-Decomposition process of transport is relatively simple and the entities contributing to the service are in a very small number as:

-the ship, with its crew approx. 15-20 people,

-general manager who holds the "key" business,

-deputy managers, namely those responsible for the ship, logistics, technical and marketing approx. 4-6 people.

-Primary activity is the transportation of goods, containing loading and unloading the ship.

-Support activities are only those related to:

-service provision quality control on board,

-ship safety control, carrying cargo and shipping control,

-ships' supply,

-human resource management.

The last two "support" activities can be outsourced to specialized companies that take over the company tasks and even if they help to increase the value of services, the activities don't belong directly to the company. These are agency companies, for ships' supply and crewing companies, for employing seafarers. Using the value chain for a shipping company, mainly, is not different from that of a land company. It consists of the following steps (Băcanu, 2006):

-decomposition process,

-costs distribution,

-identifying critical activities,

-identifying valuable employees,

-identifying links generating value,

-optimizing connections.

But all these have characteristics and features different from those of the processes from the land companies.

1).Decomposition process. Value generating activity is represented by loading the ship (Stan, 2003). When the contract stipulates that the loading / unloading operations to be done with the help of the board, the service will increase, but the share of such additional activity is quite low, practically only some types of cargo and Ro-Ro's can be made, and some ships have no such possibility because of the way they were built and the abandonment of facilities onboard for these operations.

2).Costs distribution. For company shipping, the main costs groups are the following (Iordanoaia, 2006):

-Administrative and overheads costs of the company.

-Ship operating expenses.

-Decreasing value of the ships.

-Travel expenses.

-The loading / unloading of ships expenses.

The expenses of the maritime shipping companies can be structured on groups' costs as follows:

-Ship operating expenses where the share is as follows:

-30-45 % crew expenses,

-20-30 % technical expenses,

-10-15 % insurance expenses,

-7-12 % maritime supply expenses and equipment expenses,

-4-8 % lubricants expenses.

-Financial expenses which are given by the amount of taxes.

There are also a number of external factors that affect costs according to:

-Ship-type, if it is an oil tanker, chemical tanker, bulk carrier (bulk transport), cargo (general cargo transport), Ro-Ro (roll-on-roll-off) for car transport on wheels, etc.

-Area navigation, in inland seas (The Black Sea, Mediterranean) or the world's oceans (Pacific Ocean, Atlantic Ocean).

-Hazards of the shipped goods, from the chemical, oil, gas, to weapons and ammunition.

-Insurance for the ship and crew, etc.

3).Identifying critical activities. The introduction of the International Safety Management Code has forced companies to draw up lists of critical situations that may arise on board and that can have its negative effects on commodities and crew (ISM Code, 2002). Avoiding critical situations is the responsibility of the crew, and of the other factors of responsibility in the company.

The Code required that a person at the company headquarters to respond directly to the ship's safety issues, this person being "designated person". The implementation of the Code and obeying its provisions means that, during one year, additional guarantees are made for the brokers (owners of goods), that their goods will reach their destination on time and keeping their commercial characteristics. Through the procedures used on board and kept at the company, it will be kept a strict record of all these potential critical situations.

4).Identifying valuable employees. This step is easier done in "tramp" shipping companies (the "tramp" ships which are waiting cargo in port, or in close areas), where brokers are those who seek cargo, bring charterers to the owners to sign transportation contracts, these being the brokers' owner (called "shipbroker"). But charterer can use a broker to find appropriate transport ship, being called "Chartering agent". Maintaining relationships with them is very important and their role in this type of navigation cannot be underestimated, sometimes being considered essential. On line shipping companies, valuable employees are treated as business partners with whom the company has entered into a contract of carriage on a long or very long term.

5).Identifying links generating value. In maritime transport, relations are among the most important, basically there is very little chance that a shipping company manages to resist on the market, without realizing a system of relations with partners and maintain these relationships. The existence of a supply chain, in which a maritime navigation company takes part, is the situation which would solve many of the problems faced by a shipping company, which is operating in a "tramp" market and would make the switch to line navigation, i.e. at a long-term partnership.

6).Optimizing connections. This step is accomplished through what is described as "naval operations management", which is conducted by maritime shipping company managers in connection with the company's fleet, with all ships altogether and according to the specific, with each ship. In order the connections to be optimized it is needed to prioritize activities as follows:

-Ship management considered the most important for company management.

-Supply ship, finding the best and cheapest supply solutions.

-Searching charter contracts, producers, exporters, importers or large international trading houses (called "traders").

-Search for the best trained officers and sailors, as a crew of professionals is an additional guarantee that a transport contract will be respected.

-Office management company, etc.

Hence, it is noted that naval operations management is "a transportation service, marketing and business management", "human resource management and administrative management". This is the reality of the current maritime shipping companies. Taking into account the facts presented in this chapter, the entry of a company in a supply chain would solve the most important issue of the ship owners and managers, namely that of having cargo to transport.

c).Making strategic alliances. This principle of logistics has become so important that it is considered that only the companies that are part of a strategic alliance can deal with the maritime market fluctuations, increased competition and have guaranteed business success. For a long time it has been known the fact that most of the shipping is based on a series of relationships established between ship owners and charterers and the search for cargo or ships is made available through brokers who can work preferentially with certain partners and bring the best transport offers to their "friends " ship owners (Bolero 2004). Partnership relations can be both in the product chain or channel chain, depending on the type of cargo or ship, in a medium term but especially in a long term. In some situations after close links with certain business partners there have been established new companies, holding shipping and logistics companies.

In this regard it will be presented the Japanese group of companies "Nippon Yusen Kaisha Group" (NYK Group, 2012). These partnerships cannot succeed without an open and direct exchange of information. So shipping companies and partners must communicate to each other all the operational and financial data, their forecasts and planning. General scheme of shipping alliances is shown in Figure No.1. Making strategic alliances is not easy in maritime transport as members of an alliance are, as a rule, companies in different countries, and these alliances are multinational by their nature. This is a goal that requires a lot of attention, coordination with suppliers and customers, full support from their own staff that will actually keep in touch with the partners. Alliance formation in the early stages will mean some expenses for training and operational support, but active involvement of company management, too.

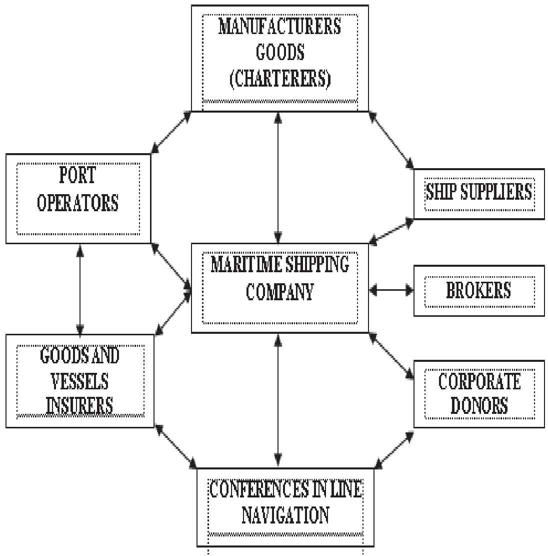



Fig. 1. Strategic alliances in shipping.
Source: Florin Iordanoaia "Logistics shipping", Publisher "Nautica", 2006, p.135.

Japanese group of companies "Nippon Yusen Kaisha Group is a model of maritime shipping company that understood very well the role of supply chain and made a series of investments to achieve such chains in different fields. The Group has the following organizational structure, (NYK Group, 2012):

1).Global Logistics Group, made by:

-Port-container shipping company "NYK Container Line" Ltd, with 120 ships.

-Ship-specific Navigation Company "NYK Hinode Line" Ltd, with 51 ships.

-Ports and port terminals owned in Japan, Asia, North America, Europe and Australia.

-Air cargo company "Nippon Cargo Airlines Co. Ltd, with 9 cargo planes such as Boeing 747-400F, 8 aircraft and one Boeing 747-8F.

-Logistics and business-centers by company "Yusen Logistics" Ltd, with a total of 332 centers in 36 countries.

-Road transport, with own trucks or rented.

2).Group of bulk cargo shipping companies (Bulk Shipping Business) comprising 5 shipping fleet as follows:

-Fleet of Car Transport, with 100 ships.

-Fleet of Dry Bulk Transport, with 205 ships.

-Fleet of Tanker Transport with liquid bulk goods, for oil products, chemical and LPG (Liquefied Petroleum Gas), with 78 ships.

-Fleet of LNG (Liquefied Natural Gas) Tanker Transport, with 28 ships.

-Offshore Business Group, two specialized ships, one for oceanographic research and one for submarine cable installation.

3).Group of Cruise Business, with 4 large cruise ships.

4).Real estate investment group (Yusen Real Estate Business), dealing with real estate development and leasing space to third parties.

5).Group of research and development, consultancy, education and employment of seafarers. The group has developed a research institute, environmental protection and quality assurance in transport, a maritime training center and a nautical college and in many countries it has branches for hiring crew (crewing companies). But, NYK Group is also part of the conference of a great navigational called "The Grand Alliance", along with two other major maritime shipping companies "Hapag-Lloyd Container Line" Gmbh in Germany and "Orient Overseas Container Line" Ltd in Hong Kong.

The advantages of strategic alliances for a shipping company may be the following:

-Reducing search costs for goods transportation.

-Improving operational process.

-Prompt response to customers' orders, it means that they can provide for the charterers the required ships, even if they are not in their property. So do the partners in the alliance**.**

-Certain control of transport tariff for line ships and of freight ships to those of tramp, but that does not mean a monopoly, but cooperation and an increase of the economic efficiency.

-Increasing market share because the company becomes a supplier preferred by customers.

-Increase profits.

Shipping companies demonstrate how they can be full partners of manufacturers and retailers in the logistics supply chain. As the maritime market competition has become fierce, logistics began to play a larger role in customer service. But only those companies that will best foster strategic alliances with suppliers, shippers, brokers and customers can obtain higher profits than companies that do not consider such alliances.

D).Shipping channel distribution. The term "distribution channel" refers to commercial agreements concluded in order to ensure the flow of a product from point of production to final consumption, but the product and its ownership does not always go through the same route (Gattorna et alt., 2001). Activities included in this distribution channel can be divided as follows:

1).Activities involving change of ownership of goods, trade channel, including:

-Negotiations

-Buying and selling.

2).Activities involving physical delivery of the product, physical distribution network:

-Road or railway transport.

-Storage

-Maritime and river shipping.

3).Ancillary activities to facilitate the first two types of activities:

-Collection and dissemination of information, usually through brokers.

-Risk insurance for the goods and ship, with insurance companies or clubs P&I.

-Funding, with their own reserves or bank loans.

-Promotional activity, etc.

Distribution channels very often consist of chains of companies, which, apart from the original manufacturer and the final consumer, play an intermediation role. Each intermediary carries out a number of activities that either deals directly with the travel product and/or ownership to the final users, or facilitates such travel. Intermediaries involved in marketing activities (wholesalers) prefer to be paid from profits, and companies specialized in distribution and transport services may receive a fixed amount of money (negotiated) for their services. In Figure 2 there are presented the distribution channel components of maritime transport, which are the following:

-Producer goods.

-Exporter (international shipping house) also called charterer.

-Inland transport (road, railway or pipeline) or river transport

-Charterer broker (manufacturer or exporter).

-Port operator, warehouses or charger.

-Shipping company which owns the ship (owner).

-Downloaded port operator, warehouses.

-Charterer broker (the final user or importer).

-Owner broker (for "tramp") shipping companies.

-Inland transport (road, railway or through pipelines) or river transport.

-Final user (wholesale or industrial user).

Distribution channel structure is determined by the following items as follows:

-Final customer requirements, which put together, will lead to a group of consumers with similar needs, i.e. at a market segment.

-The possibilities of the supplying company.

-Availability and willingness of the intermediaries to participate in the channel.

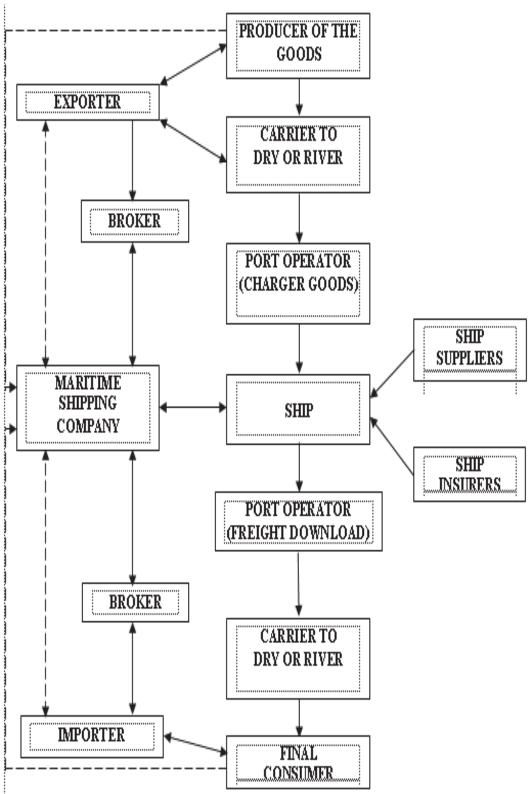



Fig. 2. Distribution channel in shipping
Source: Florin Iordanoaia "Logistics in shipping", Publisher "Nautica", 2006, p.153

Commercial channel is a variable of the mix marketing and therefore it is important that the marketing department of the shipping company should take over the initiative in designing and management of the channel, as it is in the middle of it, both physically and as a maritime ship owner which has an important role in this channel, under modern international trade. Service image, transport price and promotional efforts or partners search can be strengthened or endangered within the used distribution channel. This structure shown in Figure 2 is extended, but in many cases this can be simplified, because some of intermediaries can be eliminated, but there can occur any other intermediaries. NYK Group has several distribution channels, which control the transport, storage, loading and unloading goods, as shown in Figure No.3.

In this figure it is shown the supply chain for motor vehicles, produced in Japan and exported into the United States of America. In this chain there are the following partners:

-Car factory in Toyota City, Aichi region, Japan.

-Car-carrier with specialized trucks, owned by NYK Logistics, from Toyota City, until port terminal in Osaka City.

-Port terminal in Osaka City.

-The ship for car transport "NYK Galaxy Leader".

-Port terminal in San Francisco, U.S.A.

-Specialized car carrier trucks from port to authorized dealer.

-Landlord vehicles, authorized importer, The "San Francisco Toyota Scion" company, in San Francisco, USA.

As shown in Figure No.3, only "Toyota" cars factory and the importer from U.S.A. don't belong to NYK Group.

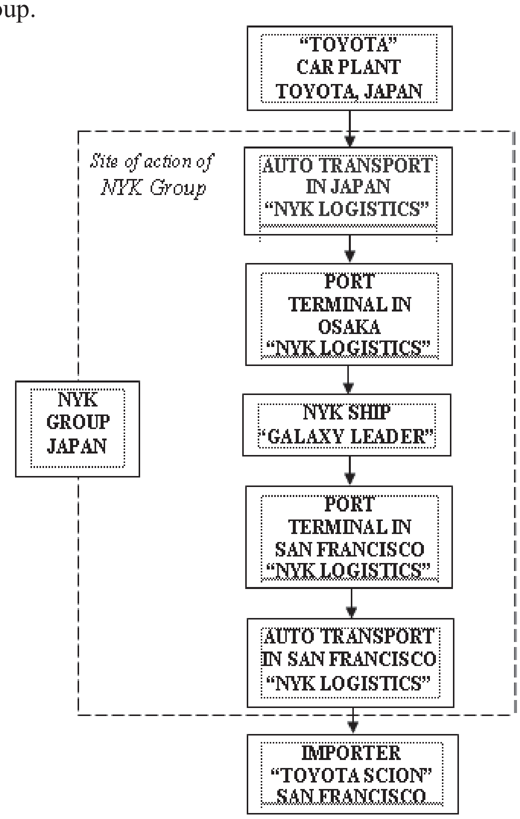



Fig. 3. Distribution Channel of NYK Group.
Source: NYK Group 2012, author's research

This situation is linked very well to "the concept of power" within the distribution channel relationships. This concept is defined as "representing the ability of a channel member to control the decision variables of marketing strategy of the other members of the channel, situated on a certain level of the distribution process" (Gattorna et. alt., 2001). In most channels it is known that there is or will be a leader. Traditionally this is being considered to be the manufacturer, who is the most powerful channel member, being called "the right leader" (Gattorna et. alt., 2001).

For comparison, it will be analyzed the situation of a shipping company with Romanian capital, the Romanian ship owner "Histria Shipmanagement" Ltd. Constanta, which has 9 ships such as oil and chemical tankers, with flag of convenience. This company carried unlimited cargo transport, at all seas and oceans. A distribution channel which includes this company is as follows, Figure No. 4:

-Exporter of crude oil, the national oil company of Libya "National Oil Corporation".

-Port operator "Socialist Company for Ports" Benghazi branch, Libya.

-Ship for crude oil transport "Histria Tiger".

-Port operator "Oil Terminal" SpA. Constanta.

-Carrier through pipes "Petrotrans" SpA. Ploiesti.

-Importer "OMV Petrom" SpA. Bucharest, for "Petrobrazi" refinery, Ploiesti.

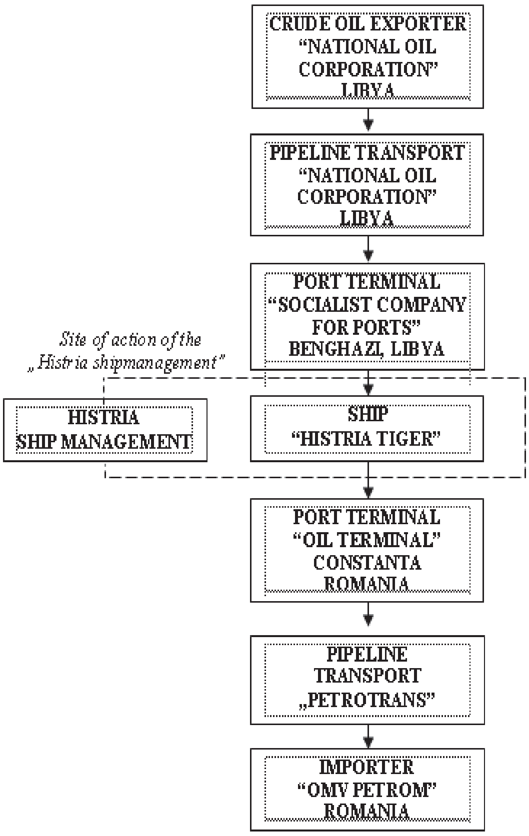



Fig. 4. Distribution channel of the "Histria Shipmanagement".
Source: Histria Shipmanagement 2012, author's research

But, from the analysis of the two cases it results that "NYK Group" can easily be a leading channel, even if it is not the manufacturer, and the company "Histria Shipmanagement" has a completely different position, taking into account the partners within the channel to which it belongs. So in shipping there are two situations that can change the "rules of the game", i.e. the leader could become the charterer (as an importer or exporter) or the owner. The real situation is given by prices (comparable rate) on the "tramp" market which are fluctuating. They have evolved over time, often unpredictable. The most important factors that influence the freight and its rate are supply and demand of tonnage. It is considered to exist the following situations (Branch, 1998):

i).When there is little cargo for transport it results that:

-there are many available ships in port or nearby,

-the rate of freight is low,

-the position of the charterer is strong, the market is generic called "of the charterer's".

ii).When there is cargo for transport but:

-there are less available ships in port or nearby,

-the rate of freight is high,

-the position of the ship owner is strong, the market is generic called "of the ship owner's".

On the ship owner market, there are very large variations of the freight; its evolution is very sensitive to the occurrence of political, economic or military events. But in the case of the shipping line, the ship owner position is more stable, the greater the business is and the more important the partners are. Of the two cases presented, it results the positions that they hold, the owner or the charterer, within the channel, depending on the amount of cargo and number of ships available. In this sense we can say that for shipping that which controls the "carriage charge" can control the distribution channel, meaning to be the leader. Hence, it results the need for cooperation and practically it ends the independent organization model of the activities within distribution channel, and of the traditional management of the years 1970-1990, from the international shipping.

E).Partnership formation within the distribution channel. Shipping companies that are strategically focused, in fact, recognize that interdependence relationship and not that of coercion or conflict, is necessary to achieve long-term profitability. Interdependence involves cooperation and establishes mutually beneficial relationships. Hence, it appears a question linked to the incentives that may cause a company to abandon opportunism and to adopt an approach based on cooperation within the relations of distribution channel. This incentive is offered to create added value, i.e. the process by which a product becomes more and more valuable as it moves inside the channel, from supplier to consumer (Gattorna et. alt., 2001). Shipping is a service whose value is influenced by customer and market circumstances which occur on the maritime market. This may explain the development of "express" transport, where the customer is prepared to pay an additional sum of money for fast and safe transport.

The improvement of the relations between distribution channel members can be achieved through marketing activities, carried out between partners in order to make a profit. Strategy implementation "marketing philosophy of partnership" consists of the following actions:

-Determining the effectiveness of distribution by checking it regularly.

-Reviewing agreements within the channel.

-Taking into consideration the changes that can be made to these arrangements.

-Implementing the marketing practices by selecting the members of the distribution channel.

Understanding the vision of other members of the distribution channel is essential for imposing a spirit of reciprocity and not one of polarity. Through this combination of forces, all members of the distribution channel can work effectively having a common goal, namely making a profit. For the partnership to be effective in the channel, the relations between members must be interdependent, not of domination or power (Gattorna et. alt., 2001). Thus there are many opportunities to develop joint marketing plans and to seek new business partners. But shipping has its specifics, different from that of the production or of the sales on the land. The main advantages of a maritime partnership are the following:

-Establishing a unique program delivery, such as "door-to-door".

-Improved communication and electronic data exchange, with international standard and standardized and typed documents.

-Optimal conditions for developing trade relations.

-Favorable lending agreements with financial companies and with banks.

-Packaging of goods according to the type of ship used for transport, in order to optimize the amount of goods which needs to be transported by a ship available as soon as possible.

-Logistics, "just on time" type.

-Liability for damage to goods during transportation, which belongs to the ship owner, but in certain situations it belongs to the charger, too.

-Promoting common activities.

-Opportunities for negotiation depending on the quantities of goods that are available to be shipped.

Thus, partners have common goals and similar strategies to achieve them, but also a common means of defense against any element of intrusion in this partnership from any competitors, both on the maritime market and of the major trading houses, seeking monopoly or dominance in a particular market. Through the partnership they become allies, not enemies, who want long-term profits and not occasional gains.

f).Obtaining financial performance. Logistics function must use a set of indicators for measuring performance such as:

-efficient use of assets, i.e. of ships,

-added value,

-level and type of costs, at the company headquarters and especially on ships board,

-ships operating standards.

Knowing the financial performance of the logistics business department of a shipping company is particularly important for the planning activity and the conduct of all operations according to their financial effects is necessary to achieve performance predicted in the objectives and strategic plans of the company. To measure this performance can be used, (Batrinca, 2004):

-Efficiency rate of assets use.

-Rate of return of the investments.

1).Efficiency rate of assets use is considered to be the most important financial indicator for measuring profitability. After the use of this index, companies began to look for a number of companies providing logistics services in order to reduce investment in logistics assets. Through this, it was sought the reduction of the assets level and increase the value of the indicator.

2).Rate of return of the investments is an indicator that requires a scientific approach to planning and making proper investment decisions, according to the value of this indicator.

Main factors logistics measurement which relates to strategic planning can positively influence company profitability. Thus it is used the concept of "total cost of logistics system" or "total cost of shipping", from search partners, up to products delivery at the destination port. From this perspective one can easily appreciate the role of logistics in shipping, which is given by the following aspects (Iordanoaia, 2006):

-It can help the managers to lead the activity of the company on the maritime market, one that represents a highly dynamic environment.

-It is used for understanding maritime market influences upon the activities related to: maritime transport, demand and supply ships, supply and demand of goods.

-The use of basic principles of logistics leads to provide a link between the strategy of the shipping company ( on medium and long term) and logistics for global organization of activities, the effective use of information from maritime market, the full involvement of human resources as an important concept of logistics, (Gattorna et. alt., 2001).

-In the integrated logistics it is very important to establish strategic alliances with partners in this field, these alliances leading to obtaining financial performance which is essentially the ultimate goal of each ship owner and charterer.

-Establishing an optimal level of shipping service to eliminate incidental costs, to avoid situations of displacement of empty ships, without cargo and to reduce the time for current or capital repairs.

## 4. CONCLUSIONS

To reduce costs and increase profits in the supply chain which includes shipping, partners should consider the following issues:

-Individual partners' strategies must be designed taking into account those of all partners in the supply chain. Specifically, charterers and port operators must know the advantages and servitude of shipping in order to eliminate those negative aspects which influence transport, which delay the ship and which lead to losses for the ship owner.

-When a maritime shipping company formulates its management strategies and objectives for future must take into account its level of integration in the chain, but also those of other partners, because it is possible that each company individually, to be integrated differently or have different interests from those of the entire chain.

-Maritime shipping company should also aim to plan in detail how to achieve integration in the chain, increasing the speed of flow of information and of documents required for transport.

-Some maritime shipping companies that have many ships of different types, can have a certain advantage because they are covered in many supply chains systems on different fields: oil, gas, minerals, cereals, etc. In this way, the company can diminish the risks specific to business in the marine transport sector and at the end of the year to come out in profit, even if some of its ships did not contribute to it.

-Another important aspect is represented by the operational research, the one which has contributed to get some information and correct transport forecasts on the development of models and projects that were subsequently used for coordinating the flows of the materials and information within the supply chain. Nowadays, it appeared a large number of specialized electronic programs of shipping data and information storage. These programs can be used to find at least theoretical solutions to existing situations. But even so, many issues and opportunities remain unused by ship owners, most related to marketing and finding customers.

Supply chain management has ensured its future in shipping, especially since it is still not very well known and it is still not working after its principles in many maritime shipping companies.

## 5. REFERENCES

1. Bacanu B., (2006). *Strategic management practices*, pg. 45-48, ”Polirom” Publisher, Iasi.
2. Balan C., (2006). *Logistics*, pg. 22-24, “Uranus” Publisher, Bucharest.
3. Batrinca G., (2004). *Financial management in shipping*, pg. 11-12, “Arvin Press” Publisher, Bucharest.
4. Branch A.E., (1998). *Maritime economics, management and marketing*, pg. 146-147, “Stanley Thornes” Publishers Ltd., London.
5. Druker P.F., (1954). *The practice of Management*, pg. 118-119, “Harper & Row” Publishers, New York and Evanston.
6. David P., Stewart R., (2008). *International Logistics. The management of International Trade Operations*, pg. 54-55, “Thomson” Corporation, Ohio.
7. Gattorna L.J., Alling C.P., Tyndall R.G., Cristopher M., Ehnbom S., Robinson C., Hatton G., (2001). *Logistics and distribution management*, pg. 223-224, “Teora” Publisher, Bucharest.
8. Iordanoaia F., (2008). *The reduction of the costs of the shipping company*, International Science Conference „Knowledge based organization”, pg. 79-84, (Sibiu).
9. Iordanoaia, F., (2006). *Logistics in the maritime transport*, pg. 121-123, 189-190, “Nautica” Publisher, Constanta.
10. Porter, M.E., (1980). *Competitive Strategy*, pg. 8-9, “Free Press” Publisher, New York, 1980.
11. Stan, A.V., (2003). *Maritime transport treatise*, pg. 19-21, “The Family Universe” Publisher, Bucharest.
12. Teodor, M., (1998), *Organizing, administration and the management of the ship*, pg. 12-14, University course notes, Civil Marine Institute, Constanta.
13. International Safety Management Code (I.S.M. Code), (2002), London,.
14. Nippon Yusei Kaisha Group (NYK Group), (2011). Management Plan “*More Than Shipping 2013. Grow with Asia, Expand across the Globe*”, Tokyo.
15. “Bolero Carriers” Ltd. Company, (2004). Operational documents for brokerage, Constanta.
16. “Histria Shipmanagement” Ltd. Company, (2012). Files freight, Constanta.
17. Nautical Institute, (1994). “The Institute of Chartered Shipbrokers”, London.

Web sites visited:
www.histria.ro/ Accessed: 15/09/2012.
www.imo.org/ Accessed: 25/09/2012.
www.iso.org/ Accessed: 25/09/2012.
www.nyk.com/ Accessed: 15/09/2012.
www.nyk-hinode.com/ Accessed: 16/09/2012.
www.nct-ho.co.jp/ Accessed: 16/09/2012.
www2.nykline.com/ Accessed: 17/09/2012.
www.nykcontainerline.com/ Accessed: 17/09/2012.
www.nca.aero/ Accessed: 18/09/2012.
www.sftoyota.com/ Accessed: 20/09/2012.
www.toyota-global.com/ Accessed: 20/09/2012.
www.yfk.co.jp/ Accessed: 17/09/2012.
www.worldshipping.org/ Accessed: 14/09/2012.
http://en.noclibya.com.ly/ Accessed: 18/09/2012.
http://en.wikipedia.org/ Accessed: 20/09/2012.

# THE PEOPLE'S IPO - THE MODERN TREND OF STRENGTHENING OF KAZAKHSTAN'S BUSINESS

KARZHAUBAYEVA O.ZH.

Caspian State University of Technologies and Engineering Named after Sh.Esenov, Aktau city, Kazakhstan.

**ABSTRACT**

In 2012, Kazakhstan initiated the first wave of People's Initial Public Offerings (IPOs), in which some of the largest and most profitable corporations in the country went on the market. The aims of the programme are ambitious. Upon completion of the People's IPO campaign, it is expected that Kazakhstan will have attracted unprecedented domestic investment into the Kazakhstan Stock Exchange (KSE) in Almaty. This will make the country the most dominant investment and stock trading center for all of Central Asia.

The programme is also designed to share the wealth of the nation and significantly expand the middle-class sector of society.

**Keywords:** *People's Initial Public Offerings (IPOs), investors, shareholders, cooperation*

## 1. INTRODUCTION

The People's IPO (Initial Public Offerings) - the modern trend of strengthening of Kazakhstan's enterprises, involving the distribution of national wealth in the hands of the people. The Head of the State Nursultan Nazarbayev has repeatedly pointed out the importance of this type of privatization, stressing out that it will maintain high rates of economic growth, attracting additional funds into the company, and will give the public the opportunity to receive further benefits for their development and growth. The topic of the People's IPO was especially raised in a separate address to the nation "Strategy Kazakhstan-2050: a new policy of the established state".

Today, many countries in the world use this kind of national investment experience of which demonstrates the workings of the People's IPO. An illustrative example of a successful company is Google, whose investors have become 5 times richer in less than 4 years whereas the price per share value of $ 85 has increased to 593. It should be noted that investors not only receive dividends, but in the event of changes in the securities market they also carry the risks along with the owners of companies.

The practice of the People's IPO in Kazakhstan is relatively new. Its first implementation in the country became known in 2011. A list of joint stock companies, whose shares are offered for sale, has been determined mainly for enterprises related to infrastructure: oil and gas, energy, railroad companies, etc. In this case, the phased implementation of the project was solved systematically by 2015.

Despite a marginal experience, the results of the first People's IPO in Kazakhstan can be predicted for the future, being mostly widespread among the population.

Even today, the holders of "KazTrans-Oil" common shares earned about 100 tenge each security only on the growth rates. Its value has grown from an initial 725 tenge - more than 13%.

While on preliminary calculations it was assumed that the shares of one company will be allotted to 16 thousand people, and the results showed great potential of the program, ahead of forecast by almost half.

This program has lots of advantages, especially, in particular, through the involvement of the population in the economic activity of the country. This, in turn, will increase the transparency of public enterprises and more public scrutiny of their activities. Investors of companies and enterprises will monitor the prices on the exchange market, will calculate the possible risks and methods in order to avoid them, will participate in joint meetings, which generally will change the mentality of the people, directing them to the financial and legal literacy, active cooperation and partnership with the state in the economy.

The head of state in the article "Social modernization of Kazakhstan: Twenty Steps to a society of universal labor" also noted a significant role of this program for the employees of the enterprises themselves, stressing out that it will not only be a possibility of the shareholders, but also make a significant contribution to overcoming the alienation of workers. In particular, employees will better understand the entire mechanism of the economic component of the enterprise, to objectively evaluate any changes and issues to influence decision-making, to make proposals for their removal and settlement. For example, one-fifth of the "KazTransOil" shares were bought by the company's employees, suggesting "a fairly high degree of participation of employees of the companies in the next IPO".

A positive aspect of the program, of course, is that its members may be limited to citizens of the Republic of Kazakhstan. This will allow the population to become shareholders of large domestic companies without outside competition, investing money in support of our nation's economy.

Currently, the issues of the active involvement of the population in the republic's economy gained strategic importance. The development program of the

People's IPO in Kazakhstan will become an effective tool in this regard. The progress of the first experience is already available, and further success – is only a matter of time.

## 2. CONCLUSIONS

In the long-term, Kazakhstan should also allow foreigners, especially institutions, to invest in their profitable companies as that would encourage an additional lucrative flow of outside investment into the country. The Kazakhs are much more likely to attract foreign investment capital into their country if they establish a share system in which foreigners can buy.

It is much more preferable to attract portfolio investment than private investment into any developing country.

But with more than $150 billion in foreign direct investment already successfully attracted into the country since independence, it's easy to see why the government of Kazakhstan is encouraging domestic investment to spread the profits and benefits more widely now. It's a policy that combines the market with social vision.

## 3. REFERENCES

1. Business Week number 22 (1047) 2013 г.
2. Message from the President of the Republic of Kazakhstan - Nursultan Nazarbayev to the people of Kazakhstan Strategy "Kazakhstan-2050" Astana, Acorda, 2012
3. Kazakhstan Pravda № 205-206 (27479-27480) 2013
4. www.google.kz

# TECHNOLOGY OF TEACHER AND STUDENT "PORTFOLIO" IN PRIMARY SCHOOL AS EDUCATIONAL INNOVATION

KARZHAUBAYEVA O.ZH., KOKSHEEVA Z.T.

Caspian State University of Technologies and Engineering Named after Sh. Esenov, Aktau city, Kazakhstan.

**ABSTRACT**

If pedagogical innovation implies the understanding of some idea, method, tool, technology or system, the innovation of this system will be the process of implementation and development of an innovative approach. An illustrative example in this respect is the portfolio which is a form of organization and the technology process of the products of cognitive student activity are intended to demonstrate the analysis and evaluation for the development of reflection, in order to understand and evaluate the results of their activities, and understand their own subject position.

**Keywords:** *innovation, novelty, approach, creative thinking, culture, educational paradigm*

## 1. INTRODUCTION

The concept of "innovation" is translated from Latin and means renewal, innovation or change. This concept first appeared in the $19^{th}$ century and it meant the introduction of some elements of one culture to another. The problem of innovation has long been considered in the economic studies. However, over time there has been a problem with the evaluation of qualitative characteristics of innovative changes in all spheres of public life, but only with respect to determining the changes in economic theory if possible. A different approach to the study of innovation is required, where the analysis of innovative problems involves the use of modern advances not only in the field of science and technology, but also in the areas of governance, education, law, etc. The creative elaboration of ideas, principles, techniques, and in some cases is bringing them to the project types involving conditions of their adaptation and application - all this leading to innovation in education. It should be distinguished between innovation and novelty. If under pedagogical innovation is to understand some idea, method, tool, technology or system, the innovation in this case will be the process of implementation and development of this innovation. The concept of "novelty" is synonymous with "innovation". At the beginning of the $20^{th}$ century a new area of knowledge, i.e. innovation, emerged - the science of novelties, in which the pattern under study involves technical innovations in the sphere of material production. With reference to the pedagogical process of innovation that means the introduction of new targets, contents, methods and forms of education and training, the organization of joint activities of the teacher and the student. Pedagogical innovation - innovation in teaching activities, changes in the content and technology education and training, in order to enhance their effectiveness. Innovative processes in education are considered in three main areas: socio-economic, psychological, pedagogical, organizational and managerial. These aspects depend on the overall climate and the conditions in which innovation occurs. The existing conditions can promote or hinder the innovation process. The innovation process can be in the nature of both natural and consciously controlled.

The innovation process consists in the creation, deployment, and application of innovation. This is a three-part process of innovation and is often subject to studies in educational innovation, as opposed to, for example, didactics, where the object of scientific research supports the learning process. Novation - is the means (a new method, technique, technology, software, etc.), and innovation - is a process of development of the medicine. Innovation - is a purposeful change, bringing in new environment a set of stable elements that cause a transition from one state to another. In the educational literature a large set of classifications and group innovation is provided. For closer innovation, in order to develop new forms, techniques and methods of the educational process, innovation is designed to address the new curriculum and new ways of structuring it. Through innovation, we also need to know that innovation implies a set of measures designed to ensure the innovation process at a given level of education, along with the process itself. The main functions of innovation refer to a component of the pedagogical process: meaning, objectives, educational contents, forms, methods, techniques, training tools, systems of management, etc. In today's educational environment personal qualities such as independence, responsibility, initiative, are relevant and meaningful. Innovative technology, adequate to the formation of key competencies, are different in that the primary condition for their implementation supports the following principle - the student in the work of this technology is the subject of their work. This position is not seen as the ultimate goal, but as a prerequisite. One of the educational technologies that supports the competence-based approach in education, the development of independence is the technology of the portfolio. The term "portfolio" (a term used in the technology of critical thinking or briefcase - the adaptation of the term in Russian) came along in pedagogy, as well as a request for a new educational paradigm of politics and business. It is familiar to all such concepts as "ministerial portfolio" or "portfolio investment." Portfolio may be official, professional, business and presented in written and in electronic form.

There are different approaches to the definition of the portfolio. Portfolio - is:

• a method of recording, storage and assessment (including self-assessment) of individual student achievement in a certain period of training.

• a collection of the student work and results demonstrating his/her efforts, progress and achievements in the various fields of their choice.

• a systematic and specially organized collection of evidence used by teacher and students to monitor the knowledge, skills and attitudes in students.

In this case, the student acts as an active participant in the process of assessment and self evaluation which is aimed at a monitoring progress of training, the effort and the results of learning and cognitive activity. The portfolio also takes into account a variety of student outcomes in educational activity: the actual training, creative, social, communication, making it an essential element of a practice-oriented approach to education.

A portfolio is both a form of organization and the process technology of the products of cognitive student activity, intended to demonstrate the analysis and evaluation for the development of reflection, in order to understand and evaluate the results of their activities, in order to understand their own subject position. These factors determine the urgency of the problem and its significance to the modern education system. A classic portfolio consists of four sections, which are presented in the work of Danyluk A.Y.: “Portrait”, “The Collector”, “Working Papers”, and “Achievements”.

The “portrait” is designed to provide information about the author of the portfolio. This section should display the characteristics of the personality's portfolio which may include a record of other people’s characteristics, approvals, etc. For example, a portfolio of achievements in this section may be a brief period of success. This portfolio section is carefully placed opening chapter - the rationale, which formed the goal of a given portfolio, and accounted for certain materials included in the portfolio, the results of which they reflect thereof. In some types of portfolios in this section comments are placed, reflecting the author’s thoughts on the work presented in the portfolio.

The “Collector” includes materials, the authorship of which belongs to the author. This material may be suggested by the student teacher (instructions, diagrams, lists of references), in case you found yourself a disciple (copies of articles, materials, periodicals, illustrations) or materials band mates.

The “Working Papers” should include all the documents that are created and systematized by the author. In the section called “Achievements” the author puts those materials which, in his/her opinion, reflect the best results and experience for success. Moreover, in his introduction or portfolio introduction one should provide justification for these materials best reflecting his/her achievements. The introductory article or introduction to the portfolio has as a primary meaning, that it expresses the expectation of students in relation to their future actions and their own prospects; this is where a student finds their ability to achieve certain results, evaluate their progress and potential.

Work begins at the primary level of education. The aim of this work: creating conditions aimed at practical experience of forming a portfolio. Elementary school provides a basis for successful education; therefore it is important to further run the technology portfolio as it is used in different areas and at different levels of education. The structure of the portfolio puts into action core competencies that must be generated in primary school:

1. Mastery of general education and skills, ways of cognitive activity for the successful study of any subject.

2. Interest in school education and teaching, the development of educational and cognitive motivation, the desire for self-education, the ability to organize, monitor and evaluate training activities.

3. Formation of training skills for cooperation and education which demand the participation in an educational dialogue, collectively discuss suggestions, problems (formation of communicative speech and language competence) in school.

For younger students, one of the most versatile types of portfolios is a “portfolio of achievements’. It reflects the level of student progress during primary school. Working with the portfolio is accessible and age-appropriate. In elementary school, the first place is held by the learning activity, and therefore the basis for learning activities puts younger students to reflection.

The “achievement portfolio” is represented by the following sections: an appeal to the author, a business card: something about me, myself and I; do others know what I mean? Me and my friends, what do I want to be? my difficulties, I - Apprentice: a graphic representation of my development as a student, I want to know, I want to able to, my favorite subjects, what I read, books that I read and love; this is what I deserved (my achievements: promotion, rewards). When working with the diary some basic principles must be kept: the principle of voluntary will (if in the first grade the pupil may found it difficult to begin work, he may turn over any period of primary school), assistance from the teacher and parent, inventory of personal interests might be helpful.

What is mandatory for a successful work is meeting with parents of students involved in technology portfolios. Parents are participants in the creation of a portfolio, as the boys of this age do not have the skill of the design. Work should be beautifully decorated; the child should feel that adults are really interested. Such a portfolio is by choice of the primary school. The second type of portfolio, which is conducted by the students, is a simplified version, which records individual educational achievement: the results of marathons, competitions, and results of competitions, research, sports achievements, and the world of hobbies. One may find attached certificates, diplomas, and other certificates. This type of portfolio can be created in the initial stage of learning, but at the next stage of education it is not productive any more, because it gives a prospect idea of the results, but does not describe the process of student individual development, his/her academic style, the variety of his/her creative activity and interests.

Moreover, it is an effective form of joint work of teacher and student. The result of this work can be “portfolio learning curriculum subjects’. This type of portfolio is composed of two types: teacher portfolio and student portfolios. The portfolio includes the teacher program development lessons (section “Working Papers”), additional material for lessons, student work (section “The Collector”). In “Achievements” the diagnosis is carried out by the subject. In parallel with the teacher, the students create their own portfolio on the same topic. Further on, the portfolio is filled during the subjects being studied. Prior experience with portfolio enables a number of advantages that include the following: a portfolio of teachers and students helps the organization of independent work, reflects their teaching activities and provides a good launch pad for students to successfully continue their education.

Thus, experienced working with portfolio enables a number of advantages which include the following: in the portfolio not only results are important, but also the creation of proper style of work for teacher, and pupil of any age; a portfolio preserves the learning individuality, emphasizes a cover page reflecting the author of the portfolio, the creation of file names - components and work with them - it is a creative process that focuses on self-selection, imagination, discovery, search, the process of creating the portfolio, working with it, sharing experiences with each other allows authors to carry out self-assessment of their independent cognitive function and improve it. Work with the portfolio can and should begin with the elementary school, and then the process is focused, on training continuity. A student, going to the next stage of training, is able to efficiently present their successes and achievements.

## 2. CONCLUSIONS

Technology is constantly changing, and so is teaching. It is imperative that we continue to examine how we currently help students learn and what we need to do to transform learning. Teachers use their knowledge of subject matter, teaching and learning, and technology to facilitate experiences that advance student learning, creativity, and innovation in both face-to-face and virtual environments.

Teachers:

- promote, support, and model creative and innovative thinking and inventiveness.
- engage students in exploring real-world issues and solving authentic problems using digital tools and resources.
- promote student reflection using collaborative tools to reveal and clarify students' conceptual understanding and thinking, planning, and creative processes.
- model collaborative knowledge construction by engaging in learning with students, colleagues, and others in face-to-face and virtual environments.

## 3. REFERENCES

1. Golub, G.B., Churakova O.B.//School technologies. -2005.-#1.
2. Dumina, V.N. Portfolio of graduate elementary school in the system of training without grades.
3. Petrova O.V., Solodova V.A., Zhilina S.V., Rogozina E.A. The portfolio as a form of monitoring of student//The class teacher. -2007.- #8.

Novikova, T.G. Estimating by using portfolio// Education. – 2006- #7.

# THE IMPACT OF THE ECONOMIC CRISIS ON PORT DEVELOPMENT

NECHITA DANIELA

*"Dunarea de Jos" University of Galati, Romania*

**ABSTRACT**

In order to meet the European and global standards in the maritime industry, extensive efforts are required that aim at re-arranging all system components in a logic vision, upgrading the existing infrastructure to an efficient level, protecting the environment, providing security to passengers, stimulating the private initiative, restructuring transport capacities, reshaping cultural awareness of institutions that operate in this sector. Moreover, European transport integration is an issue related to the integration of large dynamic systems that rely on changing the national systems in order to meet the requirements of the European ones, and based on harmonizing the existing infrastructure networks, standards, rules and regulations. At the same time, the strategies that should be adopted require the avoidance of the risk related to the less developed transport systems that may orbit around the developed ones, providing solutions to the issues regarding authority and power in integrate power in integrated logistics systems.

**Keywords:** *globalization; integration; port industry; port activities; economic development; maritime industry.*

## 1. INTRODUCTION

Numerous companies are stagnating not due to the lack of energy or personal ambition but to the lack of realism and also to the failure to define goals and failure to acknowledge the fact that the organisation cannot be oriented to solve short-term problems. In this respect, strategic management can offer a thorough analysis of the competitive behaviour of the market, estimation of opportunities and substantiating decision-making on the available resources.

The transition from the traditional to modern guidelines involves significant changes in the structure of the mechanisms generating the market's current and future dimensions, which in turn impose the reshaping of the management systems and rethinking strategic activities in order to show dynamism, creativity, flexibility and functionality inherent in the market economy system.

The increasingly expanding globalization has exacerbated inequality in several countries, providing insufficient development opportunities for certain fields of activity, which might have become powerful engines for change and economic growth. Thus, within the context of market globalization, port activities may be regarded as an important factor in maintaining and increasing European competitiveness, which relies not only on the technical quality or productivity but also on all types of transport, on the possibility of improving the infrastructure, with the purpose of increasing accessibility of other sectors of the new market economy, of integrating technical breakthroughs and benefiting from these innovations.

Moreover the essential changes that have occurred in the port industry over time, have also had a continuous and significant impact not only upon some other important sectors of the economy but also upon the port activity and management. It should be emphasized that all these changes require a more active and competent involvement of the government particularly regarding the applied strategies that deal with the existing regional discrepancies in providing infrastructure, in training staff and managing the economic and financial levers to determine an accurate and fair pricing mechanism for port services.

Under these circumstances, the port industry which is in fact a global industry is aware of the urgent need for some effective measures that should be taken in order to achieve sustainable development of all port activities. Moreover the current financial crisis provides opportunities to governments for shaping and completion of investments in the port area and for adopting strategies to support this long-term development and to enable all countries to collaborate and cooperate in a global economic system.

## 2. CURRENT GLOBAL ISSUES IN PORT DEVELOPMENT

Due to decentralization and increasing degree of financial autonomy, funding the port sector witnesses various levels of financial autonomy and non-repayable public funding in the EU member countries, facing at the same time the lack of transparency in port pricing. In this respect, the European Commission has allocated € 32 billion for major transport projects. Thus out of 150 projects financed from EU structural funds, carried out by Romanian managing authority, only 83 have been labelled as relevant according to the criteria of EU Strategy for the Danube and the Black Sea Region. Among the most relevant such projects financed by SOP-T (Standard Operation Procedure for Transportation - 2007-2013) are those projects that are still being carried out in the ports of Constanța, Galați and Oltenița.

Moreover, numerous ports are facing blockages and obstacles generated by capacity, connections or management. In this respect, the review and improvement regulations is highly recommended on land use, upgrading IT systems and creating databases on ports, waterways and preliminary data traffic, creating new security and telecommunications systems, acquiring new automated port equipment and interoperability of European surveillance system, that have a major role in simplifying the transport procedures and supporting the development of maritime transport market within the internal market.

For example, in the port Galați, the project - *Rehabilitation and modernization of vertical quay Dana 31-* has been encountering difficulties in its implementation, in achieving its modernization objectives due to numerous disputes over land.

From the economic globalization perspective, modern ports play the role of commercial services centres that must provide an efficient transport, adequate technical facilities and communication that comply with the international standards in order to ensure customer access to local and global markets.

Furthermore, they must ensure a wide range of value-added services, ports becoming service platforms, designed to ensure customer satisfaction to the highest degree. The use of IT in port administration, extended to the entire port, leads to the streamlining interdepartmental communication between different departments of the port administration and their partners as well as rapid access to information.

For instance, Bull-Siveco Romania consortium inaugurated in 2011 the integrated IT system of Constanța Port Administration - Neptun, which covers a wide range of business, defined by 850 processes, contributing both to performance increase of the entire port system and to a better organization of specific activities APM Constanța. In 2012 was created the portal of this organization, which is an essential source of information for both community members of Constanța port due to the available information related to specific port activity as well as other for other visitors due to the marketing information, general information and statistical studies provided. This portal is mainly one of the main tools for promoting the port of Constanța, Romanian companies or those from abroad interested in carrying out activities in the port of Constanța.

Moreover, the infrastructure requires standards, procedures and equipment for the proper conduct of all port activities, using various institutional and legal systems as management tools on infrastructure.

The sustainable development of the Danube region will continue to emphasize the geostrategic importance of the Black Sea; the two strategies should be complementary and mutually reinforcing. For the implementation of these strategies and for their success implicitly, all public and private actors must apply the management of the 4C - connectivity, cooperation, coordination and competitiveness in the post-crisis global competitive environment.

Among the most relevant such projects financed by SOP-T(Standard Operation Procedure for Transportation 2007-2013) are those projects that are still being carried out in the ports of Constanța, Galați and Oltenița that amount to 206.3 million euros, we mention the following:

- building of a road bridge at km 0+540 of the Danube – Black Sea Canal and afferent infrastructure works of road building and access to Constanța port, totalling € 36.8 million;
- extension of offshore breakwater ( from 1.050 meters to 5.900 meters) in the port of Constanța, amounting to € 148 million;
- development of railway capacity in the river-maritime area of Constanța port, amounting to € 21.5 million.
- out of the eligible projects for funding, totalling €96.1 million, we mention the following:
- modernizing port infrastructure by ensuring the increase of channels and basins depth and safety of navigation in the port of Constanța, taking into account the global shipping industry trends in recent years and orienting towards ships with increased cargo carrying capacity – the estimated value of works is € 49.5 million;
- building a connecting steel bridge road and a passage over the existing railways, which will ensure the connection between the river and sea region and the artificial island of the port of Constanța, as well as achieving its connection to the internal and external of the port – totalling € 40 million;
- extending southwards the port of Constanța's overall berth – totalling €4.6 million.

The start up of the project - *Rehabilitation and development of port infrastructure in the port of Oltenița* was in April 2012 by the Managing Authority for Sectorial Transport Programme and National Company Maritime Danube Ports Administration Giurgiu plc. The main objective of this project was to achieve the technical project as well as the execution of infrastructure works in the port of Oltenița, in order to increase port traffic and reduce operating costs. The project's estimated value is 24.603.881 lei, of which 12.096.760 is non-refundable grant allocated by the European Commission through the European Regional Development Fund.

In Galați, the DaHar project (Danube Inland Harbour Development) has as main objective the achievement of a better integration of inland navigation within transport logistic chains by investigating and using the multimodality potential of ports and port areas in middle-sized port cities of Southeast Europe, along the Danube. The project runs from April 2011 to March 2014 and has a total budget of €1.966.100.

On the other hand, the project - *Rehabilitation and Modernization of the Vertical Quay - Berth 31* - aims at inaugurating its first container terminal, located on the maritime Danube in Galați port docks. Achieving this objective will lead to higher growth of containerized cargo and generate the emergence of new services and opportunities to provide to the local and regional economic environment.

In the future, port may develop as intermodal hubs where goods are taken over and handled, especially those goods that are suitable for container traffic. This development is advantageous because it would reduce the negative effects of pollution as well as transport costs. However, the economic crisis impairs the implementation of development strategies for intermodal ports as well as small businesses that have been started in ports so far. Thus, the container terminal in the port of

Galați was inaugurated in 2008. For about 3 years no container passed through it and the investments made for this purpose were significant, approximately € 10 million in the development of port infrastructure for the 16.000 sq meters, and works of quay modernization, over a length of 136 meters, amounting to 34 million lei.

Due to the reviving transport flows, the port of Galați will face fierce competition, generated by the building of a container terminal in the port of Giurgiulești that is interconnected to the railway that was built in the past two years on the Moldovan banks of the Danube river. This competition also involves another competitor of the port of Galați, namely the port of Reni, Ukraine, towards which are heading all ships that cross the Bastroe channel, so we can conclude that the benefits of infrastructure were wasted.

The impact upon the environment is a key element in port development and the environmental law ensures the proper functioning of ports. In this respect, progress in environmental management was achieved, while the constraints of environmental protection contained in the port sector projects resulted in complex procedures. In Galați there are two major ongoing projects, namely the WANDA project - WAste management for inland Navigation on the DAnube and the CONEDAV project.

The WANDA project has as main objective the creation of a concept of ship-waste management system along the Danube which adopts a coordinated transnational approach, which is sustainable in terms of environment, including the development and implementation of appropriate measures to protect this source of water as well as its complex ecosystems. The project was conducted between April 2009 and March 2012 and the total budget amounted to €1.667.240.

The CONEDAV project is co-financed by the European Regional Development Fund through the Sectoral Operational Programme-Transport (SOP-T) and has as main objective the creation of a ship-waste management system. The waste is collected from ships in maritime Danube ports in order to minimize the negative environmental impact and create proper conditions for improving the quality of water and current environmental factors of the Danube. The total budget of CONEDAV project is 48.669.426 lei and it is conducted between December 2010 and December 2014. At the same time, at the level of South-Eastern Europe, Hungary and Romania are responsible for the sustainable development of the Danube and must strive for better coordination and collaboration for its promotion. In this respect, the two countries are subject to generate a set of rules that are to be implemented in each bordering country for the sustainable development of the river.

On the other hand, professional training is of utmost importance for a safe and efficient operation of ports, and currently, there are no specific community rules on professional training of port workers. European ports are vital elements in the system of European cohesion by providing freight and passenger transport intra and extra community, representing the source of over half a million jobs in the EU and generating investment for entire regions, being recognized in the Treaty of Lisbon strategy as key priorities in sustainable social and economic development of the EU

Two aspects that are essential and complementary at the same time in ensuring the continuity of the European port system are the free access to port facilities and infrastructure security in ports, as the basic structure of the entire European legislation. This legislation is designed to harmonize national legislations in order to develop a unified network of ports at EU level. Despite this, EU failed to adopt a directive on free access to European ports. Implementing a single policy on the level of European authorities on free access to ports has experienced difficulties whore repercussions are felt even nowadays as EU failed to adopt a directive, there is only a proposal and not all Member States have agreed with it. Thus, countries like Greece and the Netherlands, which have the most important ports in the EU, drew up their own proposals for the directive, designed in order to satisfy all stakeholders. However, it is important that such countries do not entirely agree with the EU policy of unifying the legal framework, which is generically called "one size fits all ports", as their positions promote a policy that was characterized as protecting the monopolist interests of a giant operator or manager of several ports.

Moreover, the process of opening the transport markets involves the achievement of fair conditions for competition both at the individual level for each type of transport and between them. For this reason, the harmonization of laws, regulations and administrative provisions, including the prevailing technological, social and tax conditions, has gradually become increasingly important.

## 3. CHANGES AND CHALLENGES OF PORT INDUSTRY IN GLOBAL ECONOMY

In the context of expanding globalization, port industry places a great emphasis on the correlation between the economic growth and the increase of passenger and freight transport. The successful completion of the internal European market, the removal of internal borders, reduced transport prices due to the opening and liberalization of transport markets as well as changes occurred in production systems and in storage conditions have led to a steady increase in transport volume. In this respect, the statistical studies provided by Eurostat on the volume of goods handled in the main ports, shows a significant increase which is revealed for the ports in Europe (Table no. 1.) ranging between 107.93% for Germany to 225.3% for Greece. For the other ports, the changes displayed, be it about decreases or increases, are within normal limits imposed by the post-crisis conditions.

**Table 1. – Transport of containerised merchandise (TEU)**

| | 2011 Trim I | 2011 trim II | 2011 trim III | 2011 trim IV | 2012 trim I | 2012 Trim II | 2012 Trim III |
|---|---|---|---|---|---|---|---|
| Germany | 3.595.823 | 3.887.817 | 3.939.116 | 3.770.567 | 3.874.902 | 3.881.239 | ----- |
| Greece | 372.779 | 455.983 | 515.680 | 589.910 | 750.961 | 829.444 | ----- |
| Holland | 3.633.206 | 3.827.730 | 3.917.145 | 3.511.314 | 2.794.817 | 2.931.451 | ----- |
| Rotterdam | 3.582.349 | 3.789.704 | 3.881.042 | 3.476.859 | 2.755.700 | 2.896.388 | ----- |
| Croatia | 36.372 | 41.694 | 41.188 | 35.199 | 35.394 | 40.034 | 36.660 |
| Slovakia | 149.022 | 150.881 | 141.602 | 145.408 | 244.158 | 140.533 | ----- |
| Bulgaria | 33.326 | 37.560 | 40.007 | ------ | 40.923 | 44.822 | ----- |
| Romania (Constanța) | 143.673 | 171.586 | 179.124 | 158.923 | 141.149 | 196.689 | 177.833 |

Source: www.Eurostat.com

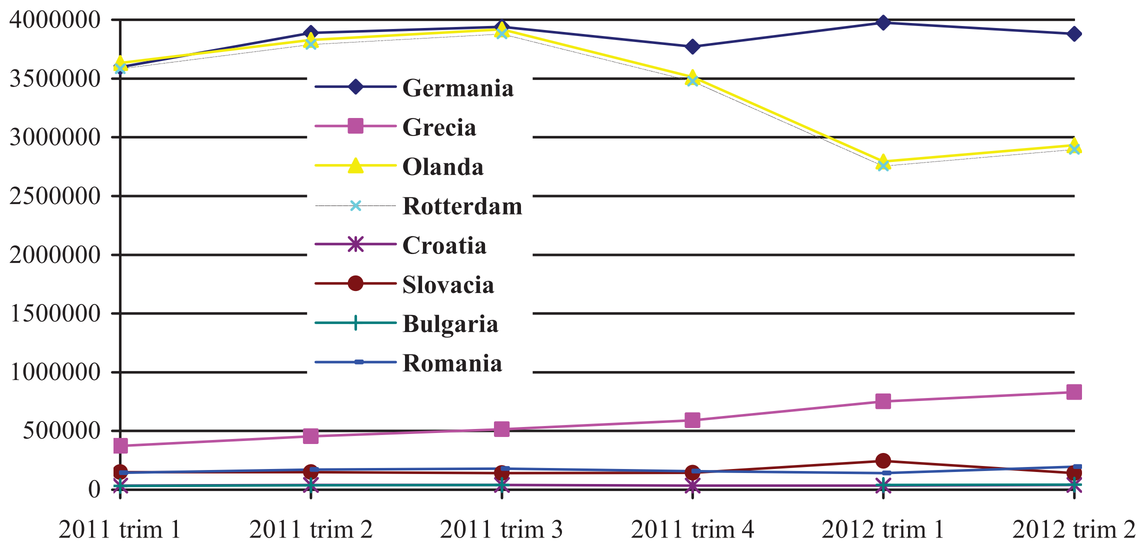



Figure 1.Transport of containerised merchandise(2011-2012)

In the ranking carried out by Eurostat, based on traffic data recorded between 2009 and 2012, the port of Constanța occupies the 19th position, climbing from the 20th position in the latest top achieved. In terms of containerized freight traffic, the port of Constanța occupies the 18th position. Table no. 2. shows according to the primary information provided by Eurostat, a perspective upon the share freight transport in GDP. Thus significant increase from this point of view during the period analyzed are recorded in Germany, Hungary and Bulgaria. The rest of the countries analyzed by Eurostat, display variations that hold steady within the normal limits of the economic environment generated by the international trade evolution.

**Table 2. – Volume of merchandise transport in GDP (%)**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Germany | 106,0 | 117,0 | 115.1 | 118,9 | 144,6 | 156,2 |
| Austria | 98,1 | 101,6 | 97 | 91,3 | 79,1 | 80,5 |
| Hungary | 105,5 | 118,9 | 134,1 | 132,4 | 133,1 | 131,6 |
| Slovakia | 93,7 | 87 | 92,2 | 91,5 | 86,2 | 85,8 |
| Bulgaria | 126,8 | 117 | 115,1 | 118,9 | 144,6 | 156,2 |
| Romania | 174,2 | 171,4 | 165,6 | 148,5 | 113 | 105,8 |

Source: www.Eurostat.com

This analytical presentation is also emphasized by the graphical representation of the share of goods volume in GDP, which reveals the relative changes that are somehow insignificant for the period analysed.

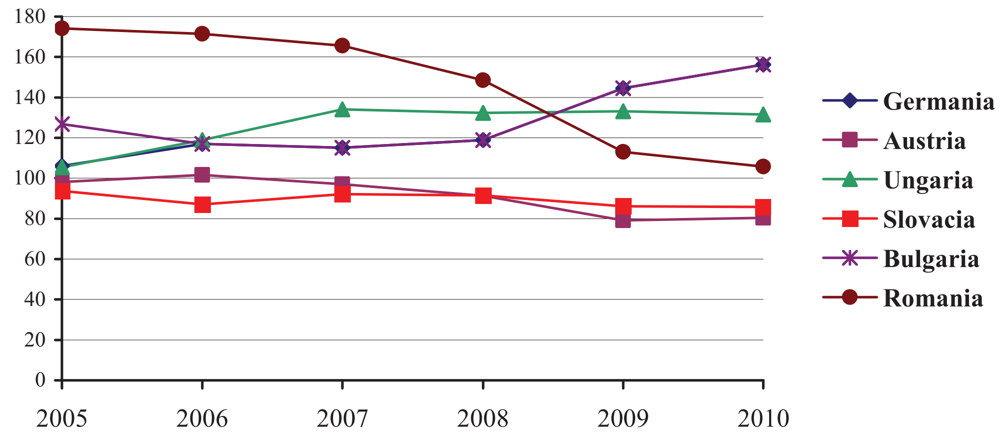



Figure 2. Share of goods volume in GDP

For our country, the table no. 3 shows the traffic of goods handled on the maritime Danube between 2010 and 2012, which reveals a slight, almost insignificant increase of the goods in transit though the ports of Galați, Midia and Constanța, respectively of 11.42%, of which 14.71% increase for the port of Constanța, 4.16% for the port of Midia and a decrease of 24% for the port of Galați, which means that the above-mentioned ports are operating below their potential.

**Table 3. – Maritime transport of goods (thousand tons)**

| | Romania | Constanța | Galați | Midia |
|---|---|---|---|---|
| 2010 trimester | 9.121 | 7.380 | 421 | 1.320 |
| 2010 trimester III | 9.685 | 8.242 | 451 | 992 |
| 2010 trimester IV | 9.896 | 8.562 | 384 | 950 |
| 2011 trimester I | 8.125 | 6.436 | 413 | 1.276 |
| 2011 trimester II | 9.163 | 7.456 | 284 | 1.423 |
| 2011 trim III | 10.131 | 8.447 | 468 | 1.216 |
| 2011 trim IV | 10.069 | 8.639 | 425 | 1.006 |
| 2012 trim I | 8.006 | 6.394 | 289 | 1.323 |
| 2012 trim II | 10.755 | 8.945 | 458 | 1.352 |
| 2012 trim III | 10.161 | 8.466 | 320 | 1.375 |

Source: www.Eurostat.com

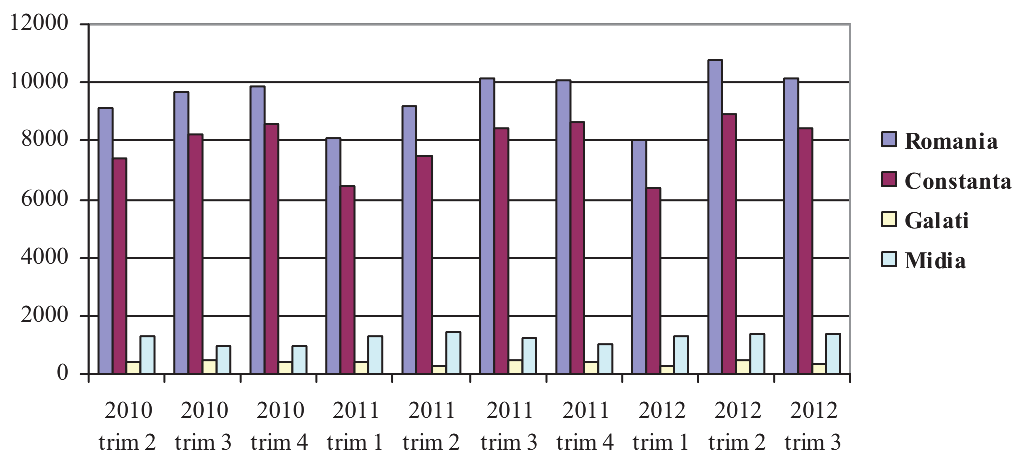



Figure 3. Maritime transport of goods (2010-2012)

One of the major strategic challenges in the development of port industry is the development and promotion of the national system of intermodal freight transport in order to develop freight and improve the environmental impact of transport as well as traffic safety. And if we have to talk about the hindrances of this major change in the port industry, we can mention the following:

- organizational barriers – which are due to bureaucratic aspects of the transport sector, lack of cooperation between stakeholders and lack of clearly-defined responsibilities;
- infrastructure-related obstacles – lack of inter-operability, inadequate capacities, necessity for different types of cargo-handling equipment;
- operational obstacles – lack of information transparency in the transport chain, lack of operative measures flexibility, lack of information on the services available in ports, problems related to the integration in the chain of logistical activities;
- legislative related obstacles – lack of a harmonized framework of financial, technical and organizational provisions in the transport and freight logistics;
- economic and financial obstacles - high investment costs, high operating costs, especially the transfer and storage ones, unclear costs structure, lack of subsidies granted to transport operators.

The transport sector, although it is highly effective and economically dynamic, it faces however increasingly higher additional social and environmental costs. Therefore, the model of "sustainable mobility" has increasingly gained significance. This model is located in the confrontation area of two different categories of objectives. On the one hand, it is aimed to provide an efficient mobility and fair prices for people and freight, as a central element of the EU internal market which is competitive and which relies on the free movement of persons. On the other hand, it is outlined the need to control the increasing traffic and to minimize the costs arising form accidents, respiratory diseases, noise, harmful effects on the environment or congestion.

## 4. CONCLUSIONS

The important role of management in the current economic environment is imposed by the necessity creating a general capacity of innovation, flexibility and even if the environment is uncertain, management should be as stable as possible, thus ensuring the success of opportunities most limited situations. By pointing out the need for an operational management, certain management transition-related issues are brought forward, namely the need for a change of management concepts and practices at the micro level. These two components are converging, influencing each other at the same time.

In the current economic context, success in the real economy, transport activity performance and competitiveness of companies that conduct their business in this area depend largely on the quality of management. Under these circumstances, without a rigorous management it is difficult to grasp the current and future size and structure of market requirements. Moreover new policies and rational strategies will be difficult to develop and implement. In this respect, the reshape of management system will be difficult to achieve as well as to demonstrate the dynamism, creativity, flexibility and functionality that are inherent in the market economy system.

## 5. REFERENCES

[1] Caraiani, Ghe., *Marketingul şi managementul în activitatea de transporturi*, Editura Lumina Lex, Bucureşti, 2002;
[2] Ion, Ghe., *Managementul transporturilor*, Editura Eficient, Bucureşti, 2001;
[3] Nechita, D., *Eficientizarea activității portuare prin strategii moderne de marketing*, teza de doctorat, 2005;
[4] Trevor, H., *Maritime Logistics*, ITMMA courses, 2002;
[5] Batrinca Ghe., *Marketing şi management naval*, Editura Cartea Universitară, Bucureşti, 2004;
[6] Batrinca Ghe., Caraiani, Ghe., *Marketingul şi managementul în activitatea de transporturi,* Editura Lumina Lex, Bucureşti, 2002;
[7] Batrinca Ghe., *Considerații privind fundamentarea deciziilor în transportul maritim*, Editura AIT Laboratoires, 2004;
[8] Muntean, M.C., Nechita, D., Nistor, C., Şarpe, D., *Development of Port Management in the Transport Economy*, WSEAS TRANSACTIONS on BUSINESS and ECONOMICS, Issue 4, Volume 7, October 2010, ISSN 1109-9526, Published by WSEAS Press www.wseas.org, pp. 414-423, ID: 88-364, Included in ISI/SCI Web of Science and Web of Knowledge;
[9] Muntean, M.C., Nechita, D., Nistor, C., Şarpe, D., *Port management importance in port activities development*, The 3rd WSEAS International Conference on URBAN PLANNING and TRANSPORTATION (UPT '10), LATEST TRENDS on URBAN PLANNING and TRANSPORTATION, Mathematics and Computers in Science and Engineering, A Series of Reference Books and Textbooks, Corfu Island, Greece, July 22-24, ISSN 1792-4286, ISBN 978-960-474-204-2, Published by WSEAS Press www.wseas.org, pp. 180-186, ID: 646-803, Included in ISI/SCI Web of Science and Web of Knowledge;
[10] www.eu.europa.eu;
[11] www.romanian-ports.ro
[12] www.portofconstantza.com
[13] International Transport Forum, Leipzig, Workshop – Transport for a global economy, 2009.
[14]Vîrlănuță F., *Evaluarea economico-financiară a proiectelor de investiții din agricultură*, 2010, Publishing House Europlus, Galati, ISBN 978-973-950-73-0.
[15]Buhociu F.,Vîrlănuță F., *Evaluarea şi finanțarea proiectelor de investiții*, coautor, Editura Didactică şi Pedagogică, Bucuresti, 2005, ISBN 973-30-1340-4.

# FUTURE DEVELOPMENT OF EUROPEAN MARITIME REGIONS

[1]PANAIT CORNEL, [2]STANCA COSTEL, [3]BUZU GEORGIANA

[1,2,3]*Constanta Maritime University, Romania*

**ABSTRACT**

The *European Seas and Territorial Development, Opportunities and Risks (ESaTDOR)* project, financed by ESPON, was intended to analyze the current state of maritime regions, opportunities and risks for territorial development, as well as their effects on maritime regions under different scenarios until 2050. The paper aims to present the results of the project highlighting the most probable scenarios for future development of European coastal areas.

**Keywords:** *European maritime regions, territorial development.*

## 1. INTRODUCTION

The European Seas and Territorial Development, Opportunities and Risks project (ESaTDOR), funded by the European Observation Network for Territorial Development and Cohesion (ESPON), began in January 2011 and gathered experts from various universities and research institutes across Europe.

It is the first ESPON project to look at the European space as a whole and consider the seas an integral part of it, rather than merely an adjunct to the land. Moreover, it was meant to give a future-oriented vision of Europe, which could frame an informed discussion about the European maritime regions and the generation of proper policy recommendations for the stakeholders.

ESaTDOR project aims to:

- Analyse current patterns of land and sea use and land-sea interactions in maritime regions,
- Develop a typology of maritime regions based on these patterns and interactions,
- Identify developmental opportunities (and constraints) for different maritime regions,
- Explore best practice in terms of terrestrial-marine governance ,
- Provide guidance and advice on how critical land-based and marine assets can be effectively and democratically managed, and
- Suggest further areas for research to maximise opportunities, but minimise human impacts on maritime regions.

When taking into consideration the present and future challenges on the European territory, as well as the diversity of European regions, the need for maritime planning became clear. To this purpose four spatial development scenarios have been drafted and tested, that could allow us to see their implications for each maritime region and, consequently, to find the ways to reach the most desirable outcomes from each scenario and draw political recommendations.

A mapping of the different patterns of sea use and land-sea interactions across Europe was conducted, in order to develop a maritime region typology. Three existing ESPON datasets were used in this attempt, namely Europe's Marine Environment, Land/Sea Flows and Europe's Coastal Areas. The former includes data regarding the state of the marine environment, the second relates to the movement of goods and persons across maritime regions, while the latter gathers data on employment clusters in various maritime sectors. The four spatial scenarios have been built based on these three categories, as follows:

## 2. DEVELOPMENT SCENARIOS

This chapter presents each of the four scenarios, with a focus on their implications for the European maritime and coastal regions.

### *2.1 A Europe of flows:*

Globalization plays an important role in this scenario and brings about increased flows of goods, people and services. Maritime and inland connections become stronger. Regions become more dynamic and they adapt better to change. Under this scenario the emergence of transnational and cross-border zones is envisaged. The development of long distance networks and strategic energy and transport corridors connecting European centres of production and consumption with the rest of the world is also expected.

As far as Europe's Marine Environment is concerned, an increase of environmental risks in transport corridors and port areas is to be expected. A stronger competition between traditional and new uses of the marine space is also envisaged.

Regarding Europe's Land/ Sea Flows, this scenario anticipates a strong increase in long haul traffic, as well as potential expansion opportunities in less congested port areas. This will bring about the expansion of smaller ports focused on short sea trade and serving national and regional markets subject to appropriate landward connections being approved.

The cruise and leisure boating will expand beyond the traditional locations, while migration, both formal and informal will increase. The Arctic and Mediterranean areas will experience an increased incidence of accidents resulting in rapid development of maritime monitoring.

The satellite technology will be increasingly used, at the expense of telecommunication cables, which will lead to a less significant role of the seas in this particular field. This first scenario announces an expansion of oil and gas pipelines in Mediterranean, Baltic and Black Seas, as well as in green grid infrastructure along Europe's western seaboard. The exploration of oil and gas is expected to expand in the Arctic area. At the same time, old oil and gas fields will take on new roles as carbon storage facilities.

The implications of this scenario for Europe's Coastal Areas include the growth of logistics services around key transhipment points, as well as the creation of opportunities for adding value to imported and exported goods. The rising of new maritime activities will also bring about new opportunities for cluster development. Lastly, an intensification and development of transnational and multimodal networks across land / sea is also envisaged.

*2.2 A Europe of creative cities:*

Under this scenario the weight lays upon large cities and centres of population and economic power. These are characterized by innovation, entrepreneurship and economic growth. The strengthening of transport between metropolitan areas will play an important part in the political intervention.

Regarding Europe's Marine Environment, it is worth noting that coastal cities, due to climate, natural resources and marine employment and investment opportunities will become more and more attractive. At the same time, the development of short sea shipping connections between clusters of coastal cities will lead to increased environmental risk in the Baltic and Irish Seas.

As far as Europe's Land / Sea Flows are concerned, this scenario anticipates the development and improvement of multimodal landward connections. Moreover, large coastal cities will become the focus of research and development regarding clean shipping, green grid development and marine renewables.

As for Europe's Coastal Areas, this first scenario implies the development of coastal cities both in terms of marine cultural heritage and research and development. Coastal cities are expected to become centres of excellence in maritime skills development.

*2.3 A Europe of balanced regions:*

This scenario is based on specific regional strengths and implies an attempt to reduce economic and social unbalances at local and regional level. The strengthening of public institutions at the regional scale is sought in order to facilitate a balanced development throughout Europe.

The future implications of this scenario on Europe's Marine Environment are as follows: Marine resources will be the key assets in regional self-sufficiency and development, which will lead to a differentiated development of European areas, according to their resources. An increased development of fixed development / infrastructure associated with renewable energy, oil and gas is expected in Northern Sea areas, which will compete with traditional marine users.

At the same time, those regions depending on tourism, fishing or marine aquaculture are expected to take more measures to preserve the marine environment.

As far as Europe's Land / Sea Flows are concerned, it is worth noting that the development and intensification of maritime transport connections will lead to the development of sea basins and sub-sea areas as cohesive regions. Regional self-sufficiency in energy and exploitation of diverse marine energy sources and associated infrastructure will become a key focusing point.

The implications of this scenario on Europe's Coastal Areas have to do with the cooperation, differentiation and specialisation between ports. Regional cooperation and flows will be encouraged by targeting of public money at relatively weak and underperforming coastal regions. In conclusion, the growth of maritime economic activity and intra-regional connections are highly expected.

*2.4 A Europe of self-sufficient towns:*

In this scenario, the focus lies on ecology, especially on energy supplies and climate change. Efforts are made towards greener energy, even with the cost of slower economic growth. With the increase of the importance of local markets comes the migration from urban centres towards rural areas. Bottom-up organisation and self-sufficiency are the key features of political intervention.

The implications on Europe's Marine Environment focus on the increased sustainable use of marine resources, so as to meet local resource needs. At the same time, this scenario envisages a decreasing of environmental damage associated with reducing long distance maritime traffic in certain areas. The introduction of higher environmental standards on flows from inland areas and areas outside the European Union are also expected.

Regarding Europe's Land / Sea Flows, this scenario envisages the expansion of smaller port and short sea shipping, as well as a growing role for inland waterways as sustainable transport routes. An increased protection of local energy resources for local communities is thought to oppose the multinational development interests in sea areas. Lastly, long haul shipping related to EU trade is expected to decrease.

As far as Europe's Coastal Areas are concerned, this scenario anticipates a small scale localised development responding to local and regional markets favouring small coastal towns. Small scale industry is expected to grow, as a response to the distinctive maritime character. Coastal areas of good environmental quality will be favoured, while coastal areas of poor environmental quality are expected to decline without public intervention related to regeneration and environmental improvement.

*2.5 Weaknesses of the four scenarios*

The four scenarios mentioned above proved to have several weaknesses when tested. The most relevant relate to the overlapping of the dimensions analysed and to the poor effectiveness in finding and proposing alternative development paths.

Consequently, it was more helpful to the purpose of the project to focus only on two distinct spatial scenarios which could offer an idea of how the European territory might be structured in the future. The two scenarios are presented below.

*2.6 Final scenarios*

After the consultation of major stakeholders the two territorial development scenarios which were thought to provide the basis for a discussion on the future of Europe are considered to be *Europe of Flows* and *Europe of Self-Sufficient Maritime Regions*.

## 3. POLICY DEVELOPMENT

The project concluded on a number of recommendations related to relevant issues to be taken into consideration for future policy development.

It is clear that the marine environment is increasingly being recognised by many European coastal states as an integral part of their territorial space. The demands being placed on the marine environment are growing rapidly, and commercial exploitation of marine resources, combined with a need to protect environmental integrity, calls for more effective governance mechanisms (both in terms of structures and processes).

Maritime spatial planning is increasingly regarded as an approach that will bring about integrated, both sectorally and spatially (across territories), policy responses to deal with competing uses for marine resources. However there are challenges in terms of how effectively terrestrial planning regimes will link with new maritime planning regimes.

Furthermore given the broad nature of the project, our conclusion and recommendations are targeted at a variety of stakeholders at different levels (although often these should not be seen as being exclusively targeted towards a particular group). Our policy recommendations focus on technical issues associated with data and mapping, the role and scope of the EU in facilitating integrated sectoral policy both within the marine environment and in relation to land sea interactions, and specific thematic priorities.

*3.1 Data and mapping*

The fragmented, inconsistent and incomplete data which is collected for a variety of different purposes makes the process of integrated and consistent marine planning problematic. Work is already going on at a European level to try and address such issues, especially through the INSPIRE Directive. However, some inconsistencies exist between what is expected here and the requirements of the Marine Spatial Framework Directive.

**Recommendation 1**. There should be a rational and consistent approach to the collection of data, particularly within a marine context to facilitate integrated spatial planning. As part of this process, there needs to be agreement about an appropriate spatial resolution that the data should be available at creating a marine equivalent of the NUTS regions on land. The use of grid squares enables a range of different data types to be consistently mapped across the regional seas. Furthermore inconsistencies of approach between European regimes, (e.g. MSFD and INSPIRE) should be resolved.

**Recommendation 2.** Data availability remains patchy and this should be addressed with agreement on: key information sets (for example, fisheries data, regarding the stocks and where they are caught and landed, is still problematic); collecting regional sea the data in a compatible manner; making critical data sets publically accessible (a particular challenge with marine data).

**Recommendation 3.** Data collection focuses mainly on land or sea based attributes, but there is a paucity of data or information which focuses specifically on the land-sea interactions; these are assumed but largely unproven. For example, the degree of dependence of coastal communities on their links to the sea.

*3.2 Integrated Governance*

Whilst there is a growing recognition that in policy terms the marine environment is an important part of European space, which needs to be managed carefully in its own right, there is also a requirement the inter-linkages between land and sea are carefully managed so that the opportunities for and threats to territorial cohesion can be sensitively and sensibly managed. In order for this to happen integration between land and sea regimes and between different levels of governance need to be further developed.

**Recommendation 4.** There is a need to think much more carefully and creatively around the regimes for managing the marine environment and there integration with each other and land based planning jurisdictions. Many of the regimes that have developed organically over time to deal with specific issues are sectorally specific, often regionally or sub-regionally sea focused and generally weak both politically and financially. There is a need for better integration between sectoral groups with an interest in the seas at a variety of scales. At a European scale integration of the marine into territorial cohesion agendas implies closer collaboration between DGs Environment Move, Energy and Regio for example). Experimentation is taking place and some good practice is emerging. A facilitating and enabling role by the EU through supporting and improving programmes through financial support and encouragement is likely to produce more meaningful results. The development of regional seas and sub-regional seas basin strategies are illustration of this approach.

*3.3 Thematic Priorities*

Various sectors will continue to place demands on Europe's seas, and this in turn will intensify their use. The optimal development of sea related activities needs to be undertaken carefully using a precautionary approach. A clear theme that permeates all potential policy development is that restoring and maintaining environmental quality is a prerequisite for the full potential of the seas to be realised,.

Economic Activities Traditional maritime sectors are important for Europe and particularly some coastal communities. New maritime activities are likely to develop in the short to medium term and the emphasis needs to be on developing high quality, high value forms of employment, often associated with cluster and network development.

**Recommendation 5.** Further research is needed to investigate the relationship between coastal communities and the maritime economy, so that effective maritime cluster development can be facilitated and economies vulnerable to changing maritime economic circumstances can be carefully managed.

Energy Pipelines and Cables. With regard fossil fuels the importance of some traditional areas are likely to wane, although new prospects for exploration and exploitation are opening up. But the seas will remain an important source of energy as new renewable energy sources, wind, wave and tidal energy, develops. Meanwhile the seas are likely to be increasingly used as a conduit for energy supply between countries an across regions.

**Recommendation 6.** Careful consideration needs to be given to the effective planning and management of offshore energy activities as an integrated whole. This includes better access to information about the existing and potential offshore production methods and transnational grid and pipeline systems.

Transport remains a dominant sector within the European economy, although the disaggregation between the importance of land and sea based transport is difficult to ascertain. Innovation will be required to respond to changing global trends and to the requirements for transport to reduce its environmental impacts. Europe’s transport sector is well geared to meeting these challenges.

**Recommendation 7.** For maritime transport to maintain its relative importance to Europe’s economy, careful integrated planning will be needed to facilitate connectivity between Europe and the rest of the world, and within Europe and its regional seas.

### *3.4 Environment*

There is a growing realisation that environmental quality sufficient to support a diverse marine ecosystem is critical for regional seas to realise their potential. Nevertheless there are some inconsistencies between European policy approaches making it difficult to achieve a consistent approach with regards to this important but complex dimension to the risks and opportunities for the seas.

**Recommendation 8.** There should be greater integration and internal consistency to measuring the quality of the marine environment between the INSPIRE and Marine Strategic Framework Directives and in the terminology used between the MSFD and the European Environment Agency.

### *3.5 Regional Seas*

Whilst many of the regional seas are characterised by their distinctiveness and diversity, and the specific issues and policy recommendations are considered in more detail in the specific regional sea reports, there are a number of common themes which lead to generic recommendations.

**Recommendation 9.** There is a need to improve data collection and integration as a basis for better and more informed integrated land-sea research knowledge exchange and stakeholder capacity building.

**Recommendation 10.** Future research should focus on sustainable management and businesses practices to ensure that the uptake of territorial opportunities does not create unsustainable pressures on the environment.

**Recommendation 11**. Improved integrated governance at all scales needs to be effectively and efficiently promoted, with a particular emphasis placed on stakeholder and civic engagement.

## 4. REFERENCES

Barca, F.,(2009) *An agenda for a reformed cohesion policy: a place-based approach to meeting European Union challenges and expectations*. Independent report commissioned by the EU Commissioner for Regional Policy.

CEC (2007) *Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)*

CEC (2010a) *Europe 2020:A strategy for smart sustainable and inclusive growth,* COM2010)2020

CEC (2010b) *Investing in Europe’s Future: Fifth Report on Economic Social and territorial Cohesion*, Brussels

Commission Communication *COM (2007) 575 final of 10 October 2007 on an integrated maritime policy for the European Union*.

Commission Communication *COM(2010) 771 of 17 December 2010: Maritime spatial planning in the EU – achievements and future development*.

*DG Mare (2012) Blue Growth Scenarios and drivers for Sustainable Growth from the Oceans, Seas and Coasts, Final Report*, May 2012

ESPON, European Seas and Territorial Development, Opportunities and Risks (ESaTDOR) Project, *Final Report,* http://www.espon.eu/

# PERFORMANCE INDICATORS FOR SMEs ACCESING EU FUNDS

POPA ADINA-SIMONA

*University "Eftime Murgu" of Resita, Romania*

**ABSTRACT**

Being the best supporters of national economies Small and Medium Sized Enterprises are actively searching alternative sources of finance for sustaining their goals and their performances. European Union is sustaining the SMEs access to finance by direct funding: grants from the European Commission and indirect funding: financial intermediaries in the SMEs origin country. Considering the importance of SMEs for national and European economy we will analyze the relationship between the EU funding and performance of SMEs that applied for and received non-refundable EU funds.

**Keywords:** *business performance, SMEs, EU funds.*

## 1. INTRODUCTION

Being small is not always equivalent with being unimportant, especially when we talk about European companies. The SMEs are an important generator of employment and growth and was recognized as the backbone to any economy (Jamil, Mohamed, 2011). European Commission (EC) is sustaining the small businesses through its regional policy: helping them realize their growth potential, their importance in regional and global economy and creating a friendlier business environment. More than 20 million companies in European Union are SMEs and they play an important role in the dynamics of the national and regional economy. The EC had designed special rules for these companies, facilitate their access to funding, help SMEs to get most out of the EU's Single Market, create an entrepreneurial environment, and adapt public policy tools to SMEs' needs.

In the present paper we investigate how SMEs are sustained at national and European level. Using a quantitative research method we investigate what are the main important performance indicators for those SMEs that accessed European funds. For developing this empirical study we focus on the SMEs from the V West Region that apply for and implement projects for accessed EU funds.

The paper is structured in five parts: after introduction we present the European assistance scheme for SMEs, in the next paragraph we review the literature regarding the performance and performance measurement system for SMEs, afterwards we emphasize, based on a quantitative research, the performance indicators for those SMEs that accessed European funds, the paper ends with the conclusion.

## 2. EUROPEAN FUNDING OPPORTUNITIES FOR SMEs

The European Commission define SME as: „the category of micro, small and medium-sized enterprises (SMEs) … made up of enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding 50 million euro, and/or an annual balance sheet total not exceeding 43 million euro" (EC, 2005). SMEs representing more than 98% of all enterprises, out of which over 92% are microenterprises' with fewer than ten employees and accounted over 67% of total employment and over 58% of gross value added of the European union economy (Ecorys, 2012).

Having regarded the above data it is obvious that SMEs are "the backbone" of the European economy and EC should take care of small companies. Commission includes SMEs in its regional policy and developed an assistance scheme consisting of grants and programmes managed at national or regional level for sustaining their activities, competitiveness, growth and development. Direct and indirect funding opportunities are available in different forms, such as: grants, loans and guarantees, sometimes for SMEs.

There are four pillars in the European Union SMEs assistance scheme: structural funds, financial instruments, thematic funding opportunities and support for the internationalization of SMEs, for those that wants to access markets outside the EU.

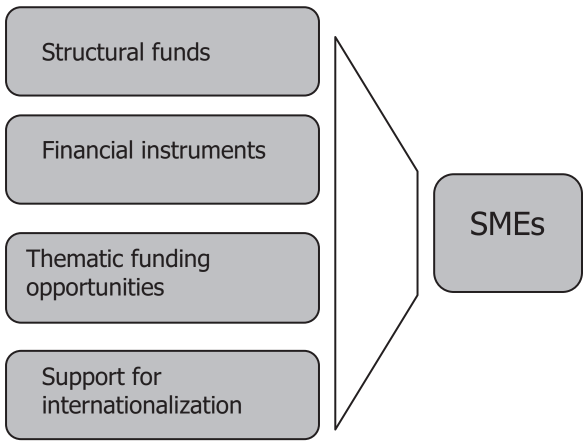



Figure 1 Pillars of European assistance scheme for SMEs

The Structural Funds allocated by the European Commission for the member countries should help to reduce disparities in the development of regions, and to promote economic and social cohesion within the European Union. Member States co-finance the regional projects. EU structural funds are: European Regional Development Fund (ERDF), European Social Fund

(ESF) and European Cohesion Fund (ECF). Among these European Regional Development Fund is the most popular funding instrument for SMEs. In order to increase the competitiveness of SMEs, the ERDF co-finances activities in a broad range of areas: entrepreneurship, innovation and competitiveness of SME; improving the regional and local environment for SMEs; interregional and cross-border co-operation of SMEs and investment in human resources (along with funding from the European Social Fund). The beneficiaries of structural funds receive a direct contribution to finance their projects on different thematic programmes, but as many other EU funding sources, ERDF programmes are managed by national and regional authorities not directly by the Commission (EC, 2012).

SMEs could apply directly through sustainable and value added projects for thematic funding. Thematic funding, such as environment, research, education are implemented by various Departments of the European Commission: Life+, Competitiveness and Innovation Framework Programme, The Seventh Framework Programme for Research and Technological Development, EUREKA - A Network for market oriented R&D, Education and training, Culture and media.

For structural funds and thematic funding co-funding is the general rule: the support of the European Union cover only a part of the project costs, the other part is being covered by member states and project's beneficiaries.

The European Investment Fund (EIF) manages most of the financial instruments that are available for SMEs. But EIF not interact directly with companies, it works via national financial intermediaries, such as: banks, credit institutions or investment funds. The role of these instruments is to increase the credit volume available for SMEs and to encourage the intermediaries to develop their SMEs lending capacity.

Support for the internationalization of SMEs consists of assistance to intermediary organizations and/or public authorities in order to help SMEs to access markets outside the EU. EC had developed for this purpose: the instrument of pre-accession assistance (IPA), the European neighborhood policy, European Bank for Reconstruction and Development programmes for SME finance facility and non financial support, European Investment Bank loans for SMEs in Eastern neighborhood countries and Mediterranean partner countries, cooperation programmes with Latin America and Asia countries.

European Union established the general framework for managing the Community funds and each member state choose its own system. In Romania, the payment and management authorities are situated within the structure of some distinct institutions, but the Finance Ministry is the payment authority for every programme (Nanu, Buziernescu, Spulbar, 2008). Among the management authorities for the structural funds for SMEs are: Industry Ministry, Regional Development and Public Administration Ministry.

SMEs play in the national and regional environment a key role, the structural funds finance the increase of competitiveness and productivity of Romanian companies', in compliance with the principle of sustainable development, and reducing the disparities compared to the average productivity of EU. The size of every company contribution to the development of the region is influenced by its past, present and future performance. The structural funds could be accessed only by those companies that reach the performance criteria. And companies' performance indicators should have higher levels after the absorption of the unreimbursement funds. Performing like this every company will contribute to the development of the regional economical environment and to diminish the disparities between the Community regions.

## 3. WHAT MEANS PERFORMANCE FOR SMEs?

All businesses are created bearing in mind at list one goal: the profit, but most of them had more than one strategic goal, being it financial or not. Performance represents the way an organization target its goals from a financial or a non-financial perspective. The attention of the companies' managers had been focus firstly to financial performance, but in the last decades, they had to reorient to their stakeholder needs and different non-financial values that had been considered important for companies performances. The non-financial measures start to coexist together with the financial ones in the companies' performance measurement systems. Jamil and Mohamed (2011) summarized in their research the most popular and widely used performance measurement models, such as: performance measurement matrix (Keegan *et al*., 1989), performance pyramid system (Lynch and Cross, 1991), performance prism (Neely, *et al*., 2002), Balanced Scorecard (Kaplan and Norton, 1992, 1996), performance measurement system for service industries (Fitzgerald *et al*., 1991), integrated performance measurement system (Bititci *et al*., 1997), organizational performance measurement (Chennell *et al*., 2000), integrated performance measurement for small companies (Laitinen, 2002) and focus on the process of assessing effectiveness of the companies performance measurement system (Van Aken et al., 2005).

Performance is seen different by large compared with small businesses. Large companies are using complex systems and measurement instruments for performance, but the small ones, due to different factors, more often, do not measure it, or they use a limited number of key performance indicators. But, it is very crucial that entrepreneurs understand and monitor their company's performance (Hvolby, Thorstenson, 2001). Garengo, Biazzo and Bititci (2005) reviewed the research regarding the specific characteristics of SMEs and they made the following list of the factors they considered to be obstacles for defining a performance measurement system for these companies: lack of financial and human resources, limited managerial capacity and capital resources, a reactive approach in administrating the enterprise's activities, tacit knowledge and little attention given to the formalization of processes, misconception of performance measurement.

Even though, these barriers exist, Laitinen (2002) had developed an integrated performance system for small companies based on the idea of activity-based costing (ABC). His proposal takes into consideration both external and internal factors. The external factors are financial performance and competitiveness and the internal factors are: costs, production factors, activities, products, and revenues. Based on a questionnaires research, the study also emphasis, that small companies consider for performance measurement, as well important, elements such as: the employee motivation (production factors dimension), customer satisfaction (products), product profitability (revenues), company profitability, liquidity, and capital structure (financial performance). Tatichi *et al*. (2008) observed that small companies use financial measurement tools for measuring performance, such as return on investments (ROI), return on equity (ROE), and return on capital employed (ROCE), which are basically used by large firms, but the tendency is to focus on performance from a non-financial perspective.

Cocca and Alberti (2010) developed a framework that SMEs can use to assess their performance measurement system in order to identify the main weaknesses and take corrective measures. Perrera and Baker (2007) examine the use of financial and non-financial performance measures in small and medium size manufacturing enterprises in Australia. The authors observed that sample companies use more often financial than non-financial measures for performance, and also those enterprises where managers are different from owner make greater use of formal measurement systems than owner-managed enterprises. As company size increase, its tendency is to use more the non-financial measures.

## 4. PERFORMANCE INDICATORS FOR SMEs THAT ACCESSED EU FUNDS

A challenge in performance measurement is the decision regarding what to measure. The performance measurement should focus on most important areas of activities, of a project or an enterprise. Across the European Union SMEs play an important role and if we are watching them at a macro level, their performance is measured with three main indicators: the number of enterprises, their output via their gross value added (GVA) and the number of employees on their payroll. Gross Value Added (GVA) includes depreciation, rewards to labour, capital and entrepreneurial risk, GVA remains when the intermediate costs are deducted from the sales or turnover. These three indicators reveal a mixed picture of European SMEs (Ecorys, 2012).

But if we are watching a single economic entity the performance indicators are quite different. The priority is to identify quantifiable factors. These factors should be linked to the drivers of success in the entity and or in its projects. When an entity wants to access EU funds it should elaborate and submit a project proposal, within performance measurement represents a necessary toolkit for developing the proposal. A set of performance indicators are also necessary for a less subjective selection and approval of EU funding projects and to demonstrate that selected projects will insure the best funds allocation.

Performance indicators used in project selection and approval have to reflect technical and economical efficiency of the project. They consists of static indicators calculated without taking the time factor into consideration and dynamic indicators calculated in cost – benefit analysis which are used for determine the efficiency of long terms investment projects.

Observing the EU assistance scheme presented in the second paragraph we will focus our attention on structural funds available for Romania that are oriented to small and medium sized enterprises. In this regards we performed a quantitative research grounded on questionnaire-based inquiry. The questionnaires were disseminated to enterprises located in the West Region of Romania that apply for and access European funds. Twenty-two out of 40 questionnaires distributed were returned.

Compared with Management Authority, projects beneficiaries have different interest, when accessing EU funds through projects. For projects beneficiaries performance indicators should quantify: the new products or services introduced on markets, the number of new jobs created, the production surfaces constructed, rehabilitated or improved and equipped.

Based on the opinions about the performance indicators of the owners-managers of these enterprises we find out what are the most popular performance indicators for them. We emphasis the answers of the surveyed companies in figure 2.

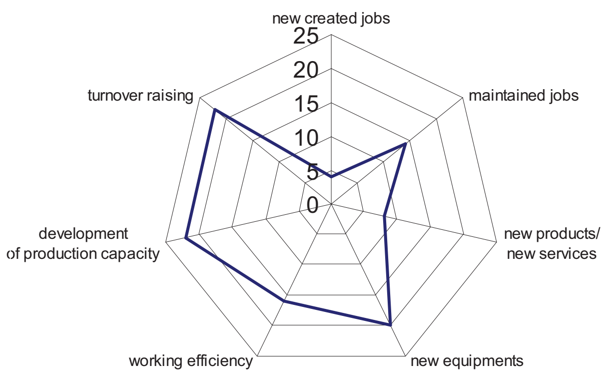



Figure 2 Performance indicators for SMEs which accessed Structural Funds in Romania's V West Development Region

All the respondents considered that accessing EU funds their company's performance increase in terms of: development of production capacity and turnover and acquiring new equipments. Less than 40% of the respondents considered that European money help them in promoting new products and services.

There were enumerated in the questionnaire, performance indicators that take in consideration the human resources. All these indicators that referred to the number of working places created or maintain during and after project implementation, as well as working efficiency, are considered less important by SMEs managers. They motivate their answers by the financial and economical restrictions generated by the economical crisis. These restrictions affect SMEs that proposed to create new job by their projects. At macro level direct foreign investments decreasing, slowing of capital movements, cash protection had a negative impact on new job creation. Even though the European Community programmes for increasing of economic competitiveness and reducing disparities in regional development are not financing direct operations for employment and social inclusion they represent important instruments for generated new working places and in the actual environment of unemployment increasing are factors that contribute to counterbalance the situation. Most of the interviewed companies had difficulties in creating new jobs. That's the reason why, over 80% of the respondents, didn't considered this indicator in the performance list. Even though during the project implementation companies hire employees, due to the additional funds infusion, for project sustainable development: maintaining the job is a challenge. Number of maintained jobs is considered a performance indicator by more than 60% of the respondents, while 72% of them appreciate working efficiency to be on the performance indicators list while accessing EU funds.

## 5. CONCLUSIONS

Performance measurement system is a due for every company, but not many SMEs have one because of different obstacles, such as limited material, financial and human resources. There is a challenge for every entrepreneur in the decision regarding what to measure. Analyzing the answer of the respondents of the Romanian SMEs from V West Region that accessed EU funds we found out that development of production capacity, turnover and acquiring new equipments are the most used indicators for measuring the company performance. The answers of the managers are connected with the goals of their implemented projects. Most of them had accessed the community funds for developing their production capacity and buying new equipments, creation of new working place being a secondary indicator, only.

## 6. REFERENCES

[1] BITITCI, U.S., TURNER, T., BEGESMANN, C., „Integrated Performance Measurement System: a development guide", *International Journal of Operation & Production Management*, vol.17, no.5, pp. 522-534, 1997

[2] CHENNELL, A., DRANSFIELD, S., FIELD, J., FISHER, N., SAUNDERS, I., SHAW, D., "OPM: A System for Organizational Performance Measurement", *Conference Proceedings Performance Measurement – Past, Present and Future*, (Cranfield: Cranfield University), pp. 96-103, 2000

[3] COCCA, P., ALBERTI, M. "A Framework to assess performance measurement systems in SMEs", *International Journal of Productivity and Performance Management,* vol.59, no.2, pp. 186-200, 2010

[4] ECORYS, *EU SMEs in 2012: at the crossroads. Annual report on small and medium-sized enterprises in the EU, 2011/12,* 2012

[5] EUROPEAN COMMISSION, *European Union Support Programmes for SMEs*, 2012

[6] GARENGO, P., BIAZZO, S., BITITCI, U., „Performance measurement systems in SMEs: A review for a research agenda", *International Journal of Management Reviews*, vol.7, Issue 1, pp. 25-47, 2005

[7] HVOLBY, H-H., THORSTENSON, A., "Indicators for performance measurement in small and medium-sized enterprises", *Proceedings of the Institution of Mechanical Engineers*, 215(B), pp. 1143-1146, 2001

[8] JAMIL, C.Z.M., MOHAMED, R., "Performance Measurement System (PMS) In Small Medium Enterprises (SMES): A Practical Modified Framework", *World Journal of Social Sciences,* Vol. 1. No. 3, pp. 200-212, 2011

[9] KAPLAN, R.S., NORTON, D.P., „The balanced scorecard ± measures that drive performance", *Harvard Business Review*, January-February, pp. 71-79, 1992

[10] KAPLAN, R.S., NORTON, D., *The Balanced Scorecard: Translating Strategy into Action*, Harvard Business School Press, Boston, MA, 1996

[11] KEEGAN, D.P., EILER, R.G., JONES, C.R., "Are your performance measures obsolete?", *Management Accounting*, June, pp. 45-50, 1989

[12] LAITINEN, E. K., "A dynamic performance measurement system: evidence from small Finnish technology companies", *Scandinavian Journal of Managemen*t, vol.18, issue 1, pp.65-99, 2002

[13] LYNCH, R.L., CROSS, K.F. (1991), *Measure Up ± the Essential Guide to Measuring Business Performance*, Mandarin, London, 1991

[14] NANU, R., BUZIERNESCU, R., SPULBĂR, C.M., „The experiences of the new member states in the Structural Funds field. Lessons for Romania", *Annals of the University of Craiova, Economic Science Series* Vol. 5, 2008

[15] NEELY, A., ADAM, C., KENNERLY, M. (2002), *The performance Prism: The scorecard for measuring and managing stakeholder relationship*, Prentice Hall, London, 2002

[16] PERERA, S., BAKER, P., „Performance management practices in small and medium size manufacturing enterprises in Australia", *Small Enterprise Research, 15*(2), pp.10-30, 2007

[17] TATICCHI, P., BALACHANDRAN, K.R., BOTARELLI, M., CAGNAZZO, L., "Performance Measurement. Management for Small and Medium Enterprises: an Integrated Approach", *JAMAR*, vol. 6, no. 2, 2008

[18] VAN AKEN, E.M., LETENS, G., COLEMAN, G.D., FARRIS, J., VAN GOUBERGEN, D., "Assessing maturity and effectiveness of enterprise performance measurement systems", *International Journal of Productivity and Performance Management*, Vol. 54 No.5/6, pp.400-418, 2005

# INTERNATIONAL IMPLICATIONS CONCERNING THE LEGAL REGIME AND POLICY OF SHIP REGISTRATION

[1]XHELILAJ ERMAL, [2]KSENOFON KRISAFI

[1]University "Ismail Qemali" Vlore, Albania, [2]European University of Tirana, Albania

**ABSTRACT**

The legal concept of the nationality and registration of ships has been controversial throughout its existence. This ambiguous legal situation in the maritime realm appears to prevail even in nowadays. Furthermore, open registration regime has been criticized based on numerous important issues such as the legislative framework, safety, security, and employment. On the other hand, close registries, which implement stringent regulations concerning ownership, manning, management and administration and involve a genuine connection by virtue of national, economical and social ties among the ship-owner and its State, generally are considered effective. In light of these considerations, the authors will discuss the ship's nationality and registration from the legal perspective as well as the possible safety implications that close and open registries may cause, which in turn could contribute towards substandard shipping. The authors argue that there are legal issues currently vis-a-vis ship's registration and nationality, and that several open and close registry States are being efficient in legal and safety aspects while other States have shown deficiencies in this respect.

**Keywords:** *Maritime law, international law, ship nationality, registration of ships, opens registries, close registries, safety at sea.*

## 1. INTRODUCTION

The freedom of the high seas is considered one of the most important principles within the domain of the public international law. Hence, the vessels of all nations, have unrestricted rights upon the waters outside the national jurisdiction of any coastal State. With the purpose of preventing the disorder and misuse that may derive from the exercise of such freedoms, in the international law is established a structure of regulatory instruments which authorizes the sovereign States to ensure the compliance of these regulations in respect to the applications of these freedoms by their national vessels. Reasons such as the prevention of the maritime accidents and the suppression of the piracy compelled the States to restrict their authority over ships, which subsequently created a sense of balance among the freedom of navigation and the protection of the law and order on the high seas. All vessels accessing the international waters must possess a national character and every State has exclusive jurisdiction and control over their national vessels. The failure to apply these rules can lead to a stateless vessel which according to the international law enjoys no protection. Accordingly, every State under the international law has the jurisdiction to establish the standards for the grant of nationality to their flag vessels, recognizing accountability for it and obtaining authority over it.

Perceived as an important element of the international maritime law and policy, ship's registration and nationality plays an imperative function towards safety and security of the maritime realm as well as significantly contributes towards the protection and preservation of the maritime environment. For that reason, ship registration system, predominantly close and open registry, has been subject of many studies and research in order to analyze and better clarify the main issues regarding these essential legal components. Considering the complexity, difficulty and sensibility that ship registration system and nationality represents currently in the maritime industry, it is in the opinion of these authors that yet there are legal issues that need to be tackled. Taken under considerations these concerns, the aim of this study is to analyse some legal aspects of nationality and registration of ships as well as safety and security issues pertaining to ship registration system. Hence, in order to have a comprehensive discussion of this central theme; first it will be analysed the legal notion of nationality and registration of ships and; then, the discussion will focus on the legal regime of close registries as well as on open registration system and its potential impact on substandard shipping.

## 2. THE LEGAL CONCEPT OF NATIONALITY

The globalization of the shipping industry in the 20$^{th}$ century necessitated the need for vessels to sail in international waters in order to carry out their task. This situation brought as a result several legal implications to the law governing these ships in high seas, since these waters are considered *mare liberum*, i.e. common heritage of the mankind and no State has jurisdiction over it. It is understandable that in their national waters every State has the right to exercise jurisdiction over the vessels, but if these vessels are navigating in high seas, then it appears that they are floating in a legal vacuum (Mukherjee, 2007). Nonetheless, the unique character of the vessel which implies a legal personality is recognized by national laws worldwide (Pamborides, 1999). For these reasons, a legal regime is required in order to regulate the relationship among the personnel onboard as well as the legal situations emanated from international relation with other entities. Without the nationality it will be impossible for a vessel to have the legal right to visit foreign ports; to engage in international trade and; can also be a critical factor in the dispute resolution involving private parties (Sohn & Noyes, 2004). From this standpoint, it appears that the nationality of the vessel is a significant theoretical notion of substantive law in the public international law (Mukherjee, 2007). In this respect, it may be relevant to point out the *Lotus* case (1927), where the Permanent Court of International Justice held that only the flag State can exercise its jurisdiction over its vessels in the international waters. Another important case where the *floating island theory* was forwarded, underlying the significance of ship's nationality with respect to crimes onboard, was *R. v. Anderson* (1868), where the court judgment was that a vessel on the international waters, hoisting a national flag, is part of the territory of that State whose flag she carries. Both cases indicate the significance of granting the nationality to a vessel which is sometimes regarded also as the "extension of territory" theory (Mukherjee, 2007, p.2).

Although the flag State has exclusive jurisdiction over its vessels on the high seas, the situation differs when the same vessel is situated within the jurisdictional waters of another State. In this case, both States may apply their jurisdiction over this vessel, i.e. the given ship may be subject of parallel jurisdictions (Mukherjee, 2007), which may complicate the legal issues in jurisdictional disputes. At any rate, from the legal and practical point of view, the flag State is primarily responsible and has substantial authority for its vessel even in the national waters of another State. Another concern regarding ship's nationality is the complexity towards the determination of the appropriate law to be applied when there is a collision on the high seas, in cases of parallel flagging, or when a vessel flies a flag of convenience (Tetley, 1994). These issues yet appear to be ambiguous in the international law, resulting in legal implications in the context of dispute resolutions.

The codification of the customary maritime laws in the 1958 Geneva Convention on the High Seas, laid down formally for the first time in the international law the basic principles of the nationality and registration, which allows the vessel to possess the nationality of the State on which it belongs, upon registration (UN, 1958). The Convention was the first international legal instrument which provides that every State has the right to set the conditions for granting nationality to their national vessels (Article 5). According to the Convention, the term nationality is defined as the relationship between the flag State and its vessel, within which a genuine link is required in order for the vessel's nationality to be effective (Article 5 & 6). The flag State's principle in the Convention underlies the theory that the jurisdiction of other States upon its vessel is essentially restricted (Sohn & Noyes, 2004). Similarly, the LOS Convention 1982, in Article 91 and Article 92, provides that the right to fix the conditions for the grant of the nationality to its vessels as well as for the registration of its national vessels and their right to hoist its flag is depending solely upon every sovereign State (UN, 1983). A genuine link must exist between the flag State and the ship, which should fly the flag of that State only and must be subject to its exclusive jurisdiction on international waters (UN, 1983). The Article 87 of the Convention highlights that the freedom of the high seas must be exercised with due regards to the welfare of other States, and Article 94 lay down certain requirements for the flag States in order to effectively maintain the jurisdiction and control upon their vessels (UN, 1983).

The genuine link principle was evolved in the law of the sea based on the deliberations of the ICJ in the 1955 *Nottebohm* case, which normally concerned a person's nationality. When taken into account the concept of genuine link in relation to the nationality of the ships, it must be noted that this principle is still unclear in the international law due to the absence of the description of this concept in terms of preconditions for the grant of the nationality and sanctions applied in the absence of such link (Coles, 2002). The advisory decisions of ICJ in relation to the constitution of MSC of IMCO in 1960, appeared to confuse the issue even more (Coles, 2002), revealing the diversity and the controversial viewpoints of different States regarding genuine link concept, which remains a debate currently. Vienna Convention on Diplomatic Relations (1961), is another international treaty which forwarded the basic principle that "in the present state of international law, questions of nationality are in principle within the domain reserved to the States" (UN, 2005, Article 20). Although that several international legal instruments bring to the fore the aforementioned principle, this does not mean that the granting of nationality is totally an unlimited right of every sovereign State. The Hague Convention on Conflicts of Nationality (1930) provides that "it is for each State to determine under its own law who are is nationals; the law shall be recognized by other States insofar as it is consistent with international conventions, international customary law and the principles of law generally recognized with regard to nationality" (Article 1). This is an essential legal point which may be applied to legal issues pertaining to the nationality and registration of vessels.

As previously stated, the international law allows each State to set the conditions for granting nationality to their vessels and for entering in the national registry. A dispute resolution concerning ship's nationality normally involves the applications of both international and domestic laws. As a rule, the international courts such as LOS Tribunal, according to the Article 293 of the LOS Convention, should apply the provisions of the Convention and the international law which is compatible with the Convention *per se* (UN, 1983). However, in the case of ship's nationality issue the court must also consider the national laws, which are different in many States. This issue it appears that may lead to a considerable interpretative challenges and ambiguity which may obscure the dispute resolution by the court (*Belize v. France, 2001*). Generally, the terms nationality, documentation, flag and registration are perceived as underlying the same connotation. Nonetheless, every one of these legal terms encompasses a different meaning in connection to the recognition and exercise of the authority over vessels (Farthing & Brownrigg, 1997). In this regard, the application and the interpretation of the law of the sea and the international conventions may be difficult and can lead to substantial perplexity and ambiguity, due to the possibility of the incorrect employment of these terms (Ready, 1998). In order to avoid these legal implications, the disparity and the interrelationship between these significant terms must be clearly comprehended (Mukherjee, 2007).

## 3. LEGAL ISSUES CONCERNING REGISTRATION

The flag of the vessel is an external demonstration of the nationality of that vessel, and it is also utilized for other purposes such as courtesy, to determine the status of the ship, and so forth. As a legal element in the dispute resolution the vessel's flag is an important factor, but it appears that is only one of many components towards the establishment of the governing law (Tetley, 1994). Another point of the ship's flag is that save the cases when the flag serves as a mean of identification, the international law does not provide mandatory rules for ship's flag to be flown continuously on the high seas (Farthing & Brownrigg, 1997). The permission to fly the State's flag may be *prima facie* evidence that a vessel possesses the nationality of that State, but the flag *per se* is not a proof of nationality. Therefore, the national character of the vessel is attributed solely to the registration act, which can be defined as the admission of the vessel in the public records of a State Registry (Coles, 2002). In general, this is considered a satisfactory connecting factor for concerning the vessel as possessing that State's nationality (Ready, 1998). Registration act is considered a procedural law opposed to the nationality which is substantive law (Mukherjee, 2007). Although the flag characterizes the nationality of the vessel, from the legal point of view, the registration is the conclusive evidence of the nationality and ownership (Coles, 2002). Boczek (1962, p.2) supports this opinion by stressing that "the real proof of a ship's nationality lies in its registration in the flag State, which fact is recorded in the documents carried on board the ship". For that reason, the registration is the procedural machine through which nationality as well as collateral rights and responsibilities are conferred on a vessel (Özcayir, 2001). Registration proves the ownership's title to the vessel and in addition provides the legal foundation for the effective statute of mortgages the other right *in rem* on the vessel (Hill, 2003). Through the registration, the ship enjoys the privileges granted by the flag State, but on the other hand empowers the flag to enforce national and international regulations (Giles et al, 2003). Another advantage of the registration is that it provides the legal bases for giving a specific name to the vessel for trade, legal and navigation purposes.

Obviously, a distinction between documentation and registration should be clarified, because both terms play significant roles in the legal functionalities of the vessels. Registration, as it was previously explained, contains the ownership title as well as serves as a conclusive evidence of the nationality of the vessel. On the other hand, the documentation entitles the vessel the right to fly the national flag (Ready, 1998), and can arguably confirm the national character of the ship (Coles, 2002). Before the customary maritime law was codified, the documents of the vessel were regarded generally as an important factor in dispute resolution. In the *Meritt* case (1873), the US Supreme Court held that the most satisfactory evidence of the ship's nationality is the documentation the vessel carries onboard. The Article 94, (2-a), of the LOS Convention 1982, provides the legal platform for registration system specifying that "each State should maintain a register of ships containing the names and their particulars of ship flying its flag" (UN, 1983). Similar provisions are found in the United Nations Convention on the Conditions for Registration of Ships (1986), which stipulates that "a state of registration shall establish a register of ships flying its flag, which should be maintained in a manner, determined by that State and the provisions of this Convention" (Article 11).

The ship's registration *per se* involves both public and private law dimensions. The Justinian in ancient Rome described these two dimensions as *"Publicum ius est quod ad rei Romanae spectat: privatum quod ad singulorum utilitatem"* (Ready, 1998, p.6). When considering the two-fold roles of the registration, it is crucial to point out that the public law aspect deals with administrative and regulatory matters pertaining to national welfare (Mukherjee, 2007). The main functions of the public law aspect are as follows (Ready, 1998):

1. granting of nationality and the right to fly the national flag;
2. subjections of the vessel to the State's jurisdiction for the purpose of safety regulations, crewing and discipline onboard, pollution matters;
3. privileges to engage in maritime activities within the territorial waters of the flag State; and
4. the right for naval and political protection, as well as the right of the flag State to utilize the ship's services in war situations

The private law functions below involve private proprietary interests in vessels (Mukherjee, 2007):

1. providing *prima facie* evidence of title and ownership;
2. protecting the title and the ownership rights; and
3. preservation of priorities between individuals holding security interests over the ship, such as mortgages

Accordingly, it may be submitted that the public law side considers the ship some sort of floating community which reflects the sovereignty of the flag State; and the private law perceives the vessel as a movable property over which certain individuals may have rights upon it (Ready, 1998). Yet, it seems that both law functions of the ship's registration involve public policy implications as the national interest and the ownership identification in the registry towards the public are subject of public policy.

## 4. THE LEGISLATIVE REGIME OF CLOSE REGISTRIES

The close registry, which sometimes is regarded as traditional or national registry, are by definition those registries which involves a real connection by virtue of national, economical and social ties among the owner of the vessel on one hand, and its State on the other (Ready, 1998). Normally, close registries' States lay down stringent conditions as regards ownership, manning, management and administration in order for a vessel to enter in their registries. The vessel in these regimes is subject to the jurisdiction and control of the flag State, which ensures that its flag ship comply with the international treaties ratified by that State. Additionally, the ship in close registry is subject to stringent rules in connection to the fiscal regime applicable in that particular State (Ready, 1998). The fundamental principle on which the close registry is established is based on the policy of conferring nationality to the ship only if it owned by the nationals of that State (Mukherjee, 1993).

In general, a close registry includes requirements such as the beneficial owners and the majority of the share holders must be nationals of the flag State; the ship-owning company *per se* must be situated in the territory of the State; the personnel onboard should also be nationals of the flag State and; in some countries such as USA, the vessel must be build by that country's ship-building company (Mukherjee, 2007). These prerequisites may vary in a number of close registry countries (Li & Wonham, 2001), and there are varying levels of strictness among these registries (Mukherjee, 1993). Whereas in several close registry States the ship-owner must be a natural born citizen to be qualified for the registration - in other countries, a national can simply be a domicile or a resident without necessarily being a citizen of that State (Li & Wonham, 2001). Hence, among the regimes of close registries prevails an immense diversity of requirements, laws and regulations rather than a consistent legal approach. In the past, the main reasons why close registries was preferable, was probably due to States' national protection; lack of profit taxes as well as for nationalistic factors (Ready, 1998). Other significant elements were that the globalization was not a major characteristic of the maritime trade and perhaps the employment of the national seafarers was not regarded as a problematic issue as it is presently. It appears that in time memorial the close registries were fairly preferred by the nationals of the State of registry.

During the years 1930-50, the maritime world experienced a major fleet transfer from closed registries towards other flag States which implemented more lax regulations in terms of registration (Ready, 1998). This main event of course was stemmed from the globalization of the maritime business which began to develop at that time. The progress of the global trade entailed the need for changes in maritime laws, registration requirements and predominantly in shipping business which eventually developed in order to cope with the situation. Only in the UK, the deadweight tonnage of the fleet reduced dramatically from nearly 43 million tonnes in 1980, towards 4.5 million tonnes in 1990 (Ready, 1998). Other major merchant fleets of the traditional maritime powers such as Spain, USA, Netherlands and France were reduced considerably in terms of deadweight tonnage. These figures indicate that except from the benefits that globalization of trade brought, the operational expenses, taxes, stringent regulatory requirements and other administrative rules implied by the national flag States towards the shipping industry increased steadily and became a financial burden particularly for the ship-owners, which strived to find alternative options in order to stay in business (Ready, 1998). The majority of the European countries for instance, have generally strict criterion pertaining to the employment of the nationals and ownership, i.e. in order to be qualifying for a registration the vessel should be manned and owned mainly by nationals of that State (ICSOM, 2006).

The U.S.A and China are considered among the most classical closed registries implementing strict policies (Li & Wonham, 2001). According to Chinese Ship Registration Regulation (1994), the vessel must be owned by a citizen of the PRC whose residence and its place of business are situated within its territory. The Chinese crewing regulations are rigorous, allowing thus Chinese ship-owners to employ only Chinese crews, save exceptional cases when foreign crews can be employed with special permission from the P.R.C Bureau of Harbour Superintendence. Similarly, the US registration system applies stringent regulation in connection with the ownership, enterprises and crewing of its national vessels. In order to be qualified for the US registry the ship-owner should be a citizen of the United States (Li & Wonham, 2001). All the members of the ship-owning association or joint venture must be citizens of the US and their place of business is required to be located within its territory (Li & Wonham, 2001).

According to the Report of the UNCTAD Secretariat (1982), other States which apply stringent rules regarding the ownership and crewing, and require the principal business to be situated in their territory are Belgium, Russia, Poland, India, Colombia, Argentina and Mexico. The same source cites that 28 flag States require 100% national crew in their ships; some 52 flag States require the principal place of the ship-owning company or their office to be located in their territory as well as the manager and the chair must be present in the State of registry (UNCTAD, 1982). The vessels in close registries are subject to the fiscal regime of the flag States, which generally imposes high taxes, including commercial and operational taxes to the ship-owners (Ready, 1998). Another issue which has influenced the immense transfer of ships from the close registry is the situation of the economical and political issues of the original State of registry. This situation may not allow the ship-owner to benefit from the financing institution, forcing him to register to another flag State which may have a comprehensive legal system more acceptable for the financial institution to normally enforce its security (Coles, 2002).

Even though that close registries are perceived as efficient legal approaches in terms of vessel's safety, stringent security measures, better employment conditions and wages as well as lowest percentage of maritime disasters, the point is that even among these registries there are States, particularly developing countries, which lack substantially safety and security measures, and substandard ships comprise a considerable percentage of their fleets. It is apparent that an absence of uniformity and harmonization exists among the maritime legal systems of close registry States, which may lead to possible consequences in term of safety and legal issues in the maritime industry. On one hand, several close registry States such as Canada (Canada Shipping Act, 2001), have in place an efficient legal system and enforce their regulation in a satisfactory level, minimizing effectively sub-standardization in shipping. Albania and North Korea, on the other hand, lack significantly the aforementioned features and are considered the poorest performing flags recently (Paris MOU, 2007-2008), resulting in a situation when sub-standard ships are a serious concern in national and regional level. The situation is aggravated more when taken into account that the definition of ship's nationality at the international level lacks uniformity, let alone considering this concern at a national level, which appears to be more complicated and the nationality of the ship is generally defined according to the interests and objectives of each State.

When bearing in mind the financial situation of current shipping industry, it is obvious that the considerable employment expenses and the operational costs incurred by the strict requirements of the close registry States are unfavourable for the ship-owners' economical interests, particularly for minor shipping companies, wherein in order to survive, hunt for another alternative flag State. Hence, the labour expenses for a UK registered 30 000 deadweight bulk carrier with British crew, were approximately twice as much as compared with Philippine crew ITF approved rates (Ready, 1998) which evidences the fact that the shipping industry is suffering financially due to stringent labour regulations established by the close registry States. High taxes imposed by the national registry's authorities are extra financial burden for the ship-owners, which again find themselves forced to flee to other flag States with more flexible registration policies (Ready, 1998). All these stringent regulatory rules, high taxes and employment expenses as well as other running costs incurred to the shipping industry by the close registry States, seems to render the competition among the ship-owners considerably hard, particularly when taken into account that their partners in open registry States enjoy many of financial advantages. Another concern revealed recently pertaining to close registries, is that older vessels unclassified by IACS members are more likely to be nationally flag rather than foreign flag (Hoffman et al, 2005). This is an interesting fact since historically national registries are considered safe and secure regimes.

What it may be submitted at this point, is that the legal regime of close registry appears to reflect a multi-standardization legislative approach, and to a large extend diversified, where dissimilar regulations, laws, requirements and implementation policies may lead to obstacles and legal implications in respect to financial matters, competitiveness and dispute resolution within the shipping industry. The current situation of these registries suggests that generally the safety matters are considered problematic issues in many of these flag States, which appear to have some deficiencies in this respect.

## 5. OPEN REGISTRIES IN LIGHT OF LEGAL AND SAFETY CONCERNS

Open registry development is among the most controversial issues that the maritime industry has known recently. The frequent utilization of open registry appears to be a 20$^{th}$ century phenomenon, having its genesis most likely in August 1919 when the Canadian cargo ship *Belen Quezada* in an effort to avert American alcohol prohibition laws was transfer to the Panamanian flag (Coles, 2002). The commercial and financial impact of open registries caused apprehension among traditional maritime powers only after 1940's, when the shipping industry experienced an immense transfer of tonnage from long-established national registries towards open registries or flags of convenience (Pamborides, 1999). Panama and Liberia (Ready, 1998) are considered the first open registries which started to use this regime in order to attract foreign vessels under their flags by implementing flexible registration policies. An important issue in connection with the open registries is that other terms which are often used synonymously such as flags of convenience, flags of refuges and flags of necessity can lead to confusion and controversy over this matter. In this paper in order to avoid complexity, only the phrase open registry will be utilized.

The definition of open registries, it appears to represent a difficult matter which lacks a universal standard and, therefore these registries are easier to differentiate than to explain. Nonetheless, according to Mukjerjee (1993, p.33) open registries generally may be described as the "….national flags of those states with whom ship-owners register their vessels in order to avoid, firstly, the fiscal obligation, and secondly, the conditions and the terms of employment or factors of production that would have been applicable if their tonnage was entered in the register of their own country". Yet again, even though this particular definition mirrors an essential progress concerning the legal regime of open registries, in light of recent technological, legal and economical developments, it seems that there are also other important issues currently which need to reconsider in order to obtain a universal and comprehensive definition of the regime of these registries.

When taking into consideration the international organizations, may be relevant to cite the UN definition in 1985, which describes open registry as a "device enabled the traditional maritime countries to maintain ownership and control over world shipping despite the fact that they could not operate ships economically under their own flags" (Li & Wonham, 2001). UNCTAD, on the other hand, has defined open registries as the "conferment of national character upon ships regardless of ownership, control and manning" (Li & Wonham, 2001). One important fact pertaining to the definition of the open registries is that nowhere in the IMO's conventions or documents is found a definition which would formalize this organization's position on open registries. This would subsequently indicate that IMO is somehow circumventing this important issue which involves substantial political and economical aspects. The classical statement which contained a comprehensive way of describing the characteristic of the open registries is the Rochdale Committee in 1970. According to this committee the open registry system reflects these main elements (Ready, 1998):

- The country of registry permits ownerships of its ships by non nationals
- Access to their registry is normally easy
- The registration payment, and a tonnage base annual fee are generally the only charges
- Revenue taxes are not a requirement or are very low
- The country of registry is a small maritime power with no national requirements
- The employment of its ships with non-nationals is allowed
- The state of registration lacks an effective MARAD which imposes compliance to their vessels with national and international rules

This definition is alleged to be extremely narrow (Sturmey, 1983), because presently open registry States such as Cyprus imposes rules regarding age limit of the ships and the survey of the vessels as conditions for entering in their registries. Moreover, many open registries flag States such as Panama has improved the compliance with the regulatory instruments by their vessels. It is noteworthy, however, to mention that currently there are scholars that consider many points of the Rochdale Committee's definition relevant, and hence, ships operating under open registries according to them mirror deficiencies in safety measures, pollution deterrence as well as manning competency standards (Pamborides, 1999). In this respect, it appears to be a fact that the maritime disasters in the last decades have had as the main actor ships registered under open registry flags. Hence, Torrey Canyon accident in 1967, Amoco Cadiz in 1978 (Barton, 1998), Exxon Valdez in 1989, Scandinavian Star in 1990, Sea Empress in 1996 (Coles, 2002), Erika in 1999 and Prestige in 2002 (Llacer, 2003), involved all ships operating under open registry States. Another evidence is that the casualty report of open registry fleets exposes a higher substantial rate of losses compared with the close registry countries (Coles, 2002).

The open registry regime has been in the focal point of criticism since in the initiation of its existence and this disapproval is based on several issues such as safety, economic distortion and employment. The first action against the regime of open registries was initiated in the Geneva Convention in 1958 when the political and legal mechanisms were putted forward to stop the operation of these registries. The legal implications regarding open registries in IMO gained impetus in 1959 when an attempt was made to block the Panamanian and Liberian claim for a membership on the Maritime Safety Committee, which consequently showed once again the reaction of traditional maritime countries pro the abolishment the of the open registries system (Pamborides, 1999). Similarly, the objective of the UN Convention on the Conditions for Registration of Ships in 1986 was to undermine the open registry States, but in reality this purpose was not achieved due to the strong disagreement by the open registry countries.

The main criticism regarding open registries is that there is no genuine and substantial connection between the flag State and its vessel, thus, making this link a pure profit oriented rather than a genuine link. Despite the fact that the concept of genuine link is still vague in international law, yet, the term imply that the vessels should be owned by nationals of the flag State; the principal place of business of the management or the chair must be located in that State; the flag State should exercise final control by subjecting the profits of the shipping company to taxation and; the State of registry must exercise absolute control over the safety standards and employment matters of the vessel (Tolofari, 1989). This is not simply the case in the open registries which appears to operate partially or fully in absence of the aforementioned elements. Countries such as Cyprus, Panama, Liberia, Malta, Bahamas, and Belize, usually, are implementing diverse and lax registration policies which reveal the theory that there is no genuine link in connection to their flag ships.

One of the most controversial issues on open registries' States is that the vessels under their flags are characterized by substantial deficiencies on safety and security standards. The UNCTAD Secretariat in 1981 released a report wherein were classified several reasons why the issues on safety standards are probably greater under open registries rather than in the close registration system (Coles, 2002):

- Real owners are not identifiable and can alter their identity by manipulating brass-plate companies
- The crew can avoid legal actions since are not nationals of the flag State
- Ship-owners in open registries and the flag State may lack collaboration since they do not share similar interests
- Since owners reside outside the flag State territory can refuse to testify at an inquiry aimed for safety issues and subsequently avert prosecution
- Open registries shipping operates in absence of union structure which is crucial to the application of safety and social standards onboard
- Ship-owners can easily exert pressure on the master and the officers to undertake risk decisions, because there is no appropriate government to which the personnel can protest
- Any signs of militancy among personnel onboard can be broken by the ship-owners due to policy freedom to change nationality of crew at whim
- The Port State Control influence is weaker because the sub-standard ships reported are not in factual authority and control of its flag State
- Since the sole objective in open registries is making profit the enforcement of standards over their vessels is basically inconsistent with the operation of the registration system

Although, the overall situation of safety in open registry vessels somehow is improved, most of the deficiencies stressed in the above report appear to have some rational basis, a fact which in the view of these authors indicates that there are currently safety issues with the vessels operating under some of the open registry countries. On other hand, in light of the criticism revealed recently regarding open registry issues, many States such as Panama have consolidating their rules, regulation and safety measures on ships under their flag, reflecting as a result a better and comprehensive approach towards the eradication of all the issues previously stated. Cyprus and Malta have also made progress in fulfilling all the international maritime standards concerning safety and security of ships operating under their flag, which in the opinion of these authors have resulted to be efficient measures towards largely improving the safety and security situation.

## 6. CONCLUSIONS

Consequently, it may be submitted that the legal concept of parallel jurisdiction and the complexity towards the establishment of the appropriate legislation to be implemented when there is a accident on the high seas, in cases of parallel flagging, appears to be ambiguous in the international law, resulting in legal implications. The genuine link concept is even more ambiguous in the international law due to the absence of the description of this concept in terms of preconditions for the grant of the nationality and sanctions applied in view of the nonexistence of such link. The unclear and confounded decision of ICJ, revealed the diversity and controversial perspective of different States regarding genuine link concept, which yet remains a debate presently. Even though a number of international legal instruments underline that in the international law, questions of nationality are in principle within the domain reserved to the States, this does not mean that the granting of nationality is totally an unlimited right of every State since this law shall be recognized by other States insofar as it is consistent with international conventions and international customary law.

It is significant to emphasize that among the legal regimes of close registries prevails an immense diversity of requirements, laws and regulations rather than a uniform legal approach. The situation is aggravated more when considering that the definition of ship's nationality at universal level lacks uniformity, let alone considering this issue in a national level, wherein the nationality is defined in a way that is best suitable for State's own interests. Thus, the legal regime of close registry appears to reflects a multi-standardization legislative approach, and to a large extend diversified, where dissimilar regulations, laws, requirements and implementation policies may lead to obstacles and legal implications in respect to financial matters, competitiveness and dispute resolution within the shipping industry. What is more important, this study has revealed that even among these registries, perceived as efficient and comprehensive legal approaches, there are States which lack substantially safety and security measures, and substandard ships comprise a large percentage of their fleets.

The definition of open registries, which appears to be a complicated matter, lacks a common standard and for that reason these registries are easier to differentiate than to describe. Nowhere in international maritime conventions or documents is established a definition which would formalize IMO's position on open registries which implies that this organization is circumventing this smatter which involves vital political and economical features. Furthermore, the maritime disasters in the last decades have had as the major actor ships registered under open registry flags. UNCTAD's casualty report of open registry fleets reveals a higher substantial rate of fatalities in comparison with the close registry States based on several important reasons. The majority of these deficiencies emerge to have some realistic foundation, a piece of evidence which may point out that there are safety and security issues with vessels operating under several open registry flags. Nonetheless, many open registry States recently have consolidating their rules, regulation and safety and security measures on ships under their flag, exposing perhaps an improved and comprehensive approach towards the eradication of all the issues formerly underlined.

## 7. REFERENCES


[1] Barton, J.R. (1998). *Flags of Convenience': Geoeconomics and Regulatory Minimisation*. Review of Reviewed Item. Royal Dutch Geographical Society KNAG.

[2] Boczek, B.A. (1962). *Flags of Convenience: An International Legal Study*. Cambridge: Harvard U.P.

[3] Canada Shipping Act (2001). *Regulatory Reforms: Part 2, Registration, Listing and Recording.* Canada

[4] Coles, R.M.F. (2002). *Ship Registration: Law and Practice*. London: ed, LLP.

[5] Farthing, B. & Brownrigg, M. (I997). *International Shipping*. 3rd ed, Business on Shipping. London: Hong Kong: LLP.

[6] Giles, O.C. Gaskell, N.J.J. Debatista C. & Swatton, R.J. (2003). *Chorley and Giles Shipping Law*. 8th ed. London: Financial Times Pitman Publishing,.

[7] Hague Convention on Certain Questions Relating to the Conflict of Nationality Laws. 1930.

[8] Hill, C. (2003). *Maritime Law*. 6th ed. London; Hong Kong: LLP.

[9] Hoffman, J. Sanchez, R. J. & Talley, W.K. (2005). "Determinants of Vessel Flag." In *Shippings Economics: Research in Transportation Economics*, 173-219: Elsevier Ltd.

[10] I.C.S.O.M. (2006). *Ship Operation and Management*. London: Witherby & Co. Ltd.

[11] *Lauritzen Vs Larsen*, 345 U.S 571 (1953).

[12] Llacer, J. M. F. (2003). "Open Registers: Past, Present and Future." Review of Reviewed Item. *Marine Policy*, no. 6.

[13] Li, K.X. & Wonham, J. (2001). *The Role of States in Maritime Employment & Safety: A Legal and Economic Study*. Dalian: Dalian Maritime University Press.

[14] *Liechtenstein V. Guatemala*, I.C.J. Rep. p. 4 (1955).

[15] Mukherjee, P.K. (2007). *The Changing Face of the Flag State Implementation: Experience with Alternative Registries. 30*: World Maritime University.

[16] Mukherjee, P.K. (1993). "Flagging Options: Legal and Other Considerations." *Mariner*, no. January/March: 31-37.

[17] Mukherjee, P.K. (2007). *Nationality, Registration and Ownership of Ships. 9:* Unpublished Lecture: World Maritime University.

[18] *Naim Molvan Vs. Attorney General for Palestine*, A.C. 351 (1948).
[19] Özcayir, Z.Oya. (2001). *Port State Control*. London; Hong Kong: LLP.
[20] Paris M.O.U. on Port State (2007). *Paris M.O.U. Announce New Black-Grey-White-List.*In Paris MOU.(accessed 2008).
[21] Pamborides, G.P. (1999). *International Shipping Law: Legislation and Enforcement*. The Hague, Boston, Athens: Kluwer Law International.
[22] Ready, N.P (1998). *Ship Registration*. 3rd ed. London; Hong Kong: LLP.
[23] *R. V. Anderson*, II Cox Crim. Cas. 198 (1868).
[24] Ship Registration Regulation of P.R.C. *(*1994).
[25] *S.S. Lotus,* P.C.I.J. Series A, No. 10 at 25 (1927).
[26] Sturmey, S.G. (1983). *The Open Registry Controversy and the Development Issue*. 8 vols. Bremen: Institute of Shipping Economics.
[27] Sohn, L.B & Noyes, J.E. (2004). *Cases and Materials on the Law of the Sea*. Ardsley, NY: Transnational Publishers.
[28] Tetley, W. (1994). *International Conflict of Laws: Common, Civil and Maritime*. Montreal, Quebec: Blais & International Shipping Publications.
[29] The "Grand Prince" *(Belize V. France).* (2001), *Judgement. ITLOS Case No.8*.
[30] Tolofari, S.R. (1989). *Open Registry Shipping: A Comparative Study of Costs and Freight Rates.*
[31] *The Meritt,* 84 U.S. (17 Wall.) 582 582 (1873).
[32] U.N. (1958). *Geneva Convention on the High Seas*. In, U.N. (accessed 10 May, 2008).United Nation Publication
[33] U.N. (1983). *The Law of the Sea: Official Text of the United Nations Convention on the Law of the Sea*. London; New York: Croom Helm; St. Martin`s Press.
[34] U.N. (1986). *United Nations Convention on the Conditions for Registration of Ships*: UNCTAD. United Nation Publication
[35] U.N. (2005). Vienna Convention on Diplomatic Relations 1961. United Nations, Treaty Series, vol. 500, p. 95.
[36] UNCTAD/TDR/2. (1982). *Trade and Development Report 1982:* Report by the U.N.C.T.A.D Secretariat," (Vol. I).

**ISSN 1582 – 3601**

„Nautica" Publishing House,
Constanta Maritime University

Editura
NAUTICA