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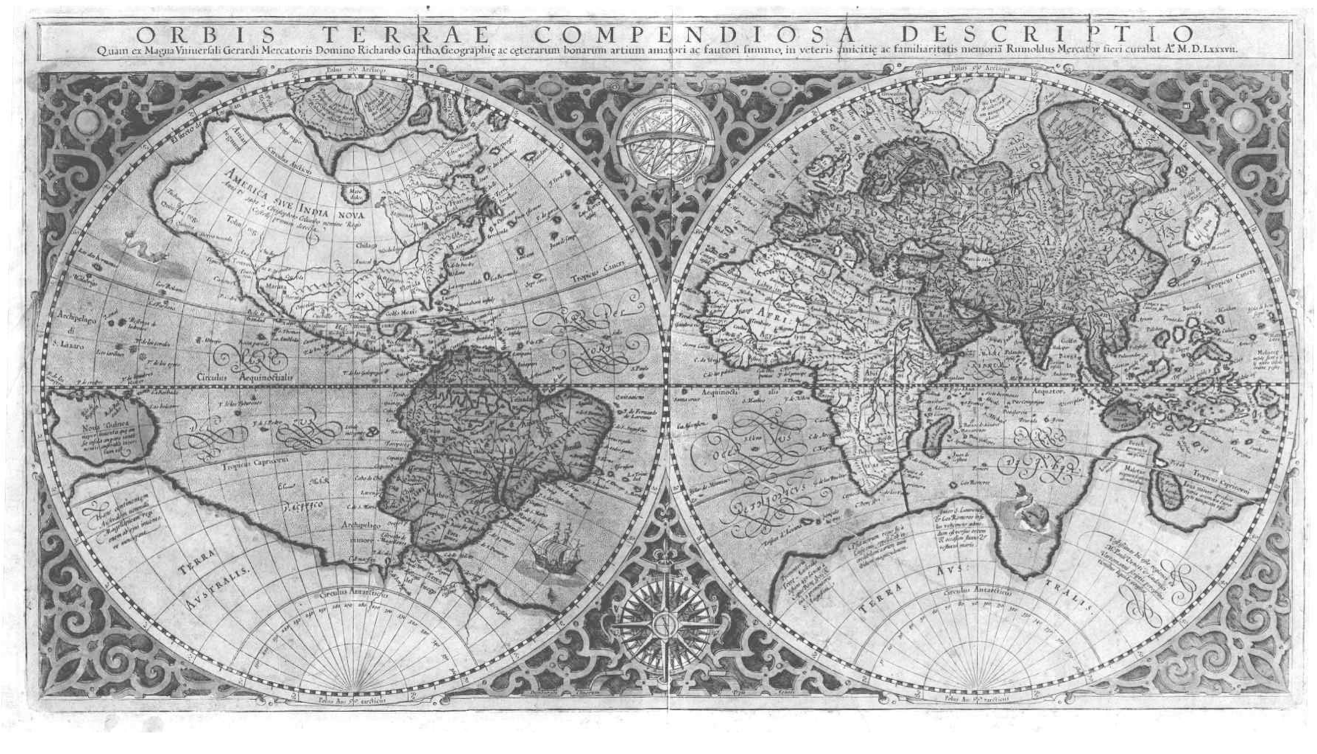

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SECTION I

NAVIGATION AND MARITIME TRANSPORT

METHODS OF THE ENERGETIC CONSUMPTIONS OF SHIPS

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ABSTRACT

The energetic crisis within the context of maritime transport is to be approached with in the economic crisis that exists on a global scale. The oil crisis, triggered periodically, in the years 1973, 2000, 2008 and accentuated as the years go by, has led to spectacular increases in the prices of the crude oil fuels.
The problems concerning energetic savings with in transportation have appeared immediately after the beginning of the energetic crisis. Starting with the year 1975, the freighters, the navigation companies and most of the states which own fleets have started a large program of studies and research in order to find the most efficient ways which should lead to energy savings on board ships, with preponderance on the grounds of the savings of crude oil fuels, and implicitly the reduction of the exploitation costs.

Keywords: *energetic crisis, energy savings, exploitation costs, crude oil fuels.*

1. INTRODUCTION

The effectively useful energy used in a process to which the balance sheet makes reference is, in many cases, a notion whose content may have various interpretations, and therefore its definition is more or less a conventional one.

With relation to the useful energy it must be shown the fact that there are processes within which useful energy also comprises a series of energetic consumptions that actually represent losses, and, just as energetic losses, may be susceptible of reductions.

The energy losses of diversified categories must be broken down in their turn, by taking into account the criterion of the cases that generate them, as are:

- the constructive imperfections of the used installations;

-the inadequate state of the installations following the result of some poor exploitation, maintenance, the delay of undertaking of the necessary repairs, the undertaking of repairs at a unfit qualitative level, etc.;

- digressions from the optimal regime;

- the functioning in vain of the installations, etc.;

- the accumulation and the later dissipation of energy in the case of the intermittent work regime (the heating and cooling of the installations, the turning off, and restarting of the installations, etc.).

It is well known the fact that more than half of the total quantities of fuels that are introduced in the thermal machines (engines, donkey boilers, etc.) are lost within the surrounding area through gases that are evacuated at the chimney, through radiation, cooling waters, conduct leeks of some hot fluids, etc.

The burning gases form the main engines, from donkey boilers and from auxiliary engines which are exhausted into the atmosphere with high quantities of energy are utilised in economisers/heat changers through which heat for other diverse energetic necessities on board of the ship is utilised. At least 30-40% from the quantities of heat contained within the exhaust gases are recoverable economically.

Another source of losses is the burning of fuels for the production of the energy, that in many of the cases is incomplete, and through measures of automation of the burning regulation, of over-charging with air, the optimal working temperatures for fluids reductions of 15-20% are realised at the specific fuels consumptions.

The realisation of a thermal isolation of a high quality both for the equipment as well as for the installations will lead to a diminishing of the losses through radiations (considered at 70-80%) that can influence the consumptions of fuels with up to 15%.

Also insuring an optimal correspondence between the steam sources and the consumers, from the perspective of the temperatures and of the pressures, through the usage of intermediate relaxation within the steam turbines, properly dimensioned and not of the installations of reduction-cooling, will allow the obtaining of some energy that can be utilised by different consumers, solution that will lead to an improvement of the net thermal-energetic efficiency.

If we take into account the total energy consumption, or the specific one, for ships one can consider the following factors of analysis:

- the efficiency of the propulsion installations, including that of the transmission lines;

- the economical speed of the ships;

- the resistance to advancement of the ship through the making point of some programs of choosing of the shapes of the ship, the optimal choosing of the dimensions and of the coefficients of the hull, the choosing of the propellers with a high diameter and small revolutions;

- the usage of residual fuels and the recovery of the residual heat;

- the capacity and the degree of usage of the ship;

-the concrete conditions of exploitation.

In the case in which one extrapolates the analysis at the level of transports in general, the domain of energy conservation can be suited due to a general strategy and orientation that should lead to minimal expenses and as low as possible pollution.

The most important orientations within this general strategy could be:

- the limitation of certain types of transports and/or the compensation with other types (for example in Italy they are trying to reduce auto transports and they extend the sea-fear transports, and those along the coast, in order to diminish the pollution of the environment, as well as the to obtain the diminishing of transportation costs and fuels consumptions);
- the rational repartition of tasks upon different transportation systems;
- the extension of combined transportations (the usage of containers);
- the reduction of the dead mass (absolute and relative) of the transportation means;
- the intensive utilisation of the transportation means.

2. METHODS AND MATERIALS

Amongst the solutions utilised for the recuperation of the residual energy there are:

- The utilisation of a part of the heat from the exhaust gases for a turbo-blower of over-fuelling of the main engine for the improvement of the burning efficiency;
- The utilisation of the exhaust gases for the production of overheated steams utilised in the operation of a turbo-alternator with electrical energy production;
- The utilisation of the exhaust gases for the production of steams within a recovery donkey boiler, steams that have multiple destinations on board of ships;
- Heating fuels and oils for technological purposes;
- The heating of the living rooms;
- Gears operations, etc.;
- The utilisation of a power plug on the axis of the main engine for the usage of an electric generator that should cover the marching regime.

Let us stop a little over this second solution that leads to equipment that is more or less sophisticated. In the case in which one decides the installing of a turbo-generator one tries to produce a maximal electrical power from the heat contained within the exhaust gases. The recovery donkey boiler and the transformation of the saturated vapours into over saturated vapours are essential. Also one can utilise an evacuated condenser instead of the atmospheric one for reasons of efficiency, to which one can add as well the preheating of the water supply. The advantages of such a system are obvious, the most important one being the economy in fuel (in general superior) the diesel fuel, that should be utilised by the groups that are diesel-generators for the production of the necessary electrical energy on board, and in the case in which the energy delivered by the turbo-generator is sufficient one can completely turn off the generator-diesel groups, fact that results into savings through the deduction of the maintenance costs.

Such a system also shows some inconveniences. Amongst them one can note the ones that are linked to the main engine that allows the obtaining of a supplementary steam quantity, or on the contrary, of an insufficient quantity for the production of electrical energy on board, especially that the obtaining of a high efficiency at the diesel engine will lead to the obtaining of some more „cooler” exhaust gases.

This has led to divers solutions out of which we present:

a) The automation of the turbo and diesel generator systems in such a manner that one can use at any moment the whole quantity of electrical energy produced by the turbo-generator;

b) The PUSH-PULL system, the newest method, that had as a departure point the compensations of the lacks of the classical turbo-generator, namely, the lack of slenderness and a diminished degree of recovery.

In principle the PUSH-PULL system works in this manner:

- if there is a surplus of available calories with regard to the strictly necessary to the production of electrical energy for the ship, these calories are re-injected under a mechanical shape within the line of trees and from here to the propeller, improving the efficiency of the propulsion;
- if on the contrary, there is a lack of calories for insuring in total of the electrical energy on board, the energy supplement is taken under a mechanical shape from the line of trees, exactly like in the case of the axis generator, with the difference that here one picks up a partial power, that is necessary for the production of the electrical energy supplement that is not covered by the generator.

Of course, the multitude of solutions has not been run short of through the examples that were presented above, but we have shaped with their help the searches on a global scale for the reduction of fuel consumptions on a global scale.

The aim of this paper is to find ways of diminishing the consumptions for the ships that are in use.

Methods proposed for ships that are in service:

1. The ones that were presented before hence constitute solutions for the planners, researchers and the ship builders. In exploitation, for the existing fleet, one must find new and newer solutions that should lead to the diminishing of fuel consumption, and in this paper we shall stop upon the measures that can be chosen by different types of ships that are in exploitation.

2. The thermal regimes and the characteristics of the naval engines

The functioning regime of a naval engine is characterised by the exploitation terms, which are sketched through the indicators of mechanical power and of economy, these ones being analysed from the point of view of the thermal and mechanical solicitations. There are three fundamental bulks that define the functioning regime of an engine: the cargo, the revolution of the bent tree and the thermal regime of the aggregate. For the qualitative and quantitative appreciation of the functioning regime, one uses the following categories of indicators: economic-energetic (fuel consumptions, the power, the revolution, the pressures of the fuel mixture, etc.) and of exploitation (pressures and temperatures of the work fluids).

3. The functioning regimes of the thermal engines

The naval propulsion engines function in different conditions of exploitation, that are determined by the technical state of the ship and of the propulsion installation, but also of the extreme navigation conditions, the type and the cargo of the ship, the manner of energy transmission from the engine to the driving mechanism.

- The stabilised regime (permanent)

The stabilised regime is the one in which the functioning indices of the engine (n-revolution, M-couple, thermal state, etc.) do not vary in time, its functioning being a stable one, and one of a great time length.

Thus, according to the duration of the engine functioning, one can distinguish:

• continuous functioning regimes;

• discontinuous functioning regimes.

The continuous functioning regime is that regime in which, at any revolution, the engine develops in a continuous manner the highest effective power, the highest moment effective motor and the highest mean effective pressure, with the condition that the technical-economical reliability indicators remain constant. The heights that are enumerated are called effective continuous heights and they are noted with Pec, Mec and pec. The intermittent functioning regime is the one in which the effective power, the effective engine moment and the mean effective pressure are superior to the Pec, Mec and pec heights for short time intervals, without the durability and the set-up of work for the engine being affected. The maximal values of the power, of the engine moment and of the mean pressure that it develops at discontinuous regimes are named: effective discontinuous power (Pei), discontinuous engine moment (Mei) mean discontinuous pressure (pei). In the same figure one indicates the geometrical place of all the Pei and Mei points, the hatched domain represents the domain of over-powers of the diesel engine. One also notices the fact that Pec and Pei go through maximal values („the power peaks” Pec max and Pei max). The corresponding revolution to the power peak is named maximal revolution power np. In an equivalent manner, Mec and Mei reach maximal values („the peak of the moment”), and the corresponding revolution is called revolution of maximal moment nM. At the diesel engines, the high Pe max is located outside the functioning domain.

- Transitory regimes

The transitory regime is the one in which one registers the variation in large limitations of the functional parameters, case in which the generated power by the engine differs from the utilisation power (the power at the propeller). This supposes an evolution in time between two stabilised states; it insures the passage from a permanent regime to another, as well as the operations of the starting (launching), the inversion of the marching direction and the turning off of the engine. The time variable character of a certain functional parameter of the engine presents a practically different interest because it illustrates a series of dynamical properties that determine its behaviour during exploitation.

- The characteristics of the transitory regimes

For the analysis of the non-stationary regime or of the functioning transitory one of a diesel engine, one takes into account the variation according to time of one of the parameters.

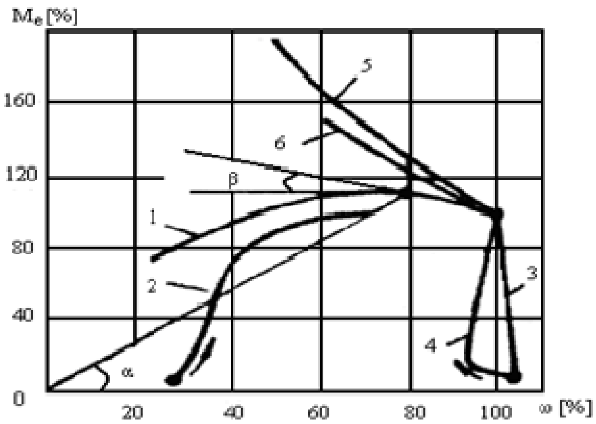

Fig. 1- The static and dynamic characteristics of the engine at transitory regimes

in which:

are the partial derivatives of the respective couple, of the angular rotation speed.

In figure 1 the static and dynamical characteristics that are specific to a diesel engine are shown as follows:

1 – the exterior static characteristic;
2 – the dynamical exterior characteristic;
3 – the static charge characteristic;
4 – the dynamical charge characteristic;
5 – the static characteristic of constant power;
6 – the dynamical characteristic of constant power.

The chart traced within the coordinates Me = f(ω), can be represented in the fields of the stationary regimes of the engine, thus permitting the possible application of the same dependence relations, as well as the determination of the degree of utilization of the possible static powers of the engine in non-stationary functioning conditions. The determining instantaneous values of the moment of a diesel engine are, usually, smaller than in the case of the stationary regimes.

3. RESULTS AND DISCUSSION

At the present the majority of the ship builders target their attention towards the recuperation of an as large as possible quantity of residual energy that results from the functioning of the main engine. The fact is known that the most effective present diesel engines have reached an efficiency of 50%, so, only 50 % from the energy that is introduced within the engine is transformed into mechanical energy at the tree of the main engine, the rest being lost through the exhaust gases, the cooling fluids as well as through the frictions between the parts that are in motion.

4. CONCLUSIONS

The transitory regime (non-stationary), to which the couple engine and angular rotation speed varies continuously in time, is not recommended for the aggregate, because in this situation takes place the significant reduction of its economy, on the background of the growth of inertial losses due to the worsening of the formation of the fuel mixture, but also to the deficient burning in the case of repeated accelerations.

The transitory acceleration regime is wished to be as short as possible, because the kinetic energy of the masses found in rototranslation movement, taught to be as low as possible. For the naval domain the situations have been enumerated when a M.A.C. is exploited in transitory regime, these regimes can be shorter or longer (they are being dictated by both the external factors of the body of the ship, as well as by the internal factors).

Through the existence of some fittings (needles), in the framework of the optimisation variances of the overcharging of the naval engine, the process of gases exchange chimes in with itself. But through the asymmetrisation of the process there is an increase in the exploitation indicators and the economy of the diesel engine, its functioning is improving during the time-frame of the transitory acceleration regime.

5. REFERENCES

[1] http://www.nauticamagazine.ro
[2] Ghe.Caraiani, Maritime transports, Lumina Lex Publishing House, 2005
[3] Martin Stopford, Maritime economics, 3rd edition, Routledge Publishing House, 2009
[4] Maritime transport – Eurostat.

TAILOR MADE TRAINING FOR BRIDGE AND ENGINE ROOM TEAMS' COOPERATION

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ABSTRACT

This paper underlines the assessment results of some specific bridge resource management scenarios, focused on emergency navigation and cooperation between bridge and engine room teams. These types of courses were undertaken at managerial level and the trainees were specialized in container ships. In the scenarios that will be analyzed, the own ship was a VLCC full loaded, navigating in shallow waters. The main event simulates a small fire at the electrical circuits on the bridge, followed by loss of remote control to engine and steering systems. Consequently, the trainees must transmit verbal order to engine room and emergency steering compartment in order to safely maneuver the VLCC towards a safety anchorage place.

Keywords: *training, maritime simulation, FMSHS, ER.*

1. INTRODUCTION

T The idea of this paper was born after a few rounds of training undertaken at managerial level for deck and engine officers hired by the different international owners and having as main objective the enhancing of cooperation between deck and engine team. The three days course included 16 hours of simulation and is focused on ship resources management and emergency navigation. The topics of the course and the content of the scenarios were agreed with the Owner representatives. Because this type of course is tailored made, the team of Constanta Maritime University (CMU) simulation instructors was always receptive to all the requirements and suggestions made by the course beneficiary. One month before the first scheduled course, the cooperation between the CMU simulators staff and Owner representatives was very close and productive.

For these courses, we used both simulations facilities owned by the Constantza Maritime University, respectively the full mission ship handling simulator (FMSHS), DNV class A, type Transas NT Pro-5000 and the engine room simulator (ERS), type Kongsberg Neptune.

2. COURSE SCENARIOS OVERVIEW

The course was planned as a collective training program for deck officers (Masters and Chief Mates) and engineers (Chief and First Engineers) and includes three joint simulations. We have tried to include in the scenarios own ships (OS) with characteristics similar with the most common ships from the owners fleet. We also created some of the exercises in maritime area well known by the deck officers in accordance with some of the most used maritime routes (New York harbor, Baltic Sea, Solent Channel). We deliberately placed other exercises in unknown navigation area, such as the Irish Sea or the Constantza Port.

Tables 1, 2 and 3 showed the outlines of the simulation sessions, undertaken for the deck and engine department. All simulations were up to 90-110 minutes long, including the briefing and debriefing sessions.

Table 1. Deck Department Simulations

Simulation 1 – Familiarization with Own Ship type 1 & 2 handling characteristics and navigation equipment • Open waters scenario
Simulation 2 – Collision avoidance • Own Ship type 1 – Container Ship 3 / OS approaching and passing TSS Off Skerries, inbound to Liverpool pilot station
Simulation 3 - Advance piloting & collision avoidance • Own Ship type 1 – Lo-Ro Ship • Own ship at anchor, proceeding to channel and open sea - outbound in Solent Channel
Simulation 4 – Emergency procedures – Loss of steering • Own Ship type 1 – Lo-Ro Ship • Own ship moored starboardside alongside jetty (New York Harbor).

Table 2. Engine Department Simulations

Simulation 1 – Familiarization with Kongsberg ERS
Simulation 2 – Operate ERS from Dead Ship condition to DG 1 & 2 in operation
Simulation 3 - Operate ERS from DG 1 & 2 in operation condition to prepare the main engine for starting.
Simulation 4 - Operate ERS from start main engine ready for departure to full ahead in normal operation conditions.
Simulation 5 – Operating the main engine in normal and abnormal conditions. .
Simulation 6 – Malfunctions with ship in normal operating conditions (full ahead).
Simulation 7 - Malfunctions to engine systems.
Simulation 8 - Malfunctions to engine systems

Another interesting aspect of this course derived from the occasional presence of the Owners' representatives, their main mission being to supervise and support the delivery of the course. Due to the presence of these Owners' officials the trainees wrongly assumed that their performances would be evaluated with possible consequences on their professional carrier and as a result [7] they tried to show their best professional skills and to solve the events from the scenario as realistic as possible.

The main technical problem that we had to solve in order to be able to organize this course was raised by the differences between our ship handling and engine simulators. The full mission ship-handling simulator (FMSHS) is a TRANSAS NT Pro 5000. The engine room simulator (ERS) is produced by Kongsberg, type Neptune and is simulating a main engine MAN B&W 5L90MC for a VLCC. As showed in table 3, the only solutions for putting in practice the joint exercises was to use on the FMSHS the same own ships as in the ERS, respectively a VLCC [5]. Because the two simulators are not physically connected, synchronization of the same events on both simulators was made by continuous radio communications between FMSHS and ERS instructors. Communications between bridge teams and engine room teams was also performed using real portable VHF radios.

It seems that it is “en vogue” to ask for combined FMSHS and ERS simulations. Logically speaking, joint training of deck and engineers officers could be benefic because it facilitates a better understanding of the problems that arise, on both departments, especially in emergencies [1]. As we saw from the owners' requirements, they wanted for the deck officers to better comprehend the activities that must be accomplished in engine room when a technical malfunction or emergency appears. In other words, these simulations intend to explain and demonstrate to Masters and Chief Officers why the engine watch team could not carry out faster some of the orders sent from the bridge.

3. JOINT SIMULATIONS FOR DECK AND ENGINEERS OFFICERS

The aim of this paper is to discuss mainly about the practical advantages and disadvantages related to this type of combined simulations, simultaneously involving bridge and engine teams. In the bridge resources management course, we have two types of common training session: joint lessons and joint simulations (see table 3).

Table 3 - Joint simulations for Nautical Officers & Engineers

Joint Lesson for Nautical Officers & Engineers • Effects of extreme engine maneuvers – Crash Stop
Joint Lesson for Nautical Officers & Engineers • General electrical power failure – Black Out
Simulation 1J - Joint operation of FMSHS & ERS. • Own Ship type 1 – VLCC ballast • Own ship leaving port (Constantza), traffic inbound/outbound • Malfunctions to main engine systems • Engine failure • Own ship must anchor • Request tug for towing to anchorage area
Simulation 2J - Joint operation of FMSHS & ERS. • Own Ship type 1 – VLCC full 16.7 m • Own ship passing confined waters (approaching East Bridge Great Belt) • Wind & current • Loss of remote control from the bridge to engine and steering gear • Ship must find a safe place for anchoring • Engine room team must respond to verbal orders from the bridge

Joint lessons are performed in the ERS with participation of all the trainees (deck officers and engineers). During these lessons, using the ERS facilities we simulate:

- a crash stop (from full ahead to full astern) maneuver, in the automatic and manual alternatives of reduction of engine revolutions and put in reverse of the main engine;
- a total loss of power (black out) accident.

Instructors and Chief engineers (from the trainees) are explaining to the deck officers the required steps that must be followed by the engine room team, in order to perform the emergency stop maneuver and the actions that must be done in order to regain power. Role and functions of modern protection and automation are also explained, for of better understanding of the required time intervals that must be attended in order to obtain the desired outcome.

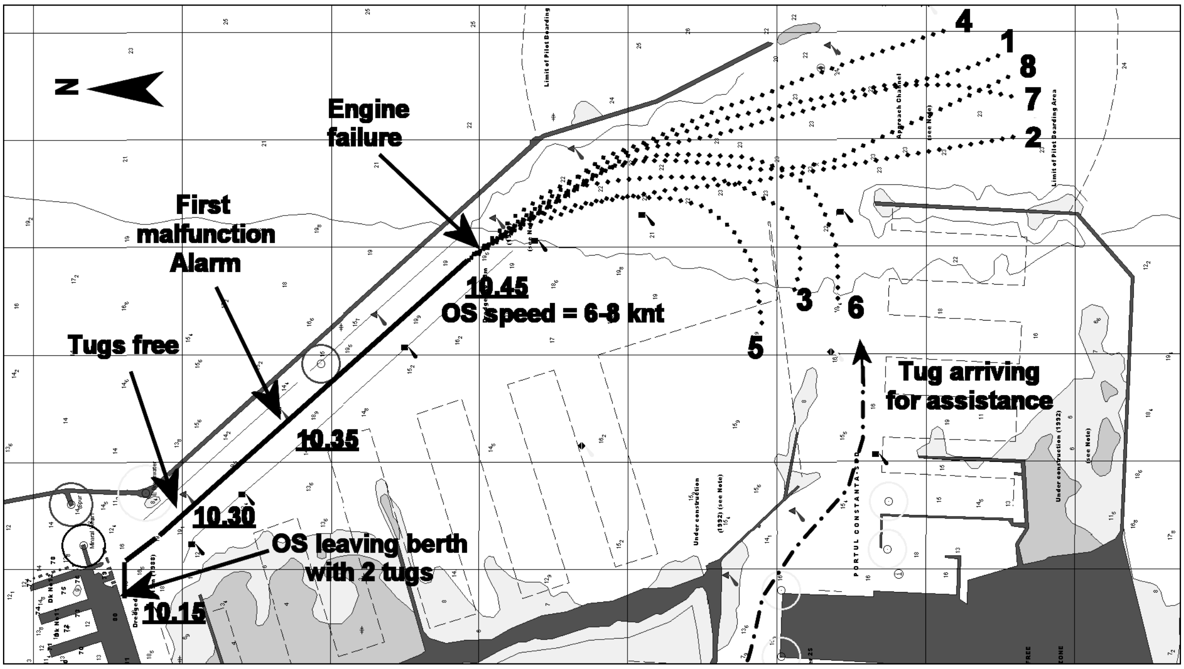

Figure 1 Nautical map for Constantza Port

We consider that these lessons are useful, because deck officers did not have many occasions to assist at demonstration and logical step-by-step explanation regarding routine and emergency operation of the main technical systems. The Chief Engineer usually gives such information, and all Masters are convinced that every Chief engineer is reluctant in carrying on sharp maneuvers [6], arguing in many cases that, technically, it cannot be done. This belief is in most of the cases true, because every Chief Engineer tries to avoid risks that could generate breakdowns or malfunctions to some equipment. Another goal of this type of courses appears from here. Joint trainings are seen as a solution for increasing the confidence between the top-level officers from the deck and engine departments, when they have to reach common decisions, especially in difficult situations.

For the second stage of dual training, we perform two types of exercises (table 3) - a scenario involving engine failure and a scenario for loss of remote control (from the bridge) to the steering and engine systems. As explained before, because the ERS simulates a VLCC main engine, on the FMSHS trainees will also have to steer a VLCC as own ship. In the first scenario, the VLCC is in ballast, but in the second scenario, they have to deal with a full loaded VLCC.

There are no major problems for the engineers to become familiar with the monitoring and operation of the MAN B&W 5L90MC engine and auxiliary equipment. Instead, for the deck officers, it is more difficult to accept the idea that they have to maneuver a VLCC, their practical and professional experience being limited to conduct container ships that are much more maneuverable [3].

For the engine failure simulation (figure 1) all teams calmly and safely managed to handle the ship and to control the inertial ship track until the tug, dispatched by Port Control, arrived in assistance. Five from eight teams chose to exit between the north and south breakwaters, into open sea. Three teams, with own ship speed less than 8 knots, preferred to make a hard turn to starboard and drop anchor in the inner port basin.

The main goal of this loss of remote control scenario was to train the teams for the exchange of orders and communications between bridge and engine room, all steering and engine orders being transmitted viva-voce using portable VHF radios. Technically speaking, the engine and auxiliary equipment is running normally and the steering gear could be controlled from the steering emergency compartment, time of response for rudder being a little longer than normal (8 seconds longer than usual for a hard to port/starboard command). On the bridge, the rudder angle display and the main engine rot/min display remained functional, as well as the rest of the navigation equipment. The electrical short-circuit only cut power to the helm and engine telegraph.

This scenario created more difficulties to the bridge team, because this time the VLCC is fully loaded, the draft being nearly 17 meters, in an are proximity of the anchorage place, by putting the engine in reverse. Most of the bridge teams had the impression that the difficulties in maintaining the where the depth of water lies between 5 to 40 meters. In this exercise, the risk of grounding is maximized by the presence of a SE current with a speed of 2 knots (figure 2). The VLCC has a stopping distance of 8.5 NM (from Full Ahead to Stop), and 6 cables diameter of turn at Full Ahead speed (13 Knots), with 20 degrees rudder. In figure 3, we see the tracks of the eight ships during anchoring maneuvers.

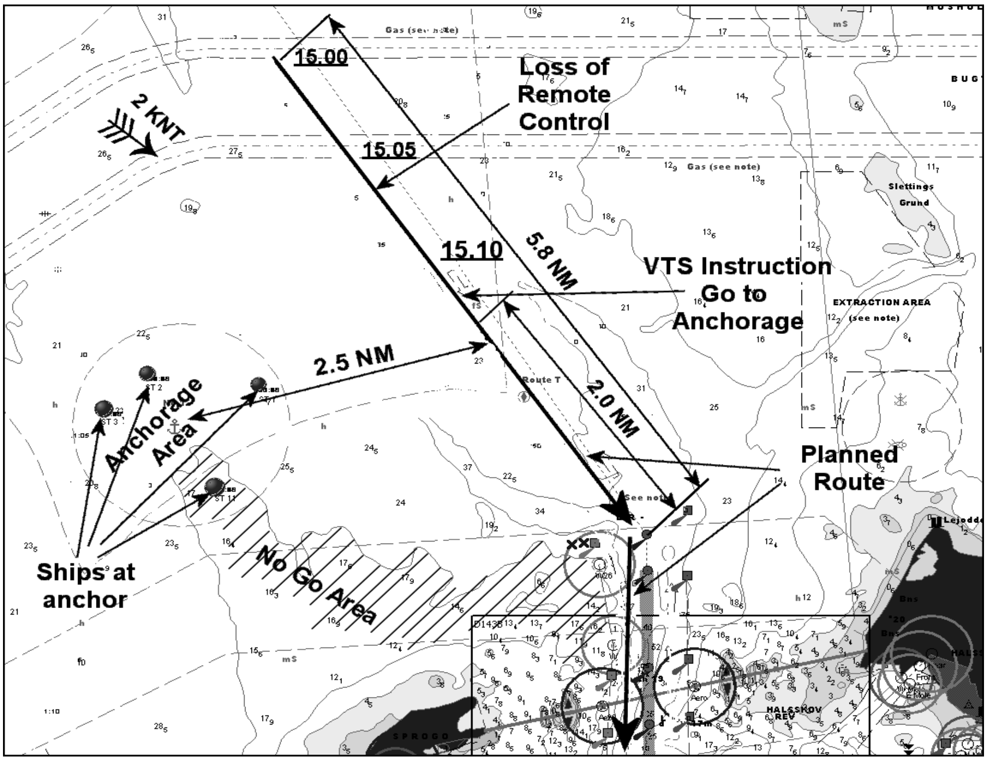

Figure 2 Loss of remote control scenario

Even large container ships (post-Panamax) also have long stopping distances (5-7 NM), all bridge teams were afraid that they will be not capable to stop the VLCC in due time. Consequently, after the loss of remote event, most of the teams, put the engine to stop without delay, as a normal reaction [5] of the approaching area with shallow waters. When the VLCC water speed reached 4-5 knots, the ship was very difficult to steer in the desired direction, due to the 2 knots current coming from starboard. It took over 30 minutes to become clear that the ship’s water speed must be maintained to at least 6-7 knots, and reduction of speed must be done only in the proximity of the anchorage place, by putting the engine in reverse. Most of the bridge teams had the impression that the difficulties in maintaining the desired track were a direct consequence of the delays in carrying on the orders by the engine team. In three of the cases, when the VLCC was dangerously heading towards the low depth area, the instructors had to advice the bridge teams to steer the ship at a greater speed in order to perform the turning towards NNE in due time.

Teams were fully accustomed to use ECDIS facilities and information and it was easy for them to understand what was really happening, after they read the COG, SOG, set and drift values [2]. None of the deck crews was very happy at the end of the exercise, knowing that they could have done better. All of them considered that the only explanation for their ships sinuous tracks was that they had to steer a completely unfamiliar ship, in dangerous for navigation area.

4. CONCLUSIONS

Before starting the final comments and conclusion, we would like to remind you that this course was designed in accordance with the beneficiary requirements and all the process from the planning stage to course delivery was supervised and monitored by Owners' representatives.

In our opinion, the engine failure scenario is not suitable for a joint exercise, because the engine team only has work to do in the first 20-25 minutes until they notice and identify the malfunctions and case of a poor quality voice transmission or from using English language with non-native English speakers.

If the coordinator (promoter) of the course has no intention to evaluate the achievements of the trainees, he must state this very clearly, from the first assembly meeting with the trainees (his employees) notify the bridge that the engine must be stopped

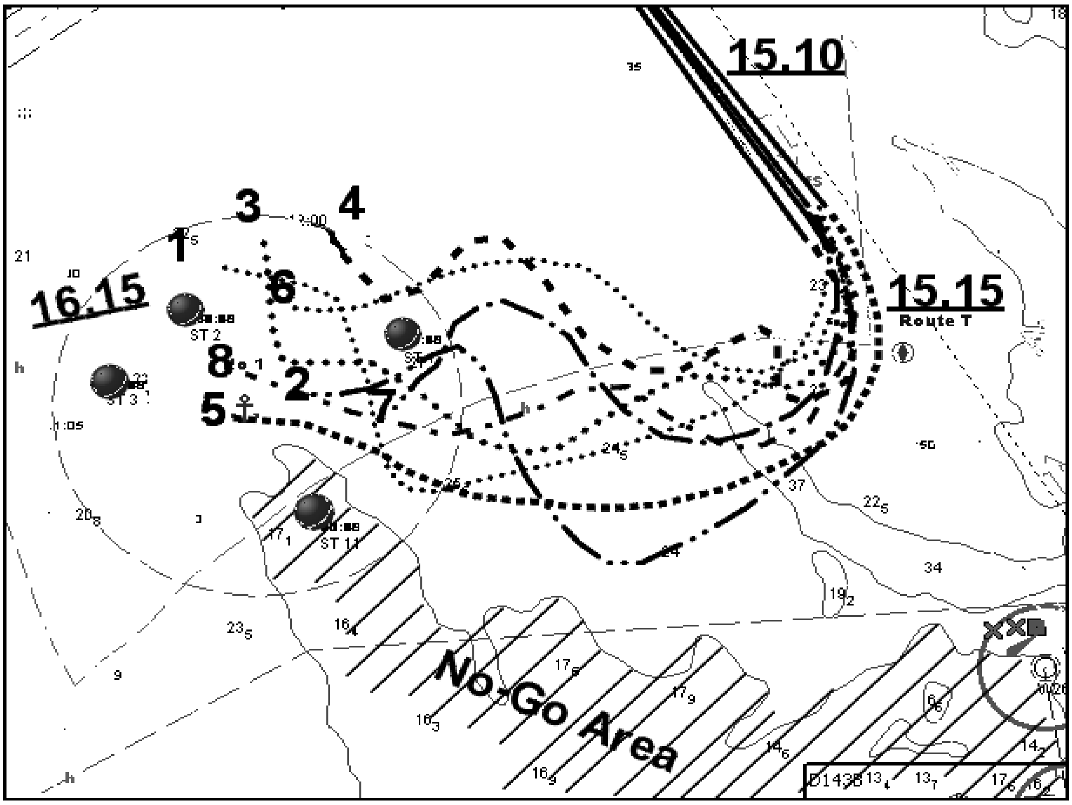

Figure 3 Loss of remote control scenario – anchoring maneuvres details

After that, they could not participate actively to the continuing simulations, the bridge team handling the ship for another 40-50 minutes, until dropping anchor or giving towing line to the arriving assistance tug.

The loss of remote scenario is very challenging for the bridge team, but it seems to be boring for the engineers, because it only involves one member of the engine team, who has to talk permanently to the VHF and press two buttons (rudder left/right) and change the vessel speed from the engine room telegraph. Boring or not boring for the engineers, this scenario clearly reveals the importance of a good verbal communications between the two compartments and the difficulties that could arise in case of a poor quality voice transmission or from using English language with non-native English speakers.

If the coordinator (promoter) of the course has no intention to evaluate the achievements of the trainees, he must state this very clearly, from the first assembly meeting with the trainees (his employees).

We designed the course only for training and the CMU instructors did not attempted to score the bridge teams' actions during simulations. Each bridge team has three members (Masters and Chief Mates) and we changed the composition of the teams for every exercise. Unfortunately, the Owners' representatives have the habitude to walk between the bridges to see what trainees are doing there. Especially some of the young Chief Mates try to take advantages of these opportunities and to show that they could manage the simulated situation better than their equal rank colleges and Masters. Such attitudes spoil the positive working atmosphere and create additional and unwanted stress pressure.

Beyond these inconveniences, however, it has highlighted the importance and benefits of such simulation exercises.

Thus, the participants of these exercises, deck officers and engineers, have achieved and evaluated in an objective way, the importance of their work, their role in the normal course of the onboard activity, the importance of collaboration between them in good conditions. In addition, it should be emphasized the role of communication and quality of spoken language, the technical limitations, witch department in doing their activity on board ships.

exist in the engine area due to the normal function process of the machinery and that lead to a delayed reaction at the commands received from bridge. The process from the engine department was better understood and thus the limitations of power and time involved by the technologies activities were accepted.

The awareness of these issues may lead to a change of attitude, a greater collaboration and a positive working atmosphere, to a greater confidence in the capacity of cooperation of

5. REFERENCES

[1] Barsan E., 2004, *Sea Service Equivalency for Full Mission Simulators training*, Advances in International Maritime Research, Pub. Nella Australia , ISBN 0-646-44200-7, Launceston, Australia

[2] Barsan E., 2005, *Integration of ARPA and AIS information on ECDIS display*, 6th International Symposium on Navigation - Gdynia, Poland 2005

[3] Dumitrache R., Stan, L.C., Dumitrache C., Hanzu Pazara R., 2010, *E-Learning and simulation in maritime*

learning process, Proceedings of the 6th International Seminar on the Quality Management in Higher Education, Section IV: Development innovative of new teaching methods/materials, July 8th -9th, Tulcea,, Romania, ISBN: 978-973-662-566-4, ISBN (Volume 1): 978-973-662-567-1

[4] Kobayashi H., 2005, *Functional Approach for Realization of Safe Navigatio*, MARSIM 2005, St. John's , Newfoundland , Canada

[5] Stan L.C., Memet F. 2011, *Simulation technology in the educational process*, Proceedings of the 7th International Conference on Management Technological Changes, pp: 433-436, September 1rd-3th 2011, Alexandroupolis, Greece, ISBN 978-960-89832-8-1

[6] Thomas K., Sørensen P., 2003, *Human Factors Assessment*, MARSIM 2003 Conference, Kanazawa, Japan

[7] Wulder J.H., Starren A., Ernst A., Bloot F., 2003, *Assessment of the Effectiveness of Bridge Resource Management Training*, MARSIM 2003 Conference, Kanazawa, Japan.

CONSIDERATIONS ON THE COURSE STABILITY AND SHIP'S HANDLING IN EXTREME WEATHER CONDITIONS

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ABSTRACT

Based on real events that occurred in the East Atlantic few years ago, the paper is analyzing and interprets a range of parameters for ship and for external forces that act on the ship captured by heavy weather and the effect they have on the maneuvering capabilities. The paper, wants to explain the strong influence of forces beyond the ship, forces caused by wind, waves or currents. Course stability and ship's maneuverability are strongly affected when the vessel proceed in a cyclonic area with extreme weather conditions due to external forces that act negatively on the ship's hull and its ability to maintain the desired course.

Keywords: *rolling moment, course stability, pitching, hydrodynamic parameters.*

1. INTRODUCTION - DESCRIPTION OF REAL EVENTS

The analysis of this paper started from a real case experienced by one of the authors during a voyage with a 65000 DWT bulk carrier in ballast sailing from Italy towards the north-west of Europe. The bulk carrier was 14th years old, with seven cargo holds. From these seven holds two of them could be used for ballast. When the vessel sailed from the discharging port in Italy all the dedicated ballast tanks (top side and double bottom tanks) were fully loaded, including the forepeak and afterpeak tanks.

After passing the Gibraltar Strait and entering the Atlantic Ocean the two cargo holds were also fully loaded with water ballast. At that moment the ship was in "heavy ballast" state, as indicated by the company procedures for ocean sailing. In this „heavy ballast" state the ship had on board 27000 m3 of water making a fore draft of 6.40 m and an aft draft of 8.25 m with a trim of almost -2 meters. Such a ballast condition is necessary for reducing the freeboard and air draught of the ship and for maintaining the propeller at the necessary depth for optimum propulsion power (AGC & S, 2013). The water speed of the ship in this loading condition was about 11-12 knots.

The voyage along the Portugal and Spain coast-line was done without problems. Before entering the Bay of Biscay the weather reports started to mention about a low pressure located over northwest of UK and the air pressure continued to drop over the next 12 hours.

After passing by Cabo Finisterre and approaching Bay of Biscay, the state of the sea gradually raised and the force of the wind increased very fast. The wind main directions was northwest in the beginning and after a few hours the direction was west-northwest and then north.

On board wind measurements had shown a speed of 30 knots, meaning 6-7 on Beaufort scale (strong breeze to near gale). The maximum wind speed was reached when the ship was approaching the northern end of Bay of Biscay having force 8 on Beaufort scale (gale).

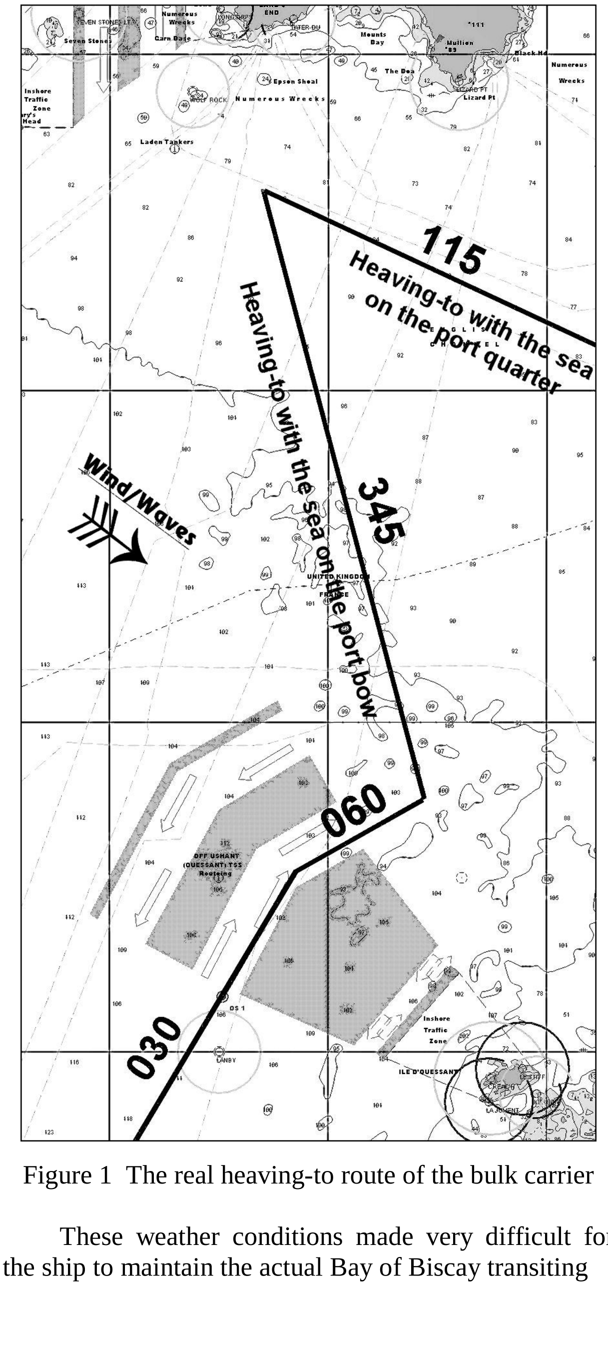

Figure 1 The real heaving-to route of the bulk carrier

These weather conditions made very difficult for the ship to maintain the actual Bay of Biscay transiting course and anticipated a very dangerous situation at the moment when the ship will have to alter course to go around Ushant Is. for entering the English Channel (Ayaz et al. 2006). Usually, in good weather conditions, such a ship is passing the Bay of Biscay in 28 hours with a speed of 12 knots. In the given weather conditions we sailed the same distance in 37 hours due to the heavy drift and necessity of reducing speed for lowering force of the waves impact.

When we tried to make the required course alteration once near Ushant Is. the ship started to roll violently due to the high waves and wind that now where from our beam (Soares et al. 2002). When we tried to proceed in true course 500-600 the ship manoeuvrability dangerously decreased the rolling in-creased, mainly on the starboard side and for a few times we were in danger of broaching.

Being afraid to loose steering control (EMSA 2008, Bitner-Gregersen & Eknes, 2001) we used the full engine power for altering course to NNW to-wards the England south coast for heaving-to with the sea on the port bow. After 8-9 hours we alter course again towards ESE (true course 1100-1200) and proceed again in the English Channel heaving-to this time with the sea on the port quarter (Matsumo-to et al. 2005, Cai et al. 2014).

The bulk carrier voyage after Ushant is shown in figure 1. The total duration of this part of the voyage was of about 19 hours and total distance sailed was of almost 120 NM.

Years after this real event we had the idea to transpose on a DNV class A navigation simulator the bulk carrier situation and to analyse the environmental hydrostatic forces and ship's motion parameters in that weather conditions (Moiseenko et al. 2013).

2. THE SIMULATION SCENARIOS

For performing the simulations the following conditions where imputed:

- Own ship (OS) is a bulk carrier with the following characteristics: LOA 261.3 m, breadth 48.3 m, slow speed diesel 15500 kw, one FPP.
- OS is in "heavy ballast" loading condition (100% ballast on board);
- The ship is trimmed by stern (-2 meters);
- Wind direction is North-northwest, rotating towards west-northwest;
- Wind force (Beaufort scale) is 7 and increasing to 8;
- Wave high 4-5 meters, increasing to 6-7 meters. The waves have the same direction with the wind;
- Sea state: moderate to high waves, later very high waves;
- Own ship (OS) speed 7-8 knots in the beginning than decreasing to 4-5 knots

The simulator's functionalities are still limited, especially when it comes to the dynamic of the air masses (Brodtkorb, 2004). The present situation was complicated by the fact that the wind is changing direction over the time.

At the beginning we tried to recreate only parts of the real voyage in order to shorten as much as possible the time of the simulation that was intend to be done in real time. So we divided the real voyage in three different parts:

The bulk carrier attempt to alter course for entering the English Channel using the required TSS from Ushant Is. (true courses 0300-060o);

The heaving-to with the sea on the port bow towards North with deviations towards NNW for avoiding the high waves and reducing the large drifting produced by the beam blowing wind;

The reattempt for entering the English Channel with a south-eastern course (1100-1200).

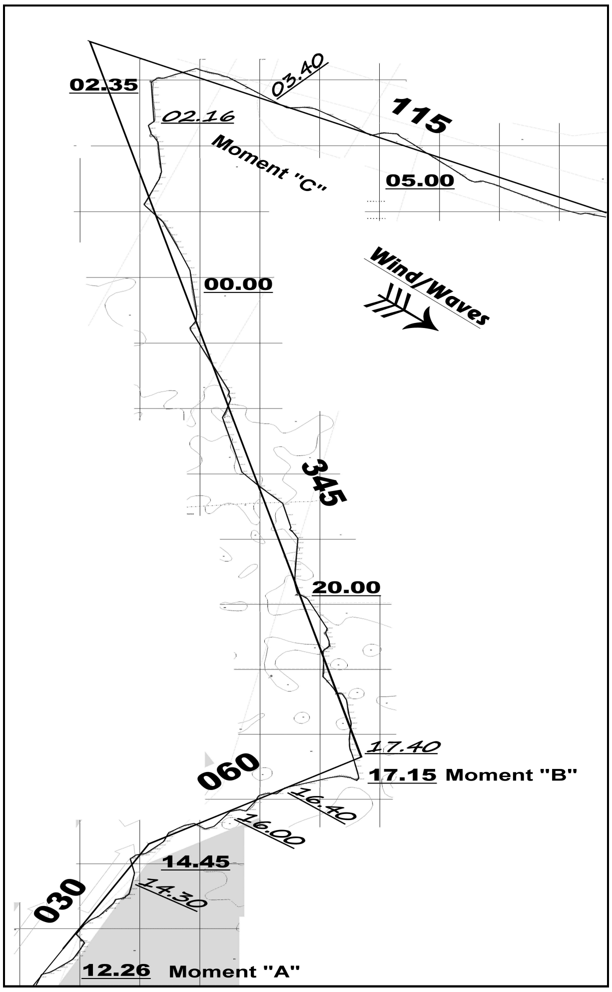

Figure 2 The simulated route
(117 NM, 17.5 hours)

We also decided that the parameters of interest (Bardur et al. 2010, Shiotani S., 2008) that should be monitored will be:

- The pitching moment (t •m),;
- The rolling moment (t •m);
- The rolling angle (0);
- The rolling period (sec.);
- The drifting angle (0).

After running each of the above simulations for 3 times in real time we saw that can be same significant differences between the values of the monitored parameters. So we decide to run only one simulation but for all the 120 NM sailed in reality by the bulk carrier.

Due to the very long simulation time (the final result was of 17.5 hours) we should done most of the simulation with accelerated time (x10) and to work in real time only in the moments when we manually steer the ship for reducing the cross track error ac-cumulated and to try to come back to the planned route. The simulation result cannot be identically replicated during another simulation because it is impossible to steer the OS exactly in the same manner during another similar simulation. The track of own ship during simulation is shown in figure 2.

3. SIMULATION RESULTS

After the simulation we compared the hydrostatic and OS motion parameters from the moment when the own ship alter course to enter the Ushant TSS (defined as moment “A”) with the same type of parameters obtained after OS took the course for heaving-to with the sea on the port bow towards north (defined as moment “B”) and later towards east-southeast (defined as moment “C”). On the ESE course of approx. 1150 we were heaving-to with the sea on the port quarter and were confirmed to be the easiest way to proceed further on the English Channel. In figure 2 we have marked the time for moments A, B and C.

We draw graphs of the above mentioned parameters for all the simulation time and after that we identified the most interesting and representative moments (time intervals) of the heaving-to sail.

These time period that we finally choose for a de-tail analyses are:

- 1st time interval: 14.30 – 16.00
- 2nd time interval 16.40 – 17.40
- 3rd time interval: 02.16 – 03.40

In figure 2 are also marked (italic letters for time) these hours that are defining the time interval for analysis. In figure 3 we have details of the own ship track during simulation on the above mentioned time intervals.

3.1 Analysis of hydrodynamic parameters

3.1.1 The Rolling moment

The rolling moment has variable values with positive and negative maximum values (port side/starboard side) +/- 50000 (t•m) at 14.40, the moment when the ship was on her way towards Northeast. In the moment in which altering course was performed for the entrance through the English Channel, in true course 060°, at hours 14.46, we notice a high progressive increase of the rolling moment at 14.48.15 of approximately 140000 (t•m) for it to reach the maximum negative value of – 102581 (t•m) in a 20 seconds interval at 14.48 35.

Transfer from one board to the other is performed rapidly, high values of the rolling moment being noticed at 14.56.10 with the value of 103329 (t •m), at 15.03.30, -78339 (t•m).

A maximum value on the starboard side is reached at hours 15.37.50, with the value of 250875 (t•m) corresponding moment for the ship’s trial to maintain the course between 055°-065°. Rapid changes of the values of the moment show a high rolling movement, violent one, not allowing the ship to stay on course.

Further on, the values of the rolling moment vary within the limit of +70000 /- 80000 (t •m). Values continue to be high, with high oscillations port side/ starboard side up to hours 17.15 when the ship, after passing a maximum rolling moment at 17.14, with an approximate value of -105000 (t •m) and + 65000 (t •m), altered course to NNW, in a true course be-tween 345°-355°.

Moment B starts at hours 17.15 and the chosen interval for the analysis was the one between 17.15 and 17.40. Change are noticed in values, the great majority within the limit of -/+ 20000 (t•m), with a positive and negative maximum value at 17.24 (+55000/-51000 t •m), as a result of the fact that the ship is not able to maintain the exact course of 345°.

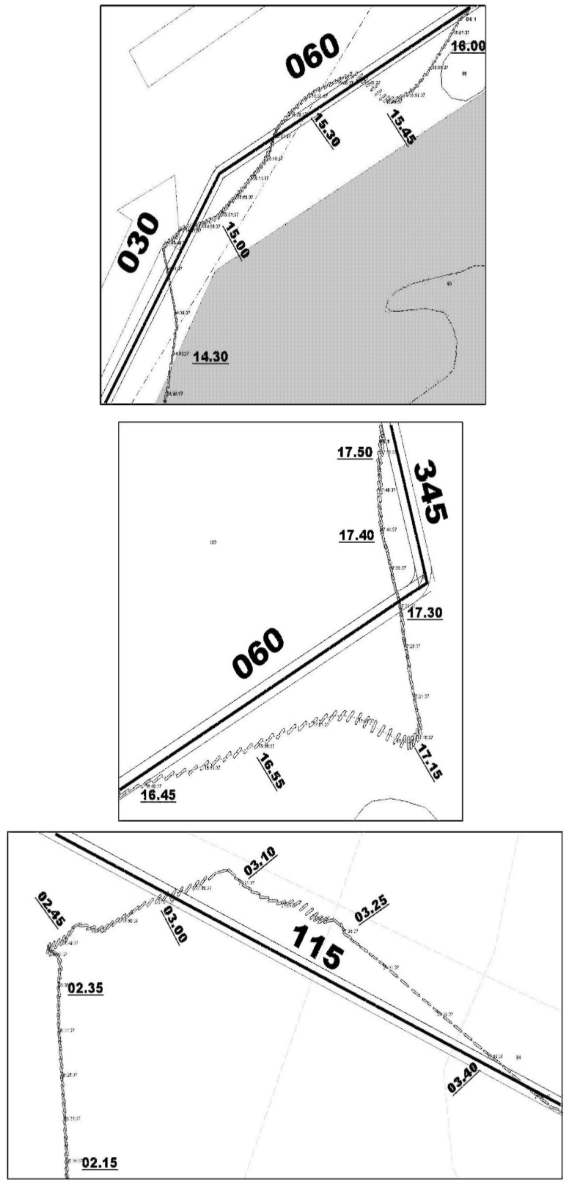

Figure 3 Details of the OS track during simulation

Wind and waves from port bow have the tendency of pushing the bow of the ship to starboard and the situation in which the value of the rolling moment is higher on starboard side or port side is due to the ship being adrift, orientating the ship on a NNE and NE direction, which makes the value of rolling to increase by the action of wind and waves directly from abeam (Myrhaug Dahle, 1994). During the simulation for moment B there were no high values signaled for the rolling moment. Anyway, the maximum values registered are way under those for the first time period.

Moment C happens between 02.36 – 05.00 and the chosen interval for the analysis is 02.16 – 03.40. (time 02.16 corresponding to moment B) .

As we can notice from the figure 3, representing the entire route of the ship, at hours 02.16 the ship was on her way to North, close to changing to ESE.

In the period 02.16 - 03.08 the ship altered course progressively from 115°. One can notice the values of the rolling moment, most of them around the values of +/- 50000 (t•m), with maximum values from -170000 at +160000 (t•m) at hours 02.59.30 and -145000 (t•m) at 03.08.00. After altering course to ESE, the diagram of the rolling moment presents most of the values below the limit of +/- 20000.

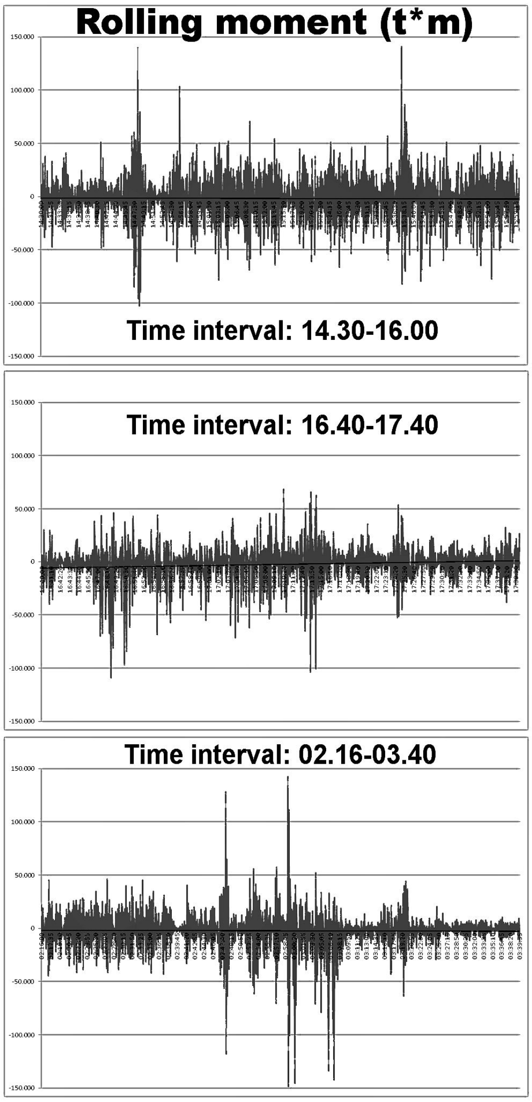

Figure 4 The Rolling moment

We may say that at hours 03.26 the ship was stabilized on the course of 115°, in which the values of the rolling moment are very low, comparatively with the values registered in moment A. Compared graphs for the rolling moment in all three time periods analysed are shown in figure 4.

3.1.2. The Pitching moment

The Pitching moment illustrated for the three moments in figure 5 is analysed for the same time intervals.

In the interval of analysis 14.30- 16.00, we observe high values of the pitching moment in the interval 14.52 – 14.55, with maximum values of +400000 (t•m) / - 400000 (t•m), and afterwards for approximately 30 minutes the majority values are maintained below +/- 100000 (t•m).

Other maximum values are registered in the interval of 15.41 and 15.45, from +550000 (t •m) at – 640000 (t •m). If we observe the same interval for the rolling moment, we notice that its value is not so high.

The maximum positive moments of the pitching moment alternate with the maximum values of the rolling moment. The ship has continuous movements cause by rolling and then pitching. Up to hours 17.15, when the ship changes course to NNW, in true course 350°, very high maximum values are registered at hours 16.50 with + 1100000 (t •m) and 17.06 with – 1100000 (t •m).

For moment B, starting at hours 17.15, analysis interval 17.15- 17.40, a pitching moment is indicated with very low values, the great majority under the value of 100000 (t•m) (t•m). For the same time interval, it is noticed that the rolling moment has high values, analyzed above for moment B.

Practically, low values of the pitching moment indicate the fact that the ship shall not go violently “up” and “down” on the wave from port bow (Tucker & Pitt, 2001), what actually happened for the change of course to NNW at hours 17.15. The ship has no high pitching but rolling is still affecting the ship.

At moment C we would have expected for the values of the pitching moment to be even lower than those from moment B, considering navigation in true course of 115°, with wind and wave from aft port beam (heaving to with the sea on the port quarter). As it can be observed from the resulted diagram, the values are initially good, below 100000 (t•m), in the interval 02.16- 02.39, which makes us think that except for the moderate rolling, the pitching is almost inexistent.

A maximum of 02.39 is reached with the values of +1500000 (t •m) and – 1500000 (t•m) after which values decrease. Interpreting values for moment C we observe that even though the manoeuvre for altering course to ESE, with wind and wave from port quarter is the most indicated one, the ship continues to experience pitching movements, alternated with rolling movements. Their values are sometimes higher than those from moment A and B, but the ship is not able to sail only towards N (moment B) when the values of the pitching moment are very low.

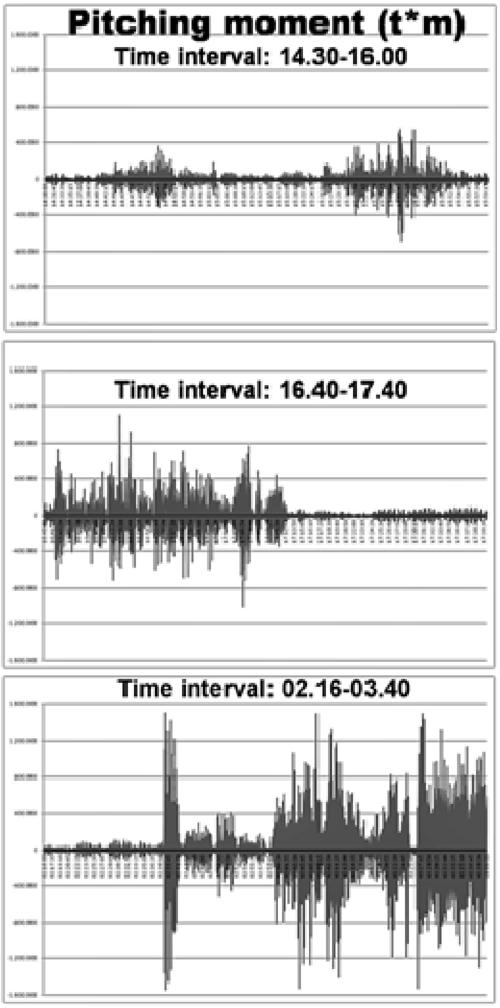

Figure 5 The Pitching moment

3.2. Analysis of ship motion parameters

3.2.1 The Roll angle

Analysis of the roll angle presented for the three time periods in figure 3.4, leads us to the following conclusions.

For moment A (analysed between 14.30 – 16.00) the values of roll angle are maintained between + 10° (14.48) and – 16° (15.37), with predominant values between + 5° and + 10°, listing on the port side being very small.

This means that the ship is rolling more on starboard side, the values of the angles on this side are higher, which is only natural when considering the fact that the wind and wave hit from port side.

This becomes even more visible for the interval 16.40 – 17.15 (which is part of moment A), where values of the rolling angles are increasingly on starboard side from + 12° to zero degrees, practically the ship rolling only on this side. It the sector in which the ship is on true course 060°, in which the influence of wind and wave abeam are maximum ones.

Rolling is violent both in the interval 14.30 – 16.00 and afterwards, till the ship altered course to NNW, in 345° - 350°.

Moment B, analysed from 17.15 to 17.40, time in which the ship was on her true course 345°- 350°, presenting us a decreasing rolling, with maximum values of +7°/- 6°(17.24), the rest of the values being below 5°, the great majority on starboard side. A more intense rolling is observed on starboard side rather than on port side.

Referring to the rolling moment, one may notice that it has a higher value between 17.24 and 17.25, corresponding to a high value in the same period for the rolling angle.

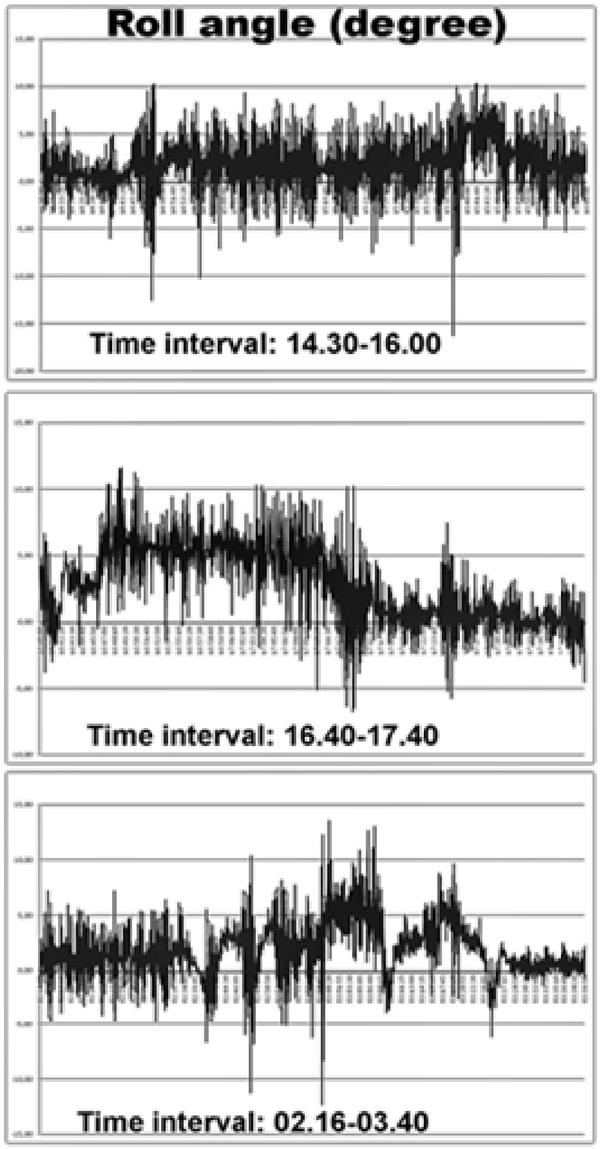

Figure 6 The Rolling angle

In a true course of 350° the ship's rolling is lower, predominantly on starboard side but it doesn't affect the ship's course stability, as it can be noticed in figure 3, where the ship was not deviated too much form the established course.

As in the case of the rolling moment, we expected that the roll angle would have low values (GDV, 2015) once the course is altered to ESE, at moment C. As it can be noticed in the analysed interval, the values of the roll angle start to go frequently over

5°, with maximum values of +7°/-5° (02.27), ending with the value of +12°/-12° (02.48) when the ship is on her way back towards ESE.

As the turning is made from 350° to starboard side towards 115° (a change which is quite high, 125°) it is expected for the courses of 035-070 the roll angle to be higher, as a result of the exposure of the port side to the beam wind and waves.

It is observed that the roll angle predominantly on starboard side, in the interval of 03.00-03.08 the ship being listed to starboard side. Roll angle reaches low values after 03.27, rolling moment reaches low values, and the ship is on course ESE, stable in 115°.

3.2.2 The Roll period

Roll period presented for the three moments in figure 7 is maintained within values of over 8 seconds for all situation with maximum values for moment A of 14 sec at 15.36 and 15.40 and then over 14 seconds at 16.51 and 17.08, for moment B almost 14 seconds at 15.30 and for moment C almost 16 seconds at 03.08 and 03.33.

Values around 12 seconds are maintained in moment A for a long period of time, from 14.50 and up to the end of the analysed period at hours 16.00. For moment B, values change from 8 seconds to 12 seconds and for moment C the great majority is represented by the values which are over 10 seconds.

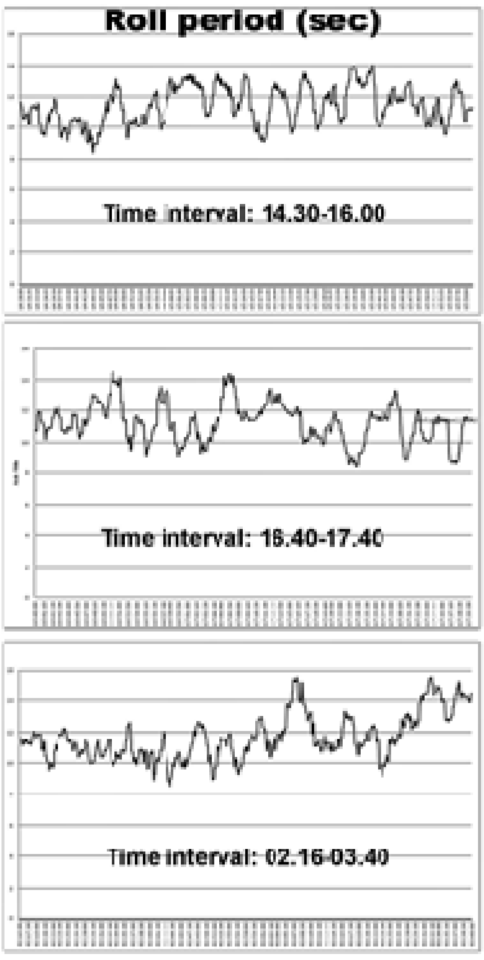

Figure 7 The Roll period

Roll period is in a direct connection with the position of the ship's metacentric height. Roll period with similar values with those resulted from the simulation is specific for bulk carriers whose metacentric height is high and the centre of gravity is low, especially in ballasting situation (Dahle et al., 1988), which induces accelerations and high loads on the ship's structure, with notable negative effects in some cases.

3.2.3 The Drift angle

Drift angle presented for the three moments in figure 8 may be estimated and only through simple analysis of figure 3.1, where the ship's course is presented. High alterations of the course are noticed, especially for moment A, in which maximum values reach - 80° (15.44) and -100° (17.12), which imposed an alteration of the course from hours 17.15.

After the alteration, at moment B it is noticed that the ship is maintained on the desired course for a period of time (true course 350°), with alterations of +10°/-15°. Anyway the ship is more stable on the course of 350°, alterations at starboard side / port side being influenced also by decreasing speed. There were situations in which speed decreased be-low the limit value for governing the ship, the ship being deviated, especially to starboard side situation experienced also by other authors (Popescu & Varsami, 2009).

For the last part of the road, moment C, deviation is maintained, with maximum values of +42°/-80° but these correspond to the moment in which the ship's speed decreased below the limit of governing the ship and there was a period of time which passed till the ship succeeded to get back on course (IMO, 2007).

Even if navigation is performed with wind and waves from port quarter, the ship's stability on course is not the best one, which is prove also by the other analysed parameters (House, 2007).

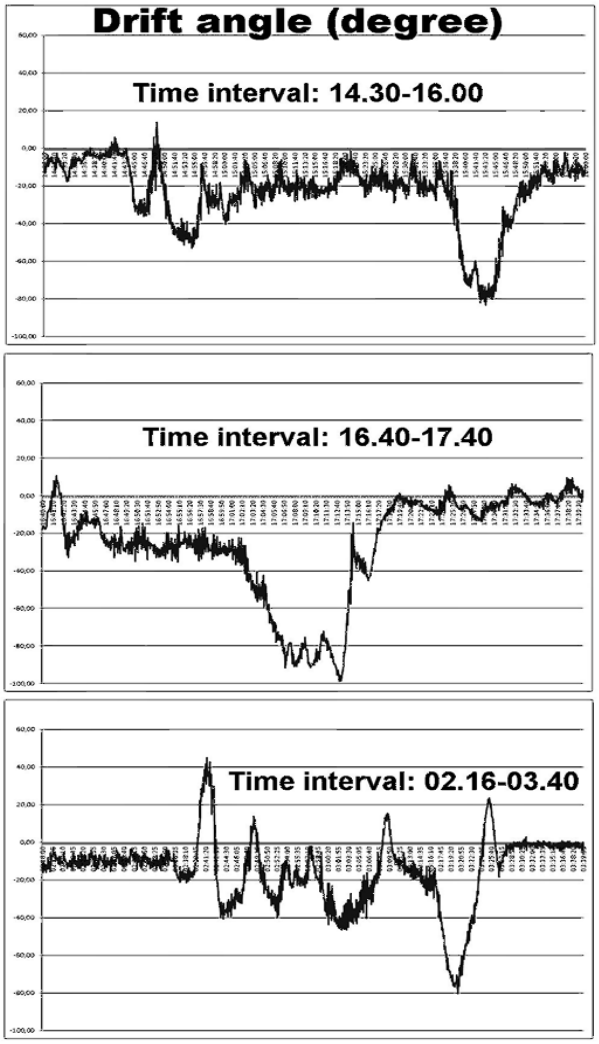

Figure 8 The Drift angle

4. CONCLUSIONS

The navigation simulator allowed us to analyze a series of parameters given by exterior forces, the analysis of which helps us to have a general view over the ship's behavior on the chosen course.

As it can be noticed, the ship had an improved behavior in moment B, in which the ship went on course towards NNW, with wind and waves from port quarter.

Probably this was the only solution for reducing the overstress on the ship's hull, the imposed maneuver of the impossibility of entering the English Channel, in true course 065°. Plus, the ship reached a position allowing her to turn towards ESE, in such a way to receive wind and waves from port quarter. According to diagrams, not always navigation with wind and waves from the stern, starboard side and port side is the most quite one, which is demonstrated by the registered values especially after moment C. In other words, not all parameters have normal values, if roll angle or roll moment are low values at a given moment, pitching moment reaches high values or drifting is high.

Anyhow is quite interesting for a Master to see and understand after such a simulation the physical explanation (Vlachos & Nikolaidis, 2002) for the hard moments experienced in real life years before, moments that marked his professional experience.

5. REFERENCES

[1]Allianz Global Corporate & Specialty, *Safety and Ship-ping Review*, Munich, Germany, 2013

[2] AYAZ, Z., VASSALOS, D., SPYROU, K.J., *Maneuvering behavior of ships in extreme astern seas*, Ocean Engineering, 2006

[3] BARDUR A.N., SIMONSEN K., MAGNUSSON A.K., *Wave forecasts and small-vessel safety: A review of operational warning parameters*, Marine Structures 23, 2010

[4] BITNER-GREGERSEN EM, EKNES, M., *Ship Accidents due to Severe Weather*, DNV report, 2001.

[5] Brodtkorb PA., *The probability of occurrence of dangerous wave situations at sea*, Department of Marine Technol-ogy, Faculty of Engineering and Science and Technology, Norwegian University of Science and Technology, 2004.

[6] CAI Y., WEN Y., WU L., *Ship Route Design for Avoiding Heavy Weather and Sea Conditions*, TransNav-the International Journal on Marine Navigation and Safety of Sea Transportation Volume 8, Number 4, 2014.

[7] DAHLE, E.A., MYRHAUG D., DAHL, S.J., *Probability of capsizing in steep and high waves from the side in open sea and coastal waters*, Ocean Engineering, 1988.

[8] European Safety Maritime Agency (EMSA), *Maritime Accident Review*, 2008.

[9] GDV, 2015, Die Deutschen Versicherer – Container Hand-book,- *Causes of damage/loss during transport-Mechanical stresses in maritime transport,* Berlin, Germany

[10] HOUSE D.J., 2007, *Ship Handling- Theory and practice*, Lon-don, UK, ISBN: 978-0-7506-8530-6

[11] IMO, *Revised Guidance to the Master for Avoiding Dangerous Situations in Adverse Weather and Sea Conditions*. MSC.1/Circ.1228, 2007.

[12] MATSUMOTO K., TANAKA Y., HIROTA K., *Reduction of wind forces acting on ships*, Proceedings of the ICMRT Conference, Ischia, Naples, 2005.

[13] MOISEENKO, S., MEYLER, L. & FAUSTOVA, O., *Prognostic Estimation of Ship Stability in Extreme Navigation*, Marine Navigation and Safety of Sea Transportation: Maritime Transport & Shipping, 2013.

[14] MYRHAUG, D., DAHLE, E.A., *Ship capsize in breaking waves, Fluid structure interaction in offshore engineering,* Southampton, UK, Computational Mechanics Publications, 1994.

[15] POPESCU, C., VARSAMI, A., *The Influence of Parametric Rolling on Port-Container's Ship Stability*, Analele Universității Maritime Constanța, Anul X, Vol. 12, ISSN 1582-3601, pag. 153-158, Constanța, România, 2009.

[16] RODRIGUEZ, G., SOARES, C.G., PACHECO, M., PEREZ-MARTELL, E., *Wave height distribution in mixed sea states, Journal of Offshore Mechanics and Arctic Engineering-Transactions of the ASME*, 2002.

[17] SHIOTANI, S., Navigational Simulation Using Tidal Simulation and Tidal Effects on Sailing Ship, 2008.
[18] SRIVASTAVA, S. D., *IMO's Activities on Ship Maneuverability*, MARSIM'93 International Conference on Marine Simulation and Ship Maneuverability, St. John's, Canada, 1993.
[19] TUCKER, M.J., PITT, E.G., *Waves in ocean engineering*, Elsevier Science, 2001.
[20] VLACHOS G. P., NIKOLAIDIS E., *Analysis of Primary Causes Concerning Shipping Safety – Owner's and Ship master's point of view*, Annual Conference of International Association of Maritime Economists-IAME, Panama, 2002.

ARCTIC NAVIGATION AND THE METEOROLOGICAL MARITIME SAFETY INFORMATION

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ABSTRACT

The climate model projections of ice reductions lead to the idea that new trans-Arctic shipping routes linking the Atlantic and Pacific Oceans could be open. In order to support and enhance the polar components of GMDSS five new METAREAs have been established by IMO in 2011. The responsibilities for the issuing and transmission of the meteorological marine safety information are presented in this paper.

Keywords: *Arctic routes, marine safety information, meteorological bulletins, Metareas.*

1. INTRODUCTION

The maritime safety information services of the GMDSS form a network of broadcasts containing information which is necessary for safe navigation. Common standards are applied to the collection, editing and dissemination of this information. The main methods for broadcasting maritime safety information are in accordance with the provisions of the International Convention for the Safety of Life at Sea are NAVTEX and SafetyNET.

Navigation near but outside of the ice and ice navigation needs proper support both for safety and efficiency in terms of regular provision of complex sea ice information. Starting with June 2011 the new five Arctic METAREAs are put into a Full Operational Capacity with new procedures to support ice edge information in SafetyNET and NAVTEX bulletins and a special "ice" GMDSS server to support exchange of information between the Preparation Services.

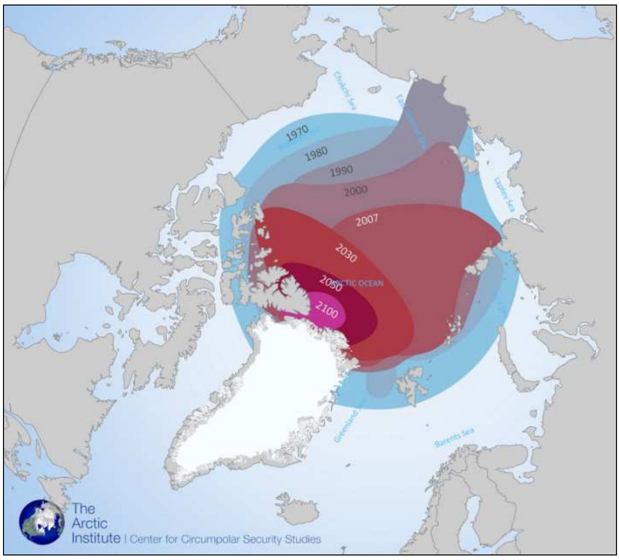
2. CLIMATE CHANGE AND THE ARCTIC ROUTES.

The climate model projections show that future changes of ice extent will increase the Arctic shipping potential. Since 1979, due to satellite multichannel passive microwave imaging systems it has been possible to monitor the extent of sea ice with a good temporal resolution. The 34-year satellite record is long enough to allow determination of significant and consistent trends of the time series of monthly anomalies (i.e., difference between the monthly and the averages over the 34-year record) of ice extent, area and concentration [2].

The overall trend observed in the Arctic is a decreasing of late-summer sea ice extent (fig. 1). The six lowest years on record occurred since 2007.

Climate model projections indicate that this overall trend will continue, leading to a seasonally ice-free Arctic Ocean later this century [5].

Generally Arctic sea ice reaches its maximum seasonal extent in February or March whereas the minimum occurs in September at the end of summer melt. The average ice extent varies between about 6 × 10^6 km^2 in the summer and about 15 × 10^6 km^2 in the winter [2]. The summer ice cover is confined to mainly the Arctic Ocean basin and the Canadian Arctic Archipelago.



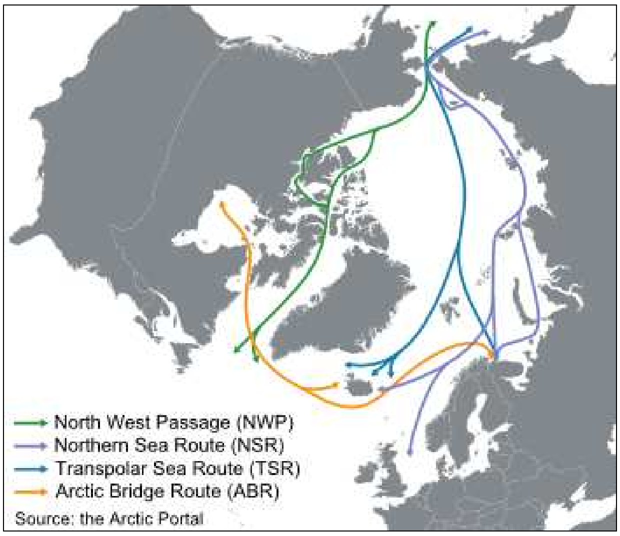


Figure 1 The decreasing trend of the sea ice extent in the Arctic (upper fig.) and the new Arctic routes (down fig.), [11], [12].

Changes in decadal averages in Arctic ice extent are more pronounced in summer than in winter. The summer minimum extent was at a record low in 2012 following an earlier record set in 2007 [8], [4].

Other significant aspects of the ice extent are the thickness and the drift of the sea ice. The techniques used for estimating the thickness distribution of sea ice are the submarine sonars, the satellite altimetry and airborne electromagnetic sensing. According to the IPCC Assessment Report, 2013, they all provided broadly consistent and strong evidence of decrease in Arctic sea ice thickness in recent years. Ice thickness is influenced by ice motion through deformation and creation of open water areas, through advection of ice from one area to another and through export of ice from polar seas to lower latitudes where it melts. Winds and surface ocean currents are the main causes of ice motion. Ice drift also depends on ice strength, top and bottom surface roughness and ice concentration. The decreases in both concentration and thickness reduce sea ice strength, reducing its resistance to wind forcing [5], [7].

The conclusions of the IPCC report published in 2013 show that the Arctic has changed substantially since 1979: between 1979 and 2012, Arctic Sea Ice extent declined at a rate of 3.8% per decade with larger losses in summer and autumn and that the mean sea ice thickness decreased by 1.3-2.3 m between 1980 and 2008.

THE ARCTIC ROUTES

These findings have important economic, strategic, environmental, and governance implications for the region. From the navigability point of view, these climate projections have led to the draft of shorter international shipping routes linking the Atlantic and Pacific Oceans (fig.1).

The *Northern Sea Route* connects the Atlantic and Pacific oceans, traversing the Arctic following Russia's and Norway's coasts. This route is defined in Russian legislation as the set of Arctic marine routes between Kara Gate in the west and the Bering Strait [1]. The main constraint to navigation is due to the presence of narrow straits: the Yugorskiy Shar Strait, 13-30 m deep and the Kara Gate with a minimum depth of 21 m and an established traffic separation scheme, both straits between the Barents and the Kara seas; the Vilkitskiy Strait, ice-covered except for a short period in some, a key NSR strait between the Kara and Laptev seas [1]; Shokalskiy Strait, a possible shipping route between the Kara and Laptev seas. Other straits are: the Dmitry Laptev Strait, oriented E-W, a passage between the Laptev and East Siberian seas, with traffic restrictions in the eastern part due to small depths; the Sannikov Strait, between the Laptev and East Siberian seas and Long Strait between the East Siberian and Chukchi seas.

The most important marine route distances are: from Murmansk to the Bering Strait - 3,074 Nm; from Kara Gate to the Bering Strait - 2,551 Nm; the Dudinka to Murmansk marine route - 1,343 Nm, this route being maintained year round [1]; it is approximately 500 Nm between the offshore region of the Pechora Sea (site of new oil terminals) in the southeast corner of the Barents Sea and Murmansk.

The *Northwest Passage* is the sea route through the Arctic Ocean, along the northern coast of North America via waterways through the Canadian Arctic Archipelago (fig. 1). It became open to ships without the need of an icebreaker in August 2007 and it opened again in August 2008. The operating season is short - from late July to mid-October, depending on the route and year.

All passages have common eastern and western approaches. In the east, ships must proceed through the Labrador Sea, Davis Strait and Baffin Bay.

In the western approaches, ships proceed through the Bering Sea, Bering Strait, the Chukchi Sea and the Beaufort Sea before deciding which route to follow.

The Northwest Passage (NWP), arguably the most historically famed of potential shipping routes through the Arctic, had the lowest navigation potential but will open substantially by 2040–2059 [6].

According to the Arctic Marine Shipping Assessment, only routes 1* and 2** are considered deep water ones, while the others have shoals and rocks that restrict the draft of vessels to less than 10 m [1].

**route 1: Lancaster Sound – Barrow Strait – Viscount MelvilleSound – Prince of Wales Strait – Amundsen Gulf.*

***route 2 is the same as 1, but substitute M'Clure Strait for Prince of Wales Strait and Amundsen Gulf.*

The *Transpolar Sea Route* is a future Arctic shipping lane running from the Atlantic Ocean to the Pacific Ocean across the center of the Arctic Ocean (fig.1). In contrast to the previous routes, it avoids the territorial waters of Arctic states and is therefore considered high seas. It is the shortest of the Arctic shipping routes but currently only navigable by heavy icebreakers. Due to high seasonal variability of ice conditions throughout the entire Arctic basin, the TSR will not exist as one fixed shipping lane, but will follow a number of navigational routes. The TSR does not follow the shallow Siberian coastal shelf, so there would be only few draft restrictions [4].

Arctic shipping via the TSR will be regulated in accordance with the two main IMO treaties, SOLAS 1974 and MARPOL 1973/1978 and other IMO instruments, e.g. among others, COLREG 1972, London Convention 1972, STCW Convention 1978/1995 and the new mandatory Polar Code* [4].

**The Polar Code is an international code of safety for ships operating in polar waters and covers the full range of design, construction, equipment, operational, training, search and rescue and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the two poles. The Code was adopted by IMO's Maritime Safety Committee (MSC) in November 2014. The Polar Code will be mandatory under both SOLAS and the International Convention for the Prevention of Pollution from Ships (MARPOL)* [14].

The *Arctic Bridge* is a seasonal sea route linking Russia to Canada, specifically the Russian port of Murmansk to the Hudson Bay port of Churchill, Manitoba. The route passes in proximity of Iceland’s waters and could further enhance the island nation’s strategic location in the middle of the Northern Atlantic.

The concept of an "Arctic Bridge", with a hub in Churchill, was proposed by Canadians in the early 1990s. On 17 October 2007, the first shipment of fertilizer from Murmansk arrived at the Port of Churchill. Two separate 9000 tonnes imports of Russian fertilizer took place in 2008, purchased by the Farmers of North America cooperative of Saskatoon from Kaliningrad.

3. METEOROLOGICAL MARINE SAFETY INFORMATION FOR THE NEW METAREAs.

In order to insure marine safety information for ships in the Arctic region, the International Maritime Organization established five new METAREAs covering this area. The new METAREA XVII, XVIII, XIX, XX and XXI limits can be observed in fig. 2.

In July 2010, EC commenced issuing meteorological Maritime Safety Information for these areas on a test basis. Final expansion to remaining waters has been accomplished as scheduled for the 2014 Arctic shipping season.

Figure 2 Limits of the new 5 METAREAs in the Arctic region [13].

METAREA XVII and XVIII

Starting with July 2012, Environment Canada expanded marine forecast service to METAREA XVII and XVIII.

The new marine forecast zones in METAREA XVII are generally located west and north of the Canadian Exclusive Economic Zone boundary while the new marine forecast zones in METAREA XVIII are generally located east and south of this zone boundary (fig. 3).

Meteorological Maritime Safety Information (met MSI) for these new zones and other waters within METAREA XVII and XVIII are promulgated by Environment Canada in accordance with the joint IMO/IHO/WMO Maritime Safety Information Manual.

During the navigation season MSI for sections of METAREA XVII and XVIII south of 75° latitude will be broadcast via Inmarsat-C SafetyNET. For high Arctic waters north of reliable Inmarsat coverage, dissemination is via HF NBDP from the Canadian Coast Guard station in Iqaluit NU. NAVTEX coverage to some coastal zones within range of NAVTEX transmitters is provided by NWS (northern Alaska coast) & DMI (western Greenland coast).

Because of the fact that, within METAREA XVII/XVIII, SafetyNET service north of 76° N is beyond the northern extent of Inmarsat’s signal coverage, for promulgation of met MSI, the Canadian Coast Guard publications specify that: “During the navigation season met MSI for sections of METAREA XVII and XVIII north of 70 degrees latitude will be broadcast via HF Narrow Band Direct Printing on 8416.5 kHz from the Canadian Coast Guard (CCG) centre in Iqaluit NU […]“.[10].

However, CCG does not guarantee HF signal coverage west of 141° W or for a portion of the METAREA north of Greenland, which corresponds to the western and eastern limit of CCG's assigned SAR.

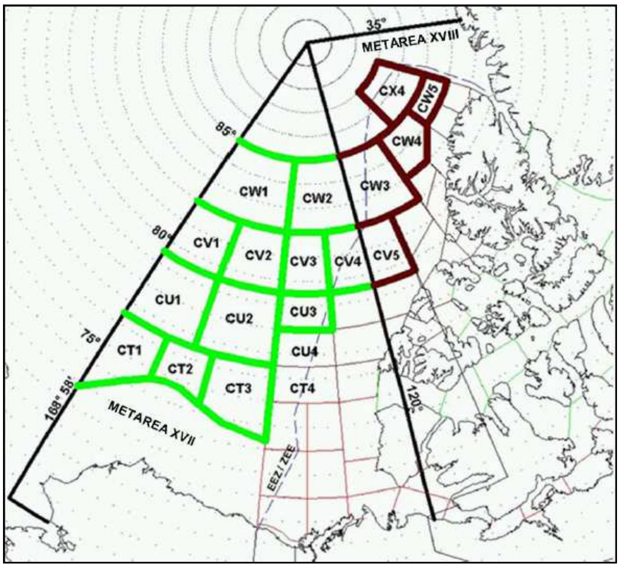


Figure 3 METAREAs XVII and XVIII [8]

METAREA XIX

Starting with 2011 the Norwegian Meteorological institute took the responsibility as preparing and issuing institute for MSI messages in METAREA XIX (fig. 4). GMDSS MSI messages for METAREA XIX have been prepared and issued twice daily [9].

The ice edge representation in the forecasts was established through a coordination between Canada, Norway and Russia. Norway and Russia are exchanging the ice edge coordinates in METAREAs XIX and XX on a regular base to ensure the consistence in ice conditions on the border between the areas. Also Norway and UK agreed that ice edge coordinates for METAREA I (under the responsibility of UK) are produced by MET Norway and distributed.

METAREAs XX and XXI

The preparation service for these areas is the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). Since June 2011 SafetyNET component within METAREAs XX and XXI is in a "Full Operational Capacity" in accordance with the IMO/IHO regulations. The SafetyNET bulletins and warnings are prepared and broadcast twice a day at 0600 UTC and 1800 UTC via INMARSAT and at 0715 and 1915 via HF NBDP (from April 2013).

The MSI content of the bulletins is coded in accordance with the latest additions to the World Meteorological Organization report no.558, including concept of the 300 nautical miles wide intersection zone to ensure continuity of the ice edge across the boundaries of adjacent METAREAs. A special polar GMDSS ftp/http server (gmdss.aari.ru) is run to support operative circumpolar exchange of information between the analysts of the Arctic METAREAs.

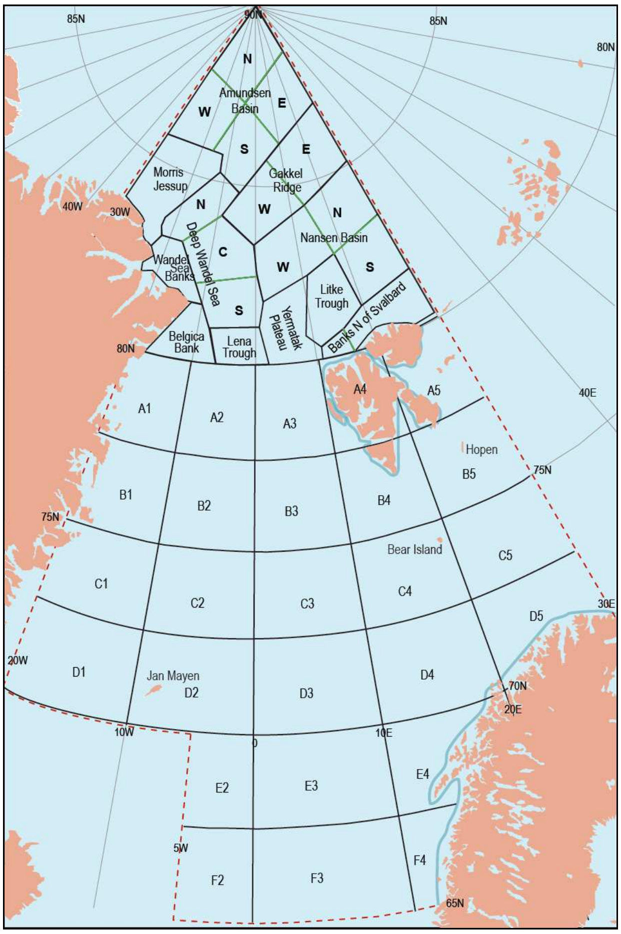


Figure 4 Limits of METAREA XIX [13].

METAREA XX extends from meridian 31°E (roughly) to meridian 125°E and is divided into 44 weather forecast areas (fig. 5), [14].

METAREA XXI is located between meridians 125°E and 168°58'W and is divided into 26 weather forecast areas (fig. 5).

Both METAREAs cover navigational areas of the Northern Sea Route and are commonly "ice free"* at their southern areas only during the period of mid-summer – end of September with bergy waters** and patches ice in navigational straits possible even at that time.

SafetyNET bulletins for METAREA XX are prepared during the whole year but because there is no navigation within the METAREA XXI from mid-October to mid-July, no SafetyNet bulletins are prepared for this area during that slot of time.

**The term "ice free" generally refers to the absence of fast ice, i.e. continuously frozen surface ice sheet cover. Ice free regions can contain broken ice cover of varying density, often still requiring appropriately strengthened hulls or ice breaker support for safe passage.*

***bergy waters are areas of freely navigable waters in which ice of land origin is present in concentration less than 1/10. There may be sea ice present, although the total concentration of all ice shall not exceed 1/10.*

During other seasons and for other parts of the METAREAs, ice conditions are much harsher and are characterized by the first-year* and old ice** present.

**first-year ice is sea ice of not more than one winter's growth, developing from young ice; thickness 30 cm to 2 m. May be sub-divided into thin first-year ice/white ice medium first-year ice and thick first-year ice.*

***old ice is sea ice which has survived at least one summer's melt; typical thickness up to 3 m or more. Most topographic features are smother than on first-year ice. May be subdivided into second- year ice and multi-year ice.*

The IMO's Maritime Safety Committee (MSC) adopted in 2012 a new mandatory ship reporting system in the Barents Area that entered into force on 1 June 2013. The following categories of ships passing through or proceeding to and from ports and anchorages in the Barents SRS area are required to participate in the ship reporting system, by reporting to either Vardø VTS centre or Murmansk VTS centre: "all ships with a gross tonnage of 5,000 and above; all tankers; all ships carrying hazardous cargoes; a vessel towing when the length of the tow exceeds 200 metres; and any ship not under command, restricted in their ability to manoeuvre or having defective navigational aids" [14].

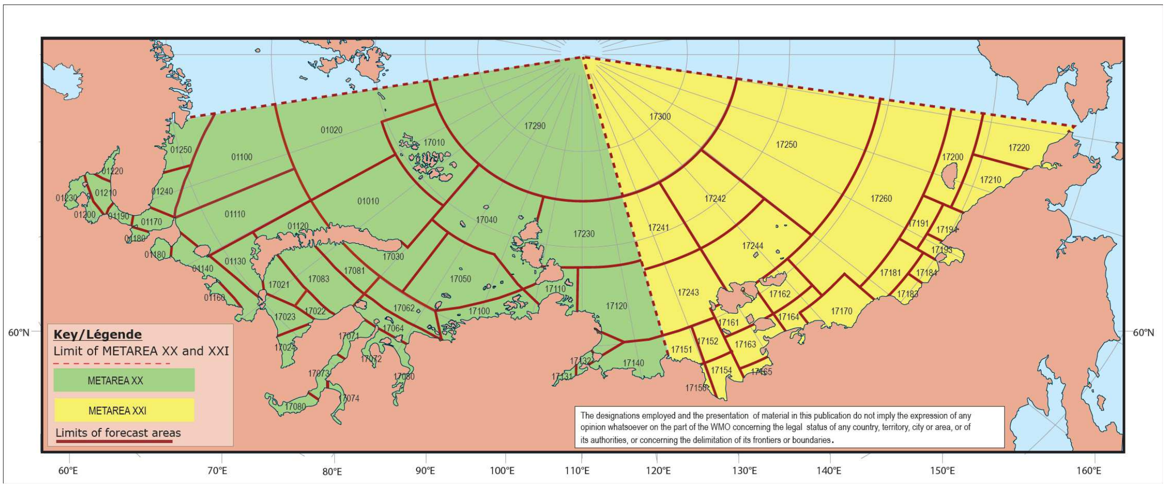


Fig. 5. Limits of forecast areas within METAREA XX and XXI [13].

4. CONCLUSIONS

Marine navigation in the Arctic is challenging during the winter and spring months when ice conditions are heavy.

Other environmental factors that make the Arctic ocean very difficult to navigate compared to temperate waters are the presence and movement of icebergs, cold air and water temperatures, variable and often unpredictable severe weather, magnetic variation, solar flare activity and extended daylight or nighttime conditions.

The arctic sea ice has been observed to be decreasing in extent and thickness, especially at the beginning of the 21st century. The climate projections have led to the draft of shorter international shipping routes linking the Atlantic and Pacific Oceans. For a safe polar navigation in the Arctic there is a need for the same suite of meteorological and oceanographic data, products and services as in other oceans as well as comprehensive information on sea ice and icebergs [1].

Five new METAREAs have been established in 2011 and marine safety information is now consistent with other areas in the world. Forecast of weather and sea conditions also use the same techniques as in other oceans.

The monitoring of weather conditions still has to face a major problem due to the scarcity of the observations.

There are also other limitations for navigation in the Arctic such as the lack of major ports, except for those in northern Norway and northwest Russia, compared with other marine regions of the world with high concentrations of maritime traffic.

5. REFERENCES

[1] ARCTIC MARINE SHIPPING ASSESSMENT, 2009 Report, Arctic Council, 2nd print.
[2] CLIMATE CHANGE 2013 REPORT. THE PHYSICAL SCIENCE BASIS (Working Group I Contribution to the 5th Assessment Report of the International Panel on Climate Change, Cambridge Univ. Press), http://www.ipcc.ch/report/ar5/wg1/
[3] COMISO J. C., PARKINSON C. L., GERSTEN R. and STOCK L., *Accelerated decline in the Arctic Sea ice cover*, Geophys. Res. Lett., 35, 2008.
[4] HUMPERT M., RASPOTNIK A., The future of Arctic Shipping along the Transpolar Sea Route, www.arcticyear book.com, 2012
[5] RAMPAL P., WEISS J. and MARSAN D., *Positive trend in the mean speed and deformation rate of Arctic sea ice, 1979–2007*, J. Geophys. Res. Oceans, 114, 2009.
[6] SMITH L.C., STEPHENSON S.R., *New Trans-Arctic shipping routes navigable by midcentury*, PNAS Plus, 2013, http://www.pnas.org/content

[7] SPREEN, G., KWOK R. and MENEMENLIS D., *Trends in Arctic sea ice drift and role of wind forcing: 1992–2009*, Geophys. Res. Lett., 38, 6, 2011
[8] STROEVE, J., HOLLAND M. M., MEIER W., SCAMBOS T. and SERREZE M., *Arctic sea ice decline: Faster than forecast*, Geophys. Res. Lett., 34, 2007
[9] http://www.jcomm.info/...
[10] http://www.notmar.gc.ca/eng/services
[11] http://www.mccip.org.uk
[12] www.thearcticinstitute.org
[13] www.weather.gmdss.org
[14] http://www.imo.org/MediaCentre/HotTopics/polar/Pages/default.aspx

SECTION II

MECHANICAL ENGINEERING AND ENVIRONMENT

AN EXAMPLE OF ENGINEERING EXPERINCE FROM UNDERGRADUATE COURSE OF THERMODYNAMICS IN CONSTANTA MARITIME UNIVERSITY

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ABSTRACT

Thermodynamics is a discipline dealing with energy in all its forms. It is used in the solving of problems specific to energy systems with major importance in our society, such as transportation systems. In Constanta Maritime University, Thermodynamics is a discipline which is included in the curricula of Navigation and Naval Transport Faculty and Naval Electromechanics Faculty.

Future graduates should be exposed to engineering calculation. In this respect, this article is a presentation of the way in which a practical example in the field of Thermodynamics is solved for the understanding of our students.

More specific, it is presented a calculus specific for the combustion of liquid fuels. The steps to be followed refer to the evaluation of the minimum amount of oxygen, the real amount of air requested for combustion, the amount of fuel consumed during 1h, the amount of air requested by the engine during 1 h and the power needed to compress the air. Students receive different input data, so comparison is possible at the end of the calculus.

Keywords: *students, marine, combustion, calculus methology, thermodynamics.*

1. INTRODUCTION

Constanta Maritime University (CMU) prides itself with over 6,000 students and state of the art learning facilities in the maritime field. CMU welcomes foreign citizens to studies.

The university is a leading member of various maritime associations in the Black Sea Region actively involved in training future marine officers.

THE EDUCATIONAL OFFER IS AS FOLLOWS

Engineers, 4 years of study, full time, offering BSc.degree- and Officer of the Watch Certificates for :

- Marine Engineering (OOW engineer officer) studies in Romanian language and also in English
- Maritime Navigation and Transport (OOW deck officer) studies in Romanian language and also in English
- Electrical Systems (OOW electrical officer) studies in Romanian language

Engineers, 4 years of study, part time offering BSc.degree- and Officer of the Watch Certificates for:

- Marine Engineering (OOW engineer officer) studies in Romanian language
- Maritime Navigation and Transport (OOW deck officer) studies in Romanian language
- Electrical Systems (OOW electrical officer) studies in Romanian language

The university also offers educational programmes in fields connected with the marine industry: Telecommunications and Electronics, Environmental Engineering and Protection of the Environment and Management and Economic Engineering in Transports.

All the programmes grant graduates the Bachelor of Science degree.

Master's Courses (Master of Science degrees) are offered to graduates from the Bachelor's degrees to complete their studies in the nautical field, such as:

- Maritime and Port Management
- Maritime Transport
- Advanced Concepts of Marine Engineering
- Advanced Systems of Electrical Engineering

Doctoral Studies (Ph. D. degree) are the following:

- Naval Mechanical Engineering, full time, 3 years
- Maritime Transport, full time, 3 years

All curricula are authorized by the Romanian Ministry of Education and comply with the provisions of the Bologna Process.

Graduates are certified according to the provisions of STCW Convention (the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) and can be employed on board vessels flying international flags.

Transportation is an important activity all over the world, being obvious that countries or regions being in the possession of a competitive transportation system will have the advantage given by economic benefit [1].

Such a gain can be achieved by technological development with implications on the personnel dealing with it.

Thermodynamics is essential in engineering as it enables the understanding of energy conversion.

In Constanta Maritime University, Thermodynamics is a discipline of study included in the curricula of future marine engineers, which aims to face the challenges of technological development in marine transportation sector.

The goal of Naval Electromechanics Faculty curricula is to create conditions to students to develop their self confidence, to achieve the requested practical competences and to gain design experience [2].

Students enrolled in Electromechanics Faculty and Naval Transport Faculty should have the experience of combustion calculus according to the teaching syllabus of thermodynamics.

At the beginning of the topic, students are familiarized with the theory of liquid fuels and after this it is presented the calculus algorithm. After this, each student receives its own input data.

The calculus is extended on two classes of seminar. During the calculus development students are checked by the professor at each stage. At the end of the calculus experience, results are checked, compared and analyzed.

2. METHODS AND MATERIALS

The part of the seminar dedicated to the theory of fuels is given bellow [3].

Combustion is the process of rapid oxidation of some substances followed by heat release. From a thermodynamic point of view, the combustion process is globally analysed, in other words, the combustion development mechanism, called combustion kinetics which is chemical phenomenon extremely complex, is not studied as well as the intermediary products combustion.

Fuels are substances which through combustion, respectively oxidation, produce quite a quantity of heat and therefore may be used as heat economical sources. For example a wooden piece of furniture, even if it produces heat after burning, may not be considered fuel because it is not an economical heat source but in particular circumstances, wood, itself, may be considered fuel.

By combustion, the chemical energy of fuels is transformed in heat by exothermal oxidation reactions.

A few conditions which should be fulfilled by a substance in order to be considered a fuel are the following:

- to exothermally react with oxygen with high speed and high temperatures;
- products resulted from combustion should not be toxic;
- to be sufficiently spread in nature, therefore to be cheap and not to present different possible more economical usages;
- combustion products should not be corrosive for surfaces which it interacts with etc.

Further on, by the term “fuels”, classical fuels are designated (coal, oil and its refined products, natural gasses etc.).

Fuels’ classification may be performed on one hand according to the aggregation state into solid, liquid and gases, and on the other hand according to their origin into natural and artificial fuels. Further on a few examples are presented:

- natural solid fuels: wood flour, wood, coal (moor coal, pit coal, hard coal etc.), schist fuels, straws;
- artificial solid fuels: charcoal, charred coal, coal briquettes, pellets etc.;
- natural liquid fuels: crude oil;
- artificial liquid fuels: benzene, petrol, black oil, liquefied gasses etc.;

The calculus of the combustion process is performed based on the combustion chemical reactions of combustion elements and it has as a purpose, besides the determination of the resulted heat, on one hand the determination of the quantity of air necessary for such reactions and on the other hand the determination of the volume of gasses resulted from combustion.

The two aspects are very important because if there is not provided enough oxygen, respectively air, combustion will be incomplete, and if too much oxygen is introduced, therefore air, the combustion temperature is lowered because air in excess must be heated and the quantity of resulted combustion gasses is increased.

Knowing the quantity of combustion gasses obtained is essential for dimensioning the tubes for their evacuation, for dimensioning the funnel and for dimensioning the recuperation of heat systems from the combustion gasses [4].

After completing the theory regarding fuels used in marine engines, students face the experience of the calculus.

The formula specific for the calculation of the liquid flues combustion is as given bellow:

The whole group of students receive the enunciation of the calculus as provided in the following.

Enunciation:

The main engine of a bulk-carrier develops a power of P…..hp. The engine has a specific consumption of c_{sp} .... g/CPh. The used fuel is given by its composition as: C=.......%, H = ...%, N =......%, S =.........%, O = ...%.

The air is compressed from its initial state described by P_1...........torrs and 40°C, till P_2 .....barrs.

It is needed the power consumed for the adiabatic compression of the air being known: the air in excess α = ..., the compressors' efficiency $\eta = 0{,}8$ and the adiabatic coefficient $k = 1{,}4$.

Solving:

Next it is presented the calculus methodology:

I. The minimum amount of oxygen „O_{min}”:

$$O_{min} = 1{,}867 \cdot \left[C + 3 \cdot \left(H - \frac{O - S}{8} \right) \right] \quad \left\lfloor nm^3 / kg.fuel \right\rfloor$$

II. The real amount of air „L_{real}”:

$$L_{real} = \alpha \cdot L_{min} .$$

Where: L_{min} = the theoretical amount of air:

$$L_{min} = \frac{O_{min}}{0{,}21} .$$

III. The amount of fuel consumed during 1h „C”:

$$C = P \cdot c_{sp} \quad [kg/h].$$

IV. The amount of air need by the engine during 1 h „D_{air}”:

First it is found the air flow in normal pressure and temperature conditions „ D^{o}_{air} ”:

$$D^{o}_{air} = C \cdot L_{real} \quad [nm^3/h].$$

Thus:

$$D_{air} = D^{o}_{air} \cdot \frac{p_o}{p_1} \cdot \frac{T_1}{T_o} \quad [m^3/h].$$

Where:

p_o = pressure in normal conditions; $p_o = 101325 N/m^2$;

T_o = Temperature in normal conditions; $T_o = 273K$.

V. The power needed by the compressor according its efficiency "P_r":

$$P_r = \frac{P_c}{\eta} \quad [kW]$$

Table 1. Input Data

Nr. crt.	P[cp]	c_{sp} [g/CPh]	α	C [%]	H [%]	N [%]	S [%]	O [%]	P_1[torrs]	P_2[bar]
1	11.000	110	1,7	86	10	0,5	2,5	1	755	1,8
2	11.500	110	1,7	86	10	0,5	2,5	1	755	1,8
3	14.500	110	1,7	86	10	0,5	2,5	1	755	1,8

3. RESULTS AND DISCUSSION

The results obtained at the end of the calculus are given in Table 2. Since the students had the same composition of the fuel, differences in result which are found appeared together with the evaluation of the minimum quantity of fuel consumed during 1 hour. Working with a highest value of the power, students are able to find that the highest values of the amount of fuel consumed during 1 hour are necessary, and also amount of air requested by the engine during 1hour. The power consumption results negative, fact which can be connected with the theory provided during courses. Students found that the lowest value of this power results when the working is ensured of the lowest value of the engine power.

Table 2. Results of calculation for three different values of power)

P [cp]	O_{min} [nm³/kgfuel]	L_{min}	Lreal [nm³/kgfuel]	C [kg/h]	D^{o}_{air} [n m³/h]	D_{air} [m³/h]	P_c [kW]	P_r [kW]
P_1 = 11.000	2,17	10,33	17,56	1.100	19.316	6,15	-937.079,1	-1.171,3
P_2 = 11.500	2,17	10,33	17,56	1.265	13.067	7,10	-589.906,77	-748,63
P_3 = 14.500	2,17	10,33	17,56	1.595	28.008	8,9	-533.027,02	-666

4. CONCLUSIONS

The calculus of combustion is one of the most important experiences gained during thermodynamics seminars by future marine engineers in CMU.

This paper describes the manner in which this topic is approached together with students enrolled in Electromechanics Faculty, second year of study.

The methodology discussed here follows the next steps:

- short review of fuels

- combustion calculation enunciation
- calculation methodology
- discussion on the need of unit measurement conversion
- allocation of input data to each student
- checking of results during the calculus
- checking of final results
- discussion of the results.

In the paper is given the case in which three students received same composition of the fuel and different values for the engine power.

The results obtained so far reveal the fact that with an increase of power, more fuel is necessary to be consumed during one hour and more air to the engine and theoretical power consumed by the compressor is less.

Comparative calculation will supply to the student informations on advantages and drawbacks of one solution or other.

5. REFERENCES

[1] MEMET, F., *Algorithm For The Analysis Of Transportation Sector On Energy And Exergy Basis*, Constanta Maritime University Annals, Year Xiv, Vol 20 (2013) pp 83-86

[2] MEMET F. *An Experience In Refrigeration Calculation Carried Out By Future Marine Engineers In CMU*, Submitted To :Constanta Maritime University Annals Year Xv, Vol 22 (2014)

[3] MADARASAN T. *Arderea Combustibililor* http://www.termo.utcluj.ro/termo/06ardere.pdf

[4] TUDOR D., TUDOR C. *Termodinamica*, *Masini si Instalatii Termice Navale*, Editura Agir Bucuresti 2002.

CORROSIVE BEHAVIOUR OF CARBON STEEL IN SEA WATER ENVIRONMENT

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ABSTRACT

Aluminum and Nickel alloys are frequently used in seawater systems for the manufacturing of equipment and mechanical parts such as heat exchanges, pumps, valves, pipes, fasteners. Depending on the application and the requirements regarding the mechanical characteristics, Ni and Al alloys can be used. Nevertheless, they suffer from certain forms of corrosion such as localized corrosion, crevice corrosion in valves or flanges assemblies [7]. In this paper we present the superficial layers deposited process based on the electrical discharge technology in impulses and their behavior in sea water. These layers are tested for corrosion, using the gravimetrical method and electrochemical corrosion [3]. The samples used in the experiments are non-alloy quality steels C 45, on their surface being deposited superficial layers using aluminum and nickel electrodes. The initial samples and the samples with deposited layers were immersed in sea water (taken from the Romanian seaside, at Mangalia) and maintained a period of 285 days. The fine determining of the topography surfaces exposed to the action of the corrosive environment was accomplished using an atomic force microscope (AFM).

Keywords: *thin layers, electrical discharge, nickel, aluminium, seawater, mass loss, electrochemical corrosion, atomic force microscopy.*

1. INTRODUCTION

The deposition layers with electrical discharge method offers improved properties such us: hardness, wear resistance, corrosion, depending on the material of the electrode. The superficial layers obtained using electrical discharge technology in impulses is part of the surfaces engineering domain. In the field of surface engineering a new kind of superficial thermal treatments of microalloying and spark deposition became currently available. Processing by sparks is a simple and cheap process, in comparison with other methods to process the surfaces and it has wide applicability in industry. The superficial treatment through electrical discharges is a procedure which improves the characteristics of the metallic materials. The phenomenon during the discharge impulses (short period), consists of an erosion of the cathode followed by the transfer of the erosion products on the treated surface. Unlike the classic processing through electric-erosion, the electric sparking uses a power that is recovered - pulse with reversed polarity. In this case the processing through electric spark is like a gas environment, where the electrode executes a vibrating movement [3]. The characteristics of the superficial layers obtained through this procedure are the same or they do not vary very much as the properties of the electrodes material being used, [3, 4]. The paper presents the research dedicated to the improvement of the resistance to corrosion, by the use of the deposition of thin layers, on the metallic surface of the mechanical parts. The results consist of technological advancement, which leads to high reliability and low costs for most of the metallic parts. After the surface treatment, it results a superficial micro alloyed layer, which was achieved by partial diffusion and deposition of electrode material with physical and mechanical complex properties [3, 6]. This innovative technology is extremely useful for marine industry and engineering due to the corrosive resistance characteristics of the surface of the parts produced by this method. Starting from our studies, new research directions emerge regarding the technology to be developed, for the current use of the superficial treatment through impulse electrical discharges, in the manufacturing and surface treatment of the maritime equipment and technical systems, exposed to weather conditions or other aggressive environments.

2. METHODOLOGY

The experiments were done for the superficial treatment through impulse electrical discharges, by the use of the ELITRON 22A equipment, which has several work regimes, for each regime being specified the electrode cross section value and the work current (table 1) [3, 4].

The work regime change has an influence on the discharge energy changes and allows controlling the characteristics of the layer that forms, to some extent (thickness, roughness, micro hardness).

The electrical discharge technology in impulses, on surfaces of materials, is based on the phenomenon of electroerosion and polar transfer of material (electrode) to the cathode (metal sample) during electrical discharges in impulses, between the anode and cathode, discharge that occurs in a gaseous medium. Unlike classical processing through electro erosion, the electrical discharge technology in impulses uses pulsating rectified current with reverse polarity. In this case, the electric sparking processing has the air as gaseous medium, the electrode executing a vibrating movement.

2.1. Tables

Table 1. The recommended values for the electrode cross section in regard to the work regime of the ELITRON-22A equipment and the current value at every regime

Electric work regime ELITRON – 22A	Electrode cross section value [mm]	Work current ***[Å]***
1	4	0.5
2	5	0.8
3	4÷6	1.3
4	5÷6	1.8
5	6÷9	2.3

During the sparking discharge process in a gaseous environment, it occurs mainly an erosion of the electrode material (anode) and a transfer of products of erosion on the samples superficial processed (cathode). Following the transfer of material and thermal changes in the discharge zone, in superficial processing of metallic materials with electrical sparks, the superficial layer of the cathode change their structure and chemical composition.

Characteristics of this layer are clearly defined, depending on the electrode material, the environment composition between the electrodes and impulse electrical discharges parameters [1, 9].

The sparking was done on parallelepiped samples with the surfaces of 0,00127512 m^2, from non-alloy quality steel - C45, the plane surfaces of the samples being previously prepared. Preparing the surfaces presumes a thorough treatment and degrease with a powerful solvent [3, 6].

The treatment through electrical discharges was done manually, the active electrode being inclined under a 60^o angle with respect to the treated surface. The surface of the electrode section is very important in superficial layer forming and for the quality of the layer, when the electrical discharge method is used. This influence could be observed at the temperature variation of the working parameters and of the current density in the electrode. The electrodes sections involved in these experiments had round and rectangular cross-sections and their length is in a range of 20-30 mm ranges [4]. The superficial processing with aluminium and nickel electrodes was realized at five work regimes of the ELITRON equipment. The micro-hardness determinations were performed using the PMT-3 micro-hardness equipment, which also allows the measurement of the layers' thickness. Determinations of the thickness and surface roughness for 10 samples processed are given in Table 2 [2].

Table 2. Thickness and surface roughness

No.	**Material**	**Electrode**	**Work regime**	**Deposited layer thickness [μm]**	**Micro hardness [μm]**
1	C45	Al	R1	16	3.0
2	C45	Ni	R1	15	
3	C45	Al	R2	21	4.4
4	C45	Ni	R2	21	
5	C45	Al	R3	29	5.6
6	C45	Ni	R3	30	
7	C45	Al	R4	40	8.5
8	C45	Ni	R4	41	
9	C45	Al	R5	50	10.2
10	C45	Ni	R5	50	

Due to the uneven surface obtained at high work regimes, to study the gravimetrical corrosion process there were used 2 samples processed in the R2 working regime of the ELITRON equipment, and for the study of the corrosion by electrochemical methods there were used 6 samples processed at three working regimes: R1, R2 and R3.

In order to study the corrosion effects, the rectangular samples obtained using electrical discharge in impulses were tied with a synthetic nylon thread Φ = 0.2 mm and set at 40 mm under sea water level. The samples were held 285 days in static sea water at ambient medium temperature [2]. The purpose of such research is to achieve a breakthrough by increasing the corrosion resistance of various mechanical parts [4]. The testing of corrosion through electrochemical methods was determined with an electrochemical system type VOLTALAB 32. The acquisition and processing of experimental data was done by the use of the specialized software VOLTMASTER 2. The samples subjected at electrochemical corrosion have the circular plane surface, cylinder shape from non-alloy quality steel - C45, the probes plane surfaces being also previously prepared [3, 4, 5].

3. RESULTS AND DISCUSSIONS

Corrosion resistance in seawater of superficial layers obtained with aluminum and nickel electrodes was determined by gravimetrical method, in order to evaluate the corrosion process speed [2]:

$$v_{cor} = \frac{\Delta m}{S \cdot t} \; [g \cdot m^{-2} \cdot day^{-1}] \qquad (1)$$

Where:
v_{cor} - rate of corrosion [$g \cdot m^{-2} \cdot day^{-1}$]
Δm – variation weight [g]
S – samples surfaces in contact with dea water [m^2]
t – time of exposure [days]

The speed corrosion variation, based on the immersion time, is presented in figures 1 and 2.

3.1. Figures

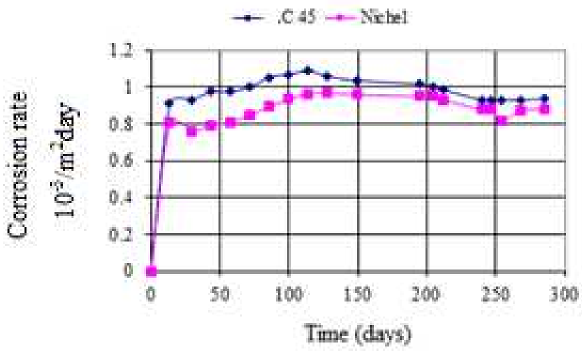


Figure 1 Corrosion rate for non-alloy quality steels – C 45 sparking with Ni electrode

The samples processed through impulses electrical discharges using Al and Ni electrodes are resistant to corrosion, in comparison with samples from non-alloy quality steel - C45, the sample processed with aluminum electrode being the most stable [4, 5, 6].

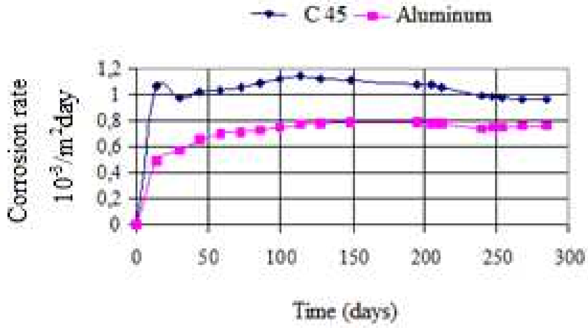


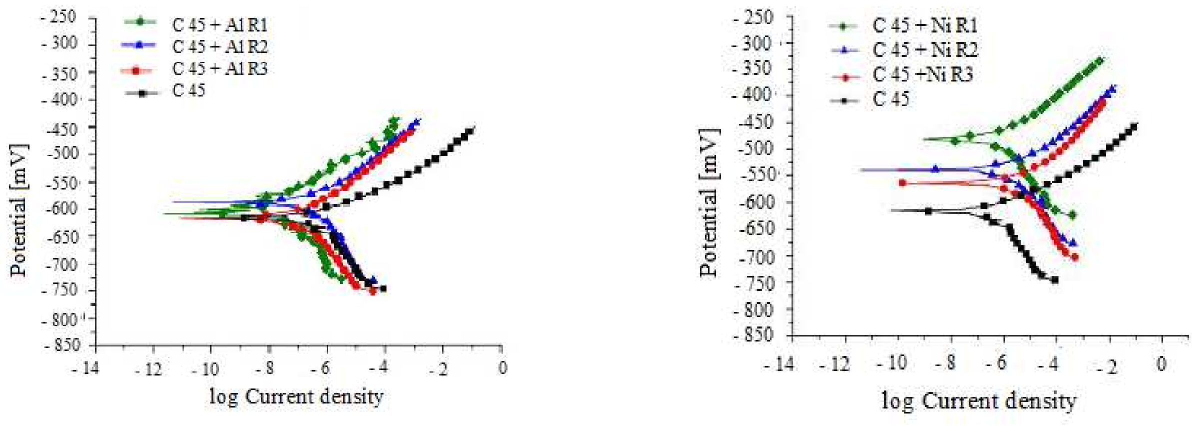
Figure 2 Corrosion rate for non-alloy quality steels - C 45 sparking with Al electrode

In the first stages of corrosion (0-30 days), corrosion rates increase rapidly, the corrosion of the nickel layer being more pronounced than the aluminum layer.

On the superficial layers subjected to sea water, initially may be observed a progressive increase of the corrosion speed, because of the oxygen absorption. After the effect of microorganism, the corrosion drops to an almost stationary value. This is because of the fact that microorganisms eliminate oxygen from the surfaces, but an anaerobic corrosion still persists [4].

The corrosion speed was measured using electrochemical corrosion method [16, 15]. Experimental results were compared for both the surface of the initial sample material (C 45) and the surface of the samples covered with an Al and Ni layer.

The corrosion potential was determined by tracing the curves of linear polarization, recorded in sea water, using the Evans coordinates: E = f(log I) [15, 8, 12] (figure 3).



a b

Figure 3 Linear polarization curves for sparking samples with (a) Al electrodes; (b) Ni electrodes

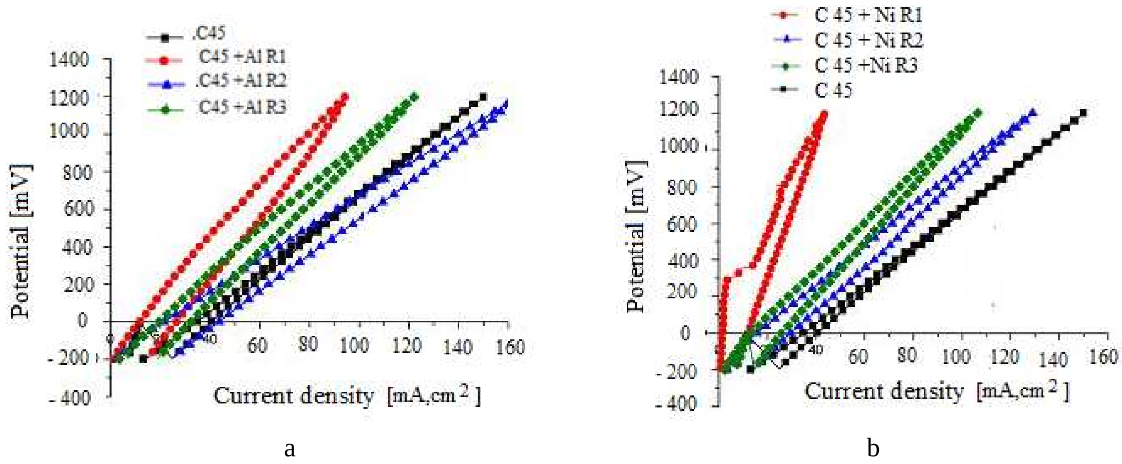


Figure 4 The cyclic polarization curves for the support specimen and for the samples covered with
(a) Al at different sparking regimes (R1 - 0,5 A ; R2 –1,3 A ; R3 – 2,3 A);
(b) Ni at different sparking regimes (R1 - 0,5 A ; R2 –1,3 A ; R3 – 2,3 A)

The base specimen but also the sparking samples, present the same type of corrosion [13, 11] which is a general corrosion being represented in the initial moments by the appearance of some corrosion dots.

For non-alloy quality steel - C45 samples sparking with Al and Ni electrodes, there may be drawn the following conclusions regarding the influence of the working condition onto the corrosive protection: the aluminium layer has a better anti-corrosive behaviour if the R3 regime (large currents) is employed; for the nickel layer the best anti-corrosive behaviour results for the R1 regimes (small currents); the aluminium has the highest corrosion tendency while nickel has the best protection.

The cyclic polarization curves were recorded for all the samples under investigation in seawater, the potential range being between (-200) mV and (+1200) mV, with a potential sweep rate of 20 mV / s (figure 4).

For the majority of the sparking specimens, the cathode branch is slightly moved forward, compared to the anode branch, but it is still linear [10, 14]. This movement can be explained by the fact that the scanning speed of the electrodes potential is relatively large (20 mV/s) and the presence of the metal on the surface induces a certain inertia.

Based on the current-voltage linear dependency and the aspect of the corrosion characteristic curves, one can notice that for the specimens covered with protective layers, the underneath iron of the initial sample is also subjected to corrosion. This is an evidence that the layer resulted from the sparking process is not uniform, the small corrosion speed being explained by the small area of iron which were not covered by the protective layers [3, 4, 5].

The “wave-mode” of the AFM microscope was used to examine the samples superficial treated with the Ni and Al [3, 4, 5] electrodes. The topography of the area under investigation is presented similar to a relief map, using coloured zones, light colours being used for the highest zones (figures 5, 6). The surfaces were scanned after the samples were subjected to gravimetrical corrosion.

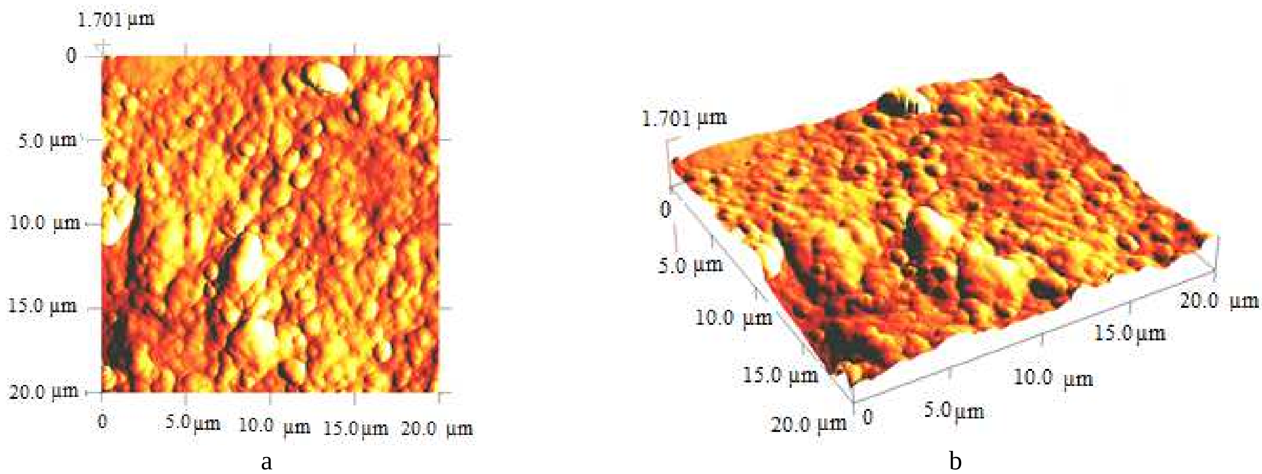


Figure 5 AFM image of superficial treated sample with Ni electrode, on a scanned area of 20x20 µm
(a) "wave mode" image – 2d; (b) "wave mode" image – 3d

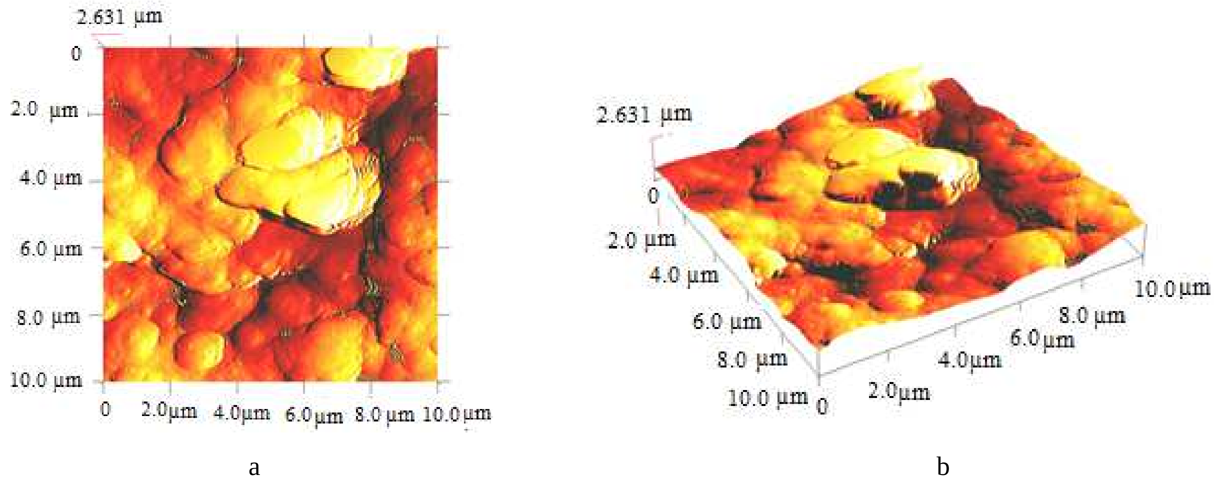


Figure 6 AFM image of superficial treated sample with Al electrode, on a scanned area of 10x10 µm
(a) "wave mode" image – 2d; (b) "wave mode" image – 3d

After 2D scanning and its transformation in 3D image is observed greater uniformity of corroded nickel layer in comparison with the aluminium layer. This can be confirmed by the difference in level between the lowest and the highest areas which is 1.701 µm for sample processed with nickel compared to 2.631 µm for sample processed with aluminium.

4. CONCLUSIONS

The originality of the study regards the resistance to corrosion in an aggressive environment of the nickel layers obtained through electrical discharge in impulses and the comparison with aluminium layers also obtained through electrical discharge in impulses, with respect to the initial C45 sample. The superficial layers of nickel and aluminium laid on non-alloy quality steel - C45 samples show an improved corrosion resistance in sea water compared to the base steel, especially for long term tests, when the corrosion speed is stabilized, remaining almost constant. Throughout the interval studied, the stability is preserved and it was noticed that the less stable is non-alloy quality steel sample coated with the Ni electrode. The cyclic voltammograms obtained, in the case the samples of the non-alloy quality steel - C45 and the samples processed are typical for the generalized corrosion (uniform corrosion on the entire surface). This aspect is more evident for the steel supports, for which the cathode branch (return) is overlapped over the anode branch (positive polarization). The investigations, using atomic force microscopy, of the samples tested for long term corrosion, emphasize the conclusion that the samples have compact and homogenous surfaces areas which had not permitted the corrosive agent to interact with the base material. Correlated with the results of gravimetric corrosion, the AFM images testify a better corrosion resistance of aluminium layer compared to the nickel layer. Aluminium layer creates a protective film which prevents the oxidation of the samples.

5. REFERENCES

[1] BARANKOVA, H., BARDOS, L., BERG, S., *Surface and coatings Technology*, No. 94-95, 1997

[2] BABOIAN, R., *Corrosion Tests and Standard: Application and Interpretation*, ASTM Publication, 2-nd edition, 2004

[3] BARHALESCU, M. L., *Researches regarding the obtaining and structural analysis on corrosion resistant thin superficial layers*, Ph. D Thesis, Jassy, Romania, 2007.

[4] BARHALESCU, M. L., *Corrosive effect of sea water on the superficial layers obtained by electrical sparking*, Proceedings of the WSEAS international conferences, Proceedings of the 2nd International Conference on Manufacturing Engineering, Quality and Production Systems, MEQAPS, 3-5 September, Constanta, Romania, 2010

[5] BARHALESCU, M. L., *Comparison of corrosion behaviour of thin layers from copper, aluminium and chromium*, ModTech International Conference - Modern Technologies in Industrial Engineering, Sinaia, Romania, 27-29 June, 2013, Modern Technologies in Industrial Engineering, Book Series: Advanced Materials Research, Volume: 837, Pages: 247-252, Published: 2014

[6] BARHALESCU, M. L., PASCU, R., DINESCU, M., *Corrosion Protection of Metallic Surfaces by Processing with Impulse Electrical Discharges* - Protective coatings and thin films 07 of E-MRS 2007 Spring Meeting, Strasbourg. 28 mai-1 iunie, 2007,

[7] DUMITRACHE, C., CALIMANESCU, I., COMANDAR, C., *Naval Standard Safety Valve Design using CAD solutions*, The 6 th International Conference on Advanced Concepts in Mechanical Engineering, ACME, 12-13 June, Iasi, Romania, 2014

[8] EZUBER, H., EL-HOUND, A., EL-SHAWESH, F., *A study on the corrosion behaviour of aluminium alloys in seawater*, Materials & Design, Volume 29, Issue 4, 2008, Pages 801-805

[9] FRANGINI, S., MASCI, A., *A study on the effect of a dynamic contact force control for improving electrospark coating properties*, Surface & Coatings Technology 204, pages. 2613–2623, (2010).

[10] KELLY, R.G., SCULLY, J.R., SHOESMITH, D.W., BUCHHEIT, R.G., *Electrochemical Techniques in Corrosion Science and Engineering*, Marcel Dekker Inc., New York, 2003

[11] MARCUS, P., *Corrosion Mechanisms in Theory and Practice*, Marcel Dekker Inc, New York, 2002

[12] OSORIO, W.R., PEIXOTO, L. C., CANTE, M.V., GARCIA, A., *Electrochemical corrosion characterization of Al-Ni alloys in a dilute sodium chloride solution*, Electrochimica Acta, Volume 55, Issue 13, 1 May 2010, pages, 4078-4085

[13] SERE, P.R., ARMAN, A.R., ELSNER, C. I., DI SARLI, A. R., *The surface condition effect on adhesion and corrosion resistance of carbon steel/chlorinated rubber/artificial sea water systems*, Corrosion Science, Volume 38, Issue 6, June 1996, pages 853-866

[14] TAKALOO, A.V., DAROONPARVAR M. R., ATABAKI, M. M., MOKHTAR, K., *Corrosion Behavior of Heat Treated Nickel-Aluminum Bronze Alloy in Artificial Seawater*, Materials Sciences and Applications, 2, pages 1542-1555, 2011

[15] TRDAN, U., GRUM, J., *Evaluation of corrosion resistance of AA6082-T651 aluminium alloy after laser shock peening by means of cyclic polarisation and ElS methods*, Corrosion Science, Volume 59, June 2012, pages 324-333

[16] WHARTON, J.A., BARIK, R.C., KEAR, G., WOOD, R. J. K., STOKES, K. R., WALSH, F. C., *The corrosion of nickel-aluminium bronze in seawater, Corrosion Science*, Volume 47, Issue 12, December 2005, pages 3336-3367

ANALYSIS OF INDUCED STRESS OCCURRING UNDER STATIC LOAD IN THE REAL-SIZE OPTIMIZED STRUCTURE OF THE DOUBLE BOTTOM OF A CHEMICAL TANKER OF 8000 TDW

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ABSTRACT

This paper aims to highlight the induced stress occurring under static load in the real-size optimized structure of the double bottom of a chemical tanker. Also, it shortly presents an algorithm of the constructive and functional optimization through the finite element method, numerical modeling of the double bottom structure for the real-size ship with continuous and discontinuous welding being due to be achieved.

Keywords: *stress, double bottom structure optimization, finite element, the objective function, limitations, continuous welding, discontinuous welding*

1. INTRODUCTION

Optimization is defined as the operation of studying problems, completed with a result that, in comparison with other possible outcomes is the best, and on its basis there may be made a technical and economic decision.

The main purpose of optimizing a structure – or, in other words, of the optimal design of structure – is to determine its form. The determination of stress and displacements is a later stage in the design process, during which it is checked if the shape and dimensions of the structure meet the requirements of the aim pursued.

In order to optimize a structure, a FEM model is drawn up for an "initial" variant of the structure. For this model, one or several design parameters are defined – also named design variables – and values and (or) their ranges of possible values, called limitations, in the form of equalities or inequalities.

The optimization process needs to determine the minimum value of a function dependent on the design variables, called objective function.

The fundamental component of the optimization process is the objective function that can be defined as linear or non-linear with respect to the design variables. The most widely used objective functions are: cost price, weight, stiffness, volume, potential energy of deformation under load system, etc. There is no restriction in principle on the definition of the objective function. The various programs require only observance of rules of "syntax" regarding the algebraic definition of function.

The design variables are basically restrictive conditions and will be considered in the optimization process as such.

As shown in the literature, for resistance structures design variables relate to:

- the geometry of the structure;
- material distribution in the structure.

The optimization process focuses both on the design, overall composition of the resistance structure and determining its shape and sizing the elements that compose it.

The functions of equality or inequality that determine the admitted fields in which the decision variables can take values are called limitations. Therefore, limitations delimit the admissible solutions to the optimization problem, and following their resolution, the optimal solution is chosen from this field. Considering this aspect, restrictive conditions should be established for each optimization problem, with discernment.

These limitations may come from the physical nature of the variables, the internal nature of the system, or due to regulations deriving from standards, requirements, or actual states outside the system which, however, the system must comply with.

In the practice of optimizing structures of resistance there are generally two types of limitations:

a) Limitations deriving from the criteria related to the resistance to limit states;

b) constructive limitations due to technological considerations and design rules.

Restrictions expressed analytically by equality or inequality, impose certain limitations on a single variable, or a group of variables, and derive from the analysis of the limit situations that arise at the stage of realization or exploitation of that resistance structure.

Then, the restrictive conditions deriving from conditionalities relating to certain extreme situations in the behavior of structure are formulated.

The objective function expresses the dependence of the optimization on the decision variables and it is obtained based on the equations of the mathematical model of the system under optimization.

Together with the system of limitations, the objective function forms the analytical representation of the optimization problem.

2. ALGORITHM OF THE CONSTRUCTIVE AND FUNCTIONAL OPTIMIZATION THROUGH THE FINITE ELEMENT METHOD

The input data contain constructive and technological information, depending on the conditions under which the mark will work, in other words, they are variants of different dimensions of marks from the database, as well as the method base containing optimization programs and engineering calculations programs. From this database, constructive variants are extracted which are accomplished and analyzed by the finite element method.

The assumptions relate mainly to the geometry of the body analyzed, the properties of materials used, the variation of the main field sizes investigated and, lastly, to the operating mode of the given system.

Finite element method consists of three main phases:

a) Pre-processing: realising the model (characterized by shape, size, material characteristics), solid model discretization in finite elements, applying boundary conditions and loadings;

b) Processing: numerically solving the equations characteristic for system behavior and getting the solution;

c) Post-processing: viewing the results in order to analyze the system behavior and identify areas with critical stresses.

Pre-processing objectives are: assigning material properties according to the model, development of finite element model, applying loads and boundary conditions.

After defining the geometry of the structure, the first step is to define material parameters of the structure analyzed .

The material parameters set in the program SolidWorks / COSMOS/M are: density, Young’s elastic modulus, Poisson coefficient which are defined in Table 1.

The structure taken into consideration in this paper is the chemical tanker of 8000 tdw. This type of vessel is built in longitudinal framing system. Its main dimensions are shown in the table below (Table 1).

Using the program Germanischer Lloyd, Poseidon, for the chemical tanker considered in the study, the preliminary structural model was accomplished, according to the rules of local and general resistance. The cross section through this vessel is shown in Figure 1.

The material used is AH36 shipbuilding steel, whose characteristics are shown in Table 2.

Generally, such a structure is made up of: bottom floor, double bottom floor, floor frame, lateral supports, bottom longitudinals and double bottom longitudinals.

Global coordinate system of the model is chosen as follows:

The X-axis: longitudinally, positive from the aft to the bow;

The Y-axis: transversely positive towards port;

The Z-axis: upwards vertical positive.

Table 1 Geometrical and material characteristics for double bottom structure

The overall length of the vessel, L_{OA}	118.160 m
Length between perpendiculars, L_{pp}	110.596 m
Width of vessel, B	18.500 m
Full load draft, T	7.400 m
Height of construction, D	10,000 m
Block coefficient, c_B	0.730
Vessel speed in calm water, v	14 Nd
Displacement, Δ	8000 tdw
Young’s modulus, E	2.1E+5 MPa
Poisson coefficient, υ	0.3
The density of steel, ρ	7.85E-6 kg/mm^3
Yield strength, R_{eH}	355 MPa
Tensile strength, R_m	360 - 480 MPa

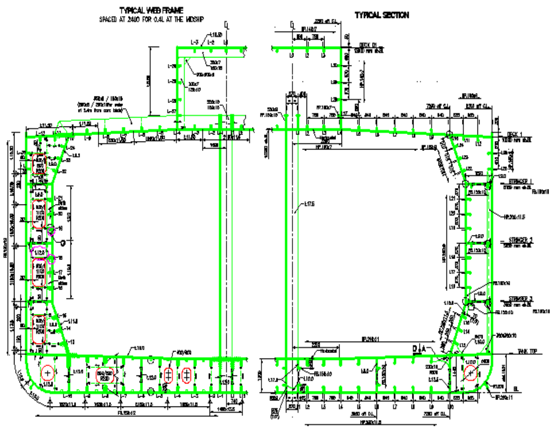


Figure 1 The cross-section to the chief frame through the real size vessel

Table 2 Material properties

Density	7.85e-006 kg mm^3
Young's Modulus	2.1e+005 MPa
Poisson's Ratio	0.3

Figure 2a) shows the interest area taken into account, and figure 2b) presents the network of elements applied to the CAD model of the analyzed structure, as well as the boundary conditions and loading conditions for the structure analyzed.

Declaring a set of modeling begins by choosing a type of finite element corresponding to the model to be analyzed.

For the models analyzed in this chapter PLANE2D membrane elements are used – this type of element has been used in the floor frame and elements of membrane and plate of SHELL4T type. These elements have been used to define bottom floor, double bottom floor, side supports, bottom longitudinals as well as double bottom longitudinals.

An important role in the correct modeling of the structure with finite elements is defining the boundary conditions.

Generally, the incorrect choice of the connections leads to local effects that vitiate the results obtained.

In the case of 3D FEM model for this structure, the following boundary conditions were considered:

- diametral plane (PD): condition of symmetry - through which all movements and spins were blocked;

- the intersection of the diametral plane and the plane of the cross framework (PD ∩ PC): – through which all movements and spins were blocked;

- the intersection of the diametral plane and basic plane (PD ∩ PB): – through which all movements and spins were blocked.

The real-size structure was loaded with forces of: 25 kN, 50 kN, 75 kN, in the knots located at the intersection of the bilge cover with the double bottom shell.

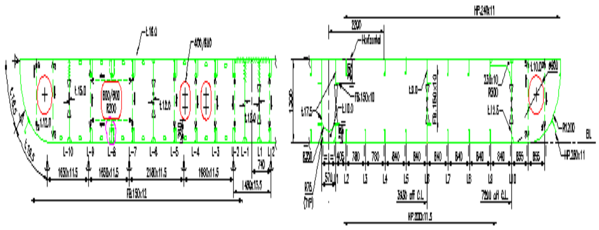


Figure 2a) Details of the structure analyzed

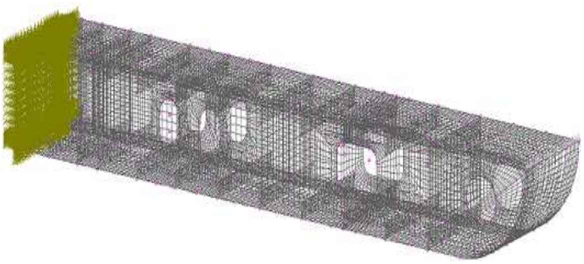


Figure 2b) Boundary conditions and loads imposed on the model analyzed

After the geometric construction of the model and specifying the material of which it is composed, the next step in an analysis with finite elements that involves the application of loads and displacement limitations so that he behavior of the model is identical with reality. Loads and restrictions apply to nodes associated with different types of geometric entities.

After a finite elements model was developed and verified, boundary conditions were applied, and numerical calculation was resolved, it's time to investigate the results. Post-processing is used to create a graphical representation of the results received from the solver, showing the distribution of stress, strain, temperature, and other aspects of the model.

The interpretation of these results is the key for identifying the areas of interest (weak areas in a model), areas with waste material, or other valuable information regarding other performance characteristics of the model, which otherwise would remain unknown without physical testing of a prototype.

After static analysis, stress concentrations were obtained in the area of the rectangular technological cutout , which result in the exclusion, in the optimization process, of these elements on which stresses concentrate (on the edge of the cutouts) and stress concentration should be resolved through constructive changes.

In order to optimize the structure of the double bottom it was highlighted both the influence of thickness and of connection radius of the cutout, as well as the influence of bordering with platbands around the technological cutout on the stress of the actual ship.

The optimization method applied to this structure is the intuitive one, which consists of in developing alternative models of structure – and by repeated attempts– its optimal variant will be achieved.

The optimization problem can be defined as follows:

– The main objective of the design is to have a minimum weight (that is the use of as little material as possible);

– The variables considered in the optimization problem are given by data, thickness of the plate sheet floors, (in this case, it is the thickness of the floor sheet): $t_{\min} \leq t_i \leq t_{\max}, i \in [11,...,16]$.

The range of plate thickness is discontinuous, and they must be positive numbers, namely: $t_i \geq 0, i \in [1,2,...,n]$.

– The restrictions of the optimization problem are given by ship resistance.

In order to optimize the structure of the double bottom, one of the important tests to be carried out is the change in thickness. In the ship floor appear both oval technological cutout and rectangular cutouts. It is known that these cutouts represent strong stress concentrations. To make more accurate assessments, modeling was performed on structures with continuous and discontinuous welding.

Processing and interpretation of results is made easily with numerous post-processing facilities, such as stress maps, displacement maps, graphics, etc.

After the process of optimization, the optimal structure from the point of view of minimum weight was obtained. The results obtained in the process of optimization are shown in tables and graphics.

3. NUMERICAL MODELLING OF THE DOUBLE BOTTOM STRUCTURE FOR THE REAL SIZE SHIP. ANALYSIS OF RESULTS

The calculations below will be made for the real-size structure. The term „continuously welded" structure will be found. Generally, marine structures are formed from sheets reinforced with standardized or non-standardized profiles. Since the experimental structure, reduced-scale, resulted with small thickness (below 2 mm) large deformations would be obtained after the welding process. Therefore, it was decided to discontinuously weld the structural elements in order to reduce the heat flux introduced and consequently to reduce deformations. To make more accurate assessments, modeling was performed on structures with continuous and discontinuous welding

3.1 Double bottom structure at continuously welded real-size ship (SC)

Based on numerical calculations carried out, the results obtained were centralized in charts which highlighted the variation in floor sheet thickness and connection radius upon the stress state.

The figure with nodes taken into consideration is shown in Figure 3.

Next, the results obtained following the optimization of the double bottom structure are highlighted.

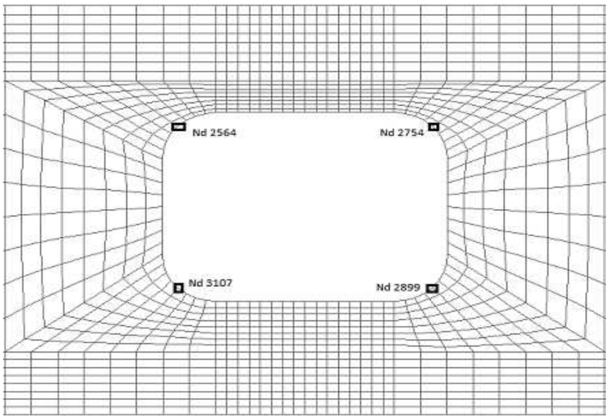


Figure 3 Place of nodes taken into consideration

Structure - R_200_optimized

Table 2 shows Von Mises stress for selected nodes on the radius of the technological cutout.

Table 2 Stress Von Mises for Structure R_200_optimized_continuously welded

Node	Sheet thickness (mm)	Von Mises Stress (MPa) Force (kN)		
		25	50	75
2563	**11.5**	226.3	452.6	678.8
2754		250.1	500.3	750.4
2899		256.0	511.9	767.9
3107		218.2	436.4	654.5

Figure 4 shows graphical comparisons for the variation of Von Mises stress for the thickness of the floor sheet resulting from the optimization process and variable load.

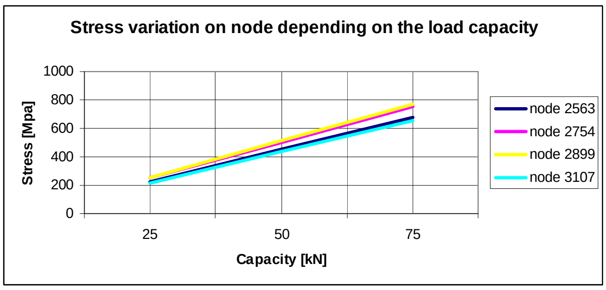


Figure 4 Stress variation on node depending on the load capacity for Structure R_200_optimized_continuously welded

3.2 Double bottom structure at the real-size vessel discontinuously welded (SD)

Structure – R_200_optimized

Table 3 shows Von Mises stress for selected nodes on the radius of the technological cutout.

Table 3 Von Mises Stress for Structure R_200_optimized_ discontinuously welded

Node	Sheet thickness (mm)	Von Mises Stress (MPa) Force (kN)		
		25	50	75
2563	**11.5**	219.4	438.7	658.1
2754		240.5	481.0	721.6
2899		259.9	519.7	779.6
3107		220.7	441.4	662.0

Figure 5 shows graphical comparisons for the variation of Von Mises stress for the thickness of the floor sheet resulting from the process of optimization and variable load.

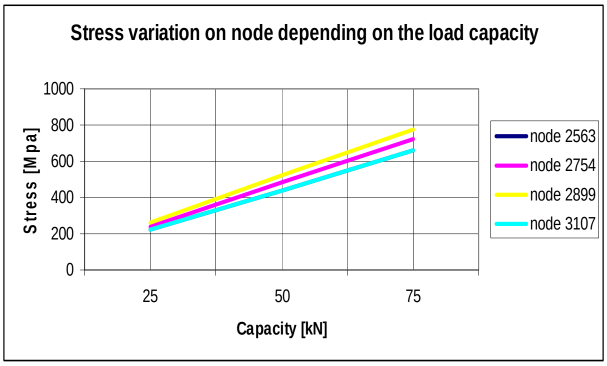
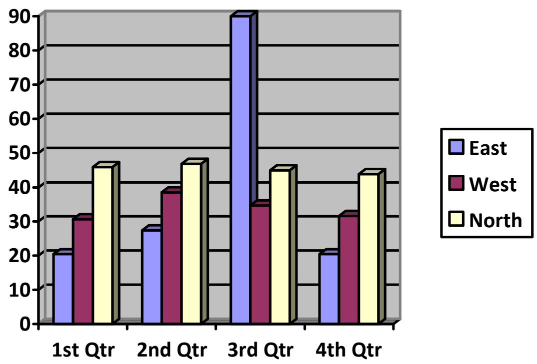


Figure 5 Stress variation on node depending on the load capacity for Structure R_200_optimized_ discontinuously welded

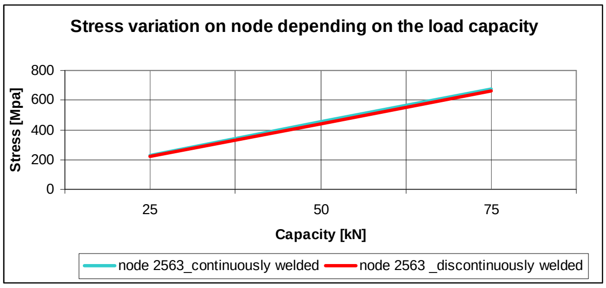
4. ANALYSIS OF RESULTS OF NUMERICAL MODELLING PERFORMED FOR THE OPTIMIZED REAL SIZE SHIP

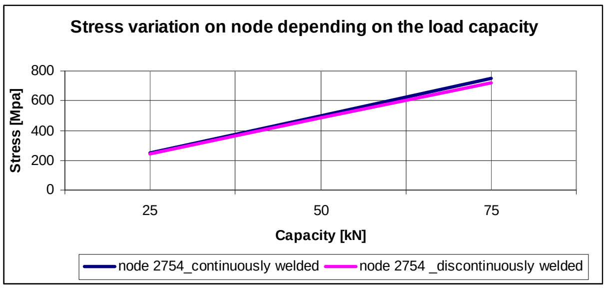


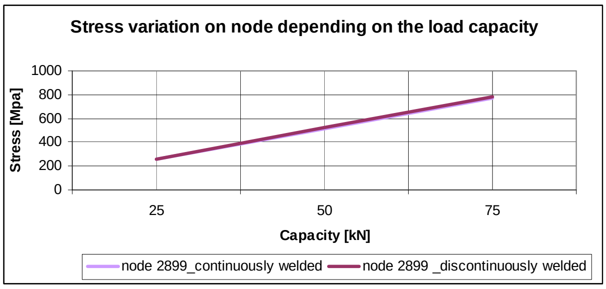
The comparison of the stresses which appear in the double bottom structure, in different load situations, is performed by evaluating the stress situations shown above.

There were no local effects, leading to misinterpretation of the stress and strain thanks to the correct choice of the boundary conditions.

Consequently, the stress that arises exceeds allowable limits of the material the components are made of, due to load tests. Taking into consideration their distribution during stress, tensions have a predictable variation.







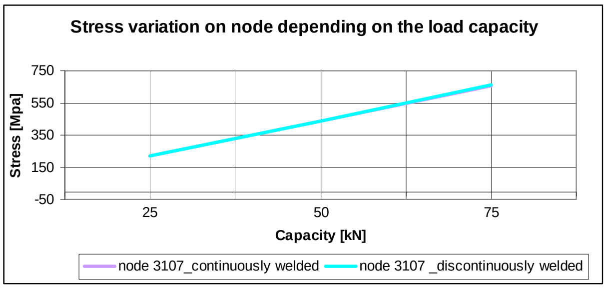


Figure 6 Variation of stress (on the node) depending on the load capacity in case of non-bordering the technological cutouts

It can be noticed from the analysis of stress in case of continuous and discontinuous welds between the components of the double bottom that (Figure 6) stresses are not very different. This can be justified through the way in which the elements neighboring nodes couple, in the finite element analysis.

5. REFERENCES

[1] BLETZINGER,K.U., E. RAMM, *Structural optimization and form finding of light weight structures*, Computers and Structures, 2001.

[2] CHENG, F.Y., *In Recent Advances in Optimal Structural Design*, ed., S.A. Burns (ASCE), 2002.

[3] CONSTANTINESCU, I.N., PICU, C., HADĂR, A., GHEORGHIU, H., *Rezistența materialelor pentru ingineria mecanică*, Editura BREN, Bucureşti, 2006.

[4] CRISTEA A.G., Teza doctorat “ *Contribuții privind optimizarea structurilor de navă”*, Universitatea “Dunărea de Jos” din Galați, 2014.

[5] DENNIS, J.E. AND R. B. SCHNABEL, *Numerical Methods for Unconstrained Optimization*, Prentice- Hall, Englewood Cliffs, NJ, 1983. Reprinted by SIAM Publications, 1993.

[6] HADĂR A., CONSTANTINESCU I.N., GHEORGHIU H., COTEȚ C.E., *Modelare şi modele pentru calcule în ingineria mecanică*, Editura PRINTECH, Bucureşti, 2007.

[7] ***SWCM, SolidWorks Cosmos/M FEM Program User Guide, Dassault Systems SolidWorks Corporation, 2008.

NAVAL PLUG VALVE DESIGN AND COMPUTER FLUID DYNAMIC ANALYSIS

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ABSTRACT

This article is a research study of NX Siemens CAD and computer fluid dynamic analysis (CFD) for most useful type of naval plug valves, also called taper plug valves (TPV), or cocks. Design of this valve contains the dimensions which has been used in manufacturing process and helps a lot during 3D accurate process. CFD is based on finite element analysis (FEM), meshing, boundary condition and loads, finally we get important conclusions regarded by velocities, relative pressure and shear resultants stresses.

Keywords: *TPV, revolve, extrude, CFD, relative pressure and shear resultant, FSI, stress element nodal – von Misses.*

1. INTRODUCTION

These taper plug valves are generally used for the same full-flow service as gate valves, where quick shutoff is required. They are used for liquids (water, oil, chemical liquid products), steam or gas fluids. These TPV are not generally used for the regulation of flow, but in some applications could be used for gas-flow throttling.

These valves can be readily repaired or cleaned without necessitating removal of the body from piping system. The pressure service are used between vacuum to 69000 kPa (69 MPa, 690 bar) and temperatures from 46 to 816 ºC [1].

2. CONSTRUCTION OF TPV

The basic design of TPV is illustrated in the figure no. 1:

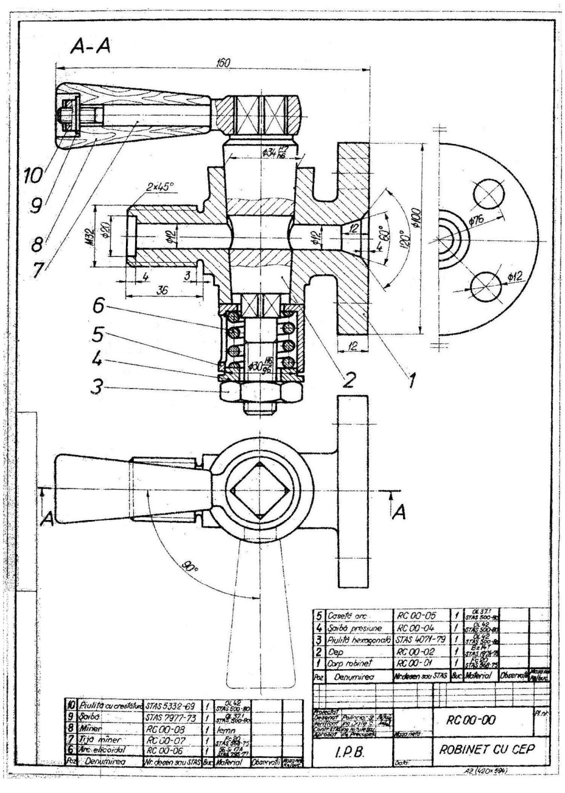


Figure 1 Basic design of regular TPV [2]

The essential feature of TPV are the body (1) and tapered plug (2). Full flow is obtained when the opening in the tapered plug is aligned in the direction of flow. When the plug is rotated with 90º flow is blocked.

Careful design of the internal contours of the valve produce maximum flow efficiency. The port in the tapered valve is generally rectangular, but also it's available with round ports. Major valve patterns are identified as regular, short, round port and multi-port.

3D Design consist of modelling each component of TPV assembly using NX Siemens CAD solution. The body valve modelling begin with sketch flange diameter and extrude it (figure 2).

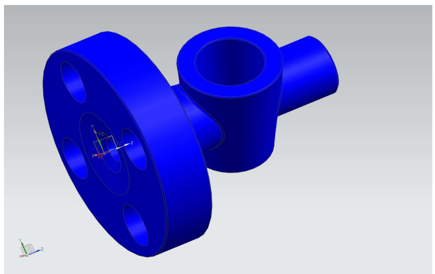


Figure 2 Body of TPV

The tapered part, also called stem was modelled using sketch major diameter and extrude operation using Draft angle of 5º. The flange and tapered parts of body was united using Boolean Unite option. The tapered plug modelling begin with the sketch square and extrude it, continues with successive extrude operation and for tapered part it's used the same extrude with Draft angle of 5º (figure 3).

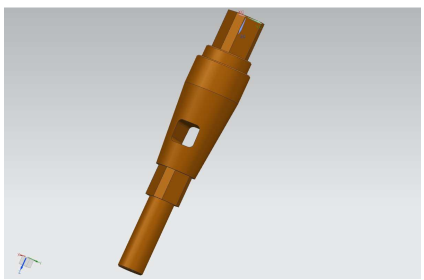


Figure 3 Tapered part (stem) of TPV

The opening in the tapered plug was released using sketch rectangular shape performed with extrude and Boolean Subtract option necessary for material removal.

The components parts was added using touching, infer center axis, concentric constraints. The final assembly is created when component objects are added to the assembly part file, each component object is mated with the corresponding objects. 3D Design of TPV is presented in the figure no. 4:

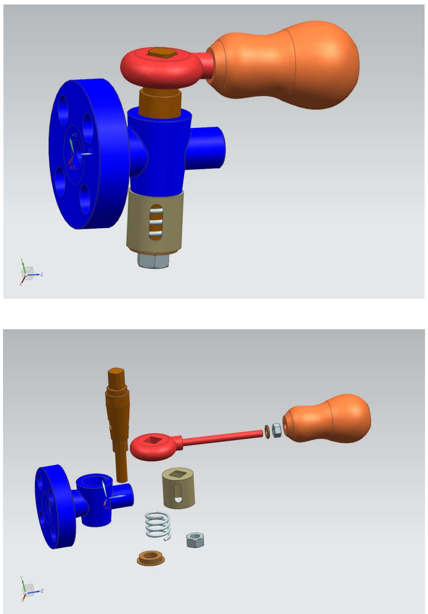


Figure 4 Unexplode and explode viewings of 3D assembly TPV

3. COMPUTER FLUID DYNAMICS

Computational fluid dynamics, usually abbreviated as CFD, is a known field of fluid mechanics that uses numerical methods and algorithms to solve and analyse problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions. With high-speed supercomputers, better solutions can be achieved. Efficient algorithms have been developed to solve the Navier-Stokes (N-S) equations used in the flow analysis around ship hulls, the work contributed to the numerical solution of the viscous flow around ship-like bodies is discussed in [3]. An experimental and numerical of a three-dimensional, complex geometry, control valve was performed for model validation and improved understanding of valve flow features is discussed in [4]. On-going research yields software that improves the accuracy and speed of complex simulation scenario such as turbulent flows [5].

The efficiency of fluid flow is given by the flow coefficient of a device C_{vm} which describes the relationship between the pressure drop across an orifice, valve or other assembly and the corresponding flow rate:

$$C_{vm} = Q \cdot \sqrt{\frac{SG}{\Delta P}}, \quad (1)$$

where:

C_{vm} = Flow coefficient or flow capacity rating of valve;
Q = Rate of flow (m^3 per hour);
SG = Specific gravity of fluid (Water = 1);
ΔP = Pressure drop across valve (m).

Flow coefficient C_{vm} is the number of m^3 of water at 15°C that will flow per hour through a valve with a pressure drop of 1.0 m of water across the valve. The use of the flow coefficient offers a standard method of comparing valve capacities and sizing valves for specific applications that is widely accepted by industry.

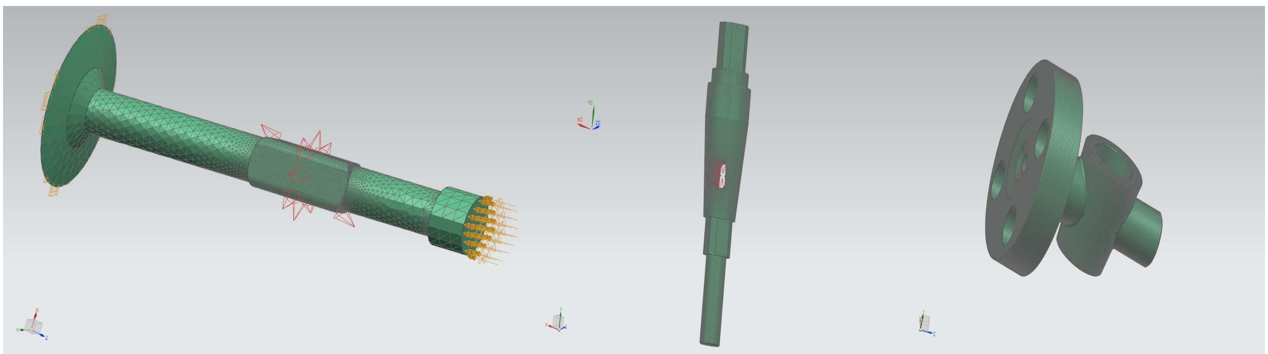
3.1 *Methodology*

The required parts, body and stem of TPV modeled in NX Siemens were transferred to Advanced Simulation module of the same NX Siemens software. Both of them were assigned to Iron Nodular material which has the mechanical properties listed in table 1:

Table 1. Mechanical properties

Young Modulus [N/mm^2]	Poisson Ratio	Yield Strength [N/mm^2]	Ultimate Tensile Strength [N/mm^2]
$1{,}62 \cdot 10^5$	0,25	250	400

The volume occupied by fluid (water) is divided using the proper tetrahedral TET(4) elements, total number of elements 72724 in mesh, stem and body are divided using CTETRA(4) elements, 193665 elements in stem mesh and 588989 elements in body mesh (figure 5).



a. b. c.

Figure 5 Meshing of TPV a.-fluid flow boundary condition; b.-stem; c.-body valve

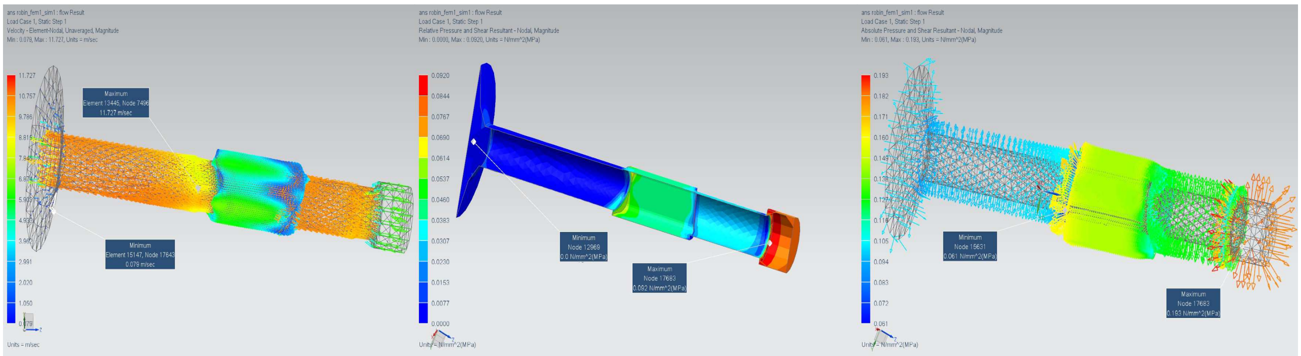
3.2 Boundary conditions

In this paper it is discussed three different steps which appear during normal function of TPV.

- In the first step it is assigned water as the fluid flow with pressure and temperature at inlet zone, 1 bar, respectively 20ºC. The outlet zone of TPV has the atmospheric pressure and 20ºC. For all three steps, the inlet and outlet zone will be considered the same and are presented in figure 5a.
- In the second step, the fluid flow has 5 bar pressure and 80ºC temperature. Because of heat transfer process between fluid flow-body valve cold structure, and environment it is considered convection coefficient 20 $W/m^2 \cdot ºC$, and 15ºC environment temperature.
- The third step is the short time moment at normal function, which will be produced at opening and closing the valve. It is recognized that an advantage of TPV are quick open and close valves. Accidentally, is better to know what is happened if it isn't working properly because of high friction on the tapered stem-body zones during opening and closing processes.

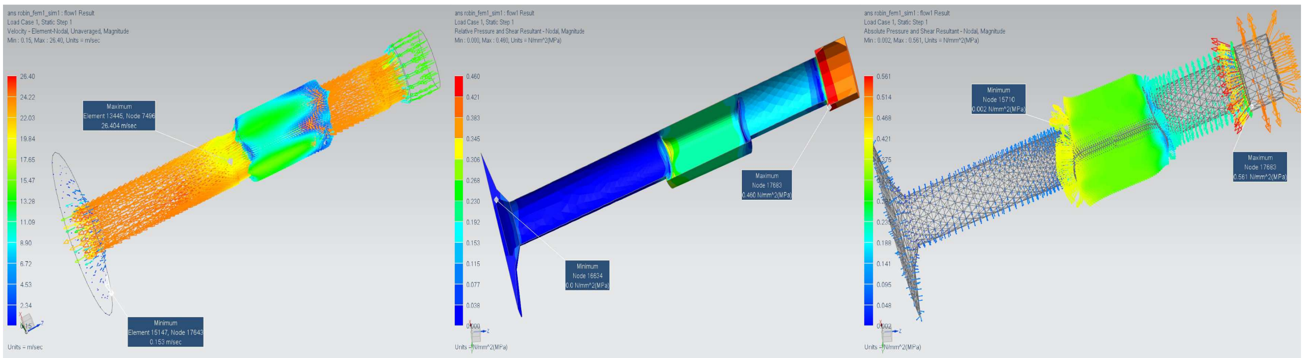
These results are presented in the figures below:

3.3 Results of CFD analysis



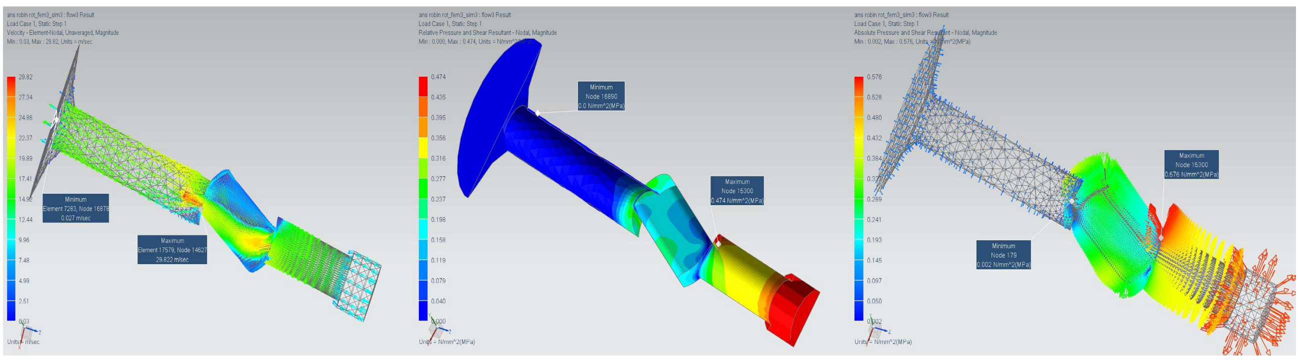
a. b. c.

Figure 6 Results first step: a.-velocity; b.-relative pressure and shear resultant; c.-absolute pressure and shear resultant



a. b. c.

Figure 7 Results second step: a.-velocity; b.-relative pressure and shear resultant; c.-absolute pressure and shear resultant



a. b. c.

Figure 8 Results third step: a.-velocity; b.-relative pressure and shear resultant; c.-absolute pressure and shear resultant

Table 2. Results of outlet discharge

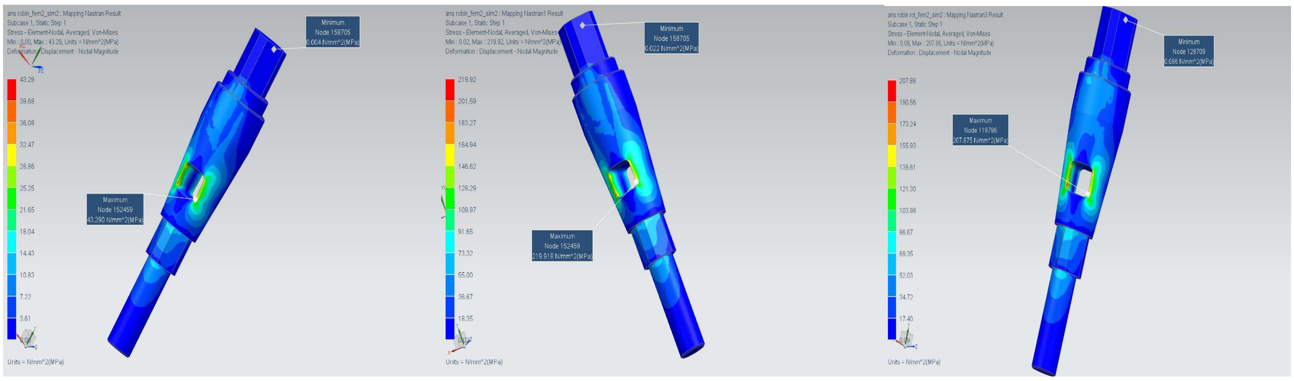
	Outlet discharge [m³/h]
Step 1	2,527
Step 2	6,063
Step 3	4,113

In the table 2 are listed the outlet discharge results (Q) calculated with relation (2):

$$Q = Area_{outlet} \cdot velocity \quad [m^3/h]. \qquad (2)$$

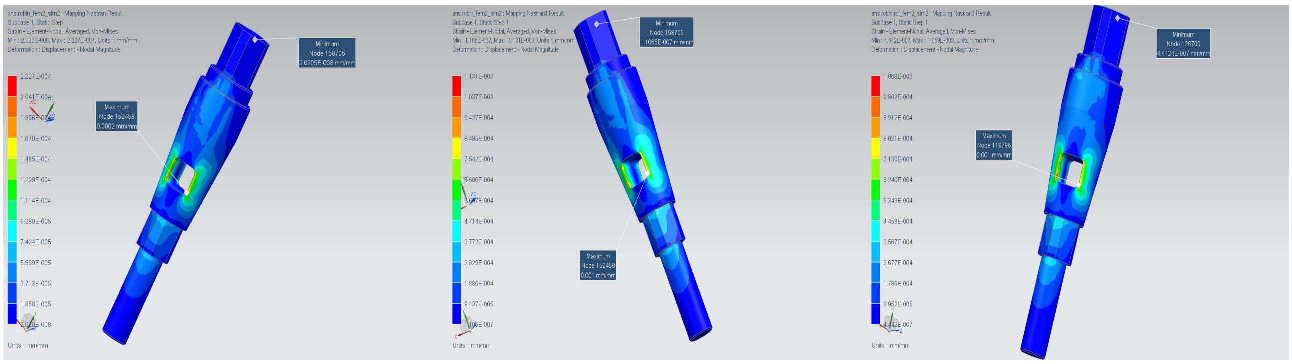
3.4 Results of FSI analysis

The fluid structure interaction abbreviated as (FSI) consists of transmission of thermal and pressure field via an interface between fluid-solid domain to the structural mesh presented in figure 5b and 5c. The pressures which were imported from CFD are relative pressure and shear resultant presented in figures 6b, 7b, and 8b, were recognized as boundary condition too and calculated using mapping operation in NX Siemens Advanced Simulation. Belong of the temperatures and pressures field we consider the fix constraints on holes of circular flange as another boundary condition. The Nastran solutions are presented in the figures:



a. b. c.

Figure 9 Stress – Elemental Nodal von Misses: a.-first step; b.-second step; c.-third step



a. b. c.

Figure 10 Strain – Elemental Nodal von Misses: a.-first step; b.-second step; c.-third step

4. CONCLUSIONS

As we can see during normal function, the pressure field is high in vicinity of inlet zone of body valve (fig. 6b-c, 7b-c). Because of malfunction, or stem which cannot be acting properly (hard friction effect), the high pressure is localized at the stem rectangular orifice (fig. 8b-c). The stresses and strains fields (fig. 9, 10) reflects that stem is the part which give us the maximum values instead of body valve. It is better to know what it's happen if we change the rectangular port with the new round port orifice.

5. REFERENCES

[1] PLUG VALVES TYPES, CONSTRUCTION, APPLICATIONS AND ADVANTAGES, http://www. Pipingguide.net/2013/11/plug-valves-types-construction.html;

[2] PRECUPETU, P. DALE C., *Desen Tehnic industrial*, Ed. Tehnică, Bucureşti, pg. 233, 1982;

[3] WANDERLEY, J. B. V., et , *A Three-Dimensional Numerical Simulation of the Free Surface Flow Around a Ship Hull*, Computer and Information Science, 1, 2011, ch.18;

[4] J. A. VALVERDE, S. H. FRANKEL, G. P. SALVADOR, *Three-dimensional control valve with complex geometry: CFD modelling and experimental validation*, 34th AIAA Fluid Dynamics Conference and Exhibit; Portland, Oregon; 2004;

[5] DELEANU D., *Approximate solutions to an appropriate model equation for finite-amplitude waves on shallow water surfaces*, Journal of Marine Technology and Environment, 2008, pag. 27-30, ISSN 1844-6116.

A GUIDE FOR ASSESSING VAPOR COMPRESSION REFRIGERATION SYSTEMS, FOR FUTURE MARINE ENGINEERS

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ABSTRACT

Vapour compression refrigeration systems (VCRS) are the most frequently used systems when it is need the heat transfer from a cooler body to a hotter one. This technology is asking for an important quantity of electric energy, problem that can be solved by the improvement of the system performance. VCRS are commonly used in marine refrigeration.

An undergraduate marine refrigeration plants course is aimed for future marine engineering personnel; its objectives are to enable these people to understand the theory of heat transfer and principles of refrigeration, to be familiar with the main components of refrigeration systems, operation of these systems, cooling arrangements, air conditioning systems, safety procedures, etc.

In this paper it is described a full assessment algorithm of vapour compression refrigeration cycles, as a reply to the need of the marine refrigeration industry to provide favourable conditions to decrease energy consumption and to preserve the environment.

By integrating the above mentioned theory in the curriculum of the future marine engineers in Constanta Maritime University (CMU) it is reached an important educational outcome: marine engineering graduates will show the ability to properly design a vapour compression refrigeration system, in the context of modern technology requirement.

Keywords: *marine, refrigeration, vapor compression, performance.*

1. INTRODUCTION

Although the world is facing an economic crisis, the demand for highly skilled marine officers is still registered, together with an increase in the number of world's fleet ships; in this frame, it is obvious that Maritime Education and Training has to strengthen its components as facilities, curriculum design, teaching and learning methodologies, quality of education (Baylon and Santos, 2011). Since very beginning, Constanta Maritime University was able to attract international attention and to build an image of a higher education entity, able to open interesting opportunities for the future, together with a good international reputation related to the delivery of skilled marine officers to the labour market (Barsan and Muntean, 2010).

Sea transportation is a very attractive mean when it is about people travelling or transport of perishables, this is why marine refrigeration is an important sector of today economy in many countries. Nowadays, are seek specialists able to face challenges in marine refrigeration, this is why the course dealing with this technology and delivered in Constanta Maritime University (CMU) has to ensure specific education.

The natural sense in which heat is transferred is from a body with a higher temperature to a body with a lower one, with no need of any external devices. The reverse process is possible, but it cannot occur by itself. The heat transfer from lower temperature to a higher one asks for special devices – known as refrigeration systems. They work respecting the principle of reversed Carnot cycle.

Vapour compression refrigeration systems (VCRS) are one of the main type of air conditioners and refrigerators, some of scientists stating that they are the most often used among all refrigeration systems (Thangavel et al, 2013).

In these systems have been used different refrigerants as working fluid, refrigerant fluids being a key component for air conditioners and refrigerators. Because vapour compression refrigeration cycles are assessed by a methodology which involves the environmental behaviour and the thermal properties of refrigerants, some of them have been placed under restriction, since they cause depletion of ozone layer and green house effect

In the following will be presented in detail an algorithm used in the assessment of VCRS, which is one of the requirements of the course called Marine Refrigerating Plants, delivered in Constanta Maritime University. The theoretical assessment is taking into discussion all the major aspects related to this type of technology and can be easily seen as guidance at disposal of future marine engineers, when it is the case of dealing with new or already in use refrigeration systems on board the ships.

2. METHODS AND MATERIALS

2.1. Background

A vapour compression refrigeration system is illustrated as seen in Figure 1 and consists of four main component parts: compressor, condenser, expansion device and evaporator (Agrawal and Matani, 2013). Its working principle is based on the alternate evaporation and condensation of the refrigerant, which is not leaving the system. In Figure 2 is given the specific cycle, in pressure – enthalpy diagram.

The beginning of the cycle is given by the entrance of refrigerant vapours in the compressor, at low temperature and pressure. In this device they are compressed till they achieve a higher temperature and pressure. With this state, the refrigerant is introduced in the condenser, where it is turned into liquid, by heat rejection to the environment.

The resulted liquid enters in the expansion valve, where its high pressure is decreased.

The low temperature and pressure refrigerant absorbs latent heat in the evaporator and occurs the phase change, resulting refrigerant vapours.

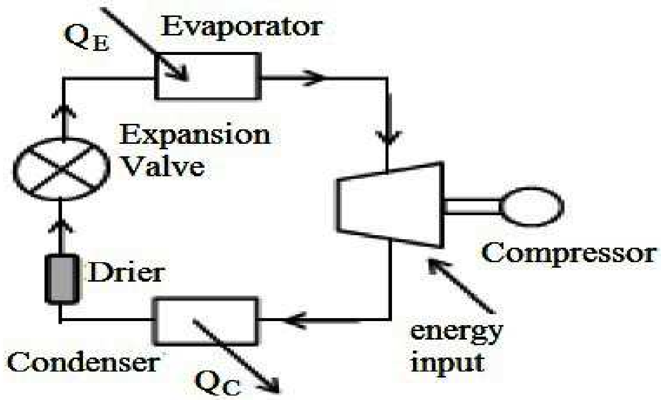

Figure 1 Vapour compression refrigeration system

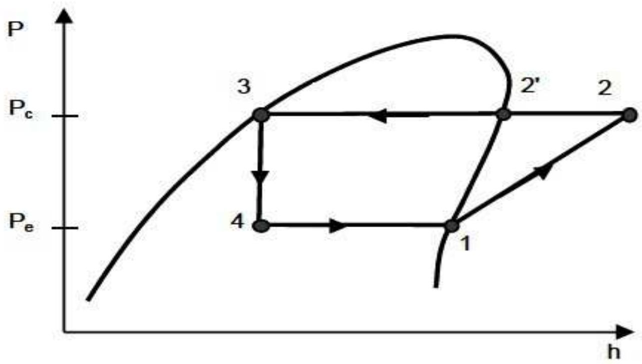

Figure 2 Vapour compression refrigeration cycle in (p–h) diagram

Processes encountered in the cycle are:
1–2: isentropic compression – in compressor,
2–2': isobaric cooling of high temperature and pressure vapours – in condenser,
2'–3: isobaric – isothermal heat evacuation – in condenser (condensation),
3–4: isenthalpic expansion – in expansion valve,
4–1: isobaric – isothermal heat absorption – in evaporator (evaporation).

The drier having silica gel and seen in Figure 1 is located on the liquid line in order to absorb moisture traces found in liquid refrigerants and avoid moisture chocking by freezing.

2.2 Environmental assessment

Because of the restrictions imposed to CFCs and HCFCs, which shows high Ozone Depleting Potential (ODP) and Global Warming Potential (GWP), new refrigerants have been developed, such as HFCs – in use for their null contribution to ozone layer depletion.

R22 was one of the most spread refrigerants in marine refrigeration and an important representative of HCFCs. Being a controlled substance under the Montreal Protocol, it was phased-out in new equipments since 2002 in Europe, the total phase-out being scheduled for 2015.

Investigations offer as alternatives of R22 in vapour compression refrigeration cycle fluorocarbons, such as R134a, R410A, R407C, etc, or alternative fluids, such as R290 or R717 (Paharia and Gupta, 2013).

2.3. Design methodology

The design methodology specific to vapour compression refrigeration cycles is based on the following assumptions (Almeida et al, 2010):

- the main components of the system are modelled as being open systems,
- the main components work under steady-state, steady-flow process,
- processes taking place in the compressor are considered to be adiabatic,

- the heat exchangers (evaporator and condenser) are considered to work at constant pressure,
- there are no pressure losses in the pipes, thus pressure changes occur only at the compressor and capillary tube,
- compressor shows ideal volumetric efficiency and ideal isentropic efficiency.

The specific thermodynamic and heat transfer conditions to be respected are as bellow (Abu-Mulaweh and Al-Arfaj, 2012):

- the refrigerant temperature in the evaporator must be lower than the temperature of air inside the refrigerator,
- the refrigerant temperature at condenser exit must be higher than the one of the environment,
- the compressor works with superheated vapours, in this respect the refrigerant at exit of evaporator must be saturated vapour or superheated vapour,
- the refrigerant at the exit of condenser must be at least saturated liquid.

The performance of systems under vapour compression technology can be improved by different strategies as (Mishra, 2014) (Baskaran and Mathews, 2012):

- the increase of the refrigeration effect (the increase of the cooling load capacity),
- the decrease of work input at the compressor,
- the application of sub cooling and superheating
- the diminishing of the irreversibility of the throttling process.

2.4. Theoretical computational model

The first law of thermodynamics states that energy cannot be created nor destroyed and its amount is kept constant in all processes. The second law of thermodynamics states that energy is degraded during any process and its quality decreases.
All real processes are irreversible and energy degrades in this type of processes.

The traditional analysis method which is based on the first law consist in writing energy balance equations, thus there is no information regarding the degradation of energy during the process. The exergy method of analysis overcomes the limitations of the first law. It combines the first and second laws of thermodynamics and it is seen as a strong tool for the evaluation of both quantity and quality of energy use.

Exergy is the maximum amount of work that can be produced by a stream of energy or matter, or from a system, as it is brought into equilibrium with a reference environment. Shortly, exergy is the expression of the quality of energy.

An accurate analysis of the refrigeration system is achieved when it is calculated first law efficiency (Coefficient of Performance) and second law efficiency (exergy efficiency).

The following equations are used when it is developed an energy analysis (based on the first law of thermodynamics) and an exergy analysis (based on the second law of thermodynamics) (Bolaji and Huan, 2012) (Mohanraj et al, 2008) (Bolaji, 2010) (Soni and Gupta, 2013):

The pressure ratio:

$$\beta = \frac{p_c}{p_e}, \qquad (1)$$

where:
p_c – condensation pressure,
p_e – evaporation pressure.

The volumetric efficiency:

$$\eta_{vol} = 1 - C\left(\beta^{1/k} - 1\right), \qquad (2)$$

where:
C – clearance ratio,
k – adiabatic index.

The refrigerant mass flow rate:

$$m_r = \frac{V_{st}\, N \eta_{vol}}{v_1}, \qquad (3)$$

where:
V_{st} – stroke volume,
N – speed,
v_1 – specific volume of refrigerant at compressor inlet.

The vapour temperature at compressor exit:

$$T_2 = T_1 + \frac{T_{2\,iso} - T_1}{\eta_{iso}}, \qquad (4)$$

where:
η_{iso} – the isentropic efficiency of the compressor.

The heat absorbed by the refrigerant in the evaporator (the refrigerating cooling effect):

$$Q_E = m_r\left(h_1 - h_4\right), \qquad (5)$$

where:
h – enthalpy.

The compressor power input:

$$W_C = m_r\left(h_2 - h_1\right). \qquad (6)$$

The amount of heat rejected in the condenser:

$$Q_C = m_r\left(h_2 - h_3\right). \qquad (7)$$

The isenthalpic expansion:

$$h_3 = h_4. \qquad (8)$$

The Coefficient of Performance:

$$COP = \frac{Q_E}{W_C}. \qquad (9)$$

Part of the factors responsible for occurring irreversibility in the refrigeration cycle may be summarized as friction and heat transfer across a finite temperature difference in the evaporator, compressor, condenser and refrigerant lines, sub cooling and superheating, pressure drops and heat gains in refrigerant lines.

The analyze of exergy destruction in each component of the system indicates where should be directed the efforts done to improve system efficiency.

Exergy destruction in the evaporator:

$$Ex_{D,E} = Ex_{E,in} - Ex_{E,out} = m_r\left(h_4 - T_o s_4\right) + + Q_E\left(1 - \frac{T_o}{T_R}\right) - m_r\left(h_1 - T_o s_1\right), \quad (10)$$

where:
Ex – exergy,
Ex_D – exergy destruction,
s – specific entropy,
T_o – environmental state temperature,
T_R – space temperature.

Exergy destruction in the compressor:

$$Ex_{D,comp} = Ex_{comp,in} - Ex_{comp,out} = = m_r\left(h_1 - T_o s_1\right) + W_C - m_r\left(h_2 - T_o s_2\right). \quad (11)$$

Exergy destruction in the condenser:

$$Ex_{D,C} = Ex_{C,in} - Ex_{C,out} = m_r\left(h_2 - T_o s_2\right) - - m_r\left(h_3 - T_o s_3\right) - Q_C\left(1 - \frac{T_o}{T_C}\right). \quad (12)$$

Exergy destruction in the expansion valve:

$$Ex_{D,EV} = Ex_{EV,in} - Ex_{EV,out} = = m_r\left(h_3 - T_o s_3\right) - m_r\left(h_4 - T_o s_4\right). \quad (13)$$

The total exergy destruction (exergy used) in the system:

$$Ex_{D,TOT} = Ex_{D,E} + Ex_{D,comp.} + + Ex_{D,C} + Ex_{D,EV}. \quad (14)$$

The overall exergy efficiency of the system:

$$\eta = \frac{Ex_{out}}{Ex_{in}}, \quad (15)$$

where:

Ex_{out} – exergy output (exergy in product),

Ex_{in} – exergy input (exergy of fuel).

The exergy input:

$$Ex_{in} = Ex_{out} + Ex_{D,TOT}. \quad (16)$$

The exergy output:

$$Ex_{out} = Q_E\left|1 - \frac{T_o}{T_R}\right| \quad (17)$$

Final form of the exergetic efficiency:

$$\eta_{ex} = \frac{Q_E\left|1 - \frac{T_o}{T_R}\right|}{W_C}. \quad (18)$$

The exergy destruction ratio (EDR):

$$Ex_{DR} = \frac{Ex_{D,TOT}}{Ex_{out}}, \quad (19)$$

or

$$Ex_{DR} = \frac{1}{\eta_{ex}} - 1. \quad (20)$$

3. RESULTS AND DISCUSSION

An important educational outcome of the Marine Refrigeration Plants course is the ability of future graduate to analyze and to improve the performance of a vapour compression refrigeration system.

The described thermal and environmental modeling can be conveniently used for the comparative assessment of eco friendly refrigerants in order to find the suitable alternative to refrigerants in use.

The refrigerating/cooling effect increases together with the increase of the evaporation temperature, due to the increase of the refrigerant latent heat value. The value of the latent heat should be high in order to get a low value for the mass flow rate per unit of capacity and better values for the efficiency and capacity of the compressor. Thus, it will be diminished the power consumption and the compressor displacement, resulting a smaller and more compact equipment.

The compressor work input is decreasing with the increase of evaporation temperature and increasing with the condensation temperature, since low pressure ratios enables to reduce the power consumed by the compressor.

The compressor discharge temperature is an important factor when it is about the selection of refrigerant. This temperature is affecting the stability of the lubricants and compressor components. A longer compressor life is reached in the case of using refrigerants showing a lower compressor discharge temperature, due to lower values of specific heat ratio.

The discharge temperature is decreasing with the increase of the evaporation temperature and is increasing with the increase of the condensation temperature, due to direct dependency between these two temperatures.

From the first law standpoint, the performance of vapour compression refrigeration system, expressed by COP, is increasing with the increase of the evaporation temperature and decreasing with the increase of condensation temperature.

This is due to the refrigeration effect increase and to the increase in compressor power with the increase in condensation temperature, since COP is inversely proportional to the power input through the compressor. From the second law standpoint, the performance of the analyzed system, expressed in terms of exergetic efficiency, is increasing with increase of the evaporation temperature, till a maximum value and after that is decreasing. The exergy destruction ratio has a reverse trend, compared to the one of the exergy efficiency.

This situation has explanation in the relationship between second law efficiency and the exergy of cooling effect, $Q_E\left|1-\frac{T_o}{T_R}\right|$. If the evaporation temperature is increasing, the cooling effect is increasing and $\left|1-\frac{T_o}{T_R}\right|$ is decreasing.

The other parameter affecting the exergy efficiency is the compressor power input, W, which is decreasing with the increase of evaporation temperature. Q_E and W have a positive effect on the increase of exergy efficiency, while $\left|1-\frac{T_o}{T_R}\right|$ has a negative effect on the increase of the second law efficiency. When combining the effects of the above mentioned parameters, the exergy efficiency is increasing till reaching a maximum, together the increase of evaporation temperature.

Since EDR is inversely proportional to the exergy efficiency, it will decrease till a minimum, when the evaporation temperature is increasing.

4. CONCLUSIONS

The employability of professionals in the maritime sector depends strongly on their skills and level of theoretical knowledge. In order to face the competitivity challenge registered in this sector, Marine Education and Training curriculum should be enriched in every aspect. In this paper it was presented an algorithm, which can be used by marine engineers in the assessment of vapour compression refrigeration systems. The described analyze methodology is a design experience presented to undergraduates in Constanta Maritime University and is aiming the gain of ability to design such a system in order to meet the required needs.

The assessment allows the investigation of the main aspects of VCRS: environmental assessment, design methodology, computational modelling, and discussion of modelling results.

The described methodology is a guidance which aims to serve as a tool toward cost effective, energy saving and environmentally friendly marine refrigeration technology at the hand of CMU graduates.

5. REFERENCES

[1] ABU-MULAWEH HI, AL-ARFAJ AA, *Engineering design experience of an undergraduate thermodynamics course. World* Transactions on Engineering and Technology Education, Vol.10, No.1: 77-81, 2012

[2] AGRAWAL MK, MATANI AG, *Evaluation of vapour compression refrigeration system using different refrigerants,* International Journal of Engineering and Innovative Technology. Vol. 2, Issue 9: 86-92, 2013

[3] ALMEIDA IMG, BARBOSSA CRF, FONTES FAO, *Thermodynamic and thermosphysical assessment of hydrocarbons application in household refrigerator.* Engenharia Termica (Thermal Engineering), Vol.9, No.01 e 02: 19-27, 2010

[4] BARSAN E, MUNTEAN C., *Enhancing Maritime Officers Opportunities for Managerial Level Positions. 11th* General Assambly of International Association of Maritime Universities – Busan, Technical Cooperation in MET, Busan, Korea: 377-383, 2010

[5] BASKARAN A, MATHEWS PK, *A Performance comparison of vapour compression refrigeration system using eco friendly refrigerants of low global warming potential,* International Journal of Scientific and Research Publications. Vol.2, Issue 9, pp: 8, 2012

[6] BAYLON AM, MA R SANTOS VE, *The challenges in Philippine Maritime Education and Training.* International Journal of Innovative Interdisciplinary Research, Issue 1: 34-43, 2011

[7] BOLAJI BO, *Exergetic performance of a domestic refrigerator using R12 and its alternative refrigerants.* Journal of Engineering Science and Technology, Vol.5, No.4: 435-446, 2010

[8] BOLAJI BO, HUAN Z, *Computational analysis of the performance of ozone – friendly R22 alternative refrigerants in vapour compression air – conditioning systems.* Environment Protection Engineering, Vol.38, No.4: 41-52, 2012

[9] MISHRA RS., *Methods for improving thermodynamic performance of vapour compression refrigeration system using twelve eco friendly refrigerants in primary circuit and nanofluid (water – nano particles based) in secondary circuit.* International Journal of Emerging Technology and Advanced Engineering, Vol.4, Issue 6: 878-891, 2014

[10] MOHANRAJ M, JAYARAJ S., MURALEEDHARAN C., *Comparative assessment of environment – friendly alternatives to R134a in domestic refrigerators. Energy Efficiency*, 1:189-198, 2008

[11] PAHARIA AK, GUPTA RC., *Effect of sub cooling and superheating on vapour compression refrigeration systems using R22 alternative refrigerants. International* Journal of Engineering Trends in Engineering and Development, Issue 3:521-531, 2013

[12] SONI J, GUPTA RC., Performance analysis of vapour compression refrigeration system with R404A,

R407C and R410A. International Journal of Mechanical Engineering and Robotics Research, Vol.2, No.1: 25-36, 2013
[13] THANGAVEL P, SOMASUNDARAM P, SIVAKUMAR T, C.S. KUMAR CS, VETRISELVAN G., *Simulation analysis of compression refrigeration cycle with different refrigerants.* International Journal of Engineering and Innovative Technology, Vol. 2, Issue 10: 127-131, 2013

ORIGINAL DIGITIZATION METHOD OF THE EXPERIMENTAL MECHANICS RESULTS GRAPHICALLY EXPRESSED AS DIAGRAMS

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ABSTRACT

Automatic calculus was a constant concern of the authors. A particular aspect regards the automatic dimensioning, which may require experimental results expressed as diagrams. Beside the data processor already developed which is used for interpolation, there is necessary an effective method to provide the input data, i.e. the coordinates of the points belonging to the curve. In the paper we present an original method which uses simple applications such as Paint and Excel and the scanned copy of the diagram. Using analytical geometry relations we are able to extract valuable information even from low resolution scanned copies or from misaligned diagrams. The method was tested using various diagrams from the Strength of Materials academic discipline and the results are accurate.

Keywords: *discretization, analytical geometry, simple system instruments, high flexibility.*

1. INTRODUCTION

Most of the complex engineering problems nowadays are solved using various principles, concepts and approaches provided either by theoretical models, analytical and numerical, or using experimental studies.

Without the confirmation of the experimental studies, theoretical studies are only able to offer interesting hypotheses, self-referenced so-to-say accurate results and nice colored graphs and interpretations of the theoretical approaches.

However, experimental studies are extremely prohibitive: they require specialized professionals, nowadays experimental concepts, modern experimental technologies, experts able to relate the results of the experiments to the theory's refined assumptions and methods. This means that experimental methods which are paramount to construct a coherent philosophy require resources which, most of the time, are unavailable.

In these conditions professionals can only hope that their creativity will offer them the necessary ideas to access new sources of information which might confirm their theoretical approaches, or they might inspire them to create modern methods to process the data in the according advanced models they are authoring.

Researchers may notice that many results of the experimental studies are expressed graphically. Therefore, it is very important to understand the degree of significance of the diagrams you see in research reports and in experimental studies, the way how they can be used in meta-level models to check and double check the theoretical models and the way they can be related.

This is why quantitative approaches must be employed, the integrative and analytical approaches being the most important instruments. This means to process the data presented in various diagrams and to draw intelligent conclusions using various concepts, ideas and theories.

This can be done only if the data to be interpreted may be expressed in a facile way in order to be easily accessed, processed and synthesized. But this may be done only if the drawings, the charts, graphs and diagrams are expressed analytically.

Staring from these general aspects we have to formulate the effective problem(s) to be solved. Therefore, we state: there must be conceived a method to process the diagrams and to express the graphical information in an analytical accessible way.

Researchers around the world understood this problem and solved it being focused on their specific field of studies, [3]. In this paper we bring our contribution to this general issue.

2. ANALYSIS OF THE PROBLEM

The final users of the diagrams expressed analytically are the structural analysts and the designers who can enhance their productivity by creating original software applications used for the initial dimensioning operations, [3]. This means that the data they use must be expressed both in analytical and graphical form. Until now we have developed a data processor which uses as input data the (x, y) nodes which approximate a curve, [3]. The output data consists of images of the interpolated curve, coefficients of the spline functions in csv format, the points along the curve in csv format and source files is C++, Java and Octave programming languages.

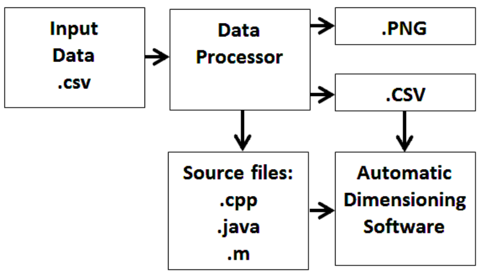

Figure 1 – Original data processor employed for the interpolation of the points belonging to a curve

3. THEORETICAL BACKGROUND

We consider that the scanned diagram is misaligned, i.e. rotated and even deformed due to the repeatedly copies done over a long period of time.

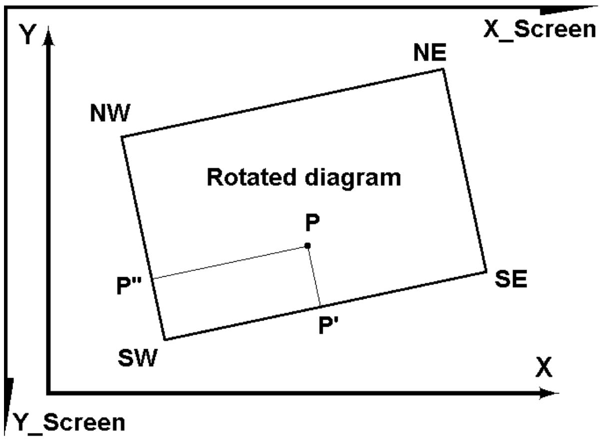

Figure 2 – Calculus scheme

The minimum number of input data consists of:

1. the maximum number of pixels on vertical direction in the current scanned image: Max_Vert;
2. coordinates of the points which border the diagram, in pixels:
   - South-West (origin): $SW(X\_SW, Y\_SW)$;
   - South-East (end of the horizontal axis): $SE(X\_SE, Y\_SE)$;
   - North-West (end of the vertical axis): $NW(X\_NW, Y\_NW)$;
3. the real values assigned to the 'horizontal' axis defined by the SW_SE line:
   - In the South-West (origin) point: H_SW;
   - In the South-East point: H_SE;
4. the real values assigned to the 'vertical' axis defined by the SW_NW line:
   - South-West: V_SW
   - North-West: V_NW

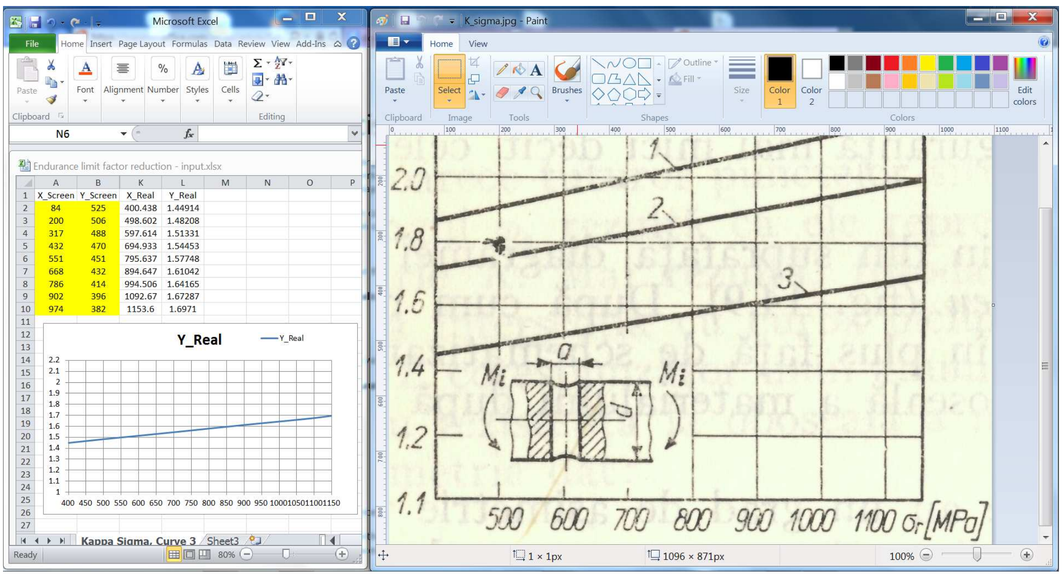

Figure 3 – Data acquisition

Because the Y axis of the screen is opposite to our axis, first we modify accordingly the vertical coordinates, i.e.

$$Y\_SW = Max\_Vert - Y\_SW$$

$$Y\_SE = Max\_Vert - Y\_SE$$

$$Y\_NW = Max\_Vert - Y\_NW$$

We calculate the distance in pixels along the 'horizontal' axis and along the 'vertical' axis. In this way we are able to correct the data because of the previously mentioned faults.

The distance in pixels along the SW_SE axis is:

$$Dist\_SW\_SE = \sqrt{\begin{matrix}(X\_SE - X\_SW)^2 + \\ + (Y\_SE - Y\_SW)^2\end{matrix}}$$

The distance in pixels along the SW_NW axis is

$$Dist\_SW\_NW = \sqrt{\begin{matrix}(X\_SW - X\_NW)^2 + \\ + (Y\_NW - Y\_SW)^2\end{matrix}}.$$

The angle between the 'horizontal' axis of the diagram and a horizontal line along the screen is:

$$\alpha_1 = arctg\left(\frac{Y\_SE - Y\_SW}{X\_SE - X\_SW}\right).$$

The equivalent angle between the 'vertical' axis of the diagram and a vertical line along the screen is:

$$\alpha_2 = arctg\left(\frac{X\_SW - X\_NW}{Y\_NW - Y\_SW}\right).$$

We consider an angle which is the mean value of these two angles:

$$\alpha = \frac{\alpha_1 + \alpha_2}{2}.$$

We calculate the slope of the 'horizontal' axis:

$$m\_horiz = tg(\alpha).$$

We calculate the slope of the 'vertical' axis:

$$m\_horiz = tg\left(\alpha + \frac{\pi}{2}\right).$$

The horizontal axis has the equation:

$$(Y - Y\_SW) = m\_horiz \cdot (X - X\_SW),$$

i.e.

$$Y = m\_horiz \cdot X + (Y\_SW - m\_horiz \cdot X\_SW).$$

The vertical axis has the equation:

$$(Y - Y\_SW) = m\_vert \cdot (X - X\_SW)$$

i.e.

$$Y = m\_vert \cdot X + (Y\_SW - m\_vert \cdot X\_SW).$$

Let us consider a generally located point whose coordinates are in pixels: $P(XP, YP)$.

The vertical line passing through P has the equation

$$Y = m\_vert \cdot X + (Y\_P - m\_vert \cdot X\_P).$$

The horizontal line passing through P has the equation

$$Y = m\_horiz \cdot X + (Y\_P - m\_horiz \cdot X\_P)$$

The projection of point P on the horizontal axis is P'. Coordinates of P' are given by the intersection between the vertical line passing through P and the horizontal axis.

$$\Delta\_X\_P' = (Y\_P - m\_vert \cdot X\_P) - -(Y\_SW - m\_horiz \cdot X\_SW)$$

$$X\_P' = \frac{\Delta\_X\_P'}{m\_horiz - m\_vert}$$

$$Y\_P' = m\_horiz \cdot X\_P' + +(Y\_SW - m\_horiz \cdot X\_SW)$$

The distance from P' to the origin is

$$Dist\_P'\_SW = \sqrt{(X\_P' - X\_SW)^2 + (Y\_P' - Y\_SW)^2}$$

The real abscissa of point P is

$$X\_real\_P = H\_SW + +(H\_SE - H\_SW) \cdot \frac{Dist\_P'\_SW}{Dist\_SW\_SE}$$

The projection of point P on the horizontal axis is P''.

Coordinates of P'' are given by the intersection between the horizontal line passing through P and the vertical axis.

$$\Delta\_X\_P'' = (Y\_SW - m\_vert \cdot X\_SW) - -(Y\_P - m\_horiz \cdot X\_P)$$

$$X\_P'' = \frac{\Delta\_X\_P''}{m\_horiz - m\_vert}$$

$$Y\_P'' = m\_vert \cdot X\_P'' + (Y\_SW - m\_vert \cdot X\_SW)$$

The distance from P'' to the origin is

$$Dist\_P''\_SW = \sqrt{(X\_P'' - X\_SW)^2 + (Y\_P'' - Y\_SW)^2}$$

The real abscissa of point P is

$$Y\_real\_P = V\_SW + +(V\_NW - V\_SW) \cdot \frac{Dist\_P''\_SW}{Dist\_SW\_NW}.$$

4. DISCUSSION

The previous relations are implemented in an Excel document. First sheet of this document is dedicated to the input data. The other sheets are dedicated to the curves belonging to the diagram.

Figure 3 presents a sheet in Excel and the according diagram in Paint. Once the coordinates of the point along the curve are identified, they are inputted in the Excel sheet. The according calculi are performed in background and the diagram in the current sheet is updated. The analyst is able to visually verify the accuracy of the coordinates belonging to the latest point.

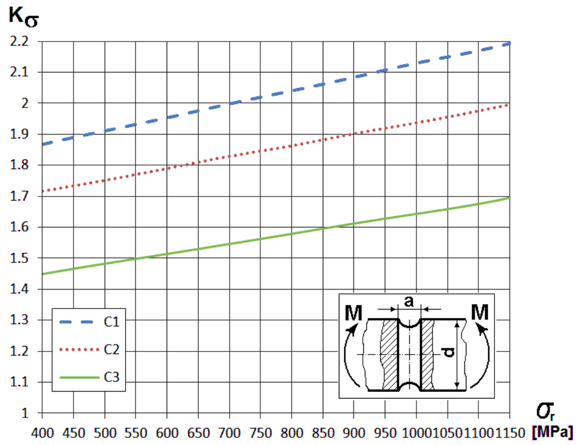

Figure 4 – The new form of the diagram

Regarding the accuracy, there are several sources of errors. Firstly, if the scanned diagrams are perfectly aligned to the screen coordinates, the slope of the vertical axis is infinite. This leads to large values and consequently to large round-off errors. However, these cases are not very often. Secondly, in Excel there are not available extended precision types, therefore it is difficult to handle large numbers. In this case the analyst must find alternate solutions: equivalent calculus relations, a new order of the operations, etc.

Last but not least, the diagram itself may produce errors. In this way, figure 3 presents a diagram, [1] page 318, Fig. 14.10, where along the vertical axis instead of '1.1' there should be '1.0' If value '1.1' is inputted, it will lead to a wrongfully scaled diagram, with obviously wrong results.

The deformed diagrams due to the scanning process or the poor graphical quality of the scanned documents are also sources of errors.

However, the analyst is able to select a pixel, therefore the data acquisition is accurate.

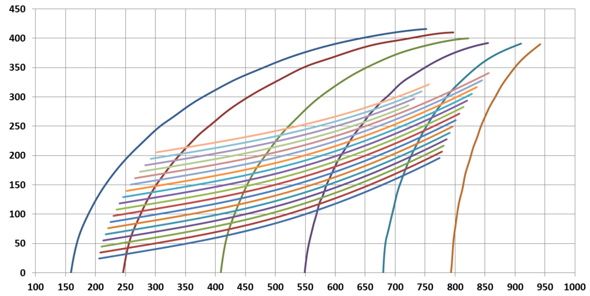

Figure 5 – Automatic generation of the isostatics in a photoelasticimetry study

A different method to process the information is needed for the variable scaling of the horizontal axis of a diagram. For instance, a factor which influences the endurance limit of the materials fatigue is the size factor, whose diagram has some peculiar aspects, such as the different lengths of line segments assigned to different ranges of the real values.

However, the computer based analytic method previously presented has important resources, figure 5 [7], and we'll extensively use it in our projects.

5. CONCLUSIONS

Intelligent nowadays concept and design require various sources of data, including results of the experimental studies. Our original method to digitize diagrams was tested and the results are accurate.

It is desirable to create a software application which can automatize all the operations, and to integrate the data acquiring process with the data interpolation, in this way being saved a lot of time.

Nevertheless the actual method is very flexible. The software used to measure the coordinates of the points along the curve and to perform the calculi may be found in any operating system. Moreover, the analyst is allowed to verify the results between the stages of data processing and to identify the eventually faults.

We plan to develop a software which can be used for diagrams with several scales along the axes.

6. ACKNOWLEDGMENTS

Ideas regarding the interdisciplinary studies based on the strength of materials theory are the result of the studies developed in the framework of the MIEC2010 bilateral Ro-Md research project, Oanta, E., Panait, C., Lepadatu, L., Tamas, R., Constantinescu, M., Odagescu, I., Tamas, I., Batrinca, G., Nistor, C., Marina, V., Iliadi, G., Sontea, V., Marina, V., Balan, V. (2010-2012), “Mathematical Models for Inter-Domain Approaches with Applications in Engineering and Economy”, MIEC2010 - Bilateral Romania-Moldavia Scientific Research Project, [4], under the supervision of the National Authority for Scientific Research (ANCS), Romania, which is the follow-up of the ID1223 scientific research project: Oanta, E., Panait, C., Nicolescu, B., Dinu, S., Pescaru, A., Nita, A., Gavrila, G., (2007-2010), "Computer Aided Advanced Studies in Applied Elasticity from an Interdisciplinary Perspective", [2], under the supervision of the National University Research Council (CNCSIS), Romania.

Ideas regarding the analytical models and the automatic calculus in structural studies are partial results of the models developed in the scientific research study ‘Development of computer assisted marine structures’, Emil Oanta, Cornel Panait, Ghiorghe Batrinca, Alexandru Pescaru, Alexandra Nita, Feiza Memet, which is a component of the RoNoMar project, [5], 2012.

7. REFERENCES

[1] VICTOR DROBOTĂ, *Strength of materials*, “Didactical and Pedagogical” Publishing House, Bucharest, 1982

[2] OANTA, E., PANAIT, C., NICOLESCU, B., DINU S., PESCARU A., NITA A., GAVRILA G., *Computer Aided Advanced Studies in Applied Elasticity from an Interdisciplinary Perspective*, ID1223-Scientific Research Project, National University Research Council (CNCSIS), 2007-2010, Romania

[3] NICOLAE APOSTOLESCU, FLORENTIN □PERLEA, *Curve Digitizer - A software for multiple curves digitizing*, INCAS BULLETIN, (E) ISSN 2247-4528, (P) ISSN 2066-8201, Volume 2, Number 2/2010, pp. 14-19, DOI: 10.13111/2066-8201.2010.2.2.2

[4] OANTA, E., PANAIT, C., LEPADATU, L., TAMAS, R., CONSTANTINESCU, M., ODAGESCU, I., TAMAS, I., BATRINCA, G., NISTOR, C., MARINA, V., ILIADI, G., SONTEA, V., MARINA, V., BALAN, V., *Mathematical Models for Inter-Domain Approaches with Applications in Engineering and Economy*, MIEC2010 - Bilateral Romania-Moldavia Scientific Research Project, under the supervision of the National Authority for Scientific Research (ANCS), 2010-2012, Romania

[5] OANTA, E., PANAIT, C., BATRANCA, G., PESCARU, A., NITA, A., MEMET, F., *Development of Computer Assisted Marine Structures*, 130 pg., Nautica Publishing House, Constanta, 2012, ISBN 978-606-8105-70-3, 629.5

[6] EMIL OANTA, CORNEL PANAIT, GHEORGHE LAZAROIU, ANCA-ELENA DASCALESCU, *Computer Aided Instrument to Be Used as an Automatic Design Component*, ModTech2014 International Conference, 13-16 July 2014, Gliwice, Poland, TRANS TECH PUBLICATIONS, Vol 1036 of Advanced Materials Research, pp. 1017-1022, ISSN 102-660, ISBN-13: 978-3-03835-255-6

[7] EMIL M. OANTA, CORNEL PANAIT, MIHAELA BARHALESCU, ADRIAN SABAU, CONSTANTIN DUMITRACHE, ANCA-ELENA DASCALESCU, *Original computer method for the experimental data processing in photoelasticity*, Proc. SPIE 9258, Advanced Topics in Optoelectronics, Microelectronics, and Nanotechnologies VII, 92582A (February 21, 2015); doi:10.1117/12.2070409; http://dx.doi.org/10.1117/12.2070409

TECHNICAL REVIEW REGARDING THE METHODS TO FORMULATE THE PROBLEMS OF THE FACTORS WHICH MODIFY THE ENDURANCE LIMIT

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ABSTRACT

Variable loading are commonly produced during the period in service of the mechanical parts. Being a wide range of shapes, sizes, technologies and environmental conditions, the behavior of the parts due to material fatigue is difficult to predict. In order to take into account the phenomena which modify the endurance limit, each influence is expressed using a given coefficient. Most of these influences were experimentally studied and the results are usually expressed as diagrams. However, there are also empirical or semi-empirical relations which approximate the experimental values. Nowadays, because of the extensive use of the computer we consider that a new approach regarding the methods to express the results of the experimental studies in computer based models becomes necessary. In this way, we propose a method to express the factors' diagrams as spline functions, a given value of a certain parameter being easily calculated in a computer based model.

Keywords: *endurance limit, factors, diagrams, functions, computer based models.*

1. INTRODUCTION

Analysing the history of the structural studies we are able to understand two factors of progress: the level of evolution of the instrument used to perform the calculi and the great importance of the experimental studies.

Firstly, the rudimentary calculus instruments required several 'generous' assumptions, on which the so-to-say 'classic' theory was developed. Accordingly, many heuristic approaches were developed in order to have a fair accurate solution of that structural problem in a minimum amount of time, i.e. with minimum calculus effort. In many cases graphical analogies and graphical methods were conceived, being considered relevant and reliable.

Once the calculus instrument has evolved, the mathematicians and structural analysts were able to develop new calculus methods, i.e. general numerical methods, the finite difference method, the finite element method aso. However, using the new computing techniques the analytic models are also able to become more accurate and more complex.

Beside the theoretical models, experimental studies offer paramount information regarding the phenomena, their results being used either to validate the theoretical studies, or to evaluate their accuracy. Most of the time the results of the experimental studies are expressed as diagrams, being are either directly created by the experimental equipment, or provided by the research reports. So far, the diagrams were used directly by a designer who was dimensioning the according parts.

If computer based models are used, the experimental data may be expressed analytically, in order to be easily accessed by the theoretical studies.

Most of the parts are subjected to variable loads and the endurance limit in various conditions is experimentally measured, the factors which influence the endurance limit being usually presented as diagrams. In the next section we analyse the basic concepts in the modelling of the factors which influence the endurance limit.

2. THEORETICAL BACKGROUND

The first step was to extensively survey the technical literature regarding the factors which influence the endurance limit and it resulted several ways to approach this problem.

2.1 Problem formulation no. 1

A first approach was identified in several books and it is mainly inspired from [1] and [2]. In the ideal case, the endurance limit for a given mechanical part, $\left(\sigma_{-1k}\right)_d$, is experimentally measured [4] and the factors which influence the endurance limit are implicitly considered. If the fatigue of the real mechanical part cannot be experimentally measured, then it may be used a specimen and its endurance limit, σ_{-1}, experimentally measured. This value is adjusted taking into account the most important phenomena which might modify the endurance limit. Therefore, according to reference [1] and [2], the according coefficients are:

- β_k, the fatigue stress concentration factor; it can be calculated using the relation: $\beta_k = 1 + \eta_k \cdot (\alpha_k - 1)$, where η_k is the material sensitivity coefficient and α_k is stress statical concentration factor;
- ε, the size factor - it was noticed that the endurance limit is decreasing once the diameter of the specimen grows; this influence was experimentally tested and it was defined the size factor;
- γ, the surface finish factor – it was noticed that the fatigue failure starts from the surface of the material because in this area the bending stresses

are maximum and here may be found intergranular flaws which accelerate the failure; moreover, if a specimen is fatigue tested and the test is stopped at 25% of the expected life, a small thickness of the surface is removed, the surface is polished, and the test is resumed, the total life of the material will be substantially longer than the expected life.

The endurance limit of the real part is:

$$\left(\sigma_{-1k}\right)_d = \sigma_{-1} \cdot \frac{\varepsilon \cdot \gamma}{\beta_k}.$$

Most of the time these factors may be found in diagrams.

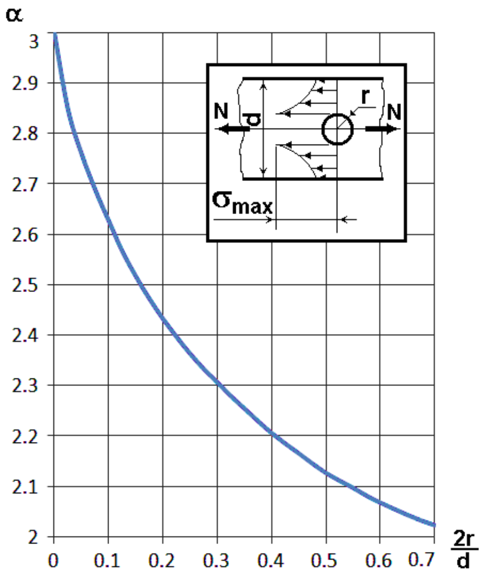

Figure 1 – Variation of the stress concentration factor with respect to the dimensions of a given concentrator

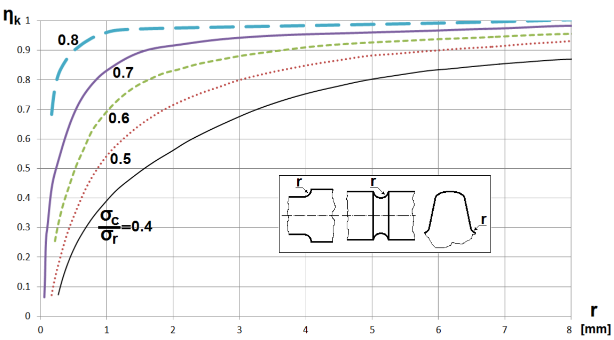

Figure 2 – Variation pf the material's sensitivity coefficient with respect to the radius of the notch

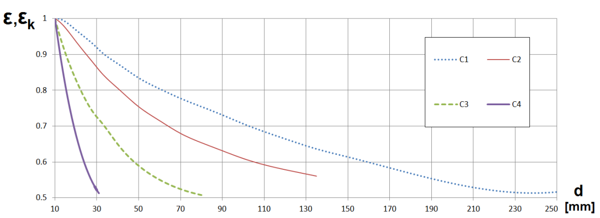

Figure 3 – Variation of the size factor with respect to the diameter of the specimen for several materials

In the previous figure the according materials are:

C1 – carbon steel, the specimen has no stress concentrators;
C2 – alloy steel, the specimen has no stress concentrators;
C2 – carbon steel, the specimen has small – medium size stress concentrators;
C3 – alloy steel, the specimen has small – medium size stress concentrators;
C4 – alloy steel, the specimen has large stress concentrators.

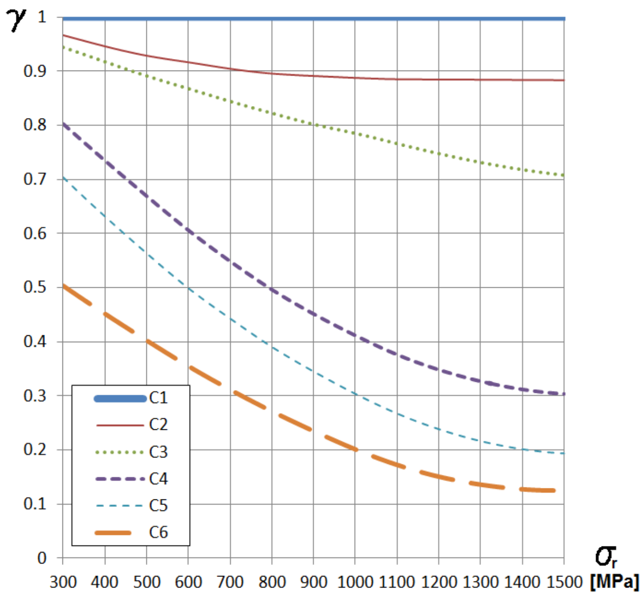

Figure 4 – Variation of the surface finish factor with respect to the ultimate stress, for several types of surfaces

In the previous figure, the according types of surfaces are:
C1 – ideally / mirror polished surface;
C2 – super-finishing or finish turning ;
C3 – grinding or rough turning;
C4 – hot rolled;
C5 – corroded in freshwater;
C6 – corroded in saltwater.

In [1] and [2] there are also given empirical relations, i.e. for α_k.

2.2 Problem formulation no. 2

Reference [3] takes into account the following influences and their according factors.

The influence of the loading on the endurance limit is expressed by the following load factors:

- K_b is the loading correction factor for reversed or rotating bending loading (usually $K_b = 1$); the according endurance limit for reversed bending loading is $\left(\sigma_{-1}\right)_b = \sigma_{-1} \cdot K_b$;
- K_a is the loading correction factor for reversed axial loading (usually $K_a = 0.8$); the according

endurance limit for reversed bending loading is $(\sigma_{-1})_a = \sigma_{-1} \cdot K_a$;

- K_s is the loading correction factor for reversed torsional or shear loading (usually $K_s = 0.55$ for ductile materials and $K_s = 0.8$ for brittle materials); the according endurance limit for reversed bending loading is $\tau_{-1} = \sigma_{-1} \cdot K_s$.

The influence of the surface finishing is expressed by the surface finish factor, denoted K_{sur}.

The influence of the size of the real part is given by the size factor, denoted K_{sz}.

The effect of the miscellaneous factors on endurance limit is given by the following coefficients:

- K_r, the reliability factor;
- K_t, the temperature factor;
- K_i, the impact factor.

Therefore, the endurance limit of a part with respect to a given loading is:

$$(\sigma_{-1})_b = \sigma_{-1} \cdot K_b \cdot K_{sur} \cdot K_{sz} \cdot K_r \cdot K_t \cdot K_i,$$
$$(\sigma_{-1})_a = \sigma_{-1} \cdot K_a \cdot K_{sur} \cdot K_{sz} \cdot K_r \cdot K_t \cdot K_i,$$
$$\tau_{-1} = \sigma_{-1} \cdot K_s \cdot K_{sur} \cdot K_{sz} \cdot K_r \cdot K_t \cdot K_i.$$

2.3 Problem formulation no. 3

Reference [11] presents the influence of the various phenomena in a similar way as the previous one, but in a more synthetic way, i.e.

$$(\sigma_{-1})_{real} = \sigma_{-1} \cdot k_a \cdot k_b \cdot k_c \cdot k_d \cdot k_e \cdot k_f,$$

where

- $k_a \leftarrow K_{sur}$,
- $k_b \leftarrow K_{sz}$,
- $k_c \leftarrow (K_b \ or \ K_a \ or \ K_s)$,
- $k_d \leftarrow K_t$,
- $k_e \leftarrow K_r$[1],
- $k_f \leftarrow$ this factor takes into account various effects, such as: residual stresses, corrosion, plating, metal spraying, fretting, and others.

2.4 Problem formulation no. 4

In reference [12] there are the same concentration factors. However, some of the factors are presented as diagrams and also as calculus relations.

The stress statical concentration factor, here denoted as K_t (α_k in problem formulation no. 1), may be calculated using the approximate formula[2]

$$K_t = B \cdot \left(\frac{r}{d}\right)^a,$$

where

- r is the radius of the fillet or of the notch;
- d is the smaller dimension of the stress concentrator;
- coefficients B and a are given for different filleted / notched / flat bars in axial tension / bending.

The size factor, C_s for circular components of diameter, d, is calculated using the relation

$$C_s = \begin{cases} 1, & d < 8\,mm \\ 1.189 \cdot d^{-0.097}, & 8\,mm < d < 250\,mm \end{cases}$$

The surface finish factor can be calculated using the following relation derived from the according diagrams:

$$C_f = a \cdot S_{ut}^b,$$

where

- S_{ut} is the tensile stress in MPa;
- a and b are coefficients given in tables, such as

Surface finish	a [MPa]	b
Ground	1,58	-0,085
Machined or Cold Drawn	4,51	-265
Hot rolled	57,7	-0,718
As Forged	272	-0,995

The temperature factor, C_t, is calculated using the relation:

$$C_t = \begin{cases} 1, & t < 450^\circ C \\ 1 - 5.8^{-3} \cdot (T - 450), & 450^\circ C < t < 550^\circ C \end{cases}.$$

The reliability factor, here denoted as C_r, has the following values:

Reliability	C_r
0.5	1
0.9	0.897
0.95	0.868
0.99	0.814
0.999	0.753
0.9999	0.702
0.99999	0.659
0.999999	0.620

2.5 Problem formulation no. 5

In reference [9] are presented several analytic, empirical and semi-empirical relations which may be

[1] "8% standard deviation in the test data requires a k_e value of 0.868 for 95% reliability, and 0.753 for 99.9% reliability"

[2] http://www.mae.ncsu.edu/eischen/courses/mae316/docs/Appendix_C.pdf

very useful for the development of a computer based study of the fatigue.

First effect taken into consideration regards the stress and strain concentrations and gradients, expressed by the fatigue notch factor, K_f, which can be calculated using the relation:

$$K_f = 1 + q \cdot (K_t - 1)$$

where

- q is the notch sensitivity of the material;
- K_t is the elastic stress concentration factor.

It can be easily noticed the connection with the first formulation of the problem, therefore

$$\beta_k \leftrightarrow K_f, \ \eta_k \leftrightarrow q, \ \alpha_k \leftrightarrow K_t.$$

Approximate formulae for q and K_f were developed by Neuber and Peterson, [9].

3. DISCUSSION

Using the data processor presented in [8], the previous diagrams may be approximated using spline functions, the according code being automatically created, figure 5.

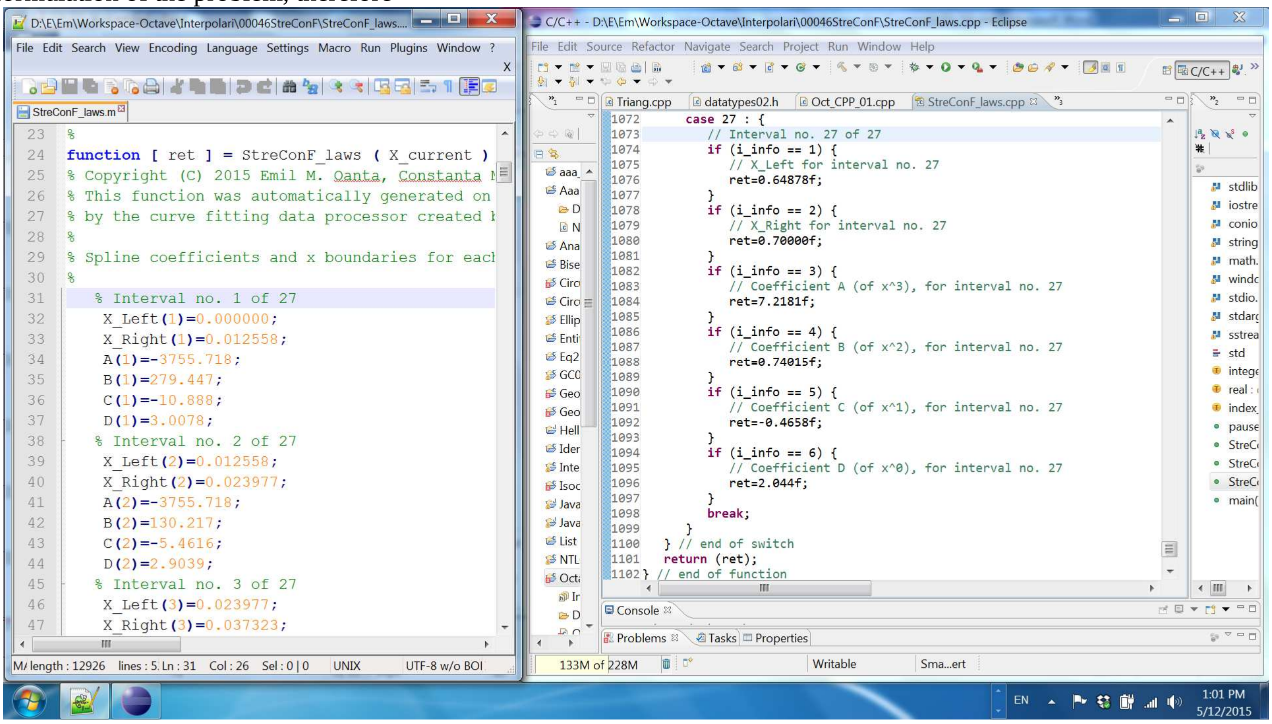

Figure 5 – Automatically generated code for the interpolation of the α_k diagram, the statical stress concentration factor

Table 1 – Coefficients of the spline curves which approximate the α_k diagram

No	x_i	x_{i+1}	A_i	B_i	C_i	D_i
1	0.0000	0.0126	-3755.7176	279.4471	-10.8875	3.0078
2	0.0126	0.0240	-3755.7176	130.2167	-5.4616	2.9039
3	0.0240	0.0373	643.1349	1.5520	-3.9569	2.8529
4	0.0373	0.0545	-321.2684	27.3012	-3.5719	2.8019
5	0.0545	0.0698	-303.3513	10.7358	-2.9181	2.7470
6	0.0698	0.0880	477.4181	-3.1817	-2.8026	2.7038
7	0.0880	0.1052	-773.1529	22.8373	-2.4455	2.6547
8	0.1052	0.1253	610.4463	-17.1266	-2.3471	2.6153
9	0.1253	0.1425	-324.1903	19.6698	-2.2960	2.5662
10	0.1425	0.1684	9.7275	2.9023	-1.9068	2.5308
11	0.1684	0.1885	2.2770	3.6574	-1.7371	2.4836
12	0.1885	0.2135	-14.2025	3.7950	-1.5870	2.4501
13	0.2135	0.2394	-24.7018	2.7324	-1.4243	2.4127
14	0.2394	0.2691	54.3888	0.8124	-1.3324	2.3772

No	x_i	x_{i+1}	A_i	B_i	C_i	D_i
15	0.2691	0.2912	-121.6827	5.6675	-1.1396	2.3397
16	0.2912	0.3258	53.5761	-2.3956	-1.0673	2.3160
17	0.3258	0.3537	-53.3007	3.1609	-1.0409	2.2784
18	0.3537	0.3815	39.5531	-1.2933	-0.9889	2.2507
19	0.3815	0.4123	5.4600	2.0121	-0.9688	2.2230
20	0.4123	0.4449	-39.2284	2.5157	-0.8296	2.1953
21	0.4449	0.4795	28.6121	-1.3299	-0.7909	2.1695
22	0.4795	0.5103	20.1955	1.6399	-0.7801	2.1417
23	0.5103	0.5488	-56.3213	3.5036	-0.6219	2.1199
24	0.5488	0.5805	69.3786	-2.9958	-0.6024	2.0979
25	0.5805	0.6074	-46.5870	3.6083	-0.5830	2.0780
26	0.6074	0.6488	7.2181	-0.1555	-0.4900	2.0640
27	0.6488	0.7000	7.2181	0.7402	-0.4658	2.0440

$$\alpha_k(x) = \sum_{i=1}^{27} \left[H(x - x_i) - H(x - x_{i+1}) \right] \cdot \left[A_i \cdot (x - x_i)^3 + B_i \cdot (x - x_i)^2 + C_i \cdot (x - x_i) + D_i \right]$$

In the previous relation it was used the Heaviside's unit function,

$$H\left(x-x_j\right)=\begin{cases}0, & x<x_j\\ +\dfrac{1}{2}, & x=x_j\\ +1, & x>x_j\end{cases},\ \forall x_j$$

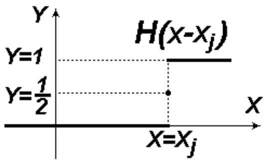

Figure 6 – Variation of Heaviside's function

As it can be noticed, in figure 5 there are the implementations of the information presented in the previous table. Moreover, the $\alpha_k\left(x\right)$ function has a fix form, in comparison to the various forms of the empirical and semi-empirical relations in the technical literature.

If all the diagrams would be expressed as spline functions, a computer based model can be easily developed, because of the code which is implementing the spline related information, code that is automatically generated.

In this way CAD applications can easily use this information in order to add intelligence into to project right from the first stages. We evaluate that there are two directions to use this approach in CAD projects. The first one is to create a dimensioning application for a particular project starting from the operational conditions, being taken into account the fatigue. The second one is to assign to geometrical entities meta-information which can be associated to the stress concentrators, roughness and size of the mechanical part.

4. CONCLUSIONS

The analytical form of the diagrams which represent the factors that influence the endurance limit may lead to added intelligence in the projects. Computer based dimensioning may be also used in CAD applications. More sophisticated computer solutions may be also based on the analytical forms of the diagrams. Last but not least, all the diagrams in the paper were analytically expressed.

5. ACKNOWLEDGMENTS

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Ideas regarding the analytical models and the automatic calculus in structural studies are partial results of the models developed in the scientific research study 'Development of computer assisted marine structures', Emil Oanta, Cornel Panait, Ghiorghe Batrinca, Alexandru Pescaru, Alexandra Nita, Feiza Memet, which is a component of the RoNoMar project, [5], 2012.

6. REFERENCES

[1] GH. BUZDUGAN, *Strength of materials*, The "Technical" Publishing House, Bucharest, 1970

[2] VICTOR DROBOTĂ, *Strength of materials*, "Didactical and Pedagogical" Publishing House, Bucharest, 1982,

[3] R. S. KHURMI, J. K. GUPTA, *A Textbook of Machine Design*, EURASIA PUBLISHING HOUSE (Pvt.) LTD., RAM NAGAR, NEW DELHI-110 055, 2004, ISBN 81-219-0501-X

[4] IOAN POPA, LAVINIA SILVIA STANCIU, *The Fatigue Behaviour of Sucking Rod Materials in Corrosive Environment*, Annals of Oradea University, Facile of Management and Technological Engineering, Volume XV (V), 2006, ISSN 1583-0691

[5] OANTA, E., PANAIT, C., NICOLESCU, B., DINU S., PESCARU A., NITA A., GAVRILA G., *Computer Aided Advanced Studies in Applied Elasticity from an Interdisciplinary Perspective*, ID1223-Scientific Research Project, National University Research Council (CNCSIS), 2007-2010, Romania

[6] OANTA, E., PANAIT, C., LEPADATU, L., TAMAS, R., CONSTANTINESCU, M., ODAGESCU, I., TAMAS, I., BATRINCA, G., NISTOR, C., MARINA, V., ILIADI, G., SONTEA, V., MARINA, V., BALAN, V., *Mathematical Models for Inter-Domain Approaches with Applications in Engineering and Economy*, MIEC2010 - Bilateral Romania-Moldavia Scientific Research Project, under the supervision of the National Authority for Scientific Research (ANCS), 2010-2012, Romania

[7] OANTA, E., PANAIT, C., BATRANCA, G., PESCARU, A., NITA, A., MEMET, F., *Development of Computer Assisted Marine Structures*, 130 pg., Nautica Publishing House, Constanta, 2012, ISBN 978-606-8105-70-3, 629.5

[8] EMIL OANTA, CORNEL PANAIT, GHEORGHE LAZAROIU, ANCA-ELENA DASCALESCU, *Computer Aided Instrument to Be Used as an Automatic Design Component*, ModTech2014 International Conference, 13-16 July 2014, Gliwice, Poland, TRANS TECH PUBLICATIONS, Vol 1036 of Advanced Materials Research, pag. 1017-1022, ISSN 102-660, ISBN-13: 978-3-03835-255-6

[9] ALI FATEMI, *Notches and their effects*, https://www.efatigue.com/training/Chapter_7.pdf, accessed 10-May-2015

[10] EMIL M. OANTA, *Basic Knowledge in STRENGTH OF MATERIALS Applied in Marine Engineering for Maritime Officers*, vol. 2, “Nautica” Publishing House, 2015, ISBN 978-606-681-063-0
[11] * * *, - *Metal Fatigue* -, http://www.epi-eng.com/mechanical_engineering_basics/fatigue_in_metals.htm, accessed 09-May-2015
[12] * * *, *Metal Fatigue and Endurance*, http://www.roymech.co.uk/Useful_Tables/Fatigue/FAT_Mod_factors.html, accessed 10-May-2015

RAPID ASSESSMENT OF TOXIC EFFECTS OF POLLUTANTS FROM SOIL

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ABSTRACT

Due to the complexity pollutants it is becoming increasingly difficult to know the capacity of different environments to allow living organisms to develop normally. Valuation techniques for negative effects are costly and time consuming.

In this paper we present an assessment method for determining the inhibitory effects of pollutants from different types of soil on seed germination and root growth of higher plants.

Keywords: *rapid soil assessment, toxicity test, Phytotoxkit.*

1. INTRODUCTION

The intensely polluting activities from extractive industries, metallurgy, chemical and energy prior to 1990, led to the local, zonal or regional pollution of the soil with hydrocarbons, heavy metals, natural and synthetic organic substances which have caused appearance and expansion of contaminated sites which currently affects human health and the environment.

To understand issues relating to soil protection must understand competitive processes that occur on the one hand, between the ecological functions of soil and, on the other hand between technical functions / industrial, socio-economic and cultural. Thus, there is competition between using land for infrastructure as a source of raw materials and as a source of cultural and geogene relics, on the one hand and, on the other hand, the production of biomass and filtering activities, buffering and transformation and a reserve of genes. There is an intense interaction between land use for infrastructure and its development and use of land for agriculture and forests.

Soil contamination of agricultural residues and sewage sludge treatment, and intensive use of fertilizers and plant protection substances is in conflict with ecological functions of soil, adding to the contamination produced through the use of land for infrastructure.

Based on data provided by the monitoring system of quality of agricultural soils in Romania is estimated that about 900 thousand ha of soil are polluted chemically, of which 200,000 ha are excessively polluted (MMDD, 2008). Chemical soil pollution is mainly due to emissions from the chemical industry, iron and steel, non-ferrous mineral processing, thermal power plants, cement factories, refineries, pesticide use, irrigation with contaminated water, vehicular traffic etc.

The biological activity of the soil is determined by fauna and soil microorganisms. Most living organisms in the soil have a general positive action (bioremediation). Therefore, the soil is a living body, which on the aside, has the capacity retention substances and chemical elements, including pollutants, but on the other hand, has the ability to gradual release, after physicochemical processes, of the elements needed for plant nutrition and, with them, of polluting elements.

Therefore, methods of investigation and assessment of contaminated sites, and how to assess the risks that contaminated sites they cause for various components of the ecosystem are becoming increasingly important.

2. DETERMINATION OF THE TOXICITY OF MIXTURES

In practice many toxicity tests are performed upon single compounds, as a necessary routine of the environmental risk assessment applied to pesticides and almost of industrial chemicals. In other situations, samples of the chemicals with higher purity are tested, but often the materials under test contain appreciable quantities of other compounds. For instance, pesticides may contain an important percent of by-products due to the technical formula and manufacturing process. There are many additives such as carrier solvents, emulsifiers, and stabilizers, which may have some effect on its toxicity. For this reason, the environmental risk assessment has to be sustained by tests carried out on the original products released into the environment, to result a realistic estimation of toxic impact (EC, 2006, 2007, 2008).

The environmental risk assessment performed on target compounds becomes more complicated due to the actual level of pollution existing in the environment. In the case of contaminated soils, the situation can be complicated by the presence of highly persistent lipophilic compounds with long biological half-lives. Theoretically speaking, toxicity levels are usually additive amounts, but there is the possibility of amplified effects of toxicity when animals or plants are exposed to mixtures, when the toxicity can greatly exceed the summation of the toxicity levels of its compounds (Nortcliff, S., 2002).

Test performed on environmental samples often measures the toxicity of mixtures. Sometimes, the measured toxicity differs markedly from the predicted toxicity and there are several possible causes for this discrepancy. One can be the potentiating or antagonist interaction between two or more compounds. There are many situations when chemical analysis may be incomplete, overlooking the presence of certain toxic molecules and neglecting the presence of others. This fact is due to the low concentrations of organic pollutants in complex mixture. In soil toxicity tests there is also the question of availability (FAO, 2006).

The routine described in the following words may be used to evaluate the toxicity of mixtures both in industrial mixtures and environmental samples. However we should be aware of the difficulties to attribute the toxicity that is measured to particular compounds, or mixtures, in the case of environmental samples. The main targets are rapid but inexpensive tests, in real time including bioassays.

In actual world, the real hazard of environmental contaminants cannot be determined by just employing conventional chemical analysis. The role of biological testing is growing rapidly and toxicity testing is now gradually included in environmental legislations of many countries. Toxicity testing procedures identifies the presence all individual pollutants in the sample, as well as their quantities too. Hence there is an effective integration of the toxicity of all the individual toxic compounds present in the tested samples. Many of these are unlikely to be detected by conventional chemical testing.

Quick miniaturized, small-scale, bioassays tools have been developed over the last years with selected test species, which are independent of the sourcing, the culturing and/or the maintenance of live stocks of test biota.

2. METHODS

In our experiment we applied Phytotoxkit, a kit produced by MicroBioTest Inc that is a short-chronic type of test which uses 3 test species with rapid seed germination and rapid early plant growth: *Sorghum saccharatum* (sorghum), *Lepidium sativum* (cress) and *Sinapis alba* (mustard).

We worked according Phytotoxkit procedure, using the seeds and the control soil from the kit bag.

Samples soils were: agriculture land (AL); land of roadside (RL); vegetable garden in rural areas (GRA); vegetable garden in urban industrial area (GIA).

For each sample of the soil, including control soil (CS), three replicates were used, and for each replicate 10 seeds were utilized.

The endpoints of the experiment were the seed germination and the mean root length which were determinate using formulas:

- For mean number of germinated seeds (in the three replicates)

$$\bar{N} = \frac{N_1 + N_2 + N_3}{3}$$

- For mean length of the measured roots (mean in the three replicates)

$$\bar{L} = \frac{\frac{\sum_{k=1}^{n_1} L_{k_1}}{n_1} + \frac{\sum_{k=1}^{n_2} L_{k_2}}{n_2} + \frac{\sum_{k=1}^{n_3} L_{k_3}}{n_3}}{3}$$

3. RESULTS AND DISCUSSION

Analyzing the results concerning germination process of plants, all three types of seed shows a germination capacity of 100% in the sample of soil AL and for the control soil (table 1).

Sorghum showed a maximum germination in all soil samples except GIA soil sample with 86.6% of seed germination capacity.

The cress presents in these three types of samples soil a germination capacity between 86.6% and 96.6%, and the mustard has a germination capacity between 73.3% (the lowest recorded germination capacity in soil sample RL) and 100 % seed germination (in samples soil GRA).

Table 1. Mean number of germinated seeds

Specia	Sample of soil				
	CS	AL	RL	GRA	GIA
Sorghum saccharatum	10	10	10	10	8.66
Lepidium sativum	10	10	9	9.66	8.66
Sinapis alba	10	10	7.33	10	8.33

In the case of the mean length of the roots except for cress in the sample soil AL, for all other situations the average length of the roots for all 3 species was smaller than their length in the control soil sample. (figure 1).

Considering this end point, the soil sample taken from agricultural land has shown similar characteristics to those of the control soil, because for all three plants were recorded increases in plant roots at least 95% of the increase registered in control soil sample.

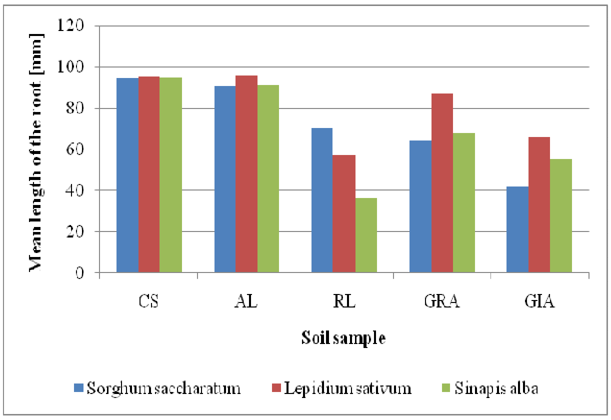

Figure 1 The mean length of roots

On average, in the GIA soil sample plant roots grew the least. Similar behavior presented root growth in the soil RL.

Sorghum root grows least in GIA and cress shows shortest average root in RL.

Mustard showed the smallest growth of the roots in the soil sample RL (only a growth of 39% compared with sample of control soil). Incidentally, in whole mustard seems to have the highest sensitivity to changes in soil properties.

Considering both phases of plant development for all soil samples observed toxic effect is manifested more intensely on root growth process (figure 2).

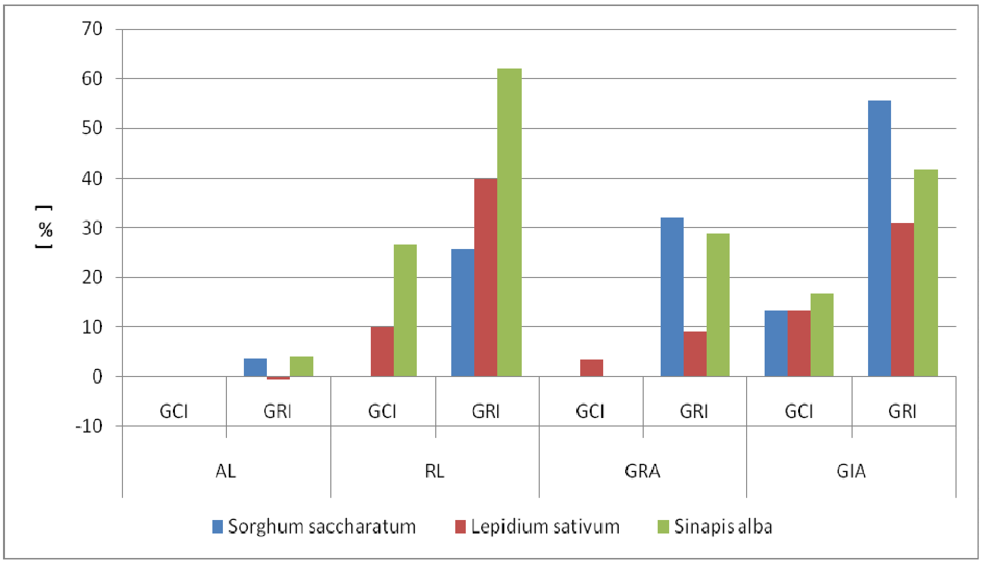

Figure 2 Inhibitory effects of various soil samples from the germination capacity (GCI) and root growth (GRI)

RL soil shows the strongest negative effect on the root growth of mustard: a growth inhibition of 62%.

GIA and GRA soils show the strongest negative effect on the sorghum root growth (a growth inhibition of 56% and 32% respectively).

In average soils GIA and RL shows the most intense inhibitory effect on the growth of plant roots, with about 43%. GRA soil sample shows an inhibitory effect on root growth of 23% and AL soil sample only 2%.

For the seed germination endpoint, the results reveal a toxic effect of RL, GRA and GIA soil samples on all three plant species between 3.4% and 26.7%.

For soil sample AL no inhibition process of the germination process was recorded.

GIA soil sample shows a similar level of inhibition of germination for the three plant species. Even if the soil sample from RL had no inhibition effect of germination for all 3 types of seeds for this viewpoint was presented the strongest toxic effect. GRA soil sample showed a low toxic level and only for seeds of cress (*L.sativum*).

S. saccharatum (sorghum) present an inhibition of germination capacity only in GIA sample (13.4%).

Although *L.sativum* shows the inhibition of the function of sprouting between 3.4% and 13.4% in three types of soil samples (GIA, RL and GRA), *S. alba* present a maximum inhibition effect of germination function (26.7%).

5. CONCLUSIONS

Results of the experiment on inhibitory effects of different types of soil on the ability of germination and root growth of plants suggests that samples of soil taken from vegetable garden situated in urban industrial area and from roadside were the most polluted, followed at great distance by sample of soil vegetable garden in rural areas.

The inhibitory effect of soil samples taken from agriculture land was insignificant.

Sorghum saccharatum is more sensitive in the soil sample taken from vegetable garden situated in urban industrial area for both germination capacity and growth of the roots.

Lepidium sativum and *Sinapis alba* are also more sensitive in the soil sample taken from vegetable garden situated in urban industrial area for germination capacity but in the soil sample from land of roadside for root growth.

In this situation the Phytotoxkit toxicity test was a practical and fast tool, which provided us data to assess the effects of a mixture of pollutants from different type of soil on higher plants.

This experiment argues statements about the benefits of toxicity tests; they provide the necessary information about the inhibitory effects of polluted environments on live organisms.

7. REFERENCES

[1] European Commission, *Impact assessment of the thematic strategy on soil protection*, 130 pg. Brussels, 2006. Available at: http://eusoils.jrc.ec. europa.eu/ esdb_archive/policies/Directive/sec_2006_620_en.pdf.

[2] European Commission, *Soil at the interface between Agriculture and Environment*, 2007 Available at: http://ec.europa.eu/agriculture/envir/report/en/inter_en/report.htm.

[3] European Commission, Joint Research Centre Institute for Environment and Sustainability, *Threats to Soil Quality in Europe*, 2008, 162 pg. Available at:

http://eusoils.jrc.ec.europa.eu/esdb/eusoils_docs/other/ EUR 23438 .pdf
[4] Food and Agriculture Organization of the United Nations , *Soil assessment*, 2006. Available at: http:// www.fao.org/fileadmin/templates/nr/kagera/Documents/ LADAmanuals/ part2_d.pdf.
[5] Ministerul mediului şi dezvoltării durabile, *Ghid tehnic privind modalităţile de investigare şi evaluare a poluării solului şi subsolului*, 2008 Available at: https://xa.yimg.com/.../ghid_investigare_draft_4_august 2008.
[6] Nortcliff, S., *Standardization of soil quality attributes. Agriculture, Ecosystems & Environment*, 88 161 – 168, 2002.

DANUBE ZOOPLANKTON DIVERSITY IN CERNAVODA AREA

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ABSTRACT

The diversity structure of zooplankton community in the Danube River waters near the Cernavoda city was studied during 1999-2010, in spring and summer periods, by performing 20 sampling and analyzing campaigns. Along this period of time, 63 species and varieties of zooplankton belonging to taxonomic groups of Rotatoria (64%), Bivalvia (1%), Cladocera (24%) and Copepoda (11%) were identified.

Keywords: Danube River, zooplankton diversity, species occurrence.

1. INTRODUCTION

Zooplankton is an important link in the food chains of aquatic ecosystems, being the most valuable source of food for numerous fish species. At the same time, it ensures the transfer of substances and energy from primary producers to consumers of higher order from ecosystems.

Studies on zooplankton in the Danube River refer especially to flood plains and the Danube Delta [1][2][3][4][5][6][7][8][9] areas, but there are poor data about temporal variation of the Danube zooplankton structure.

The goal of this work was to observe, during the decade 1999-2010, the diversity structure of zooplankton communities in some aquatic sites on Danube River, near the Cernavoda city. This area was chosen because here is located the Romanian Nuclear Power Plant which could be an important anthropogenic factor perturbing the life of zooplankton.

2. METHODS

Research has been done based on 20 campaigns of collecting samples of water from Danube River, in several sites situated between km 301 and 295 of the river (figure 1), during spring and summer seasons. The samples were taken at various water depths, on the entire water column.

Figure 1. Location of sampling points in the study area (image processed after Google Earth)

Zooplankton samples were collected using a Schindler – Patalas trap. They were concentrated by passing through 65 µm mesh plankton net and were preserved in 4% buffered formaldehyde.

The samples were examined using a MBC-2 stereomicroscope. The organisms dissection was performed in lacto phenol and a MC3 microscope were using for samples observing. For organisms identification usually guides from “Fauna Romaniei" referring to rotifers [10], cladocerans [11], and copepods [12][13] were used.

The identified individuals were grouped into systematic groups of Rotatoria (primary and secondary consumers, ROT CP and ROT CS respectively), Bivalvia (BIV), Cladocera (CLD) and Copepoda (primary and secondary consumers, COP CP and COP CS respectively), on trophic levels.

The Constancy of Occurrence of a species A was based on the constancy ecological index [14]:

$$C_{sp\ A} = \frac{\text{Number of samples where the species A occured}}{\text{Total number of samples}}$$

The species were divided into four categories:

- Euconstants – includes species corresponding with

$$C_{sp\ A} \geq 75\%$$

- Constants – includes species corresponding with

$$50\% < C_{sp\ A} \leq 75\%$$

- Accessories – includes species corresponding with

$$25\% < C_{sp\ A} \leq 50\%$$

- Accidental – includes species corresponding with

$$C_{sp\ A} \leq 25\%$$

3. RESULTS

Zooplanktonic associations identified in studied areas, counted 63 species and varieties belonging to Rotatoria, Bivalvia, Cladocera and Copepoda groups.

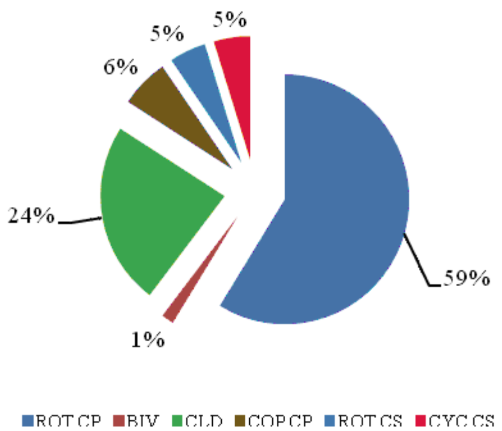

Figure 2. Average taxonomic structure of zooplankton from the study area [%] (1999-2010)

From the point of view of the specific components, the rotifers are represented by 40 species, bivalves by veliger larvae, cladocerans by 15 species, and copepods by 7 species (figure 2).

Zooplankton presented a number of 48 species and varieties during spring campaigns and a number of 62 in summer. In both seasons rotifers group have the highest specific diversity which represented 58% from total taxonomic diversity, followed by cladocerans with 21% from total species in spring and 24% from species in summer (figure 3).

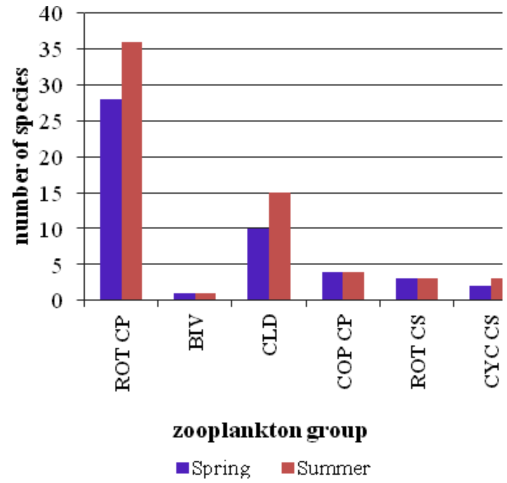

Figure 3. Seasonal average taxonomic structure of zooplankton from the study area (1999-2010)

Analyzing the specific diversity on trophic levels, it could be seen the high level of primary consumers contribution, which was about 90%.

From ecological point of view, zooplankton is presented as a mixture of species, some of them preferring pelagic areas, other pelagic-coastal areas, benthic or areas with macrophytes (figure 4).

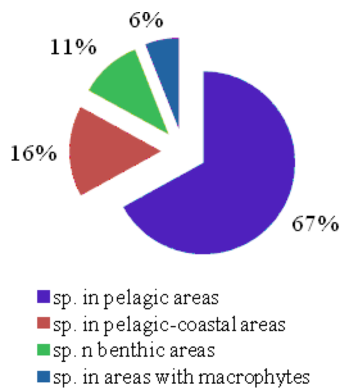

Figure 4. Ecological preferences of zooplankton in the study area

In terms of nutritional preferences, the qualitative composition of zooplankton showed the following main groups (figure 5):

- Microfiltrating species, such as Brachionus, Keratella, Filinia, Lecane and Rotaria genera, Euchlanis parva, Mytilina ventralis or Notholca acuminata, bivalves veloger larvae;

- Macrofiltrating species - secondary predators, such as *Synchaeta* and *Trichocerca* genera;
- effective microfiltrating species, such as *Daphnia sp*, *Eubosmina sp*. and *Bosmina genus* (exceptie B. *longirostris*);
- Ineffective microfiltrating species, such as *Bosmina longirostris* or oher cladocerans from *Chydorus and Diaphanosoma genera;*
- Effective macrofiltrating species, such as *Eudiaptomus gracilis*;
- predators - secondary macrofiltrating species, such as *Asplanchna genus, Acanthocyclops vernalis vernalis, Cyclops vicinus vicinus, Mesocyclops crassus.*

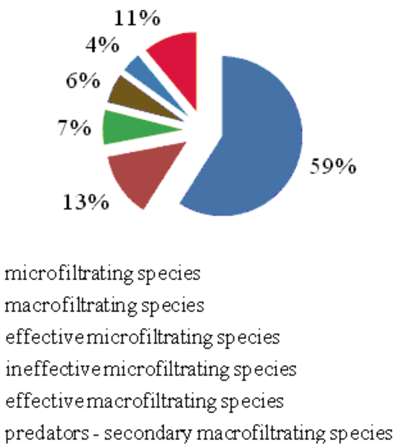

Figure 5. The qualitative composition of zooplankton function of nutritional preferences of species

In terms of *saprobic* indicators, zooplankton is varied, including:

- Oligo-saprobic species (47%), such as the rotifers Keratella cochlearis, K. quadrata, Lecane genus, Mytilina ventralis, Notholca acuminate and Trichocerca pusilla or cladocerans *Alona quadrangularis, Bosmina coregoni, B. longirostris, Daphnia galeata galeata* and *Pleuroxus aduncus aduncus,* as well as calanoid copepod *Eudiaptomus gracilis*;

- β şi α mezo-saprobic species (53%), such as Brachionus genus, *Filinia longiseta, Platyas quadricornis, Polyarthra vulgaris* and *Asplanchna priodonta from rotifers;* cladocerans *Chydorus sphaericus, Daphnia cucullata, Daphnia longispina, Moina micrura dubia, Moina brachiata, Ilyocryptus sordidus, Macrothrix laticornis.*

The frequency of occurrence proved the continuity of a species in a certain area. In the ecological balance of the zooplankton community an important role are played by the species with constant frequency. In the analyzed area, on the basis of 600 samples, Brachionus calyciflorus var. amphiceros and veligers larvae individuals have been identified during each summer campaign, in all sampling stations. Also in the summer periods, there were other euconstants species:

-on the primary consumers level: *Keratella quadrata, K. cochlearis* and *Brachionus diversicornis* from rotifers, *Bosmina longirostris* and *Moina micrura dubia from cladocerans,* nauplius and copepodite development stages of copepods;

- on the level of secondary consumers: Acanthocyclops vernalis vernalis, Mesocyclops crassus and Asplanchna brightwelli.

In the spring periods, euconstants species are represented by *Brachionus calyciflorus* var. amphiceros, *B. calyciflorus* şi *Keratella cochlearis, Chydorus sphaericus* and *Acanthocyclops vernalis vernalis.*

Concerning constancy, the zooplankton structure on the spring periods was represented by 5 euconstants species, 8 constants species, 14 accessories and 21 accidental.

In the summer we found 13 euconstants species, 11 constants species, 14 accessories and 24 accidentals (figure 6).

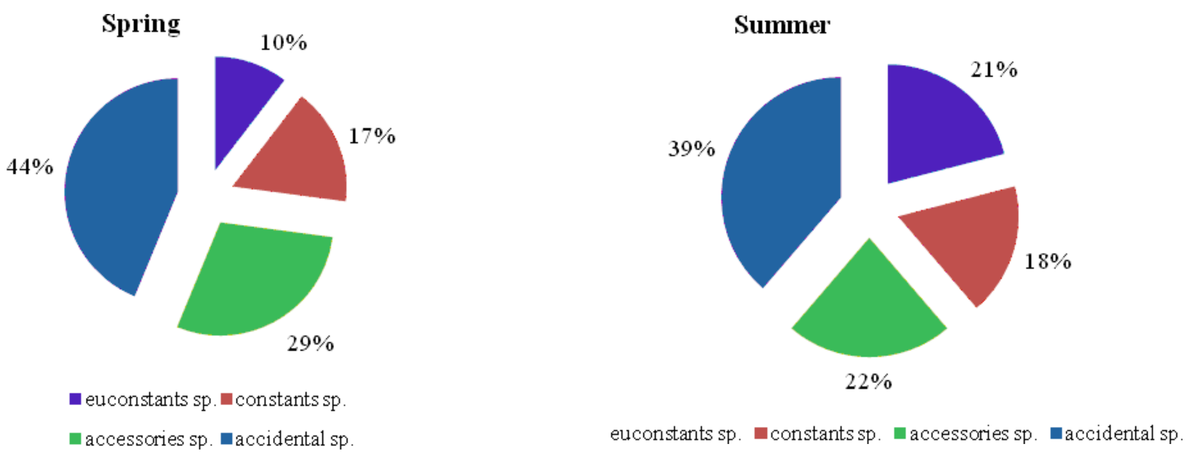

Figure 6. Seasonal taxonomic structure of zooplankton species in terms of constancy

The research did not reveal significant differences in taxonomic structure of zooplankton over time.

On the spring campaigns number of taxa ranged from a low value of 17 (April 2006) up to a maximum of

32 (April 2007 and May 2009). In summer there were recorded minimum 31 species (June 2009) and maximum 52 species (August 2010).

It has been identified a slight upward trend for taxonomic diversity during summer (figure 7). On average, in spring time 42 species have been identified and in the summer campaign 25 species.

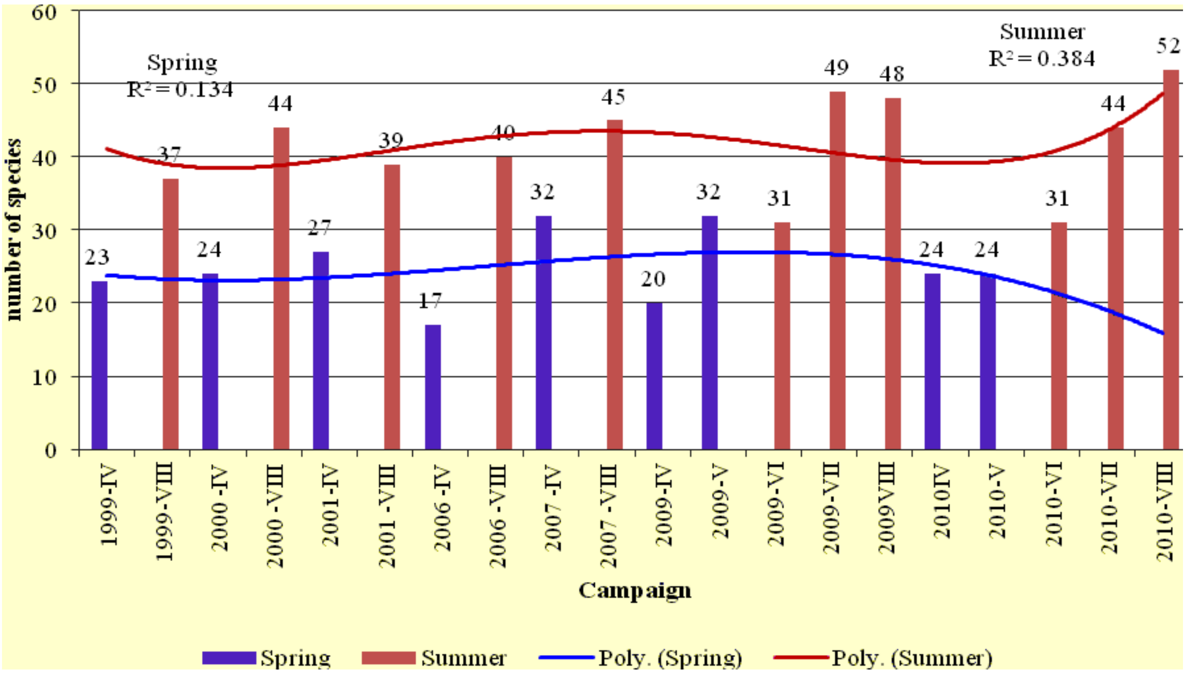

Figure 7. Seasonal variation of taxonomic diversity (1999-2010)

During 1999-2010, only copepods primary consumers and rotifers secondary consumers showed a quasi-periodic variation; for the other groups there was no significant trend, according to the values of coefficients of determination (R2) for regression curves associated with variations of the species number.

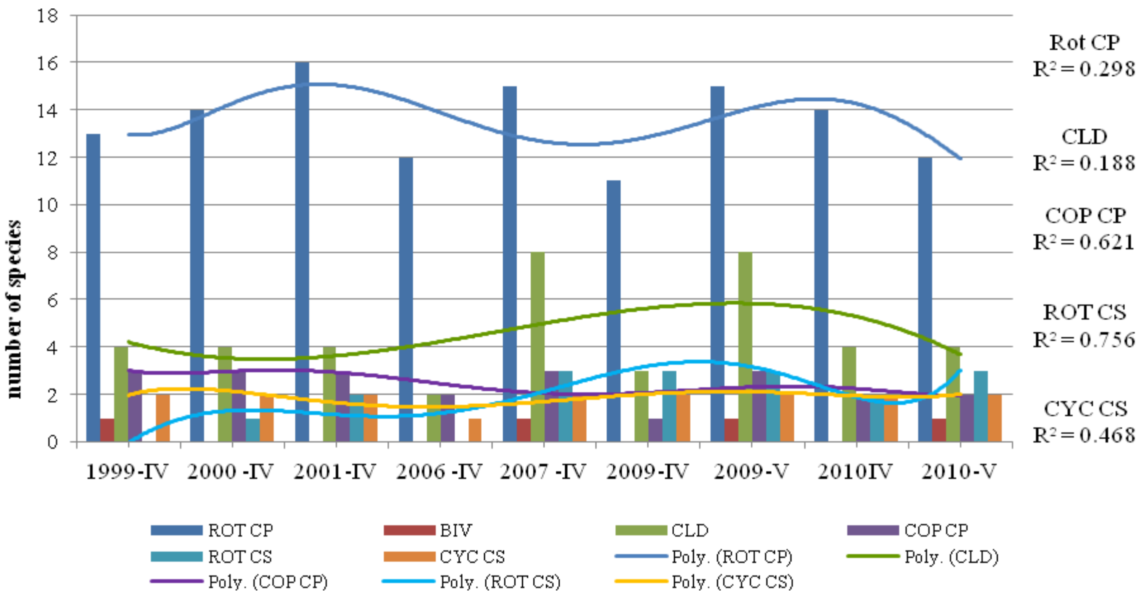

Figure 8. Structure of zooplankton groups during spring seasons

In spring seasons, rotifers showed a variation from 11 species (2009, May) to 16 species (2001). Veligers larvae are recorded only in April of 1999 and 2007 and in May of 2009 and 2010. Cladocerans present a minimum of 2 species in 2006 and a maximum of 8 species in 2007 and 2009 (May). Copepods primary consumers had the maximum of 3 species in 67% of samples and a minimum of 1 species in April 2009. Rotifers secondary consumers, found only in 4 campaigns, were recorded with 3 species and Cyclops had the maximum number of species (3) in eight campaigns (figure 8).

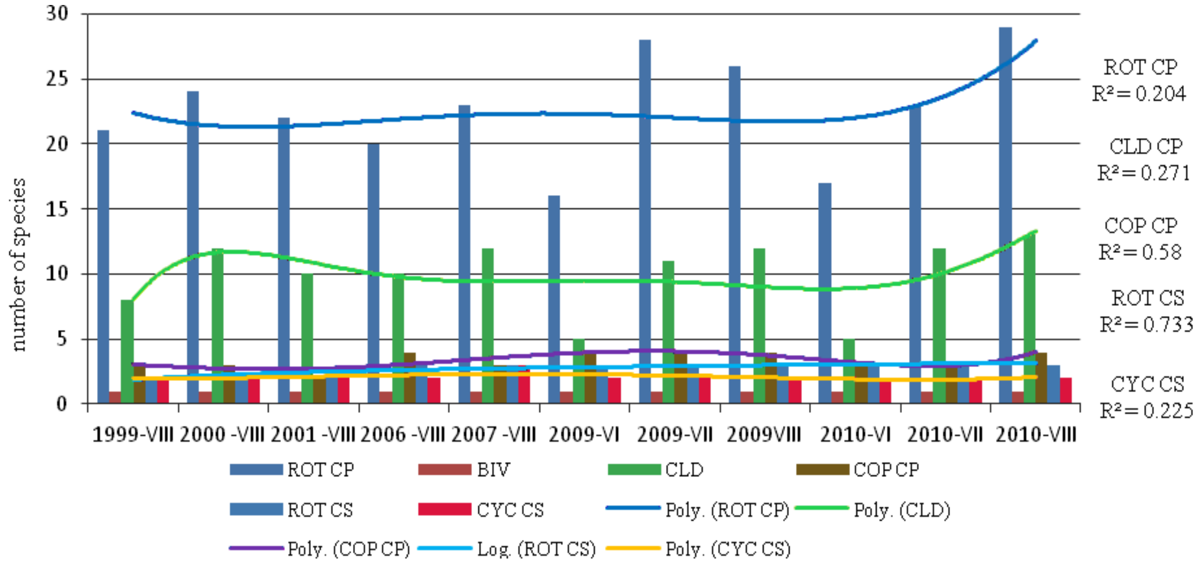

Figure 9. Structure of zooplankton groups during summer seasons

In summer seasons rotifers showed a minimum number of species in June 2009 (16) and a peak in August 2010 (29). Cladocerans species vary from 5 (June 2009 and 2010) to 13 species (August 2010). The other groups did not show significant variations in the species number (figure 9).

4. CONCLUSIONS

Research conducted during 1999-2010 in which 600 samples of zooplankton were collected from the Danube River near the Cernavoda city, revealed:

1. The presence of 63 species (including nauplius and copepodite development stages of copepods) belongs rotifers (primary and secondary consumers), cladocerans, copepods (primary and secondary consumers), and veligers larvae.

2. In summer campaigns, there were on average of 42 zooplankton forms, compared with 24 present in the spring campaigns.

3. A number of 48 species was recorded in spring seasons and 62 in the summer.

4. From an ecological point of view zooplankton is characterized by the presence of pelagic forms.

5. In terms of nutritional preferences zooplankton is characterized by microfiltrating species.

6. From a saprobic point of view zooplankton, is characterized by oligo-saprobic and β-α mezo-saprobic indicators in similar proportions.

7. 27% of species on the spring seasons and 39% of species on the summer seasons are constants and euconstants.

Compared to other areas of the Danube River, taxonomic diversity of zooplankton it is not very higher, but we can say that zooplankton communities, as a whole, are stable over time and are characterized by persistent species in the ecosystem. Hence it could be stated that the negative ecological influences of the Nuclear Power Plant over zooplankton populations are weak, reversible and they do not affect the structural stability of the diversity.

5. REFERENCES

[1] International Commission for the Protection of the Danube River, *Joint Danube Survey*. Summary of the Final Report, 30 p, 2002

[2] International Commission for the Protection of the Danube River, *Joint Danube Survey 2*. Final Scientific Report, 242 p., 2008. http://www.icpdr.org/jds/files/ICPDR_ Technical_ Report for web_low_corrected.pdf

[3] Romanescu, G.T., Dinu, C.I., Radu, A.L., Török, L.I., *Ecological chatacterization of the fluviatile limans in the south-west Dobrudja and their economic implications (Romania)*, Carpathian Journal of Earth and Environmental Sciences, October 2010, Vol. 5, No. 2, p. 25 – 38, 2010

[4] Radu, A., *Contributions to knowing the zooplankton on several lakes of south-west Dobrogea*, Constanta Maritime University Annals, Years XIII, vol. 18, pp. 147-157, 2012.

[5] Kazakov, S., Ihtimanska, M., Varadinova, E., Pavlova, M., Uzunov, Y., Pehlivanov, L. *Communities in two wetlands on the Bulgarian Danube floodplain*. International Association Danube Research, Limnological Reports 39. Proceeding, p 81-90, 2012.

[6] Kiss, A., Schöll, K., Dinka, M., Berczik, A. *Zooplankton monitoring in the Szigetköz floodplain of the Danube (Hungary) (1999-2011): long-term results and consequences*. International Association Danube

Research, Limnological Reports 39. Proceeding, p. 195-202, 2012.
[7] Schöll, K., Kiss, A., Dinka, M., Berczik, Á. *Mid-term changes of planktonic rotifer communities in the Szigetköz floodplain of the Danube, Hungary (2003-2011).* International Association Danube Research, Limnological Reports 39. Proceeding, p 179-188, 2012.
[8] Zinevici, V., Parpală, L. (2005). *The zooplankton structure in the Iron Gates II reservoir (Danube km 863-942), in 2002*. Rev. Roum. Biol. – Biol. Anim. 50 (1-2): 17-28.
[9] Parpală, L., Moldoveanu, M., Dumitrache, A., Florescu, L. *Dynamics of phyto- and zooplankton communities diversity of the Sfântu Gheorghe arm under the anthropogenic impact*. Rom. J. Biol.–zool., volume 58, No.2, P. 123–139, Bucharest, 2013.
[10] Rudescu L. (1960): *Trochelminthes.Rotaria*, Fauna R.P.R., II (2), Ed. Acad.R.P.R., 1192 p.
[11] Negrea St. (1983): *Cladocera Crustacea*, Fauna R.S.R., vol. IV, (12), Ed. Academiei R.S.R., 400p.
[12] Damian – Georgescu A. (1963): *Copepoda. Fam. Cyclopidae (forme de apă dulce).* Fauna R.P.R., Ed.Acad. R.P.R., 4, (6):.204p
[13] Damian – Georgescu, A. (1966): *Copepoda. Calanoida –forme de apa dulce*. Fauna RSR, 4,(8), 130p.
[14] Gomoiu, M.T, Skolka, M, *Ecologie. Metodologii pentru studii ecologice*, 170 pg, Ovidius University Press, Constanta, 2001.

SECTION III

ELECTRONICS, ELECTRONICAL ENGINEERING AND COMPUTER SCIENCE

STUDY OF COMPRESSIBLE FLUID FLOW THROUGH THE TURBOCOMPRESSOR OF SUPERCHARGED DIESEL ENGINE USING VOLUME ELEMENTS METHOD

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ABSTRACT

The author presents in the paper, the mathematical model used to simulate fluid flow in unsteady regime and 3D geometry. Numerical calculation is done using the model presented in the paper to flow through the turbocharger of supercharged MB836Db diesel engine (maximum power 420 HP at 1320 rpm). Calculation program developed by author was realized with personal subroutine; they are placed in software Phoenics and were obtained remarkable results as are variations of pressure, density, velocity components, turbulent kinetic energy using 3D geometry of the flow turbocharger rotor channel and turbocharger rotor channel and diffuser with a part of outlet chamber.

Keywords: *Diesel supercharged; Phoenics software; Pressure; Kinetic turbulent energy*.

1. INTRODUCTION

Paper work includes the mathematical model which permits the study and the simulation of the unsteady flow of compressible fluid in generally, and also the numerical calculation based on the volume elements method. The computer programme was realized with the Phoenics software and personal subroutines; it permits simulation of the unsteady flow in case of 3D geometry. The paper includes graphic results in a varied form obtained with the Photon software, for the variations of pressure, density, velocity components, turbulent kinetic energy, using 3D geometry of the flow turbocharger rotor channel and turbocharger rotor channel and diffuser with a part of outlet chamber (spiral chamber).

2. MATHEMATICAL MODEL

Mathematical model includes equations of conservation like as, energy, mass, momentum, also equation for turbulent flow, fluid acceleration and equation of state for fluid. Is possible to write these equations using a general form of the transport equation for variable considered Φ (scalar variable) [2], considering a single phase fluid:

$$\frac{\partial}{\partial t}(\rho\Phi)+\nabla\cdot(\rho\vec{V}\Phi)-\nabla\cdot(\Gamma\nabla\Phi)=S_\Phi \Rightarrow$$
$$\Rightarrow\frac{\partial}{\partial t}(\rho\Phi)+\frac{\partial}{\partial x_i}(\rho u_i\Phi)=\frac{\partial}{\partial x_i}\left(\Gamma\cdot\frac{\partial\Phi}{\partial x_i}\right)+S_\Phi=D_\Phi+S_\Phi. \quad (1)$$

where: S - source; Γ - diffusion coefficient; $\vec{V}$ - vector of velocity with u_i components; ρ - density of fluid.

On the basis general transport equation (1) results the following equations for the particular cases:

- equation of continuity (S=0 ; Φ=1), [2],[3]:

$$\frac{\partial\rho}{\partial t}+\nabla\cdot(\rho\vec{V})=0;\Rightarrow\frac{\partial\rho}{\partial t}+\frac{\partial}{\partial x_i}(\rho u_i)=0; \quad (2)$$

- momentum equation ($\Phi=\vec{V};\Gamma=\mu$), [2],[5],[10]:

$$\frac{\partial}{\partial t}(\rho\vec{V})+\nabla\cdot(\rho\vec{V}\vec{V})=\nabla\cdot(\mu\nabla\vec{V})-\nabla p+\vec{B}+\vec{F}+\vec{V}_f \Rightarrow$$
$$\Rightarrow\frac{\partial}{\partial t}(\rho u_i)+\frac{\partial}{\partial x_j}(\rho u_i u_j)=-\frac{\partial p}{\partial x_i}+B_i+F_i+V_i+\frac{\partial\tau_{ij}}{\partial x_j}, \quad (3)$$

where: μ - viscosity; B_i - gravitational forces; F_i - external body forces; V_i - viscous forces not accounted for by $\nabla(\mu\nabla\vec{V})$; τ_{ij} viscous stress tensor given by [5],[6]:

$$\tau_{ij}=\left[\mu\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)\right]-\frac{2}{3}\mu\frac{\partial u_l}{\partial x_l};l=i,j,k \quad (4)$$

- viscosity of fluid [6]:

$$\mu=\mu(T) \text{ or } \mu=\alpha\dot{S}^{n-1};\dot{S}=\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}, \quad (5)$$

where n and α are empirically values.

- energy equation ($\Phi=q;\Gamma=k_c$), [2],[5]:

$$\frac{\partial}{\partial t}(\rho q)+\nabla\cdot(\rho\vec{V}q)=\nabla\cdot(k_c\nabla q)+S_h \Rightarrow$$
$$\frac{\partial}{\partial t}(\rho h)+\nabla\cdot(\rho\vec{V}h)=\frac{\partial}{\partial t}(p)+\nabla\cdot(\vec{V}p)+\nabla\cdot(k_c\nabla T)+\tau\nabla(\vec{V})S_h$$
$$\Rightarrow\frac{\partial}{\partial t}(\rho h)+\frac{\partial}{\partial x_i}(\rho u_i h)=\frac{\partial}{\partial x_i}\left(k_c\frac{\partial T}{\partial x_i}\right)+u_i\frac{\partial p}{\partial x_i}+\frac{\partial p}{\partial t}+ \quad (6)$$
$$+\tau_{ij}\frac{\partial u_i}{\partial x_j}+S_h.$$

where: k_c - thermal conductivity; τ_{ij} viscous stress tensor; $\tau_{ij}\frac{\partial u_i}{\partial x_j}$ - viscous heating term considered when the viscous stresses are large in compressible flows.

- the total acceleration of the fluid in the absolute system, [10], [3]:

$$a=\frac{d\vec{V}}{dt}=\frac{\partial\vec{W}}{\partial t}+\vec{W}\cdot\nabla\vec{W}+2\vec{\omega}\times\vec{W}+\vec{\omega}\times(\vec{\omega}\times\vec{r})+\frac{\partial}{\partial t}(\vec{\omega}\times\vec{r}), \quad (7)$$

$\vec{\omega}$ - angular speed; $\vec{w}$ - the velocity in the relative system; $\vec{r}$ - the position vector in the absolute system;
- the thermal conductivity $k_c : k_c = k_c(T)$; (8)
- density gas law as: $\rho = \frac{p_{ref} + p^{'}}{RT}$, (9)

p' - local static pressure defined relative to ' p_{ref} ' .

According to the general transport Eq. (1) for a conserved scalar quantity Φ, [2], [4], [10] we consider that the value Φ in turbulent flows is comprised of a mean value and a fluctuating part: $\Phi = \overline{\overline{\Phi}} + \Phi'$, where $\overline{\Phi}$ - is the time averaged value of Φ definided as:

$$\overline{\overline{\Phi}} = \frac{1}{\Delta t} \int_0^{\Delta t} \Phi \, dt \, . \qquad (10)$$

If we consider that density fluctuations are negligible and we use the average value obtained in time, results:

$$\frac{\partial}{\partial t}\left(\bar{\rho}\bar{\Phi}\right) + \frac{\partial}{\partial x_i}\left(\bar{\rho}\bar{u}_i\bar{\Phi}\right) = -\frac{\partial}{\partial x_i}\left(\bar{\rho}\overline{u_i'\Phi'}\right) + \overline{D_\Phi} + \overline{S_\Phi} \qquad (11)$$

The Eq.(11) is similar with Eq.(1), except that each quantity is represented by its average value in time; the new term $\bar{\rho}\,\overline{u_i'\Phi'}$ represents the diffusion of variable Φ due to the turbulent fluctuations.

The Reynolds stresses are assumed to be proportional to the mean velocity gradients, with the constant of proportionality being the turbulent viscosity μ_t , [5],[2],[9]:

$$\mu_{ef} = \mu + \mu_t \ ; \ \mu_t = \rho \cdot C_\mu \cdot \frac{k^2}{\varepsilon} \ ; \qquad (12)$$

$$\rho\overline{u_i' u_j'} = \rho\frac{2}{3}k\delta_{ij} + \mu_t\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right) - \frac{2}{3}\mu_t\frac{\partial u_l}{\partial x_l}, \qquad (13)$$

where: $\rho\overline{u_i' u_j'}$ is used in Eq. 3; k - turbulent kinetic energy; ε - dissipation rate of k; δ_{ij} - variable Kronecker; C_μ =0.085, empirically constants [8] .

The value of k, ε are obtained by conservation equations similar to general transport Eq. (1), [8],[9],[6]:

$$\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_i}(\rho u_i k) = \frac{\partial}{\partial x_i}\left(\frac{\mu}{\sigma_k}\cdot\frac{\partial k}{\partial x_i}\right) + G_k - \rho\varepsilon$$

$$\frac{\partial}{\partial t}(\rho\varepsilon) + \frac{\partial}{\partial x_i}(\rho u_i \varepsilon) = \frac{\partial}{\partial x_i}\left(\frac{\mu}{\sigma_\varepsilon}\cdot\frac{\partial \varepsilon}{\partial x_i}\right) + G_{1\varepsilon}\frac{\varepsilon}{k}\cdot G_k - C_{2\varepsilon}\rho\frac{\varepsilon^2}{k} \ ; \qquad (14)$$

where: $C_{1\varepsilon}, C_{2\varepsilon}$ -- empirical constants; $\sigma_k, \sigma_\varepsilon$ -- "Prandtls" numbers governing the turbulent diffusion of k and ε ; G_k -- rate of production of turbulent kinetic energy , according [6], [4]:

$$G_k = \mu_t\left(\frac{\partial u_j}{\partial x_i} + \frac{\partial u_i}{\partial x_j}\right)\frac{\partial u_i}{\partial x_i} \, . \qquad (15)$$

3. THE NUMERICAL CALCULATION

The numerical solution for the system presented (Eq. 1-9 and Eq. 12-15) is obtained using the volume elements method, [12],[13], [2], method which includes the following stages:

a) Divide the flow area into discrete control volumes, Fig. 1a (2D geometry), or Fig. 1b (3D geometry), using a curvilinear grid, [12], [13]; the volume divided into volume elements for flow geometry rotor channel is presented in figure 2, and for flow geometry rotor and diffuser with part of outlet chamber is presented in figure 3 [11].

b) Integration of the equations on the individual control volumes to construct the algebraic equations for unknown values (velocity, pressure, density, turbulent kinetic energy, the dissipation rate). The integration of differential equations is represented using the divergence theorem:

$$\int_{volume,V} \frac{\partial}{\partial x}(\rho u) dV = \int_{Area,A} \rho u \cdot dA \, . \qquad (16)$$

For example, for one dimensional unsteady fluid flow, the equations system includes the differential equation for continuity, momentum and a generic transport equation for the conserved scalar variable, [2], [5], [11]:

$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial x}(\rho u) = 0 \ ; \qquad (17)$$

$$\frac{\partial(\rho u)}{\partial t} + \frac{\partial}{\partial x}(\rho u u) = -\frac{\partial p}{\partial x} + \frac{\partial}{\partial x}\left[\mu\left(\frac{\partial u}{\partial x}\right)\right] + F \ ; \qquad (18)$$

$$\frac{\partial}{\partial t}(\rho\Phi) + \frac{\partial}{\partial x}(\rho u \Phi) = \frac{\partial}{\partial x}\left(\Gamma\frac{\partial \Phi}{\partial x}\right) + S_\Phi \, . \qquad (19)$$

Using the divergence theorem above for integration on the control volume Figure 1a, [11], [12] these equations will become:

$$\frac{\rho_n - \rho_{n-1}}{t_n - t_{n-1}} + (\rho u A)_e - (\rho u A)_w = 0 \Leftrightarrow \frac{\rho_n - \rho_{n-1}}{t_n - t_{n-1}} + J_e - J_w = 0 \ ; \qquad (20)$$

$$\frac{(\rho u)_n - (\rho u)_{n-1}}{(t_n - t_{n-1})} + J_e u_e - J_w u_w = -(p_e - p_w)A + \left[\frac{\mu_e}{\Delta x_e}(u_E - u_P) - \frac{\mu_w}{\Delta x_w}(u_P - u_W)\right]A + F \ ; \qquad (21)$$

$$\frac{(\rho\Phi)_n - (\rho\Phi)_{n-1}}{(t_n - t_{n-1})} + J_e\Phi_e - J_w\Phi_w = \left(\Gamma_e\frac{\Phi_E - \Phi_P}{\Delta x_e} - \Gamma_w\frac{\Phi_P - \Phi_W}{\Delta x_w}\right)A + S_\Phi \, , \qquad (22)$$

where: the difference (t_n - t_{n-1}), is the time distance on the time grid; $(\rho\,\Phi)_n - (\rho\,\Phi)_{n-1}$ represents the difference between the new value at the ' n ' moment and the old value at 'n-1' moment.

c) The numerical solution for the equations system of the unsteady fluid flow (Eq. 1-9 and Eq. 12-15) are obtained if applied, the method presented above to construct the algebraic equations, on each constant plane of dimension I,J,K for the 3D geometry channel of turbocharger rotor. Using the general form of equation (22), the algebraic equation which must be solved for any variable Φ, at each time ' n ', at point P, on each surrounding point P may be written in general form, [5], [11]:

$$A_P \Phi_P = \sum_{NB} A_{NB} \Phi_{NB} + S_\Phi . \qquad (23)$$

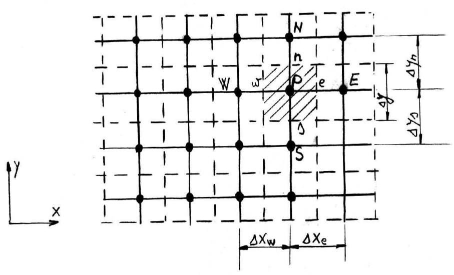

Figure 1a - 2D

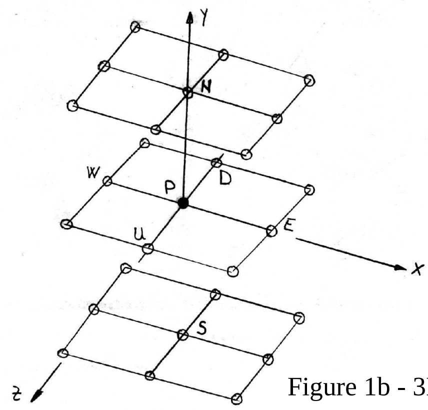

Figure 1b - 3D

The computer program can calculate the values of variables for fluid flow, such as pressure, components of velocity, kinetic turbulent energy, density, dissipation rate of turbulent energy, temperature, using the Phoenics software and personal subroutines. All details (specifications) for the calculation model and solving it, are given in [11], chapter 6.

4. RESULTS FOR NUMERICAL SIMULATION OF NONSTATIONARY FLUID FLOW, THROUGH THE TURBOCOMPRESSOR VTR-200R, USED ON DIESEL SUPERCHARGED MB-836Db

Paper presents graphical results [11], for unsteady working conditions (around speed of 10000 rpm) of turbocompressor VTR 200R of supercharged Diesel engines MB836 Db, for the second period of time. Are shown components of velocity (U, V, W on x, y, z direction) on the border and on the middle in [m/s], density of the fluid in [kg/m3], superpressure in [N/m2], cinetic turbulent energy in the turbocharger rotor channel (Fig. 4-8) and turbocharger rotor channel with diffuser and a part of outlet chamber (spiral chamber) (Fig. 9-12); Z direction is the rotation axis.

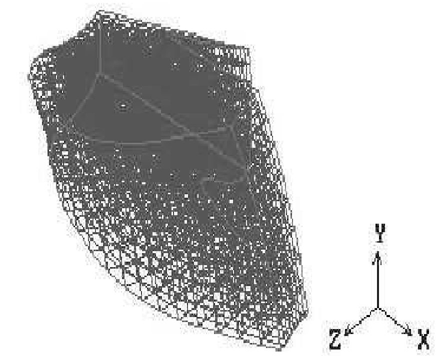

Figure 2 Grid of flow geometry rotor

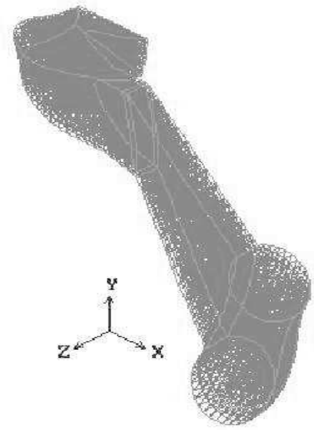

Figure 3 Grid of flow geometry rotor and diffuser with part of outlet chamber

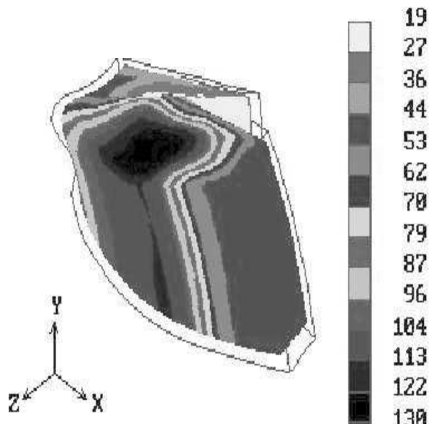

Figure 4 Values of 'U' component of velocity on the border

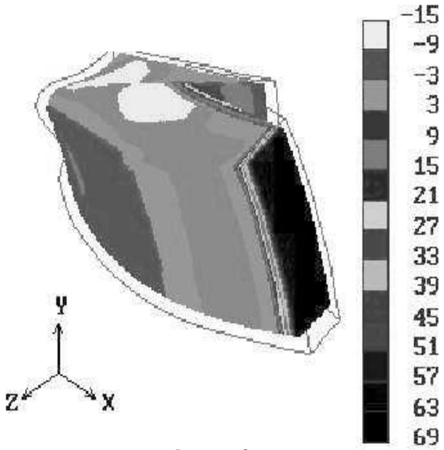

Figure 5 Values of 'W' component of velocity on the border

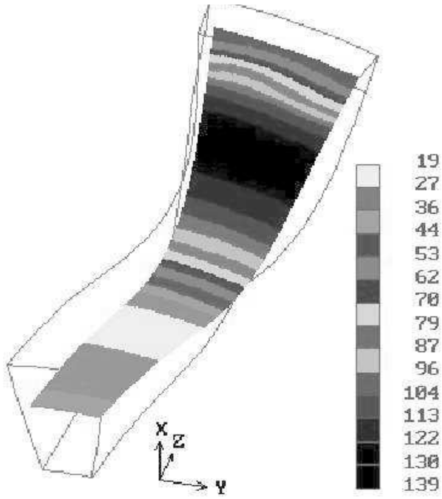

Figure 8 Values of 'U' component of velocity on the middle

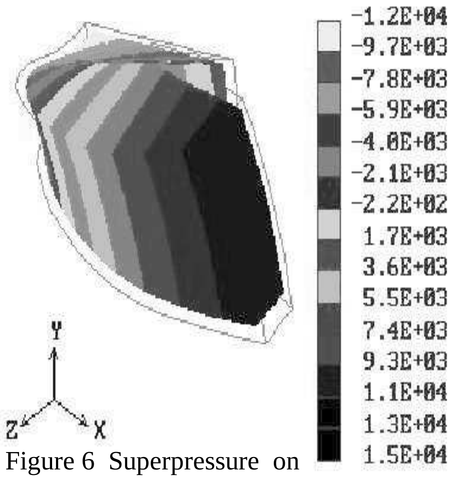

Figure 6 Superpressure on border

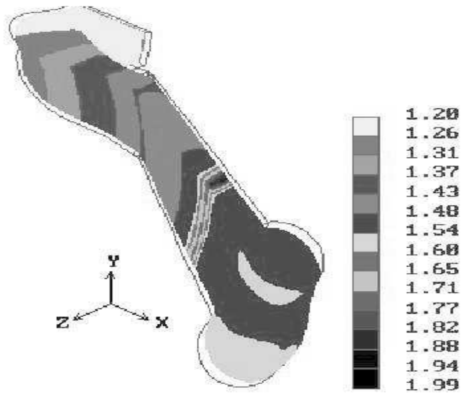

Figure 9 Density on the border

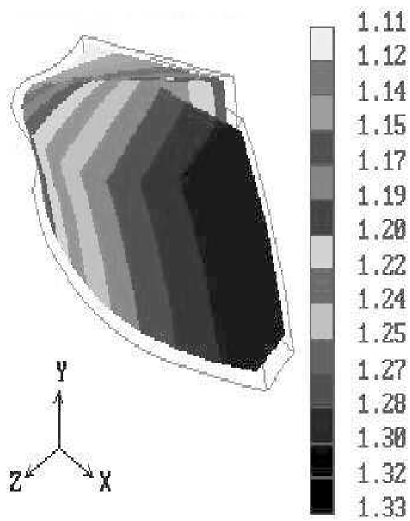

Figure 7 Density on the border

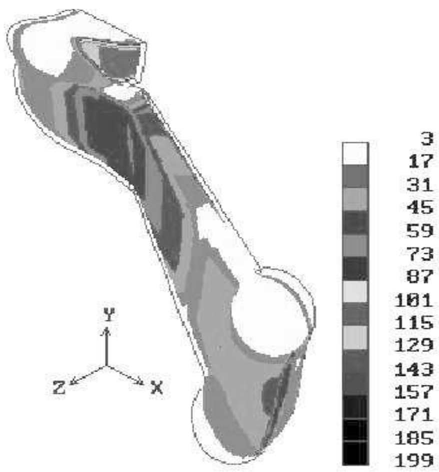

Figure 10 Kinetic turbulent energy on the border

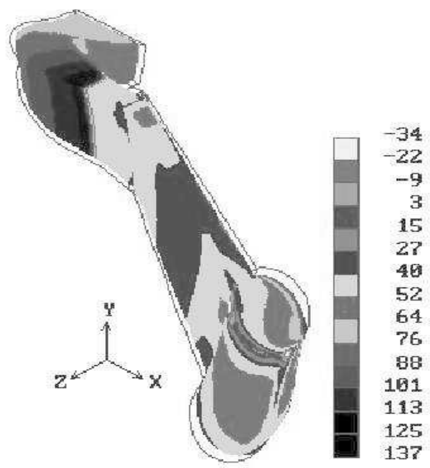

Figure 11 Values of 'U' component of velocity on the border

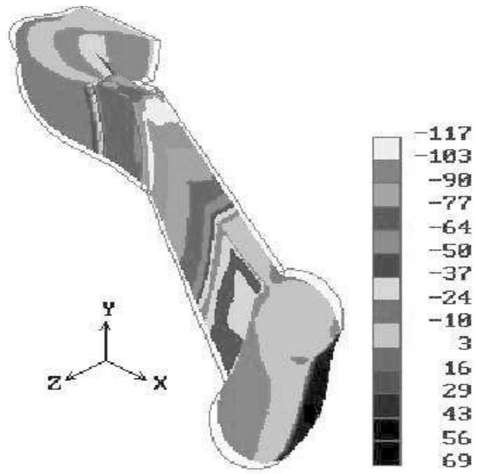

Figure 12 Values of 'W' component of velocity on the border

5. CONCLUSIONS

Using the computer programme, which was realised using Phoenics software and personal subroutines is possible to achieve the grid for 3D complicated flow zones, calculate and present on different graphs forms, the values of important parameters for the unsteady flow. Paper includes graphic results in a varied form obtained with the Photon software, for the variations of pressure, density, velocity components, turbulent kinetic energy, using 3D geometry of the flow turbocharger rotor channel and turbocharger rotor channel and diffuser with a part of spiral chamber. For this numerical simulation were added in [11] experimental results for pressure, velocity and temperature in case of the unsteady flow in turbocompressor. Numerical simulation of unsteady flow in turbocompressor, also allows the study of its influences on turbocharged engine performance, especially the influence on time response at dynamic changes on operating mode.

6. REFERENCES

[1] HINZE J.O., *Turbulence*, New York, NY:McGraw – Hill, Publishing Co.,1975

[2] Howard J.H.G., *Unsteady flow in turbomachines - Computational methods for quasi-three-dimensional and three dimensional flow analysis and design of radial turbomachinery*, University of Waterloo, 1980

[3] KRAIN H. , *A Study on Centrifugal Impeller and Diffuser Flow*, Journal of Engineering for Power, Vol. 103, No. 4 1981, pp.688-697

[4] LAUDER B.E.,and Spalding D.B., *Lectures in mathematical models of turbulence*, London, England Academic Press, 1972

[5] MARKATOS N.C., *Computer simulation for fluid flow, heat and mass transfer, and combustion in reciprocating engines*, National Technical University Athens , Greece, 1989

[6] MARVIN J.G., *Turbulence Modeling for Computational Aerodynamics*, Tech. Paper AIAA-82-0164, 1982

[7] MARZOUK M., *Simulation of turbocharged diesel engines under transient conditions*, Ph. D thesis, University of London (Imperial College), 1976

[8] PATANKAR S.V., *Numerical Heat Transfer and Fluid Flow*, Washington, DC: Hemisphere Publishing Corp., 1980

[9] RODI W., *Turbulence Models and their Application in Hydraulics*, Delft, TheNetherlands: IAHR, 1984

[10] WATSON N., JANOTA M.S, *Turbocharging the internal combustion engines*, Fluid Dynamics Institute, Darmouth College, New Hampshire, USA, and Imperial College, London, 1982

[11] BURCIU SALVADORE MUGUREL, *Contributions to the Study of nonstationary processes in the internal combustion engines overloading turbo–compressors*, Ph. D. thesis, University of,Dunarea de Jos' Galati, 2000

[12] THOMAS J. R. HUGHES, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*, Dover Publications August 2000

[13] KLAUS JURGEN BATHE, *Finite Element Procedures Part 1-2*, Prentice Hall; second edition 1995

COMPUTER PROGRAM FOR THE SIMULATION OF HEAT RELEASE IN THE INTERNAL COMBUSTION ENGINE CYLINDER

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ABSTRACT

The paper deals with the mathematical model and computer program for the simulation of heat release in the internal combustion engine cylinder, in the case that the heat addition is prescribed as function of crank angle and the calculation of dimensionless mass loss through the cylinder - rings system. The mathematical model includes the differential equations for the pressure, work, heat loss, mass loss and heat addition, prescribed as functions of crank angle. The computer program, writen using Mathlab procedures, solves the equations system on the basis of Runge-Kutta method 4/5. The paper includes in the final part, the graphic results obtained using the computer program.

Keywords: *Heat release; Work; Pressure; Internal combustion engine; Heat and mass loss.*

7. INTRODUCTION

Within the processes of internal combustion engines, when the valves are shut, a part of mass is transferred from the cylinder to the crankcase, so that the mass in the cylinders is no longer constant. In this conditions, the thermic equation of state is:

$$\frac{1}{P}\cdot\frac{dP}{d\theta}+\frac{1}{V}\cdot\frac{dV}{d\theta}=\frac{1}{m}\cdot\frac{dw}{d\theta}+\frac{1}{T}\cdot\frac{dT}{d\theta}, \quad (1)$$

where:
p, V, T - the thermic parameters of state for the engine fluid ;
m - the instantaneous mass of load in the cylinder;
θ - the crank angle (at θ = 0°, the minimum volume is V_0 at dead center at piston stroke and the maximum volume V_1 at θ = 180°).

The first law of thermodynamics in differential form, applicable to an open system must write:

$$m\cdot c_v\cdot\frac{dT}{d\theta}+c_v\cdot T\cdot\frac{dm}{d\theta}=\frac{dQ}{d\theta}-P\cdot\frac{dV}{d\theta}-\frac{\dot{m}_p\cdot c_p\cdot T}{\omega}, \quad (2)$$

where:
c_v, c_p - specific heat of fluid;
$\dot{m}_p$ = the instantaneous leakage or blowby mass rate;
ω - the angular speed of engine shaft (of crank).

Eliminating dT/dθ between equation (1) and (2) and known the adiabatic exponent of gass, yields the following:

$$\frac{dP}{d\theta}=-\gamma\cdot\frac{P}{V}\cdot\frac{dV}{d\theta}+\frac{\gamma-1}{V}\cdot\frac{dQ}{d\theta}-\frac{\gamma\cdot\dot{m}_p}{\omega\cdot m}. \quad (3)$$

In equation (3) is used the equation of continuity for mass conservation:

$$\frac{dm}{d\theta}=-\frac{\dot{m}_p}{\omega}. \quad (4)$$

It is possible to notice the ratio between the instantaneous blowby mass and entire mass in the cylinder.

$$C=\frac{\dot{m}_p}{m}. \quad (5)$$

8. THE MODEL OF ENGINE PROCESS

The equation of heat addition due to combustion and heat lost by the gases in the cylinder must write:

$$dQ=Q_{in}\cdot dx-dQ_p, \quad (6)$$

where: Q_{in} - heat addition due to combustion process;
x - a function which define the relationship between heat addition on the engine cycle and the crank angle θ;
dQ_p - heat lost by the gases in the cylinder;

According to [1], [2] the function x is suggested for the sparking engines the following form:

$$x=\frac{1}{2}\cdot\left\{1-\cos\left[\frac{\pi\cdot(\theta-\theta_s)}{\theta_a}\right]\right\};0\le x\le 1. \quad (7)$$

where: θ -- the instantaneous crank angle;
θ_s -- the angle of the combustion beginning;
θ_a -- duration of combustion;
with respect the condition:

$$\theta_s<\theta<\theta_s+\theta_a. \quad (8)$$

According to [1], [2], it's possible to use another exponential relationship for the function x = x(θ), in the following form:

$$x=1-\exp\left[-\left(\frac{\theta-\theta_s}{\theta_a}\right)^n\right]. \quad (9)$$

The heat loss to outside, according to the definition of the heat transfer coefficient, has the following form [3]:

$$\frac{dQ_p}{dt}=\alpha\cdot A\cdot\left(T-T_p\right), \quad (10)$$

where: α -- heat transfer coefficient;
A -- surface area in contact with the gases;
T_p -- cylinder wall temperature;

If we use variables without dimension we can write the following forms:

$$\overline{Q} = \frac{Q_{in}}{P_1 \cdot V_1}; \overline{T} = \frac{T}{T_1}; \overline{Q}_p = \frac{Q_p}{P_1 \cdot V_1}$$

$$\overline{\alpha} = \frac{\alpha \cdot T_1 \cdot \left(A_0 - \frac{4 \cdot V_0}{D}\right)}{P_1 \cdot V_1 \cdot \omega}; \beta = \frac{4 \cdot V_1}{D \cdot \left(A_0 - \frac{4 \cdot V_0}{D}\right)}. \quad (11)$$

$$\overline{P} = \frac{P}{P_1}; \overline{V} = \frac{V}{V_1}; \overline{L} = \frac{L}{P_1 \cdot V_1}$$

and consider the relationship for the work $dL = PdV$, equations (3) , (4), and (6) become:

$$\frac{d\overline{P}}{d\theta} = -\gamma \cdot \frac{\overline{P}}{\overline{V}} \cdot \frac{d\overline{V}}{d\theta} + \frac{\gamma - 1}{V}\left[\overline{Q} \cdot \frac{dx}{d\theta} - \overline{\alpha} \cdot \left(1 + \beta \overline{V}\right) \cdot \left(\frac{\overline{P} \cdot \overline{V}}{\overline{m}} - \overline{T}_p\right) - \frac{\gamma \cdot C \cdot \overline{P}}{\omega}\right]; \quad (12)$$

$$\frac{d\overline{L}}{d\theta} = \frac{1}{P_1 \cdot V_1} \cdot \frac{dL}{dQ} = \overline{P} \cdot \frac{d\overline{V}}{d\theta}; \quad (13)$$

$$\frac{d\overline{Q}_p}{d\theta} = \overline{\alpha} \cdot \left(1 + \beta \cdot \overline{V}\right) \cdot \left(\overline{P} \cdot \frac{\overline{V}}{\overline{m}} - \overline{T}_p\right); \quad (14)$$

$$\frac{d\overline{m}}{d\theta} = -\frac{C \cdot \overline{m}}{\omega}. \quad (15)$$

The value without dimension for the mass of gass, witch represents the cylinder fluid load follow from integration of eq. (15) with respect the form, [1]:

$$\overline{m} = e^{-\frac{C \cdot (\theta + \pi)}{\omega}}. \quad (16)$$

where θ + π is the crank angle according to the duration of cylinder process when valves are shut .

The value of C, represent the part of cylinder fluid load which was lost through the system cylinder - piston rings , expressed relatively .

In eq. (12) the heat add to the engine cycle is represented by the expression $\overline{Q} \cdot \frac{dx}{d\theta}$, which represents the heat addition due to combustion process , varies with cranck angle θ.

Refering to heat transfer coefficient, α, from cylinder gases to his wall [3], use the equation:

$$Nu = \frac{\alpha \cdot D}{\lambda_g} = 10{,}4 \cdot \mathrm{Re}^{0{,}75}, \quad (17)$$

where: Nu and Re represent the Nusselt and Reynolds criterion , respectively :

$$\mathrm{Re} = \frac{(\dot{m}_a + \dot{m}_c) \cdot D}{A_p \cdot \mu_g}; \quad (18)$$

where:
$\dot{m}_a$ = the flow air received in the cylinder;
$\dot{m}_c$ = the flow fuel received in the cylinder;
A_p =surface aria of top pistin;
μ_g = the dynamical viscousty of gas.

9. THE MODEL OF THE COMPRESSOR PROCESS

In case of compressor with piston, in eq. (1), the expression for the heat addition due to combustion process is non-existing, so that the system of eq. (12) to (15), becomes:

$$\frac{d\overline{P}}{d\theta} = -\gamma \cdot \frac{\overline{P}}{\overline{V}} \cdot \frac{d\overline{V}}{d\theta} + \frac{\gamma - 1}{V} \cdot \overline{\alpha} \cdot \left(1 + \beta \cdot \overline{V}\right) \cdot \left(\frac{\overline{P} \cdot \overline{V}}{\overline{m}} - \overline{T}_p\right) - \frac{\gamma \cdot C \cdot \overline{P}}{\omega}; \quad (19)$$

$$\frac{d\overline{L}}{d\theta} = -\overline{P} \cdot \frac{d\overline{V}}{d\theta}; \quad (20)$$

$$\frac{d\overline{Q}_p}{d\theta} = \overline{\alpha} \cdot \left(1 + \beta \cdot \overline{V}\right) \cdot \left(\overline{P} \cdot \frac{\overline{V}}{\overline{m}} - \overline{T}_p\right); \quad (21)$$

$$\frac{d\overline{m}}{d\theta} = -\frac{C \cdot \overline{m}}{\omega}. \quad (22)$$

For the expression of heat transfer coefficient α, the Reynolds criterion becomes:

$$\mathrm{Re} = \frac{\dot{m}_g \cdot D}{A_p \cdot \mu_g} \quad (23)$$

where: $\dot{m}_g$ - the flow gas (frigorific agent) received in cylinder, and the others have the signification from the expressions before.

10. RESULTS FOR NUMERICAL SIMULATION FOR INTERNAL COMBUSTION ENGINE

Further are shown some results which are obtained following the programme [7], for the calculation of differential system equations which includes the equations for the pressure, work, heat lost and variation of mass, considering the values without dimensions, on the understanding that the forms for the function of the heat addition x(θ), due to combustion process, are those which are in the paper .

The values considered are : ω = 200 [rad/s]; c = 0,8s^{-1}; γ = 1,3; λ = 1/3,8; ε = 10; n = 4; $\overline{Q}$ = 20; θ_a = 40; θ_S = -40; $\overline{h} = 0{,}2$; β = 1,5; $\overline{T}_p = 1{,}2$;
The efficiency calculated is η_i= 0,4358;

Figures 1 to 5 represent variations in, the pressure (Fig. 1 closed pressure diagram; Fig. 2 - open pressure diagram), the heat loss (Fig. 3), the work (Fig. 4), and the mass loss (Fig. 5), all depending on the angle of rotation of the crankshaft.

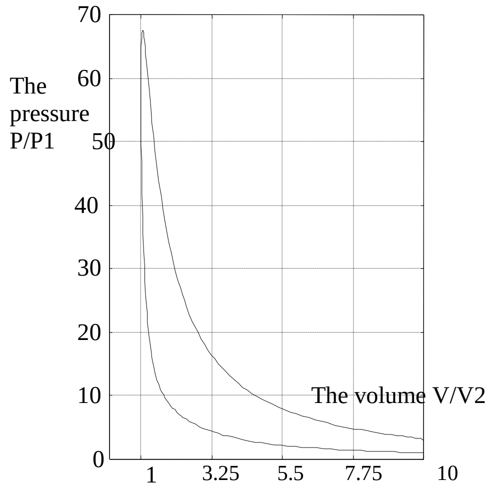

Figure 1 Closed Graph of P=P(V)

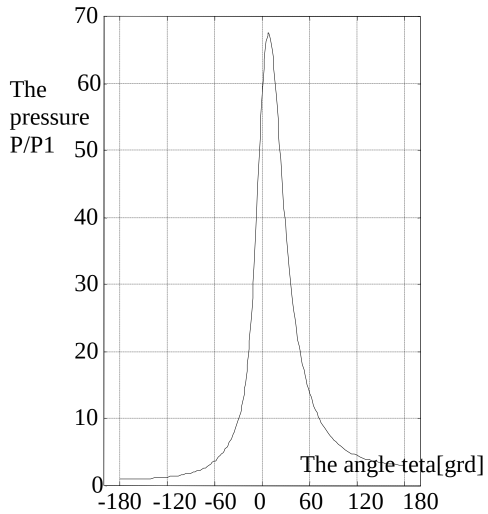

Figure 2 The pressure diagram

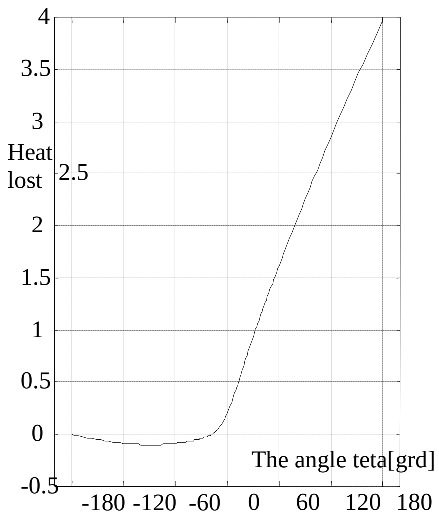

Figure 3 The heat lost diagram

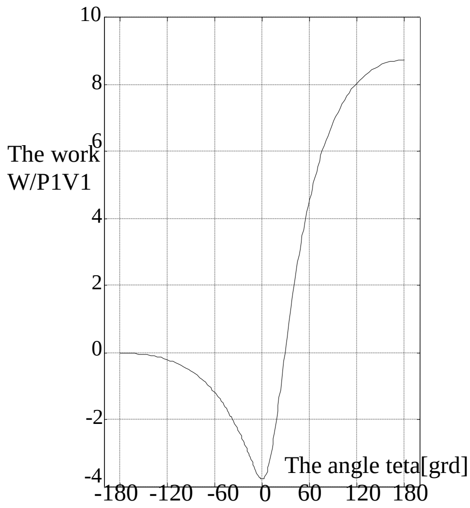

Figure 4 The work diagram

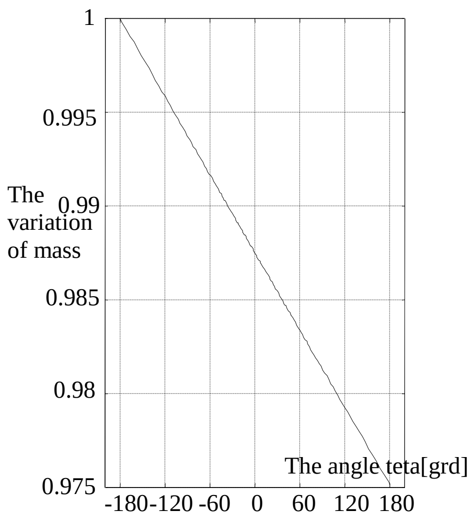

Figure 5 The diagram for variation of mass

11. CONCLUSIONS

The paper deals with the mathematical model for the heat addition process due to the combustion in the cylinder of engine on the understanding that the form for the heat addition function x(θ) is:

$$x = 1 - \exp\left[-\left(\frac{\theta - \theta_s}{\theta_a}\right)^n\right]$$ according to [1], model which contains the differential equations for the pressure, work, heat loss and variation of mass , functions variably with the angle θ, considered values are without dimensions. The paper presents graphs which are obtained using the programme written in Mathlab Software, using the 4/5 Runge - Kutta method.

Using calculation algorithm and the own calculation computer program, depending on the input data specific to each internal combustion engine or compressor, can be obtained pressure variations, mechanical work, heat and mass loss closer to reality because it is used for the heat addition, an exponential or trigonometric function such as those in relationships (9) and (7).

12. REFERENCES

[1] FERGUSON, C.R. - *Internal combustion engines, applied thermosciences* - Ed. JohnWiley & Sons, New York, 1976

[2] STONE, R. - *Introduction to internal combustion engines*- Brunel University, Uxbridge, MACMILLAN Publishess Ltd, 1985

[3] WASCHNI, G. - *A universally Applicable Equation for the Instantaneous Heat transfer coefficient in the internal combustion engine*- SAE Transactions, 1967.

[4] GRUNWALD B., *Teoria, calculul şi construcţia motoarelor pentru autovehicule rutiere*, Ed. Didactică şi Pedagogică Bucureşti 1980

[5] NEGREA D,- *Motoare cu ardere internă. Procese, economicitate,* poluare, vol I, Ed. Sedona, Timişoara 1997

[6] TAYLOR C.F., The internal Combustion Engines in Theory and Practice, vol I, vol II, The MIT Press, Cambridge, 1987

[7] BURCIU SALVADORE MUGUREL, *Motoare cu ardere interna cu piston*, Ed. Europlus 2006

IT'S ROLE IN THE INTEGRATIVE SYSTEMIC APPROACH OF MODERN ECONOMIC ORGANIZATION

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ABSTRACT

This study analyses two main aspects identified as true challenges in implementing IT solutions and services for modeling complex business processes: the increasing heterogeneity of architectural modeling languages and the new guidelines regarding the production structures and the decisional systems within the company. Another purpose of the analysis is the approach as system of complex processes of the economic activities within the economic organization. The defining characteristics of economic organization in systemic approach are presented and, based on the detailed aspects, the relations between the two concepts, enterprise and system are identified: enterprise is a system and therefore is an organized group of elements that interact and display properties, behaviors and capabilities to achieve one or more goals.

Keywords: *Economic organization, theory of systems, systemic view, Information and Computing technologies, Business Process Management*

1. INTRODUCTION

Economic organization is a generic term denoting a company, a firm, an enterprise or an economic agent. Etymologically, the word "organization" comes from the word of Greek origin "organon" which means tool or instrument. Starting from the classical approach, which considers that the organization is a tool to achieve certain objectives, definitions in the research literature converge towards certain organizational concepts (cooperation, tasks, purposes, goals, objectives), which have established the basis for a new integrative direction: the systemic approach.

The concept of system plays an important role in all scientific fields. It is a concept widely used; its diverse applicative valences provides researchers and practitioners an integrated approach that goes beyond the specifics of a particular field of application, but also tools for developing models closer to reality.

According to Keylighen & Joslyn [9] the theory of systems represents a transdisciplinary study of the abstract organization of the phenomena, independent of their substance, their type or spatial and temporal scale of existence. The theory investigates both the principles common for all complex entities but also (usually mathematical) the models that can be used for their description. Their definition captures the basic concepts of the systemic approach: unity, complexity, integration and interaction.

In [4] the use of the concept of system in different scientific disciplines focuses on two fundamental perspectives: namely the teleological perspective (or functional) and the ontological perspective (or constructive):

- *the teleological perspective* addresses the functions and the behavior of the system, without referring its operation mode. The operation and the system evolution are interpreted by its objectives, according to the aims pursued and which will influence its organization and future evolution.
- *the ontological perspective* addresses the essence (the nature of the system); system is described in its globality, considering the relationships between its essential characteristics:
- *the composition* - its set of elements belonging to a certain category: social, economic, etc; each element has a set of associated attributes identifying the status of the element at a given time;
- *the environment* - a set of elements of the same class, but distinct from the set of component elements; environmental elements are influenced by the component elements or influence the component elements.

Ontological approach emphasizes both the transformation of the relationships between component elements and the relationship between the ensemble and the environment.

These transformations can be captured, most often, in mathematical equations. Thus one can achieve a mathematical modeling of the system, which allows a simulation of its operation in different circumstances, or an optimization of the operation under a particular set of conditions [1].

- *the objectives* - govern the operation of the system and determines the orientation and adjustment of system actions depending on the disturbances occurred.

- *the finalities* - relate to goods or services produced by the component elements and provided by the elements of the environment.

- *the structure* - connections established between the component elements (subsystems) and between them and the environment.

Within the system there are structures ranked in subsystems. Lower hierarchical levels can give an idea of how the system works and about its performances, while the components of the highest hierarchical levels can give information about the role of the system in its environment [ISO, 1999].

The decomposition into subsystems usually follows two criteria:

- „*goal analysis*” criteria;
- „*behaviour analysis*” criteria

The two approaches, the teleological and ontological, are complementary, both of which are relevant to the design and analysis of complex systems.

2. ECONOMIC ORGANIZATION - SYSTEMIC VIEW

Modern economic organization is dynamically connected to environmental processes, connection reflected in the company's relationships with the external environment, the company being conceived as an open system having permanent exchanges with the environment through its informational and material flows. These flows are affected by a combination of aspects and features: unpredictable dynamic, congestion, nonlinear effects and interactions, heterogeneity, local damages or disruptions, etc. Such matters are attributes of the complexity of the system, which becomes hard to describe, difficult to optimize and often very difficult to control in real time.

According to Powell et al. [14], business processes strongly influence product quality and customer satisfaction, both aspects being of great importance in a free and competitive market.

To be competitive, an organization must respond to current opportunities, to changes that occur over time, to challenges, risks and limitations of the external environment through a process of double adaptation: internal - in relation to the objectives and external - in relation to the environment. Changes in the external environment affect the inputs in the system, which, in turn, will affect the internal processes of transformation, and finally the outputs.

Homeostasis defined first by W. B. Cannon as the relative stability of the human body or the tendency towards stability in an attempt to survive in a hostile and destabilizing environment, has proved its usefulness and applicability in the study of the enterprise as a system organized in a changing context. Thus, stability is seen as a limitation of changes allowed over the variables considered as critically important (control variables) for the individuality of the system, so that the system as a whole remains unchanged in time.

To analyze the stability of the company, those variables that should be maintained in a relatively stable state must be identified. Their selection depends on the nature of the enterprise and on its relations with external environment. Once identified, one should define the acceptable limits for these variables, the factors that maintain their stability, the changing trends identified in the past and how they were rejected by the factors resistant to changes. Whenever a modification affecting the desired state (or the stationary state) of the respective variable is detected, a corrective action (in order to bring closer the variable to the desired state) is performed.

By comparing the actual value of the output variable with its desired value, it results an error that involves making a correction by changing the input so as to produce an output close to the desired value - the feedback mechanism. As a specific form of interaction between the system and the external environment, the feedback provides correlation of the system evolution against planned objectives, allowing organizing the activities to achieve and maintain a desired level of outputs in order to achieve the proposed finality. This kind of interaction occurs both between the organization (regarded as unitary system) and the environment, as well as within sub-components. Their functional autonomy and their own mechanisms of transformation and tuning, allow organizations to react at perturbations that occur in the subsystems with which are interconnected.

The economic organization is therefore an organic system, dynamic and capable of adaptation.

Also, the systemic and integrative approach of economic organization allows its examination in terms of relations with the external environment but also in terms of interactions between its component subsystems. Using this integrated approach for the management of data, people and processes allows the transformation of IT resources into competitive advantages for the company.

Thus, it is a complex system that brings together a large number of subsystems between complexes interactions occur. According to Pavard & Dugdale [12], „a complex system is a system for which it is difficult, if not impossible to reduce the number of parameters or characterizing variables without losing its essential global functional properties”.

The emergence is probably the most interesting property of a complex system. According to Kaufmann [8] the whole has properties that its separate components do not have: the emerging collective properties. A complex system and capable of adaptation is called a complex adaptive system. Complex adaptive systems are composed of a large number of components based on self-organization and coevolution, each tending towards a higher degree of performance, but at the same time acting in accordance with the rules and in the context of the relationships with the other components and with the external environment. Bennett & Bennett [2] highlights several features of the organization treated as a complex adaptive system:

- organizational intelligence: competitive intelligence, facilitating innovation and acquisition of new knowledge, adapting and responding quickly to new and unexpected situations;
- selectivity and filtering the input information coming from external environment;
- permeable boundaries for the flows of matter, energy and information;
- flexibility in choosing the means and ways of action, in defining fundamental goals and outlook on the future of the organization;
- knowledge centering in order to achieve superior organizational performance.

Learning as theoretical premise is the consequence of increasing the role and necessity of knowledge within the organization. The organization becomes a system with self-learning capacity, with specific learning processes performed at individual or group level or throughout the entire organization. This perspective is reflected in the concept of "knowledge transfer" which is closely related to innovation: innovation occurs by sharing common experiences between organizations or at the level of the component units.

Viewed in the light of its components and in relation to other entities in the external environment, organization acquires individuality as an administrative organizational system. Enterprises are economic systems with different levels of complexity, with structures reflecting business size and scope of activity and functionalities oriented towards goals: strategic (3-5 years), tactical (1-2 years) and operative (hours, days). Thereby determining the place, the role and the interdependence between structural and functional units of the organization, one establishes a hierarchy of relationships between components.

Another concept of systemic theory is aggregation, as a form of assembling subsystems which make up a system. The existence of multiple subsystems within a system helps system to survive under the conditions of failure of one or more sub-components, while in the case of a monolithic (consisting of one sub-system), this will not survive to the failure of the single component of the system. The organization may be considered as an aggregation of people; these, in turn, are aggregated in units (departments or services); these units can be aggregated in economic units, etc. At the enterprise level, the homeostasis mechanism ensures the functioning of constituent subsystems (economic units, departments and people) in accordance with company standards, so the company maintains its individuality.

Along with aggregation, specialization (differentiation) is the "strategic approach of known threats" [19]. Specialization refers to the concentration of a certain influence on some level that may affect system stability.

Aggregation and specialization are complementary and antagonistic approaches. In the system should be a balance between socialization and aggregation: if all subsystems are identical, they could compensate just one influence, the rest of the system remaining vulnerable. The company is composed of specialized departments in customer relationships, relationships with distributors, relations with investors, etc. Each such department can be seen as a specialization for a certain influence. Specialization of a department of the company for adjusting a type of influence involves loss in the ability of adjusting other influences.

Equifinality is another feature of the enterprise from systemic perspective. In analogy to the fact that the final state of a system can be reached starting from different initial states, in different ways, equifinality principle involves possibility to meet targets through different alternatives of combining enterprise resources, using different deployment options. Since there is no single "best way" to achieve the targets, finality could be analyzed according to:

- the degree of fulfillment of the objectives and the actual result obtained (system effectiveness); effectiveness is an attribute of the quality and is essential for outsourced results;
- the amount of resources needed to achieve the objectives, on this effectiveness (system efficiency); how to minimize resources and to eliminate losses is important for the system.

3. IT CHALLENGES IN MODELING COMPLEX BUSINESS PROCESSES

Summarizing the main opinions in the literature, we distinguish two challenges in modeling complex business processes:

1) The new economic, technological and social environment requires the companies' transition to a total rethinking of the organizational working mode [5]. In order to achieve competitiveness, to enable unnecessary time reduction and for overall optimization of the product, new guidance on production structures, new decision systems and ways of organizing and managing activities within the company have emerged:

- *The concept of "Lean Manufacturing"*

Compared to the traditional system, this concept focuses on continuous improvement of processes.

A definition that captures the essence of this concept would be: a business system that enables the organization and management of product development, of operations and relationship with suppliers and customers, that requires less human effort, less space, less capital and less time to manufacture products with less defects, addressed to well identified customer desires, compared to the mass production system [www.lean.org].

The five principles of this concept are:

- designing of entire value chain;
- defining value depending on the way of perception of customers;
- the plurality of production targets and adjusting production to customer requirements;
- time management for achieving outputs;
- continuous improvement.

- *The agile production*

According to Sterman [6] the change is the most important constant of modern times. As a response to the unpredictable changes in the business environment, enterprises must be able to reconfigure, by remodeling their activity depending on the opportunities and hazards identified.

Agility and flexibility are concepts sometimes used synonymously, but distinguished by the degree of predictability. If flexibility is reflected in enabling companies to respond to a variety of customer requirements, agility is the ability to adapt to unpredictable changes in the external economic environment.

In [15] the two concepts are related on the basis of two criteria:

- Productivity: the ability to use and optimize company resources;
- Effectiveness: the ability to select and implement strategies and market opportunities in order to determine future perspectives of the company.

It follows that each company must implement both paradigms to achieve performance, within an equilibrium that would enable success.

- *The holonic enterprise*

Holonic manufacturing systems relies on the concept of "holon" proposed in [11] (as a combination of the Greek word "holos" - a whole and the suffix "on" -

from particle, neutron) to describe the organization of biological and social systems.

The idea was later introduced in the industrial context: contrary to traditional hierarchical systems, a holonic system is a decentralized system where the tasks are assigned and performed through the exchange of information and by coordination between system entities. The holonic manufacturing system integrates all production activities, from orders registration, then the design, production and marketing. Holons represent entities both physical and logical: industrial machinery, production processes, production departments, schedules, etc.

Each holon combines a lot of own skills, with skills of the partners, to achieve its own objectives and those of the system as a whole. Each holon can be decomposed into other holons, these in their turn further decomposing, which allows to reduce the complexity of the system.

Evolutionary approaches, especially Genetic Algorithms are used in the specialized literature to determine the optimal holonic structure. Such example is the fuzzy-genetic approach presented in [17], that clusters the entities of a holonic enterprise in an optimal holonic structure, dynamically configured. The evolution of the system is achieved through interactions with external systems, selected by a genetic search strategy so that the organizational structure of the new system is better than the one before the evolutionary process.

- *The fractal enterprise*

In [18] a new organizational structure - the fractal enterprise is proposed, which consists in a set of fractals - units acting independently and having well-defined performance objectives. These objectives are part of an overall, common objective.

"A fractal information system has properties of self-similarity at different scales, self organization, goal-orientation, dynamics and vitality" [10]. Self-similarity is the ability of system components to produce similar outputs from similar inputs, using different procedures and internal structures.

Dynamics is the property of adaptation to environmental changes, independent of the organizational structure and self-organization is the ability of fractals to choose their own way of structuring and performing tasks within the process, optimally, by applying appropriate methods.

Fractal enterprise as a system is characterized by a non-linear evolution, due to unpredictable changes that characterize partners, environment and internal processes. It is customer-oriented (abandoning orientation based on specialized functions).

An important feature of the fractal enterprise is the ability of fractals to communicate information via the communication system and to cooperate in order to execute processes in parallel, to achieve the same purpose. This parallelism enables flexibility and ability to react to rapid changes in the environment, characteristics that define the fractal enterprise vitality.

- *The virtual enterprise*

Customer requests for more complex products and for improved services have led to a reduction of product lead times and to a pressure on companies to cooperate closely with their suppliers as well as with their customers [20]. The rising importance of Information and Computing Technologies within organizations has led to new models for handling partnerships in organizational practice.

An important consequence is the development of virtual organizations or virtual enterprises. This concept is the result of developments in the last two decades of the Internet-based adaptive technologies for e-business and the of the globalization phenomenon that determines the orientation of the current business environment development.

In general terms, a virtual enterprise „is an alliance of separate firms (that function autonomously), interconnected, customer oriented, and acting together to take advantage of a market opportunity; when the market opportunity arises, the potential partners are meeting and negotiating through the information infrastructure, the virtual enterprise is created, the manufacturing processes are started and the product is completed; when the opportunity is exhausted or a new market opportunity occurs, the virtual enterprise can be reconfigured and so on until its mission is fulfilled and is finally dissolved" [6].

The current body of literature offers many others definitions of virtual organization. For example, Byrne et al. [3] define a virtual enterprise as "a temporary network of independent companies – suppliers, customers, and even rivals – linked by information technology to share skills, costs, and access to one another's markets (…) which will have neither central office nor organization chart, no hierarchy and no vertical integration ".

The formation of the virtual enterprise is supported by providing decision support to select the best team of partners for a specific virtual enterprise [13]. Managing of such dynamic configurations in an effective and efficient way aims for accomplish client's demands and expectations at high proficiency.

2) Another important IT challenge in modeling business processes concerns the formal languages used in systems modeling. These are characterized today by a growing level of heterogeneity and very few have the semantic power to describe a wide variety of systems that are dedicated to different fields of application. The researches in this domain have shown that it can not be identified a single model, there is no an appropriate business solution for all companies, that would produce optimal performance in all situations. Organizational transformations require the construction, analysis, adaptation and processing organizational information using various technologies and searching for new solutions and models.

The need for formal semantics in modeling business processes has led to a new generation of methods, formal methods, where concepts related to processes are rigorously and precisely defined so they can be analyzed and tested mathematically.

Hofacker & Vetschera [7] propose an approach based on mathematical formalisms for building administrative processes: activities, resources, constraints that define the domain - the limits of the process and the set of objective functions corresponding to different economic objectives established for the economic process. Although the approach is not always adequate for modeling complex constructions, the method provides analytical support for optimizing the design and allow for further improvements.

The solutions included in Business Process Management (BPM) are based on Web services and XML technologies and standards and aim to integrate business - IT within the organization and flows management with business partners. If in the traditional approach based on documents/entities (Workflow-based entities - usually documents) the workflow present more the document route and not the sequence of activities, BPM applications are based on visual modeling techniques for improving the quality and efficiency of business processes within the economic organization. These visual tools simplify the definition and integration of complex processes involving the use of heterogeneous data sources and interoperability between different applications in the organization.

4. CONCLUSIONS

Resuming researches in computer modeling of business processes, this paper address two main aspects identified as true challenges in implementing IT solutions and services: the increasing heterogeneity of architectural modeling languages and the new guidelines regarding the production structures and the decisional systems within the company.

This study argues the use of the concept of system and the systemic approach to economic processes and phenomena: the economic activity of an organization is a complex and dynamic process whose effective management requires the integration of economic dimension with a systemic and integrative view; the functionality and the economic performance of the organization are influenced both by interactions between components and by technological, social or political trends occurring at regional or global level, influences that may be direct or indirect, whether favourable or unfavourable.

The complexity of the socio-economic field requires a systemic approach to processes and phenomena in order to manage them efficiently, through specialized applications, developed based on appropriate mathematical economic models.

Using the concept of system and the systemic approach of the economical processes and phenomena allows a comprehensive view on the complex functioning of the enterprise in the market economy. Addressing all activities within the organization as a system of complex processes generates a common image, an integrated view of the organization. This involves consideration, since the origin, of all stages of the product life cycle, beginning with conception until its completion, including issues of quality, time, cost, user requirements, etc.

5. REFERENCES

[1] ALPOPI, C., *Creativitate şi inovare*, Ed. ASE, Bucureşti, 2002.

[2] BENNET, A., BENNET, D., *Organizational Survival in the New World: The Intelligent Complex Adaptive System*, Elsevier/Butterworth-Heinemann: Boston, MA, 2004.

[3] BYRNE, J.A., BRANDT, R., & PORT, O., *The Virtual Corporation*, Business Week, Feb. 8, pp. 36-40, 1993.

[4] DIETZ, J.L.G., *Enterprise Ontology - theory and methodology*, Springer-Verlag Heidelberg, Berlin, New York, 2006.

[5] DINU, S., ANDREI, G., *IT strategies for the optimization of economic processes*, Review of Management and Economic Engineering, Vol.11 (2)-iunie, 2012.

[6] DINU, S., PĂCURARU, R., *An intelligent modeling method based on genetic algorithm for partner selection in virtual organizations*, Business and Economic Horizons, Vol. 5, pp. 23-34, 2011.

[7] HOFACKER, I., VETSCHERA, R., *Algorithmical approaches to business process design*, Computers & Operations Research, Vol.28, pp. 1253–1275, 2001.

[8] KAUFFMAN, S.A., *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*, Oxford University Press, New York, 1996.

[9] KEYLIGHEN, F., JOSLYN, C. *What is Systems Theory*, Principia Cybernetica Web, http://pespmc1.vub.ac.be/SYSTHEOR.html, accessed 04. 2015.

[10] KIRIKOVA, M., *Towards Flexible Information Architecture for Fractal Information Systems*, International Conference on Information, Process, and Knowledge Management, eKNOW 2009, pp. 135-140, 2009.

[11] KOESTLER, A., *The Ghost in the Machine*, Arkana Books, 1989.

[12] PAVARD, B., DUGDALE, J., *The contribution of complexity theory to the study of socio-technical cooperative systems*, New England Complex Institute Electronic journal, pp. 8-15, 2000.

[13] PETERSEN, S.A. and DIVITINI, M., *Using agents to Support the Selection of Virtual Enterprise Teams*, Proceedings of Fourth International Bi-Conference Workshop on Agent-Oriented Information Systems (AOIS-2002) Bologna, Italy, 2002.

[14] POWELL, S., SCHWANINGE, M., TRIMBLE, C., *Measurement and control of business processes*, System Dynamics Review, Vol.17, pp. 63-92, 2001.

[15] RIIS, J.O., JOHANSEN, J., *A strategic approach to develop agile manufacturing*, Agile manufacturing: the 21st century competitive strategy, pp. 53-72, 2001.

[16] STERMAN, J.D., *Business Dynamics: Systems Thinking and Modeling for a Complex World*, McGraw-Hill, 2000.

[17] ULIERU, M., *Emergence of holonic enterprises from multi-agent systems: A fuzzy-evolutionary approach*, in *Soft Computing Agents: A New Perspective on Dynamic Information Systems*, IOS Press, pp. 187-215, 2002.

[18] WARNECKE, H.J., *The fractal company: a revolution in corporate culture*, New York: Springer-Verlag, 1993.
[19] WEINBERG, D., WEINBERG, G. M., *General Principles of Systems Design*, New York: Dorset House, 1988.
[20] WIENDAHL, H.P. and LUTZ, S., *Production in networks*, Annals of the CIRP - The International Academy for Production Engineering, Vol. 51, pp. 1 – 13, 2002.

MODELLING OF PNEUMATIC CONVEYING SYSTEMS

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ABSTRACT

Technological pneumatic conveying systems are intended to convey materials from one place to another by various phases of the production process. For example: loading/unloading materials (grain) using railway and sea transport, pneumatic dispatch tube installations or air tunnel container transport, supplying combustion plants with smut coal, etc.The system is energy saving, offering a series of advantages, such as: it is facile to fit various technological processes, it protects the conveyed material from contamination, without affecting the outer environment, it is easy to handle and it has automation possibilities and also it allows the conveying of flammable and explosive materials, in which case noble gases closed systems should be used.

Keywords: *conveying, pneumatic, grain, algorythm, modelling, pressure.*

1. INTRODUCTION

Pneumatic conveying is based on the principle of driving material solid particles by an air stream or another gas which is travelling through a pipeline at a certain velocity. This type of installations can convey solid materials of very low granularity: wheat, corn, oats, barley, ash, slag, cement, wood splinters, sawdust, cellulose, etc.

The material is conveyed on horizontal, vertical or inclined planes, over a distance of 350-400 mts and at a maximum height of 45 mts.

2. PAPER CONTENTS

2.1. Modelling Program Algorythm

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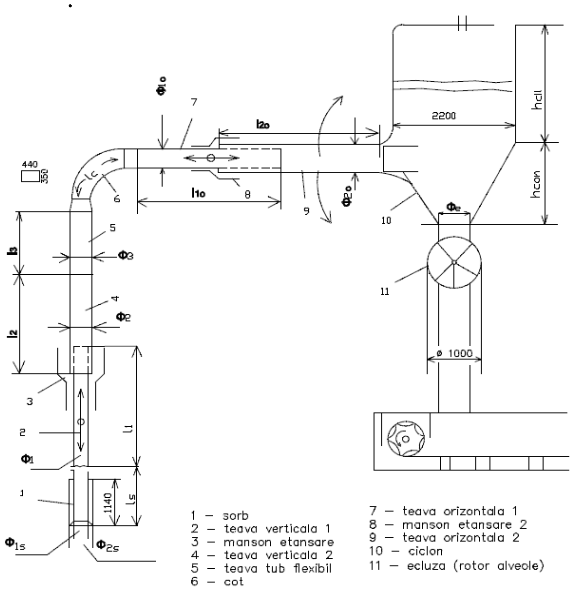

Figure 1. Suction pneumatic conveying installation of Agigea [8]

Valid calculation diagram: Autocad drawing

1 – Suction head;
2 – Vertical pipe 1;
3 – Cup packing;
4 – Vertical pipe 2;
5 – Flexible tube pipe;
6 – Elbow;
7 – Horizontal pipe 1;
8 – Cup packing 2;
9 – Horizontal pipe 2;
10 – Cyclone dust separator;
11 – Lock (seed cells rotor).

Initial data

1) Installation features:

Parts:

a) Suction head Φ_{1s}=0.625[m] / Φ_{2s}=0.450[m], suction hose length l_s=1.360[m]

b) Vertical conveying pipeline 1: Φ_1=0.450 [m]; l_1=8.210 [m]

c) Vertical conveying pipeline 2: Φ_2 =0.470[m]; l_2=11.666 [m]

d) Vertical flexible tube 3: Φ_3=0.470[m]; l_3=2.100[m]

e) Elbow at 90°: 0.430[m] x 0.350[m]; l_c=0.750[m]

f) Horizontal pipe 1: Φ_{1o}=0.500[m]; l_{1o}=8.000[m]

g) Horizontal pipe 2: Φ_{2o}=0.520 [m]; l_{2o}=9.460[m]

h) Cyclone dust separator Φ_ci=0.200[m]; hcil=4.000 [m]; hcon=1.400[m];

Φe = 0.800 [m]

L_{echiv} = 41.546 [m]

Q = 250 ÷ 350[t/h] pneumatic conveying installation flow

η – pump output ratio

2) Material features:

a = 17 ÷20 cereal seeds coefficient;

Ψ = 0,23 – bearing coefficient depending on the shape and nature of the spheric particle bearing area;

B = $2\cdot10^{-5} \div 5\cdot 10^{-5}$ coefficient (increases by granularity)

K = 0.57 shape coefficient – elongated shape with irregular surface (table 1)

d' = $4\cdot10^{-3}$[m] equivalent diameter of the particle;

γ_a = 1.2 [kg/m^3] specific air weight;

γ_m = 700÷850[kg/m^3] specific material weight – for grain;

μ = 7.1÷12.6[kg/kg] material concentration.

Output data:

1. Total pressure loss in the pneumatic conveying installation.
2. Pump drive engine power.

Table 1 [2]

Particle shape	k
- sphere	1,0
- round shape with irregular surface	0,64
- elongated shape with irregular surface	0,57
- flattened shape	0,45

2.1.1. Calculation of pressure loss in Agigea installation diagram

By analysing of length/diameter ratios [8] it has been found that all pipes fit the theory of short pipelines.

Important observation:

The calculation of pressure losses is mandatory, because the formula of fan (blower) power includes "h_{tot}".

The formula of total pressure loss is:

$$h_{tot} = h_d + h_V + (h^f{}_V)_{amestec} + (h^{cot}{}_a)_{amestec} + h^{acc}{}_H + (h_H)_{amestec} [mmH_2O] \quad (1)$$

or

$$p_{tot} = p_d + p_V + (p^f{}_V)_{amestec} + (p^{cot}{}_a)_{amestec} + p^{acc}{}_H + (p_H)_{amestec} \left[\frac{N}{m^2} = Pa\right] \quad (1')$$

where:

h_d, p_d - dynamic pressure drop due to the acceleration of air-cereal mix from zero velocity to conveying velocity;

h_V, p_V – static pressure drop due to level difference (on the vertical side);

$(h^f{}_V)_{amestec}$, $(p^f{}_V)_{amestec}$ – pressure loss by conveyed material friction;

$(h^{cot}{}_a)_{amestec}$, $(p^{cot}{}_a)_{amestec}$ – pressure loss in the ascending elbow;

$h_H{}^{acc}$, $p_H{}^{acc}$ – pressure loss for acceleration on the horizontal side;

$(h_H)_{amestec}$, $(p_H)_{amestec}$ – pressure loss by material friction inside horizontal pipelines.

The increase of h_{tot} by 5...10% is recommended in case of suction pneumatic conveying installations in order to compensate additional pressure losses of unpredictable or unquantifiable nature.

In addition to the cereal acceleration calculation, the pressure loss caused by the suction head should also be added, in case the lower end of the pipeline is provided with a suction head.

$$h_d = \xi \cdot \frac{\gamma_a \cdot v_a^2}{2g} + \frac{Q_m(v_m - v_{am})}{g \cdot A_c} \left[N/m^2\right] \quad (2)$$

in which:

ξ=2 for the suction in which the air suddenly reaches zero velocity and then also suddenly accelerates to velocity "v_a"

- specific air weight

$$\gamma_a = 1.2[\frac{N}{m^3}]$$

v_a – air velocity [m/s];

v_{am}= 0 – mix velocity upon pipeline inlet.

According to Table 2, it is recommended that the optimal air speed inside vertical and horizontal pipelines ranges between 26 and 30 m/s, in case of a coefficient k=0.2.

Table 2 [2]

Material	ρ [kg/m³]	μ [kg/kg]	v_{opt} inside vertical pipelines	v_{opt} inside horizontal pipelines	Value of K		
					Sections of horizontal and vertical pipelines	For intake groups	For ascending stream elbows
Dirt and sand dust	2600	0.8-1.0	13	15	0.7	1.0	2.2
Broken clay	2400	0.8-1.0	14	17	0.6	1.0	2.2
Wood sawdust and chips	250-300	0.1-0.5	21-22	21-22	1.4	-	-
Castiron, steel filings	7300-7800	0.8-1.0	19	23	0.8	0.4	2.0
Coal dust	900-1000	1.0	14	15	1.0	1.0	-
Cotton	-	0.2-0.5	17	18	1.5-2.2	-	-
Wool	-	0.2-0.5	17	18	1.5-2.2	-	-
Wheat	**-**	**7.1-12.6**	**26-30**	**26-30**	**0.2**	**-**	**-**
Splinters	-	0.2-0.3	22	22	1.4	-	-

v_a = 30 m/s is considered. The immediate result is the proportionality ratio between the air velocity and floating velocity which for wheat is:

9,8 [m/s] = v_p.

$$\beta = \frac{v_p}{v_a} = \frac{9.8}{30} = 0.33 \quad (3)$$

This is where the delicate issue of determining the air flow required for conveying a certain wheat seeds flow and the average travelling velocity of the mix through pipelines comes in: v_m [m/s].

We define "gravimetrical dosing coefficient (concentration)" and we take into account its correlation with the allowable driving air velocity v_a* (which does not clog the pipelines):

$$\mu = \frac{Q_m}{Q_a} \qquad (4)$$

Table 3 [8]

v_a[m/s]	26	28	30	32
μ	7.1	9.6	12.6	15.6

On the other hand, in case of an inlet diameter of 0.45 mts, it results an air flow of:

$$Q_a = \gamma_a \cdot A_c \cdot v_a \cdot 3.6 \left[\frac{kN}{h}\right] \qquad (5)$$

where:

$$A_c = \frac{\pi \cdot D^2}{4} \ [m^2] \quad \text{and} \quad D = 0.45\ [m]$$

By considering an actual gravimetrical coefficient of μ =10, it results:

$$Q_a = 1.2 \cdot \frac{\pi \cdot 0.45^2}{4} \cdot 30 \cdot 3.6 = 20.601 \left[\frac{kN}{h}\right]$$

If we consider μ=12 (up to the technical clogging limit), it results

Qm max = 247.212 kN/h.

Given such circumstances, the definition of the sliding factor becomes necessary.

According to [8], in case of vertical conveying, it is necessary that the sliding factor reaches lower values than 0.5, in case of large grains (of wheat), in order not to excessively increase the mix concentration and to clog the installation.

$$s = \frac{v_a - v_m}{v_a} = 1 - \frac{v_m}{v_a} \qquad (6)$$

Adopting s=0,4 => v_m = 18 [m/s] v_{me}=0.

Introducing all these values in the relation (2): p_d= 7706,4 [N/m^2].

As the material velocity is slower than the air velocity, the mix concentration in regimen (gravimetrical dosing coefficient) is different than the initial concentration and is reached depending on the sliding factor *s* with the relation:

$$\mu^* = \frac{\mu}{1-s} = \mu \cdot \frac{v_a}{v_m} \qquad (7)$$

Result:

$$\mu^* = 10 \cdot \frac{30}{18} = 16.67$$

Consequently, the loss of pressure due to the material vertical conveying shall be:

$$p_V = \rho_a \cdot g \cdot L_v \cdot \left[1 + \mu^* \left(1 - \frac{\rho_a}{\rho_m}\right)\right] \cdot \left[\frac{N}{m^2}\right] \qquad (8)$$

$$\rho_m = \frac{800}{9.81} = 81.55 \left[\frac{kg}{m^3}\right]$$

$$\rho_a = 0.12 \left[\frac{kg}{m^3}\right]$$

L_v=1.36 + 8.21 + 11.666 + 2.10=23.34 [m]

Result: p_V = 478.7653 [N/m^2].

The linear loss by air friction in the three vertical pipelines shall be:

$$p^f{}_{Va} = \gamma_a \cdot \frac{v^2{}_a}{2 \cdot g} \cdot \left(\frac{r_1}{d_1} \cdot l_1 + \frac{r_2}{d_2} \cdot l_2 \cdot \frac{r_3}{d_3} \cdot l_3\right)\left[\frac{N}{m^2}\right] \qquad (9)$$

where:

γ_a=1.2[N/m^2]; v_a = 30[m/s]; g = 9.81[m/s^2];

r_1, r_2, r_3 – roughness;

r_1 = 0.025; r_2 = 0.025; r_3 = 0.030;

d_1 = 0.45[m]; d_2 = 0.47 [m]; d_3 = 0.47 [m];

l_1 = 1.36+8.21= 9.57 [m]; l_2 = 11.666 [m]; l_3 = 2.1 [m].

Result: p^f_{va} = 378.2204 [N/m^2].

k_1=0.2

The loss of pressure by conveyed material friction shall be:

$$(p^f{}_v)_{amestec} = p^f{}_{va}(1 + k_1 \cdot \mu) \qquad (10)$$

$$(p^f{}_v)_{amestec} = 1134.66[N/m^2]$$

In order to calculate the pressure loss and material velocity in the ascending elbow, we survey the actual pressure upon upon the elbow inlet:

$$p^{cot}{}_i = p_{atm} - p_d - p_V - (p_V{}^f)_{amestec} \qquad (11)$$

p_{atm} = 101325 [Pa] = 101325 [N/m^2] = 101325 [kg/m·s^2]

p_d = 7706.4[N/m^2]

p_V = 478.7653 [N/m^2]

$(p^f{}_V)_{amestec}$ = 1134.66 [N/m^2]

Result p_i^{cot} = 92005.17 [N/m^2]

The specific air weight upon the elbow inlet shall be:

$$\gamma_a^{\cot} = \gamma_a \cdot \frac{p_i^{\cot}}{p_a} \quad (12)$$

Result: $\gamma_a^{\cot} = 1.2 \cdot \frac{92005.17}{101325} = 1.0896 \left[\frac{N}{m^2}\right]$

The air velocity upon the elbow inlet shall be:

$$v_a^{\cot} = v_a \cdot \frac{p_{atm}}{p_i^{\cot}} \quad (13)$$

$$v_a^{\cot} = 30 \cdot \frac{101325}{92005.17} = 33.0389 [m/s]$$

The pressure loss in the elbow (for air) shall be:

$$p'^{\cot}_a = \xi \cdot \frac{\gamma_a^{\cot} \cdot (v_a^{\cot})^2}{2g} + R_f \cdot l_{\cot} \quad (14)$$

where:
$\xi = 0.11$
1 = 0.75, with R = 1 m (elbow length)

$$R_f = \frac{\mu_a}{d_c} \cdot \frac{\gamma_a^{\cot} \cdot (v_a^{\cot})^2}{2g} \quad (15)$$

$$R_f = \frac{0.025}{0.47} \cdot \frac{1.0896 \cdot 33.0389^2}{2 \cdot 9.81} = 3.2245 \frac{N}{m^2}$$

$$p'^{\cot}_a = 9.0871 \left[\frac{N}{m^2}\right]$$

$$\left(p_a^{\cot}\right)_{amestec} = p'^{\cot}_a \cdot (1 + k_1 \cdot \mu) \quad (16)$$

$$(p_a^{\cot})_{amestec} = 9.0871 \cdot (1 + 0.2 \cdot 10) = 27.2613 \left[\frac{N}{m^2}\right]$$

The loss of velocity of the mix is determined by the iterative solution of the equation:

$$\frac{(v_a - v_{m\cot})}{v_p} - \frac{\lambda^*_m}{2} \cdot \frac{v_{m\cot}^2}{g \cdot D_c} - \beta = 0 \quad (17)$$

which leads to the solution for the material velocity upon entering the bend

$$v_{m_i}^{\cot} = 22.6 \cdot \frac{m}{s}$$

The material velocity upon outlet shall be:

$$v_{me}^{\cot} = v_{mi}^{\cot} \cdot e^{-fm \cdot \theta} \quad (18)$$

where:
f_m =0.36 friction coefficient for wheat (natural slope).
$\theta = 90^\circ = 1.57$ (90° angle pipe).

$$v_{me}^{\cot} = 22.6 \cdot e^{-0.35 \cdot 1.57} = 22.6 \cdot 0.6 = 13.52 \left[\frac{m}{s}\right]$$

Loss of pressure for horizontal acceleration:

$$p_H^{acc} = \frac{Q_m \cdot (v_m - v_{me})}{g \cdot A_c} \quad (19)$$

where:
Q_m=206 [kN/h]; v_m=22.6 [m/s]; v_{me}= 13.52 [m/s];

p^{acc}_H = 269.8807 [N/m^2]

Loss by air friction inside the horizontal pipeline shall be:

$$p^{aer}_H = \gamma_a * \cdot \frac{\mu_a \cdot v^2_a}{2 \cdot g} \cdot \left(\frac{l^H_1}{d^H_1} + \frac{l^H_2}{d^H_2}\right) \quad (20)$$

where : v_a = 33.0389 [m/s];
l_1^H =8 [m]; l_2^H = 9.46[m];
d_1^H = 0.5[m]; d_2^H = 0.52 [m];

$$p^{aer}_H = 486.9577 \left[\frac{N}{m^2}\right]$$

Loss by material friction inside horizontal pipelines shall be:

$$p^{am}_H = p^{aer}_H \cdot (1 + k_1 \cdot \mu) \quad (21)$$

P_H^{am}=1460.8731 [N/m^2]

Consequently, total losses shall be of:
p_{tot} = 10321.4 [N/m^2]

2.1.2. The input power

The input power [5] of the suction pneumatic conveying installations may be set considering the basic mechanical work performed by an Av air flow passing through the conveying pipeline from pressure *p* to pressure *p + dp*:

dL = Av dp

Total mechanical work consistent with the passing from pressure p_0 to *p* is:

$$L = \int_{p_0}^{p} Avdp$$

$$v = v_a \frac{p_a}{p}$$

result:

$$L = Av_a p_a \int_{p_0}^{p} \frac{dp}{p} = Q_a p_a \ln \frac{p}{p_a}$$

because p_a = ~100000[N/m^2], result :

$$L = 100000 Q_a \ln \frac{100000 + h_{tot}}{100000} \quad \text{[Nm/s]} \qquad (22)$$

in which: Q_a is the air flow (at atmospheric pressure) used for conveying.

In case of suction pneumatic conveying installations, the analogue process shall be obtained by:

$$L = 100000 Q^v{}_a \ln \frac{100000}{100000 - h_{tot}} \text{[Nm/s]} \qquad (23)$$

$$Q^v{}_a = \frac{Q_a}{\gamma_a}$$

Q_a = 20601 [N/h]

$Q^v a$= 20601/1.2 = 17167.5[N/h]

$$L = 51932[J]$$

Pump driving engine power shall be of:

$$P = \frac{kL}{10^2 \eta} \text{[kW]} \qquad (24)$$

in which: η is the pump output ratio;

k = 1,1 – a coefficient which considers losses by lack of sealing.

Result: $P = 714[kW]$

3. CONCLUSIONS

Inside the pipelines, the conveyed material behaves differently than the driving air, especially due to a heavier weight. The forces exerted upon the particles (friction against the pipeline walls, impact between particles, centrifuge force, weight, resistance to moving forward, etc) cause material acceleration or slowing down, so that in order to maintain the velocity required for conveying, additional energy consumption is necessary.

4. REFERENCES

[1] BOROHOVSCHII,L. A., *Proiectarea intreprinderilor de pastrare si prelucrare a cerealelor*, (lb. rusa), Izd. Kolos, Moskva, 1971.

[2] BULAT, A., *Instalatii de transport pneumatic*, Bucuresti, Ed.Tehnica, 1962.

[3] BUTKOVSCKII, V.A., *Industria moraritului*, (lb. rusa), Izd. Agropromizdat, Moskva, 1990.

[4] CARAFOLI, E., OROVEANU, T.- *Mecanica fluidelor*, Bucuresti, Ed.Acad. R.P.R., vol. I (1952) si vol.II (1955).

[5] CHELEMEN, I., CAPROIU, M., s.a., *Masini si instalatii zootehnice*, E.D.P., Bucuresti, 1982.

[6] DAVID, L. s.a., *Masini si instalatii zootehnice*, partea I, Bucuresti, 1985

[7] DEPPERT, W. si STOLL, K., *Initiere in pneumoautomatica*, Bucuresti, E.T., 1975.

[8] DUMITRESCU, G.S., *Stadiul actual al cercetarilor in transportul pneumatic al cerealelor, Raport I Cercetare* la Teza de doctorat "*Stabilirea parametrilor optimi in transportul pneumatic al cerealelor*", Universitatea Politehnica Bucuresti, Facultatea de Ingineria Sistemelor Biotehnice, 2011.

[9] DZIADZIC, A.N., *Pnevmaticeekii transport na zernopererabativaiuschih predpriatiah*. Izdatelstvo "Kolos", Moskva,1967.

[10] FLOREA, J., *Dinamica fluidelor polifazice şi aplicațiile ei tehnice* – Ed. Tehnică, Bucureşti, 1992.

FACTORIAL ANALYSIS AND PRINCIPAL COMPONENT ANALYSIS FOR MEASURED VALUES OF SQUIRREL CAGE INDUCTION MOTOR'S PARAMETERS

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ABSTRACT

The paper is concerned with the principal component analysis and factor analysis of data for three-phase asynchronous electrical machines of 300 W. The observed data which are to be used in both analysis are the measured values of: torque (M), rotation speed (n), voltage (U) and current (I).

Keywords: *principal component analysis, factor analysis, measured parameters, squirrel cage induction motor.*

1. INTRODUCTION

The considered motor is a three phase asynchronous motor of 300W, with squirrel-cage rotor. This motor is put into operation first using a star configuration and afterwards a delta configuration.
The motor is then braked down to its nominal speed using the brake mode „torque control". Using an ammeter and a voltmeter the phase variables Uphase and Iphase are measured at the same time. The measured values are to be analyzed and interpreted using principal component analysis and factor analysis.

2. FACTORIAL ANALYSIS AND PRINCIPAL COMPONENT ANALYSIS FOR MEASURED VALUES OF SQUIRELL CAGE INDUCTION MOTOR'S PARAMETERS

2.1 Tables of measured values of the parameters to be analyzed
2.2 Line plots of the parameters measured
2.3 Principal component and factor analysis of data and biplots for the principal component and factor analysis & scree plots and interpretation of results

2.1 Tables of measured values of the parameters to be analyzed

Table 1. Measured values of M, n, U, I for the star configuration

Torque – M (Nm)	Rotation speed – n (1/min)	Voltage: Uphase – U (V)	Current: Iphase – I (A)
0.0	3000	225	0.15
0.1	2910	225	0.21
0.3	2830	224	0.31
0.5	2720	224	0.44
0.7	2570	225	0.59
0.9	2270	225	0.87

Table 2. Measured values of M, n, U, I for the delta configuration

Torque – M (Nm)	Rotation speed – n (1/min)	Voltage: Uphase – U (V)	Current: Iphase – I (A)
0.0	2975	225	0.49
0.5	2919	225	0.61
1.0	2847	225	0.82
1.5	2752	225	1.15
2.0	2605	225	1.58
2.5	2320	223	2.24

Visualizing the data in the Table 1 and Table 2 the following conclusions can be made:

- in star configuration the phase current is lower
- a delta configuration offers a better speed/torque ratio as compared to star configuration

The characteristics corresponding to data from Table 1 and Table 2 are presented in the following figures:

2.2 Line plots of parameters measured

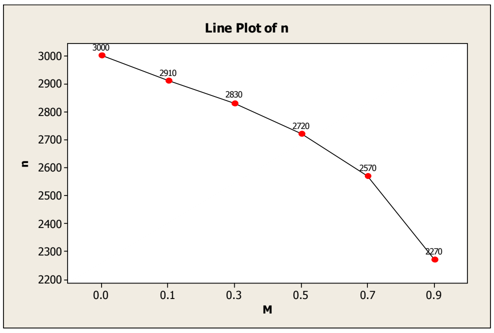

Figure 1 Rotation speed/ Torque characteristic for star configuration

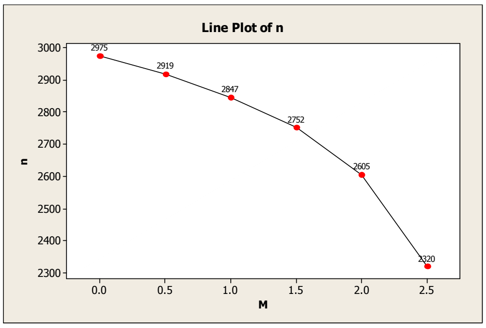

Figure 2 Rotation speed/ Torque characteristic for delta configuration

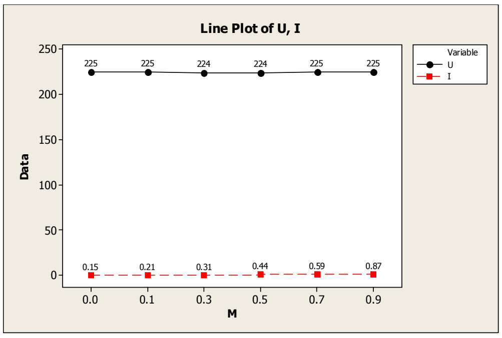

Figure 3 Voltage and current depending on torque for star configuration

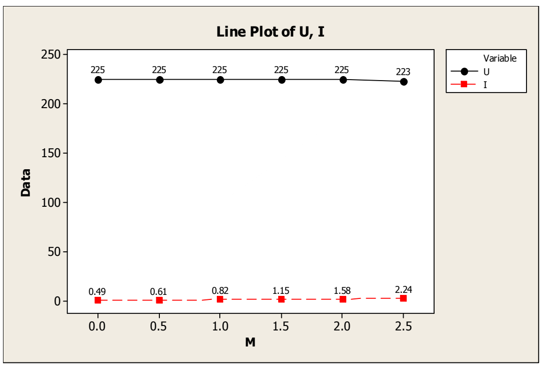

Figure 4 Voltage and current depending on torque for delta configuration

2.3 Principal component and factor analysis of data and biplots for the principal component and factor analysis & scree plots and interpretation of results

Principal Component Analysis and Factor Analysis – are two different methods, both intended to reduce the number of original variables. While the principal component analysis gives the directions with the largest variation of the data, factor analysis method reduces the number of original variables to fewer variables, named factors, using the correlations between the original variables.

Both methods are using the singular value decomposition of the correlation matrix associated with the original variables.

Principal Component Analysis: M, n, U, I for star configuration

Eigenanalysis of the Correlation Matrix

Eigenvalue	2.9896	0.9888	0.0208	0.0008
Proportion	0.747	0.247	0.005	0.000
Cumulative	0.747	0.995	1.000	1.000

Variable	PC1	PC2
M	0.568	-0.146
n	-0.577	0.009
U	0.105	0.989
I	0.578	-0.027

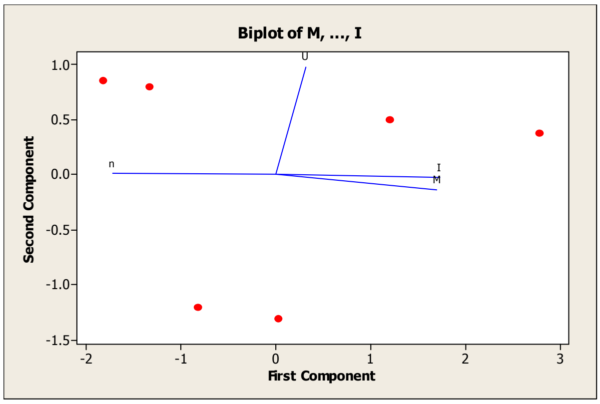

Figure 5 Biplot for principal component analysis - star configuration

Factor Analysis: M, n, U, I for star configuration

Principal Component Factor Analysis of the Correlation Matrix

Unrotated Factor Loadings

Variable	Factor1	Factor2
M	0.983	-0.145
n	-0.997	0.009
U	0.181	0.983
I	0.999	-0.027

Variance	2.9896	0.9888	3.9784
% Var	0.747	0.247	0.995

Factor Score Coefficients

Variable	Factor1	Factor2
M	0.329	-0.147
n	-0.333	0.009
U	0.061	0.994
I	0.334	-0.027

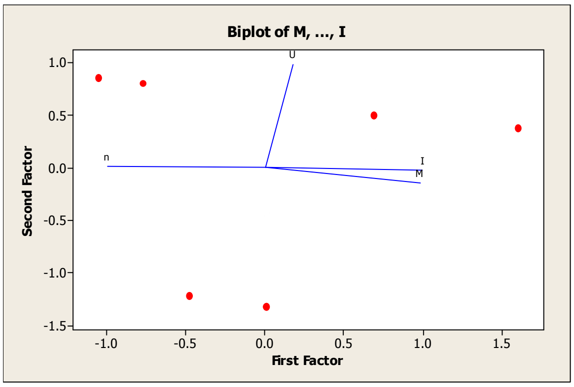

Figure 6 Biplot for factor analysis - star configuration

Principal Component Analysis: M, n, U, I for delta configuration

Eigenanalysis of the Correlation Matrix

Eigenvalue	3.6184	0.3690	0.0123	0.0003
Proportion	0.905	0.092	0.003	0.000
Cumulative	0.905	0.997	1.000	1.000

Variable	PC1	PC2
M	-0.496	-0.528
n	0.525	0.058
U	0.453	-0.832
I	-0.522	-0.162

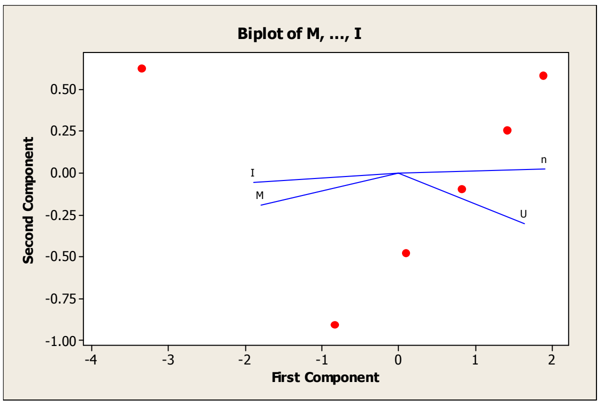

Figure 7 Biplot for principal component analysis - delta configuration

Factor Analysis: M, n, U, I for delta configuration

Principal Component Factor Analysis of the Correlation Matrix

Unrotated Factor Loadings

Variable	Factor1	Factor2
M	-0.944	-0.321
n	0.999	0.036
U	0.862	-0.505
I	-0.993	-0.098

Variance	3.6184	0.3690	3.9874
% Var	0.905	0.092	0.997

Factor Score Coefficients

Variable	Factor1	Factor2
M	-0.261	-0.869
n	0.276	0.096
U	0.238	-1.369
I	-0.274	-0.266

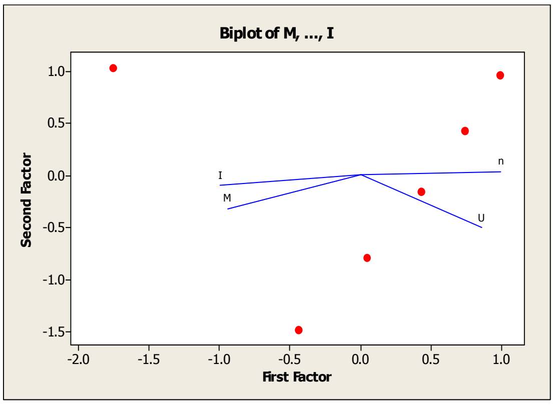

Figure 8 Biplot for factor analysis - delta configuration

Performing Principal Component Analysis and Factor Analysis on the available data, the obtained results can be interpreted as follows:

- for the star configuration, the first two components, respectively the first two factors explain 99,5% of the total variation, where the first component/factor explains 74,7% of the total variation and the second component/factor explains 24,7% of the total variation

- for the delta configuration, the first two components, respectively the first two factors explain 99,7% of the total variation, where the first component/factor explains 90,5% of the total variation and the second component/factor explains 9,2% of the total variation.

The corresponding scree plots for the star configuration and for delta configuration are:

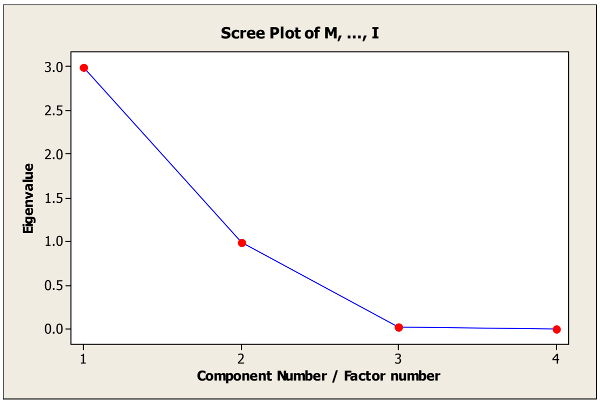

Figure 9 Scree plot for component/factor analysis - star configuration

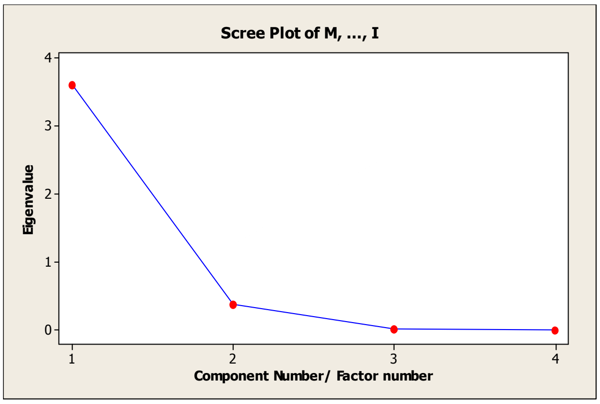

Figure 10 Scree plot for component/factor analysis - delta configuration

Taking into account that the higher the component/factor loading the more important the variable to the component is, it can be concluded that for the star configuration the variables M, n and I have approximately the same significance to the first component/factor, while the variable U has a much lower significance for that component/factor.

For the delta configuration the variables M, n, U, I have approximately the same significance to the first component/factor, while to the second component/factor the variables U and M have a much higher significance than the other two variables n and I.

The component/factor scores are calculated for each of the six recordings (for both – star and delta configuration) using the Z-transformed matrix of the data in each case and the values of the principal components/factor score coefficients. Now looking at the biplots for star configuration and delta configuration the component/factor scores obtained (represented by the points in the biplots) for each of the six data recordings can be observed. The signification of these scores is that a high score on a single component/factor means that the recorded values are mainly explained by this single component.

3. CONCLUSIONS

The number of the four analyzed variables: torque (M), rotation speed (n), phase voltage (U) and phase current (I) can be reduced using the proposed multivariate methods – principal component analysis and factor analysis.

The components/factors explaining 99,5% (star configuration), respectively 99,7% (delta configuration) of the total amount of the variation of data are the first two components/factors, so the number of variables can be reduced to only two factors.

Although very useful for explaining the relationships between the data and for simplification reasons, this reduction of the number of the variables produces a certain loss of information. The obtained components are orthogonal.

4. REFERENCES

[1] ALVIN C. RENCHER, *Methods of Multivariate Analysis*, Wiley-Interscience, 2002

[2] MORTENSEN U., *Einfuehrung in die Faktorenanalyse*, Westfaelische Wilhelms-Universitaet, 2013

[3] W. HAERDLE, L. SIMAR, Applied Multivariate Statistical Analysis, Second Edition, Editura Springer-Verlag Berlin, 2007

[4] Web sites:

Web-1:
http://www.soziologie.unihalle.de/langer/lisrel/skripten/faktxeno.pdf, Dr. Wolfgang Langer, *Explorative Faktorenanalyse*

Web-2:
http://www.molar.unibe.ch/help/statistics/spss/26_Faktorenanalyse.pdf, Felix Brosius, *Faktorenanalyse*, International Thomson Publishing

Web-3:
http://www.statoek.wiso.uni-goettingen.de/veranstaltungen/Multivariate/Daten/mvsec5.pdf

Web-4:
http://www.faes.de/Basis/Basis-Lexikon/Basis-Lexikon-Multivariate/Basis-Lexikon-Faktorenanalyse/basis-lexikon-faktorenanalyse.html

Web-5:
http://www.unikiel.de/psychologie/andres/multi07/fas.pdf

Web-6:
http://www.yorku.ca/ptryfos/f1400.pdf

Web-7:
http://webspace.ship.edu/pgmarr/Geo441/Lectures/Lec%2017%20%20Principal%20Component%20Analysis.pdf

Web-8:
http://www.cabnr.unr.edu/saito/classes/ers701/pca2.pdf

STATISTICAL PROCESS CONTROL APPLIED IN ANALYSIS OF DEFECTS IN ASYNCHRONOUS ELECTRICAL MACHINES

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ABSTRACT

The paper refers to defects recorded for asynchronous electrical motors. The aim of the paper is to conclude about the quality of the production process of the asynchronous electrical machines using the statistical process control.

The main objective of statistical process control is to find and conclude about the abnormalities in the production processes, using statistical tools of analysis and control, the so called quality control charts. For a certain measured quality characteristic, analyzing the corresponding control chart of that characteristic, one can conclude about the fact whether the respective process is getting out of the control or it is under control. These conclusions are made using the so called control limits – LCL and UCL (lower and upper control limit).

Keywords: *statistical process control, three-sigma analysis, control charts, asynchronous electrical machine.*

1. INTRODUCTION

The paper is using the data referring to defects in electrical machines, namely defects in asynchronous electrical motors of 0,37 kW nominal power, recorded by a main Romanian fabricant of electrical machines. Based on these data and using the statistical process control theory the corresponding p-control chart is represented.

The statistical process control is based on the three sigma (3σ) theory, a statistical tool used for analysis, control and improvement of production processes.

2. STATISTICAL PROCESS CONTROL APPLIED IN ANALYSIS OF DEFECTS IN ASYNCHRONOUS ELECTRICAL MACHINES

2.1 Table of the data used
2.2 Calculations made on data
2.3 Representation of the p-charts
2.4 Interpretation of results

2.1 Table of the data used:

Table 2. Monthly defects as per type of defect recorded for asynchronous electrical motors

Type of defect	**Luna 1**	**Luna 2**	**Luna 3**	**Luna 4**	**Luna 5**	**Luna 6**	**Luna 7**	**Luna 8**	**Luna 9**	**Luna 10**	**Luna 11**	**Luna 12**
Electric punctures	235	223	313	225	262	319	309	236	321	297	356	226
Phase interruption	71	74	64	84	49	92	74	70	133	135	114	111
Asymmetric currents	62	75	75	39	88	125	137	60	127	165	96	110
Eccentricity	286	300	376	344	371	377	373	278	378	377	465	331
Bearing noise	79	103	92	59	76	87	114	70	126	97	96	23
Electromagnetic noise	37	44	20	12	6	46	43	39	43	31	27	26
Other defects	0	23	22	37	20	19	30	20	0	71	58	28
Total number of defects	**770**	**842**	**962**	**800**	**872**	**1065**	**1080**	**773**	**1128**	**1173**	**1212**	**855**
Total number of tested motors	**15064**	**18616**	**22957**	**20562**	**23942**	**25141**	**24360**	**18277**	**25556**	**23054**	**24511**	**18118**

2.2 Calculations made on data:

The theory used with regard to the presented data, based on the binomial distribution, is the theory of p-charts (where p-chart stands for percent-defective chart). In order to represent the p-charts related to the data from Table 1, and then to conclude about the presented results, one has to calculate the mean proportion defective (p), the standard error of the proportion (S_p) and the upper and lower control limits of the charts (UCL and LCL).

The formulas used in order to do these calculations are:

$$p = \frac{Total\ no.\ defective\ motors}{Total\ no.\ tested\ motors}\ ; \quad (1)$$

$$S_p = \sqrt{p\frac{(1-p)}{n}}\ ; \quad (2)$$

$$UCL,\quad LCL = p \pm 3\sqrt{\frac{p(1-p)}{n}}\ . \quad (3)$$

Where n stands for sample size of the tested motors. Using the above formulas, it follows the calculated values of the proportion p, S_p, UCL and LCL.

Taking into account that the sample sizes are different (total numbers of motors monthly tested) it follows that the S_p- values and consequently the values of UCL and LCL are depending on the sample sizes, for each month of recorded defects and recorded tested motors.

The calculated value of mean proportion of defective motors is according to formula (1):

p = 11532/260158 = 0,044327.

The following table comprises the rest of the calculated statistical number values.

Table 2 Statistical numbers calculated for the total monthly defective motors

Statistical number	Luna 1	Luna 2	Luna 3	Luna 4	Luna 5	Luna 6	Luna 7	Luna 8	Luna 9	Luna 10	Luna 11	Luna 12
Defective motors percent	0.051115	0.04523	0.041904	0.038907	0.036421	0.042361	0.044335	0.042294	0.044138	0.050881	0.049447	0.047191
S_p (Standard error of proportion)	0.001677	0.001509	0.001358	0.001435	0.00133	0.001298	0.001319	0.001522	0.001287	0.001356	0.001315	0.001529
LCL (lower control limit)	0.039296	0.039801	0.040252	0.040021	0.040336	0.040433	0.040371	0.03976	0.040465	0.04026	0.040383	0.03974
UCL (Upper control limit)	0.049358	0.048853	0.048402	0.048633	0.048318	0.048221	0.048283	0.048894	0.048189	0.048394	0.048271	0.048914

2.3 Representation of p-Charts:

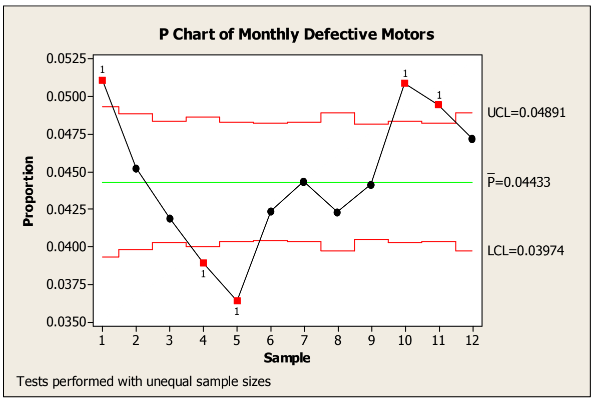

Figure 1 p-Chart for Monthly Defective Motors

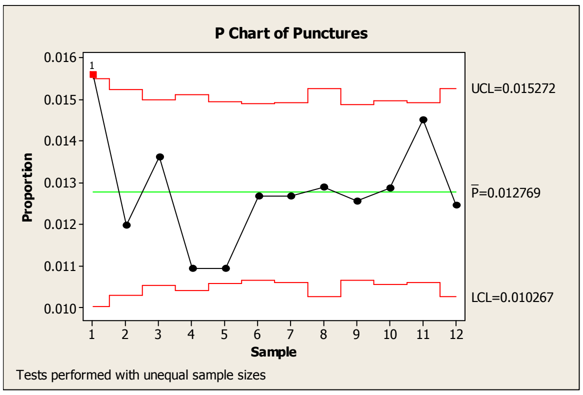

Figure 2 p-Chart for Monthly Electric punctures

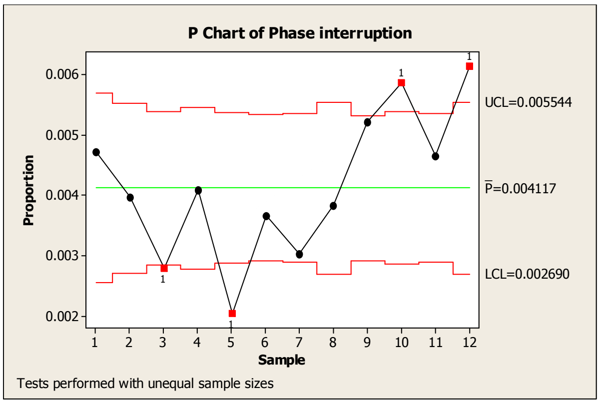

Figure 3 p-Chart for Phase interruption defects

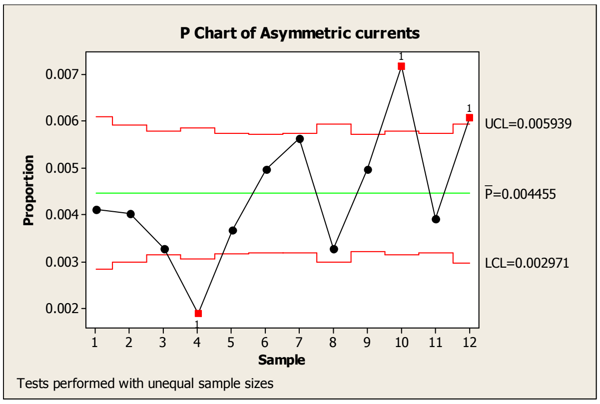

Figure 4 p-Chart for Asymmetric currents

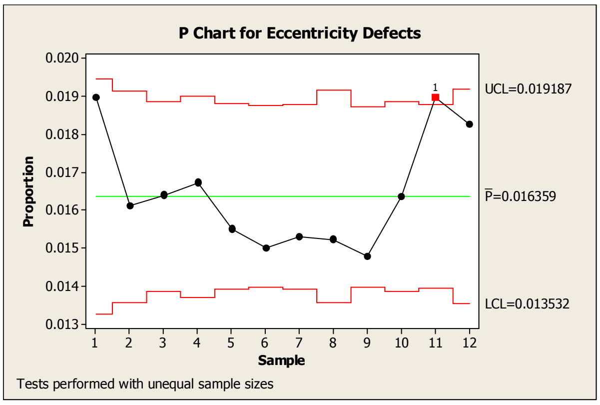

Figure 5 p-Chart for Eccentricity defects

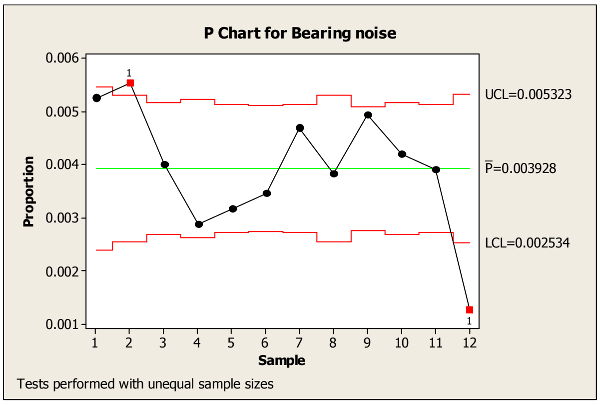

Figure 6 p-Chart for Bearing noise

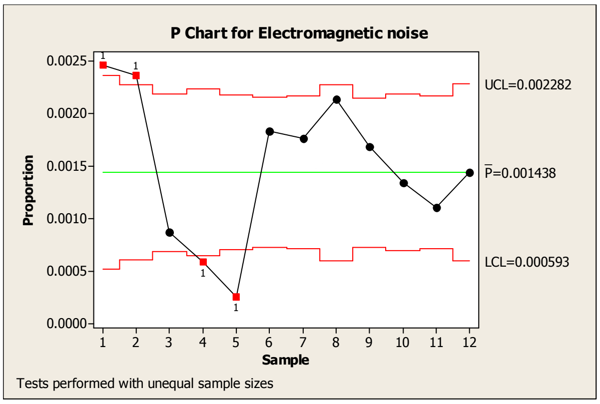

Figure 7 p-Chart for Electromagnetic noise

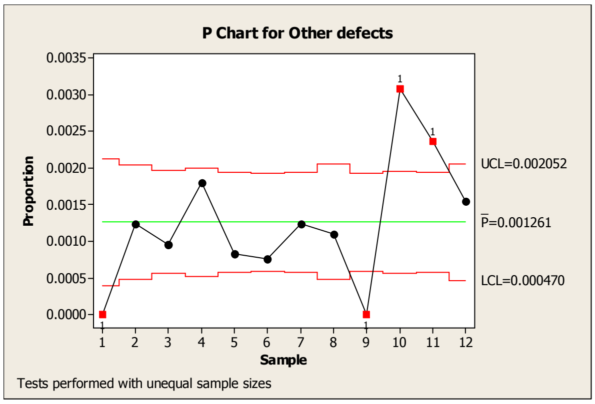

Figure 8 p-Chart for Other defects

2.4 Interpretation of results:

The charts are presenting the results recorded in each line of the Table1, corresponding to each type of recorded defect: electric puncture, phase interruption, asymmetric currents, eccentricity, bearing noise, electromagnetic noise and other defects. The Table2 summarizes the values of statistic numbers calculated for the aggregate number of defects.

As it can be seen from the charts, each of the presented p-charts shows two distinct regions:

- an area situated between the lower control line and upper control line, regarded as the region of acceptability of the process, where the process is said to be "in control"
- a second area situated outside the above acceptability region of the process, where the process is said to be "out of control".

Knowing the evolution of the process summarized by these charts, one can analyze and improve the “out of control” situations occurred in the past, or in other words, one can “control” the process, that is where the general name of the methods proposed in the 1920’s by the American Walter Andrew Shewhart comes from, namely statistical process control.

3. CONCLUSIONS

The Statistical Process Control theory applied in the present paper presents and represents only one of the possible applications of this theory, the most appropriated approach of the available production data recorded during an year by a Romanian fabricant of electrical machines.

With regard to the available data are many aspects to be discussed:

The calculations from the paper and consequently the charts presented are using as p-line, the calculated value of the percent defective, out of the data available for the electrical motors (as presented in Table1).

The application of the SPC could be also made for another value of p. This another value of p, determining another p-line and consequently another “in-control region” in our charts, which would be more adequate to use, would be the targeted value of proportion of defective motors.

This p-value could be known for the electrical machines industry of the respective country and of course substantially depends on the performance of the respective country’s industry.

This idea leads us to another important idea regarding the issue of Quality, that is the “history of recorded data”. Unfortunately, for the recent history of the Romanian industry, where in the central-planed economy more important was the quantity and little attention was paid to the quality in the past seven decades, there were very few data in respect of the quality recorded.

This approach give us an additional explanation of the poor performance of Romanian industry which unfortunately is lacking besides important knowledge also important quality data, as compared to the western industries.

With direct reference in this respect, the application of Statistical Process Control and another useful quality assurance methods requires additionally to knowledge, also the data recorded through years of observations.

Only based on historical data, much of the statistical numbers have sense and can be determined in direct connection with the sample sizes and used successfully. This applies especially for this presented area of statistical quality and process control, where, for example the coefficients for the lower and upper control lines for mean and range charts, are only known in direct connection with the respective industry and strongly depend on the analyzed sample sizes.

Although initially by Walter A. Shewhart discovered, the application and utility of the these methods were thoroughly and fully understood, first of all, by the Japanese who borrowed the methods during their industry reconstruction after the second world war. They successfully applied and substantially improved the methods of quality control and completed them with new concepts through their representants such as Kaouru Ishikawa or Genichi Taguchi.

4. REFERENCES

[1]. HOWARD D., *The basics of statistical process control and process behaviour charting,* published by Mangement-NewStyle, 2003

[2]. DIEGO TLAPA-MENDOZA, JORGE LIMON-ROMERO, YOLANDA BAEZ-LOPES: *Process improvement: The Six-Sigma Approach*

[3]. JORGE MEZA-JIMENEZ, MIQUEL ESCAMILLA-LOPEZ, RICARDO LLAMAS-CABELLO: *Statistical Process Control: A Vital Tool for Quality Assurance*

[4]. W. HAERDLE,L. SIMAR, *Applied Multivariate Statistical Analysis, Second Edition,* Editura Springer-Verlag Berlin 2007

[5]. BACIVAROV I., BACIVAROV A., TIPLICA T., *Ingineria calitatii. Initiere in Metodele Taguchi. (Quality Engineering. Initiation into Taguchi’s methods),* Euroqualrom, 1996

CONFIGURABLE RADIO FOR ELECTRIC ARC LOCATING

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ABSTRACT

This paper presents two configurable radio implementations for an Electric Arc locator system. The novelty of the work lies in the application of the Software Radio and Software Defined Radio architecture and telecommunication specific signal processing algorithms for the field of energy generation and transmission. The advantage of the proposed solution compared to other current implementations is the improved flexibility and adaptability to various working conditions provided by the configurable radio approach. The experimental results prove that the proposed systems are able to locate electric arc sources with reasonable accuracy even in the presence of multiple narrow band radio interferers.

Keywords: *Angle-of-arrival (AoA) estimation, Electric Arc, Software Radio, Software Defined Radio (SDR).*

1. INTRODUCTION

Electric arc faults are a major concern for the modern, renewable electricity generation and transmission systems [1-2]. The heat generated by the arc can melt conductor insulations and trigger an electrical fire with disastrous consequences. In response to this situation, several approaches for detecting and locating arc generating faults have been explored [3]. Among these, the most economically attractive solutions are the contactless, remote sensing approaches, as they require minimal installation and maintenance costs.

Several principles can be employed for implementing contactless, remote sensing of electric arc discharges. These devices can operate in the acoustic domain, using the sound waves emitted by the discharge [4], as well as in the electromagnetic spectrum, using visible or infrared light emitted by the plasma discharge or the radio frequency waves radiated by the conductors carrying the arc current [5-8].

This paper addresses the arc fault localization in the radio frequency domain. The novelty of the proposed systems is the employment of configurable radio architectures like the Software Radio and the Software Defined Radio and the use of specific signal processing algorithms operating in the frequency domain, inspired from the telecommunications field.

Although radio direction finding is a well known application in radio technology, the unique characteristics exhibited by the electric arcs require a specialized, customized approach. It has been observed that the spectral content of a discharge depends on the length and geometry of the conductors carrying the arc current [9]. As a consequence, the dominant frequency of the generated radio signal varies from an occurrence to another, making the classical, non-configurable architectures unsuitable. In order to successfully detect and locate an electric arc the radio receiver has to be particularly frequency-agile. Moreover, an arc locator is intended to work in industrial environment, characterized by a high level of electromagnetic interference. The solution for eliminating unwanted signals that occur in a random manner at random frequencies requires a highly adaptive, software-intensive system. In conclusion, the most natural approach for remote arc locating operating in the radio domain is the configurable radio architecture.

2. PROPOSED SYSTEMS

In order to simulate the electric arc faults the experimental setup depicted in Figure 1 was constructed.

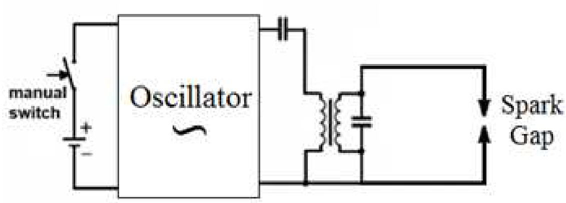

Figure 1 Electric arc generator

The spark gap consists of two sharp copper electrodes separated by air. The length of the conductors connecting the spark gap to the induction coil is about 75 cm. This setup simulates high-voltage (in the range of several kV) AC arcs by using an induction coil driven by a battery powered oscillator. The electric arcs appear across the spark gap. The electromagnetic waves are radiated by the conductors connecting the spark gap to the induction coil which behave as a loop antenna.

2.1 The Software Radio implementation

Our first attempt to implement a configurable radio arc locator embodies the most software-intensive architecture, named the Software Radio. Because the digital domain extends to the output of the antennas and all the signal processing is performed in the programmable, digital domain, this architecture provides the maximum flexibility.

The block diagram of the Software Radio arc locator is depicted in Figure 2.

The two wide-band antennas connect directly to the digitizer, a computer controlled digital storage oscilloscope. As in all Software Radios the entire signal processing is performed in the digital domain, in this case, on the computer.

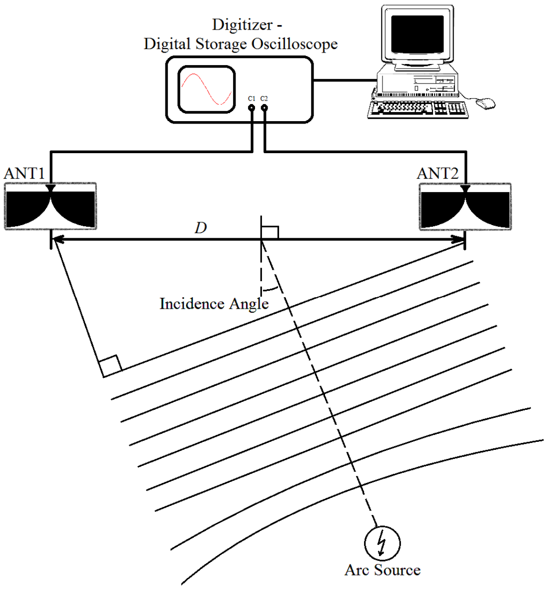

Figure 2 Software Radio arc locator – block diagram

Figure 3 presents the practical implementation of the proposed hardware.

Figure 3 Software Radio arc locator – practical implementation

The antennas used in this configuration are Vivaldi antennas selected for their wide-band and ease of fabrication [10].

On the software side, the proposed angle-of-arrival algorithm is borrowed from the telecommunications field, where it was successfully applied for direction-finding of spread-spectrum signals [11-14]. This algorithm is a variation of the classical cross-correlation direction-finding (CCDF) method, operating in the frequency domain instead of the time domain. The choice for the frequency domain is motivated by the lack of resolution in the time domain, due to the reduced available sampling rates of the current digitizers.

The fundamental idea behind this algorithm is the property of the Cross-Spectral Density (CSD) function of providing the phase-shift between the two input signals. This property can be easily highlighted by computing the CSD as the Fourier Transform of the Cross-Correlation of the two signals, which can be further expanded as the product between the Fourier transform of the first signal and the complex conjugate of the Fourier transform of the second signal, as follows:

$$CSD(f) = X1(f) \cdot conj[X2(f)] = = |X1(f)| \cdot |X2(f)| \cdot e^{j(\theta_1 - \theta_2)} \quad (1)$$

where X(f) is the Fourier Transform of x(t) and θ its corresponding phase.

If the input signals of the CSD are the outputs of the two antennas of the arc locating system, the phase, $\theta=\theta_1-\theta_2$, is related to the angle-of-arrival of the radio wave emitted by the discharge. In this case, the incidence angle φ is found as:

$$\varphi = \sin^{-1}\left(\theta \frac{\lambda}{2\pi D}\right) \quad (2)$$

where θ is the phase of the CSD at a frequency where the amplitude of the arc signal is high enough to provide a good signal-to-noise ratio, λ is the free space wavelength at that frequency and D is the distance between the two receiving antennas. Equation (2) assumes a far-field scenario; the arc source is placed far enough from the arc locating system that allows the waves impinging the antenna doublet to be treated as plane waves.

Figure 4 shows the amplitude and phase of the CSD for the signals acquired by the locating system when the arc generator is placed at a bearing of 15^0.

Ideally, the phase of the CSD should be a line passing through the origin of the coordinate system, with a slope equal to $2\pi\Delta t$, where Δt is the time delay between the two acquired signals which, ideally, should be delayed replicas one of the other.

However, the phase is linear only in the vicinity of the dominant frequency, where the magnitude of the CSD is high enough.

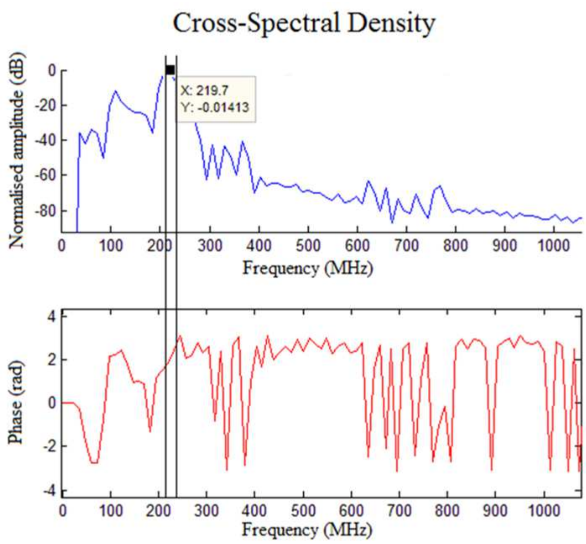

Figure 4 Cross-Spectral Density of the two antenna signals, arc source at 15^0

The explanation is the fact that the signal-to-noise ratio (SNR) is sufficient to provide a correct phase indication only in the dominant frequency region of the discharge, highlighted by markers in figure 4. Outside the selected region, the noise over imposes on the signal in such a manner that the phase indication is corrupted beyond acceptability.

This observation indicates that the magnitude of the CSD should be used as a plausibility indicator of the phase value. As a consequence, the locating algorithm should contain the following stages:

Stage A: Compute the CSD of the two received signals.

Stage B: Determine the frequency domain where the magnitude of the CSD is above a certain threshold that ensures a sufficient SNR, so that the phase indication is reliable.

Stage C: Estimate the angle-of-arrival by using Equation (2) and averaging the result over the whole frequency domain obtained in stage B.

Despite the obvious advantages exhibited by the Software Radio architecture presented above, emerging from the flexibility and adaptability provided by the signal processing being performed entirely in the digital domain it suffers from a major drawback, originating in the limitations of current available hardware. The lack of digitizers fast enough to sample the signal directly at high frequencies and the high cost of the required fast signal processors makes this architecture impractical for real-time operation.

2.2 The Software Radio implementation

In order to circumvent aforementioned limitations, a second system was implemented, using a less software-intensive configurable architecture, the so called Software Defined Radio (SDR). The core of this second arc locator is an ETTUS RESEARCH USRP N200 development platform fitted with a TVRX2 RF daughterboard. This configuration provides two input channels, each channel connected to a Vivaldi type aerial. The other components of the proposed system are the RF transmitter acting as a calibration source and a computer, as depicted in Figure 5 and Figure 6.

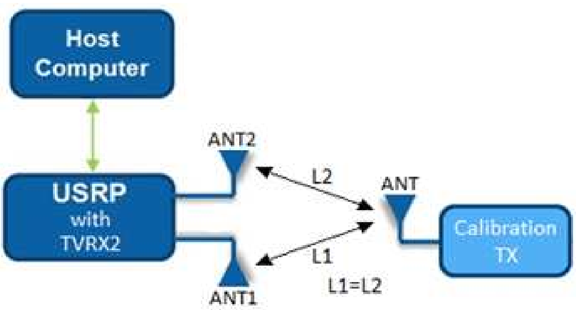

Figure 5 Software Defined Radio (SDR) arc locator – block diagram

The TVRX2 board provides two down-converter chains, implementing a low-IF architecture. The local oscillator signals for both channels are derived from the same on-board reference oscillator by using two fractional-N synthesizers. Hence, after each retune, a random phase offset between the two channels will occur [15].

This random phase offset has to be measured and compensated in order to implement the direction-of-arrival algorithm. For this purpose, a narrow band RF transmitter placed at 0^0 bearing is used as a calibration source and a phase compensation algorithm corrects the phase offset continuously.

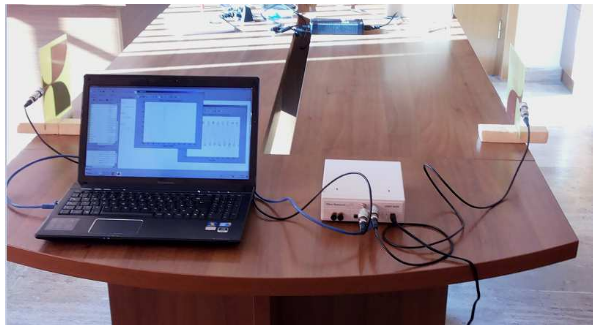

Figure 6 Software Defined Radio (SDR) arc locator – practical implementation

Figure 7 depicts the time-domain representation of the complex I/Q signals acquired during an electric arc. The signals were previously filtered in order to eliminate the calibration signal, used for phase-shift compensation. Both channels of the TVRX2 board are configured to receive on a central frequency of 80 MHz and an 8 MHz bandwidth. Antennas are separated by a distance of 1m. The discharge is clearly visible in the centre of the selected time scale.

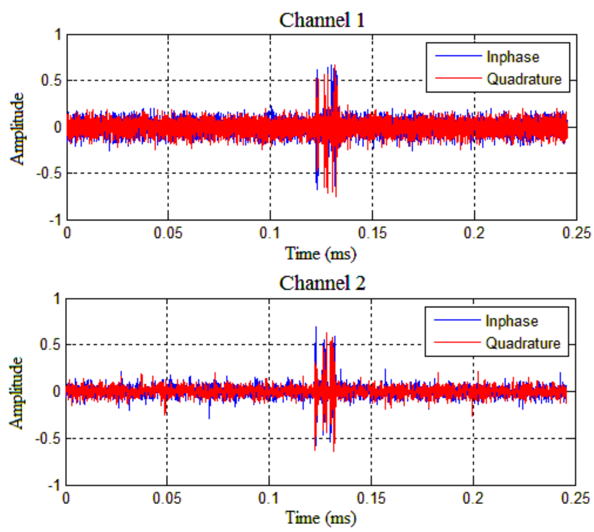

Figure 7 Time-domain representation of the arc signal on both channels

The first step of the proposed locating algorithm is to perform the discrete short-time Fourier transforms (STFT) of the two received signals. The discrete STFT is defined as follows:

$$\mathrm{STFT}\{x[n]\}(\tau, \omega) = \sum_n x[n]\, w[n-\tau]\, e^{-j\omega n} \qquad (3)$$

where w[n] is a window function.

The next step is to compute the cross-spectrogram (CS) of the two channels using relation 4.

$$CS\{ch1[n], ch2[n]\}(\tau, \omega) = = |STFT\{ch1[n]\}|\,|STFT\{ch2[n]\}| \quad (4)$$

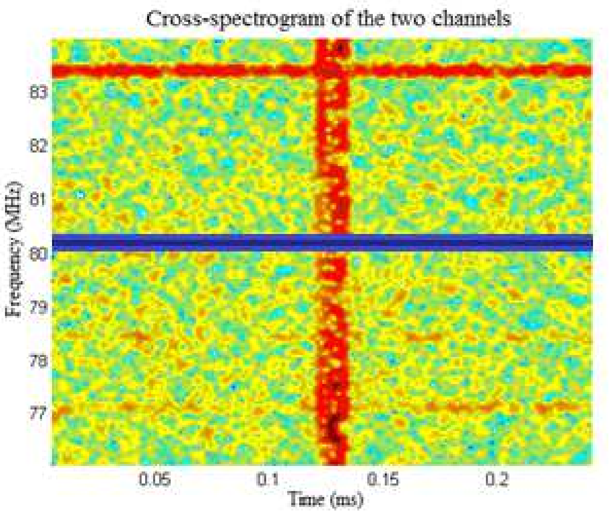

Figure 8 Cross-spectrogram of the two channels

By analyzing the cross-spectrogram depicted in Figure 8, it becomes clear that the arc generates a wide band signal indicated by the vertical line at the centre of the time scale. The cross-spectrogram also shows the presence of narrow-band interferers, the horizontal lines cantered on 77, 78.5 and 83.4 MHz. The blue line centered on 80.1 MHz is the filtered frequency band around the calibration signal, used for compensating the phase-shift between the two channels, as explained in [15].

The next step of the algorithm locates the moment where the power of the arc discharge reaches its maximum by finding the τ that maximizes the expression:

$$\tau_{Pmax} = arg\ max_{\tau}\ P(\tau) \quad (5)$$

where

$$P(\tau) = \sum_{\omega} CS\{ch1[n], ch2[n]\}(\tau, \omega) \quad (6)$$

Now, we compute the phase offset in radians, θ, between the two received arc signals:

$$\theta(\omega) = angle[STFT\{ch1[n]\}(\tau_{Pmax}, \omega)] - -angle[STFT\{ch2[n]\}(\tau_{Pmax}, \omega)] \quad (7)$$

The angle-of-arrival of the radio wave emitted by the discharge, φ, which is the angle between the direction of the arc source and the normal to the antenna array, is found as:

$$\varphi(\omega) = \sin^{-1}[\theta(\omega)\,\frac{\lambda_{\omega}}{2\pi D}] \quad (8)$$

where λ_{ω} is the free space wavelength at an angular frequency ω and D is the distance between the two receiving antennas. Equation (8) assumes a far-field scenario; the arc source is placed far enough from the arc locating system as the waves impinging the antenna doublet might be treated as plane waves.

Ideally, φ(ω) should have the same value for all the frequencies. Unfortunately, the presence of perturbations alters these values. It is, however, possible to obtain a reasonably accurate estimation of the angle-of-arrival by computing the weighted mean of these values:

$$\hat{\varphi} = \frac{\varphi(\omega)W(\omega)}{\sum_{\omega} W(\omega)} \quad (9)$$

where W(ω) is the weighting function.

The weights should be a sort of plausibility coefficients, one for each frequency. We found that satisfactory results are obtained by using the Peak-to-Average Power Ratio (PAPR) values at each frequency as weighting coefficients. In this case, W(ω) can be computed as:

$$W(\omega) = \frac{CS\{ch1[n], ch2[n]\}(\tau_{Pmax}, \omega)}{E_{\tau}[CS\{ch1[n], ch2[n]\}(\tau, \omega)]} \quad (10)$$

where E denotes the expectation operator or mean value.

This algorithm is a refined version of the angle-of-arrival estimation algorithm used in the Software Radio system, presented in the first part of this paper.

3. EXPERIMENTAL RESULTS

In order to validate the proposed implementations several tests were performed with the arc source placed at the bearings shown in Figure 9.

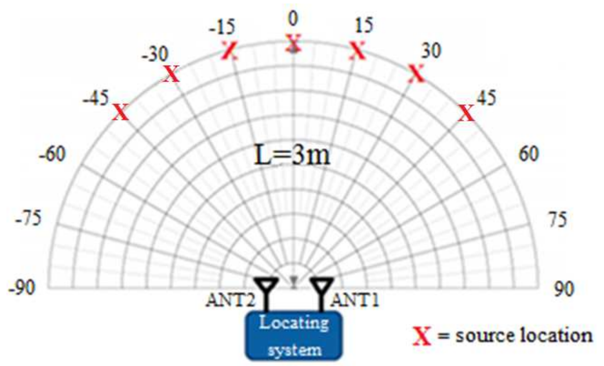

Figure 9 Arc source locations

Table 1 summarizes the results issued from the experiments performed with the first, Software Radio (SR) implementation.

Table 1. Results for the SR implementation

True angle [^{0}]	Estimated angle [^{0}]	Absolute error [^{0}]
-45	-39.55	5.45
-30	-33.28	3.28
-15	-16.71	1.71
0	6.62	6.62
15	17.27	2.27
30	23.45	6.55
45	52.23	7.23

Table 2 summarizes the results issued from the second, Software Defined Radio (SDR) implementation.

Table 2. Results for the SDR implementation

True angle [^{0}]	Estimated angle [^{0}]	Absolute error [^{0}]
-45	-52.14	7.14
-30	-34.31	4.31
-15	-17.85	2.85
0	4.32	4.32
15	14.12	0.88
30	23.87	6.13
45	50.08	5.08

4. CONCLUSIONS

This paper presents two configurable radio implementations for locating electric arc faults sources within power generation and transport related areas.

The mean absolute error of the estimated angle-of-arrival for both implementations is approximately 4 degrees.

Although seductive, the Software Radio architecture proves still difficult to implement due to the limitations of current hardware, especially the lack of high speed digitizers.

On the other hand, the Software Defined Radio architecture, as the one employed by the USRP platform, proves a good compromise between flexibility and implementation cost, allowing real-time operation at a decent price.

In a future work, we intend to implement a system capable of locating the target source in 2D by integrating the results provided by two direction finding systems as the one described in this paper.

We also intend to explore the effect of increasing the frequency domain of the receiver and investigating the arc signal at higher frequencies, where the anthropic noise is lower.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] STROBL C., MECKLER P., *Arc Faults in Photovoltaic Systems*, in Proc. 25th ICEC & 56th IEEE Holm Conference on Electrical Contacts, 2010, pp. 216-222.

[2] FRONIUS INTERNATIONAL GmbH, April, 2012, *Arcs in Photovoltaics (PV)*, Technical Article, Available online: http://hespv.ca/hesproductspecs/technical-bulletins/fronius/SE_TA_Arcs_in_Photovoltaics_EN_320589_snapshot.pdf.

[3] RESTREPO C. E., *Arc fault detection and discrimination methods*, in Electrical contacts-2007, the 53rd ieee holm conference on, 2007, pp. 115-122.

[4] DIGULESCU A., PAUN M., VASILE C., DEACU D., IOANA C., TAMAS C., *Electrical arc surveillance and localization system based on advanced signal processing techniques*, ENERGYCON, May 2014, pp. 448-452.

[5] MOORE P., PORTUGUES I., GLOVER I., *Partial Discharge Investigation of a Power Transformer Using Wireless Wideband Radio-frequency Measurements*, in IEEE Transactions on Power Delivery, Vol. 21, 2006, pp. 528-530.

[6] PORTUGUES I., MOORE P., CARDER P., *The Use of Radiometric Partial Discharge Location Equipment in Distribution Substations*, 18th International Conference on Electricity Distribution, Turin, Italy, 2005, pp. 1-4.

[7] PACHECO C., *Radiometric Partial Discharge Characterisation*, PhD Thesis, Department of Electric and Electronic Engineering at Strathclyde University, Glasgow, Scotland, 2004. pp. 16-20.

[8] MOORE P., PORTUGUÉS I., GLOVER I. A., *Radiometric Location of Partial Discharge Sources on Energized High-Voltage Plant*, in IEEE Transactions on Power Delivery, Vol. 20, 2005, pp. 2264-2272.

[9] CHA HYEON-KYU, KIM SUN-JAE, PARK DAE-WON, KIL GYUNG-SUK, *Frequency Spectrum Analysis of Electromagnetic Waves Radiated by Electrical Discharges*, in IMCAS'11 Proceedings of the 10th WSEAS international conference on Instrumentation, measurement, circuits and systems, 2011, pp. 65-69.

[10] GIBSON P. J., *The Vivaldi aerial*, in Proceedings of the European Microwave Conference, vol. 9, 1979, pp. 101–105.

[11] FINNE MAGNUS, *Methods for Direction-Finding of Direct-Sequence Spread-Spectrum Signals*, DIANE Publishing, 1996, pp. 26-31.

[12] HOUGHTON ANDREW WARREN, REEVE CHRISTOPHER DEAL, *Detection of spread spectrum signals*, Patent US5955993 A, 1999.

[13] REEVE C. D., HOUGHTON A. W., *Direction finding on spread spectrum signals using a cross*

correlation receiver, in IEE M94 Conference Proceedings, pp. 304-308, 1994.
[14] FALK J., HANDEL P. and JANSSON M., *Direction finding for electronic warfare systems using the phase of the cross spectral density*, in Proc. Radiovetenskap och Kommunikation 2002, Stockholm, Sweden, 2002.
[15] ETTUS RESEARCH – Synchronization and MIMO Capability with USRP Devices, Application Note.

SIMULATION REACTOR POWER CONTROL OF CANDU 600

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ABSTRACT

Present paper shows the evaluation of the performance of the 3-D modal synthesis based reactor kinetic model in a closed-loop environment in a MATLAB/SIMULINK based Reactor Regulating System (RRS) simulation platform. A notable advantage of the 3-D model is the level of details that it can reveal as compared to the coupled point kinetic model. Using the developed RRS simulation platform, the reactor internal behaviours can be revealed during load-following tests. The test results are also benchmarked against measurements from an existing (CANDU) power plant. It can be concluded that the 3-D reactor model produces more realistic view of the core neutron flux distribution, which is closer to the real plant measurements than that from a coupled point kinetic model. It is also shown that, through a vectorization process, the computational load of the 3-D model is comparable with that of the 14-zone coupled point kinetic model. Furthermore, the developed Graphical User Interface (GUI) software package for RRS implementation represents a user friendly and independent application environment for education. training and industrial utilizations.

Keywords: *Reactor Regulating System, Graphical User Interface, Matlab.*

1. INTRODUCTION

The reactor regulating system, as a part of the overall plant control system, directly controls the reactor power, and sets it either to an operator-allocated power set point (Alternate Mode) or to the power level required to maintain certain steam pressure in the steam generator (Normal Mode) [1]. Specifically, it includes input sensors, a collection of Digital Control Computer (DCC) programs, reactivity control devices and the related control logicsis, represented in Figure 1.

The main functions of the RRS are to:
1. Automatically control the reactor bulk power to the power set point between 10-6 FPU and 1.0 FPU at a controlled rate. This is called bulk (global) control.
2. Maintain the neutron flux distribution close to its nominal design shape, so that the reactor can be operated at the full power without violating channel and bundle power limits. This indicates the spatial (differential) control.
3. Insert or withdraw reactivity devices at a controlled rate to maintain reactivity balance in the core. These reactivity devices compensate for the reactivity change due to variations in Xenon concentration, fuel burn-up, moderator poison concentration, and refueling effects, etc.
4. Monitor some important plant parameters and reduce power quickly when any parameter exceeds the limit. Parameter limits may be specified for economic or safety-related issues.
5. Withdraw shutoff rods automatically when the trip channels have been reset following a reactor trip on SDS1.

Furthermore, as a safety-related system, the RRS also meets the requirements for preventing loss of regulation (LOR). The frequency of LOR must be as low as possible. The RRS also is required to prevent LOR on any seismic event of intensity up to design basis earthquake (DBE) intensity. The reliability of the RRS is also very important. However, the RRS is not required to be functional under conditions associated with a Loss-of-Coolant Accident (LOCA), such as high temperature.

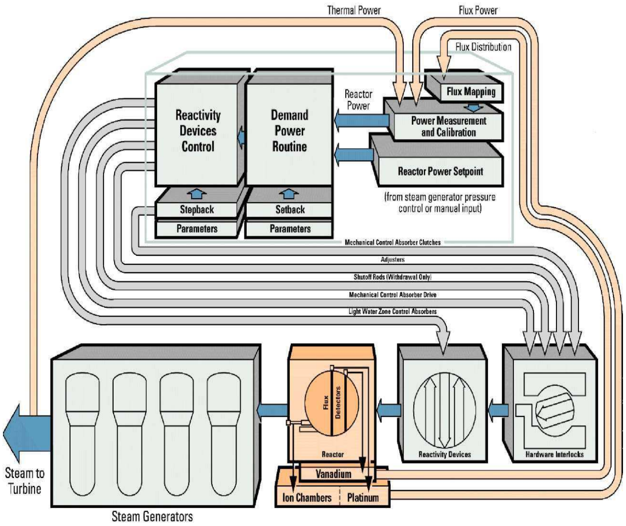

Figure 1 *CANDU RRS block modules [2]*

humidity or radiation.

2. MATLAB/SIMULINK simulation platform of the RRS

MATLAB/SIMULINK software environment has facilitated the simulation of the CANDU RRS. Since our research mainly focuses on the reactor power short-time regulating, a simplified block diagram of the CANDU RRS, which contains the most functional routines and control algorithms, is represented in Fig. 2.

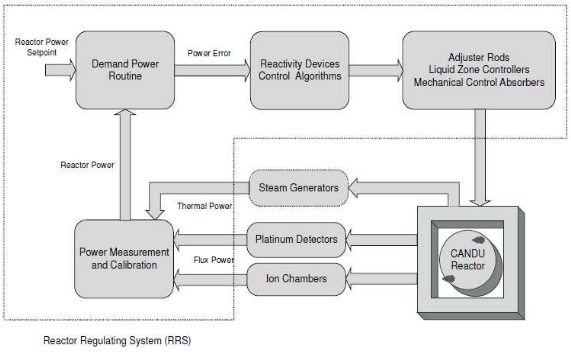

Figure 2 Block diagram of RRS in CANDU reactors

2.1 *Matrix and vector representation*

MATLAB/SIMULINK software provides a convenient environment to perform the matrix operations, such that the entire RRS system can be simulated in a matrix form. The idea is to decompose every module/routine of the RRS, express all the principles by mathematic equations, and write the equations to the criteria matrix form. Then the software chooses the appropriate synthetic internal functions from the SIMULINK library to develop each block, which represents the mathematic model of the RRS' module, and finally connects all the blocks, compiles them and performs simulations. A necessary procedure before the simulation is that the initialization of all the parameters involved in the simulation is required. For dynamic simulations, steady-state authorization also needs to be assessed.

It has been established that the basic functions of the RRS are to maintain reactor power and rate of change in power at specified setpoints (bulk control), and to maintain the reactor power distribution shape close to its nominal design shape (spatial control); the use of stable feedback controls based on neutron flux accomplishes these functions. Fig. 3 shows a block diagram of the flux control loop for bulk power control.

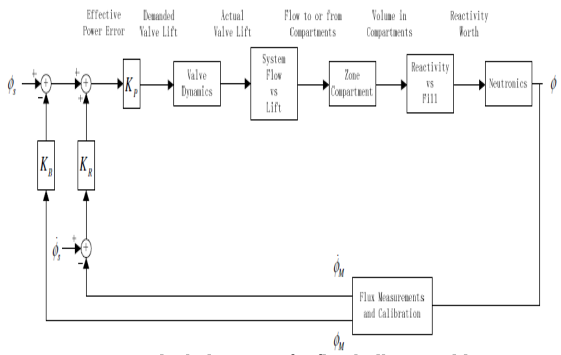

Figure 3 Block diagram of a flux bulk control loop

2.2. *Efficient implementation of the RRS simulation Platform*

A CANDU RRS simulation platform established by MATLAB/SIMULINK is illustrated in Fig. 4. As shown, main control routines and devices are simulated, including reactor neutron and thermal power measurement and calibration, demand power and power error calculation, control algorithms and mechanical characteristics of liquid zone controllers, adjuster rods and mechanical control absorbers, and the reactor dynamic system.

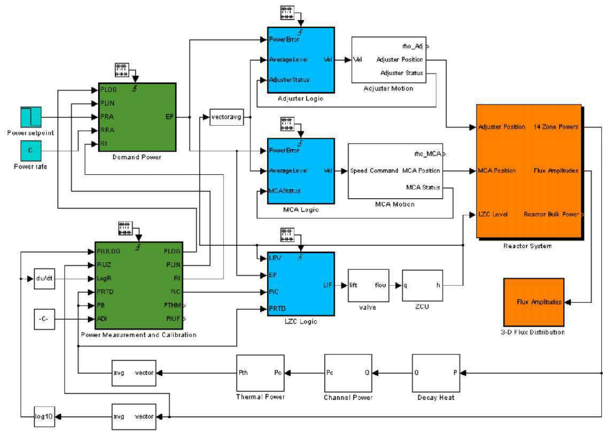

Figure 4 MATLAB/SIMULINK simulation platform for the CANDU (RRS)

2.2 *Simulations of power maneuvering operations*

In this study, power maneuvering test scenarios have been simulated. The reactor power setpoint is reduced gradually from 1.0 FPU to 0.9 FPU at a rate of 0.1 FPU/s. The reactor bulk power control under this command is illustrated in Fig. 5. For comparison purposes, the response from the coupled point kinetic model is also included. As far as the bulk power is concerned, the simulation results show clearly that both models can achieve the load following requirements successfully. The local enlargements of Fig. 5 illustrate that both the overshoot and the steady-state error of the modal synthesis model are close to those of the coupled

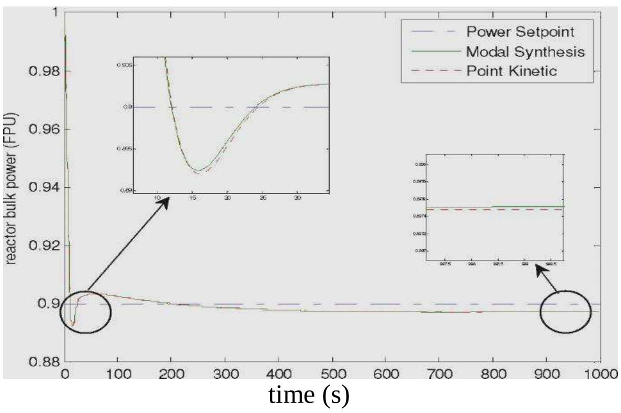

Figure 5 Bulk power responses based on coupled point kinetic and modal synthesis models (the reactor power is reduced from 1.0 FPU to 0.9 FPU at 0.1FPU/s)

point kinetic model. However, both the overshoot and steady-state error of the modal synthesis model are relatively smaller than those of the coupled point kinetic model.

Figure 6 illustrates the simulation of reactor zonal power responses under the same power maneuvering condition. The 14 curves represent normalized power dynamics within 14 zones. Therefore, it is observed that powers in 14 zones are almost regulated to the level of bulk power. Basically, the requirement of the spatial control is met, while the power distribution shape is somewhat maintained. From Fig. 5 and Fig. 6, it can be concluded that reactor modal modeling implemented within the RRS simulation platform can meet the requirement of power transient simulation and analysis.

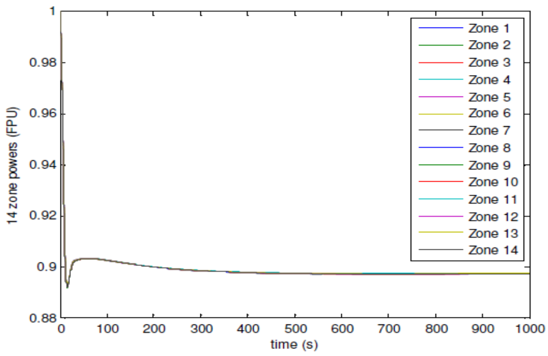

Figure 6 Simulation result of reactor power spatial control (1.0 FPU - 0.9 FPU, at a rate of 1%FP/second)

For comparison purposes, Fig. 7 illustrates the simulation of four power transients at different rates of power maneuvering. The range of power reduction is kept the same, i.e. 1.0 FPU to 0.9 FPU. However, the rates are respectively 1.0% FP/second, 0.5% FP/second, 0.25% FP/second, and 0.1% FP/second, which correspond to power-reducing times of 10 seconds, 20 seconds, 40 seconds and 100 seconds. Fig. 7 illustrates

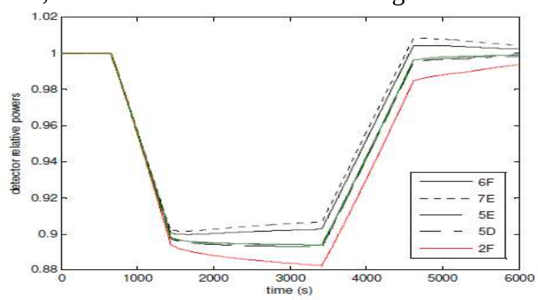

Fig. 7 Comparison of 4 power transients' simulations at different power changing rates

reactor bulk power following results. It can be observed that a smaller power reduction rate, there is a reduction in the overshoot power response.

Neutron flux dynamics within regional overpower protection detectors

The Regional Overpower Protection (ROP) system is designed to protect the reactor against overpowers in the fuel caused by either a local peaking or a general power increase in the reactor load level. Within the core, there are two ROP systems: one for each of the two shutdown systems - SDS1 and SDS2. Each ROP system consists of several fast-responding self-powered flux detectors. They are distributed throughout the core within SDS1 and SDS2 assemblies. Each ROP detector has been designed with a pre-set trip setpoint (TSP). The standard TSP for CANDU reactors is around 1.23 [3].

Fig. 8 shows a typical ROP detector distribution for SDS1 within the center cross section of the core. Fig. 9 illustrates the dynamic process of the neutron flux variation within several selected detectors during the load-following operation. The trajectories in Fig. 9 demonstrate that none of the normalized neutron fluxes

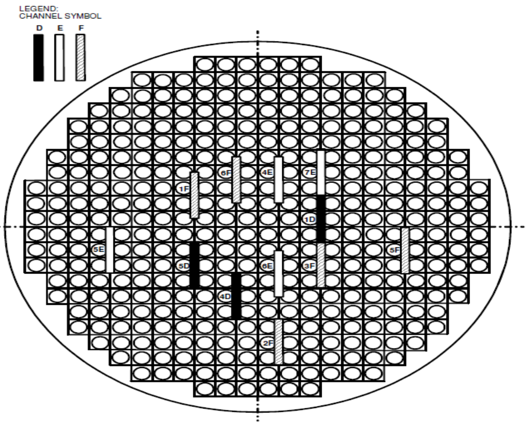

Fig. 8 ROP detector location for SDS1 within the center cross section of the core1.02

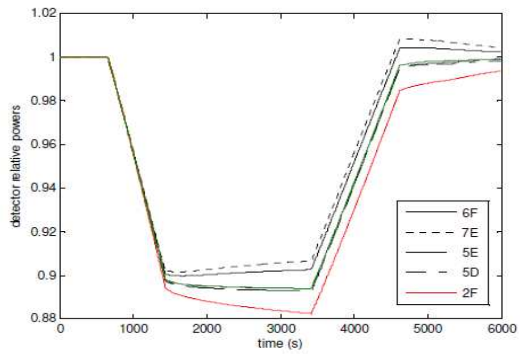

Fig. 9 Simulation results of the neutron flux varying within selected ROP detectors for load following process of the selected detectors are over the TSP, and thus the trip signal is not activated.

Core neutron flux distribution during transients

Under the RRS control, the shape of the reactor neutron flux distribution has to be close to its nominal design shape to ensure the reactor's operational safety and optimal performance. For illustrative purposes, the CANDU core is sliced into 12 layers of the same thickness, as shown in Fig. 10, where the fourth layer from the right is chosen for subsequent illustrations. The central plane is also highlighted since it divides the reactor core into two symmetric halves. The neutron flux distributions modeled by the 3-D modal power is 1.0 FPU).

The variations of the neutron flux distribution on the fourth layer during the load synthesis model at the fourth layer are shown in Fig. 11 under 1.0 FPU reactor power. As can be seen in Fig. 11, the modal synthesis method can provide much detail in terms of peaks and valleys in the core power distribution. In particular, it can be observed that due to the neutron absorption of the liquid zone controllers, there are seven notches distributed in the related zones, indicating reduced neutron flux.

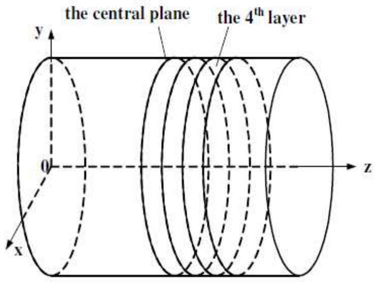

Fig. 10 The relative position of the *fourth layer within the CANDU reactor core*

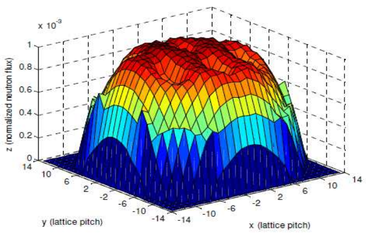

Fig. 11 Neutron flux distribution at the fourth layer along the z-direction (reactor power is 0.95 FPU)

CANDU RRS Graphical User Interface (GUI)

A Graphical User Interface (GUI) allows users to perform tasks interactively. MATLAB GUI represents a convenient software environment for users to perform tasks such as creating and customizing plots, fitting curves and surfaces, and analyzing and filtering signals [4]. Users can also create custom GUIs for others to use - either by running them within MATLAB or as standalone applications that could be run independently in the MATLAB environment.

Figure 12 it can be seen that the basic system parameters can be inputted to the "Parameter Input Panel". After running, the reactor dynamic responses including reactor bulk power and zonal power responses, 14 zonal water levels and their averaged value, and Xenon buildup reactivity, could be depicted through the "System Responses" panel. Also, by pressing the blue strip button, the 3-D flux distribution within the core is represented, as shown in Fig. 13. Furthermore, the user can modify the parameter values by "Parameters Input Panel" such that the corresponding system responses, in case of different transient conditions, can be generated.

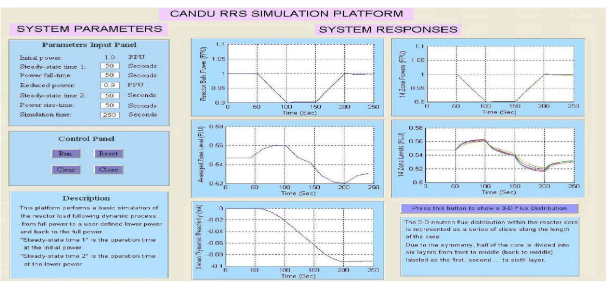

Fig. 12 MATLAB GUI for CANDU RRS simulation platform

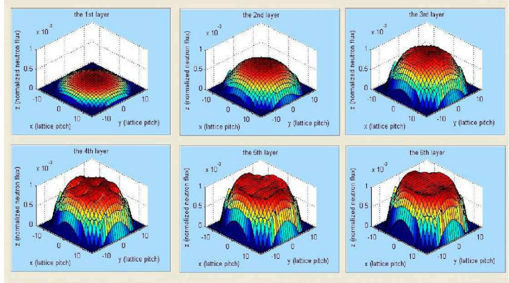

Fig. 13 3-D flux distribution module of the CANDU RRS GUI

3. CONCLUSIONS

The evaluation of the performance of the 3-D modal synthesis based reactor kinetic model in a closed-loop environment is carried out in a MATLAB/SIMULINK based RRS simulation platform. A notable advantage of the 3-D model is the level of details that it can reveal as compared to the coupled point kinetic model. Using the developed RRS simulation platform, the reactor internal behaviors can be revealed during load-following tests. The test results are also benchmarked against measurements from an existing power plant. It can be concluded that the 3-D reactor model produces more realistic view of the core neutron flux distribution, which is closer to the real plant measurements than that from a coupled point kinetic model. It is also shown that, through a vectorization process, the computational load of the 3-D model is comparable with that of the 14-zone coupled point kinetic model. Furthermore, the developed GUI software package for RRS' implementation represents a user friendly and independent application environment for education training and industrial utilizations.

4. REFERENCES

[1] J. KOCLAS, *Reactor Control and Simulation*, Chulalongkorn University, Thailand, 1996 at http://canteach.candu.org/library020044301.pdf .

[2] *CANDU fundamentals*, Atomic Energy of Canada Limited; available on the Internet at: http://canteach.candu.org/library/20040711.pdf.

[3] C. J. JEONG AND H. CHOI, “Regional Overpower Protection System Analysis for the Direct Use of Spent Pressurized Water Reactor Fuel in CANDU Reactors (DUPIC)”, *IEEE Transactions on Nuclear Science*, vol. 52, no. 1, pp. 450-456, Feb. 2005.

[4] MATLAB GUI – Creating Graphical User Interface in MATLAB, http://www.mathworks.com/discovery/matlab-gui.html

SECTION IV

MATHEMATICAL SCIENCES AND PHYSICS

A SIMPLE INVESTIGATION OF VISCOUS FLOW IN PHYSICS LABORATORY

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ABSTRACT

In this paper we present a short investigation made in physics laboratory regarding the viscous flow of a stack of small cake forms. We analyze the possibility of parametrized the air resistance force as Stokes' law or as Newton's law. The general solutions of the velocity law and movement law in these two cases are also discussed.

Keywords: *viscous flow, Stokes' law, Newton's law, Logger Pro.*

1. INTRODUCTION

A relatively simple topic to be investigate in physics laboratory is the free fall taking into account the effect of air resistance. From mathematical point of view we have to find the solution of differential equation:

$$m\frac{dv}{dt} = mg - F_A - F(v) \tag{1}$$

with initial conditions $t = 0, v = 0, y = 0$, where F_A is Archimedes force and $F(v)$ is the force due to the air resistance. In our experiment Archimedes force is negligible due to the shape of the object whose fall we study.

For small object moving with low speed the flow is laminar and the magnitude of the air resistance force is proportional to the speed of the body,

$$F(v) = kv \tag{2}$$

The proportionality constant, k, depends on size and shape of the moving body and the properties of fluid. The Eq. (2) is often used in form

$$F(v) = 6\pi\eta l v \tag{3}$$

also knows as Stokes' law, where η is the fluid viscosity and l is the radius of the object or the linear dimension of the body.

If we integrate Eq. (1) considering the initial conditions we find,

$$v(t) = v_T(1 - e^{-\left(\frac{k}{m}\right)t}) \tag{4}$$

$$y(t) = v_T\left[t - \frac{m}{k}(1 - e^{-\left(\frac{k}{m}\right)t})\right] \tag{5}$$

Where v_T is the terminal speed i.e. the speed limit from which the resistance force became equal with inertial forces which cause acceleration to be zero and the movement of the body to be rectilinear uniform.

$$v_T = \frac{mg}{k} \tag{6}$$

Knowing that,

$$e^{-3} = 0{,}0498 \ and \ 1 - e^{-3} = 0{,}95 = 95\%$$

If $\frac{k}{m}t = 3$ we can consider that the terminal velocity is reached.

An other way to parametrized the resistance force of the air is to consider a proportionality to the square of the speed Eq.(7). This is the case of turbulent flow which characterize high speed of the moving body.

$$F(v) = Dv^2 \tag{7}$$

Eq. (7) is also known as Newton's law,

$$F(v) = \frac{1}{2}\rho C S v^2 \tag{8}$$

where ρ is the density of the fluid, C is a coefficient depending on shape of the body, S is the cross-section area.

If we solve Eq. (1) for air resistance force given by Eq. (7) for the same initial conditions we find,

$$v(t) = v_T\frac{e^{2gt/v_T - 1}}{e^{2gt/v_T + 1}} = v_T \tanh\left(\frac{g}{v_T}t\right) \tag{9}$$

$$y(t) = \frac{v_T^2}{g}\ln\left[\cosh\left(\frac{g}{v_T}t\right)\right] \tag{10}$$

In this case terminal speed is,

$$v_T = \sqrt{\frac{mg}{D}} \tag{11}$$

Knowing that,

$$e^{-3} = 0{,}0498 \, ; 1 - e^{-3} = 0{,}95 \, ; 1 + e^{-3} = 1{,}049$$

If $\frac{2g}{v_T}t = 3$ we can consider that the terminal velocity is reached.

To define if the flow is laminar or turbulent, *Reynolds number* is introduced as a dimensionless quantity given by the ratio of inertial forces to viscous forces for an object moving in a fluid,

$$Re = \frac{l\rho v}{\eta}, \tag{12}$$

Roughly speaking low Reynolds number is related to laminar flow and high Reynolds number is related to turbulent flow.

If we have a viscous flow of different objects with different speeds but having the same Reynolds number we can applied the principle of dynamic similarity, the whole pictures of the motion is the same only the scale is different. In engineering design this imply that objects like ships, airplanes, etc, can be tested using a scale models which have similar proprieties like reals one.

2. EXPERIMENTAL METHOD

The purpose of our experiment is to study the free fall of the small cake forms and to see if the resistance force of air is defined by Stokes' law (2) or Newton's law (7).

We used LabPro interface with Go!Motion sensor and Logger Pro software for collect and analyse experimental data. As a free falling bodies we used stacks of small cake forms (one, two, …ten pieces).

Stacks of cake forms (one, two,…ten) were dropped down and the position is recorded at every 0,04 second with an accuracy of 2 mm. Even if we have one or two cake forms in the stack the fall is stable and rectilinear. For small stacks the terminal speed is quickly reached. Heavier stack take a long time to achieve the terminal velocity. For this reason our experimental setup (only 2,30 of free fall) limits the number of forms in the stack for which the terminal velocity can be found from position-time graph analysis.

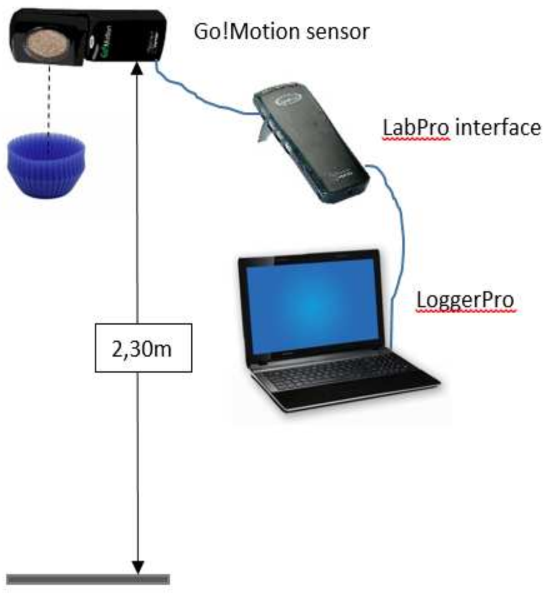

Figure 1 Experimental setup

3. EXPERIMENTAL DATA AND ANALYSIS

We performed the experiment using one, two …ten cake forms in the stack. The mass of one cake form is m = 0,34g and the diameter is about 7cm. One, two,…ten forms in the stack are indicated by 1m, 2m, …10m.

The position-time graph is represented in Fig. 2. The distance over time graph is limited at about 2,30m when the body in fall reaches the floor. For this reason the Fig 2 graph has a limit around 2.30m.

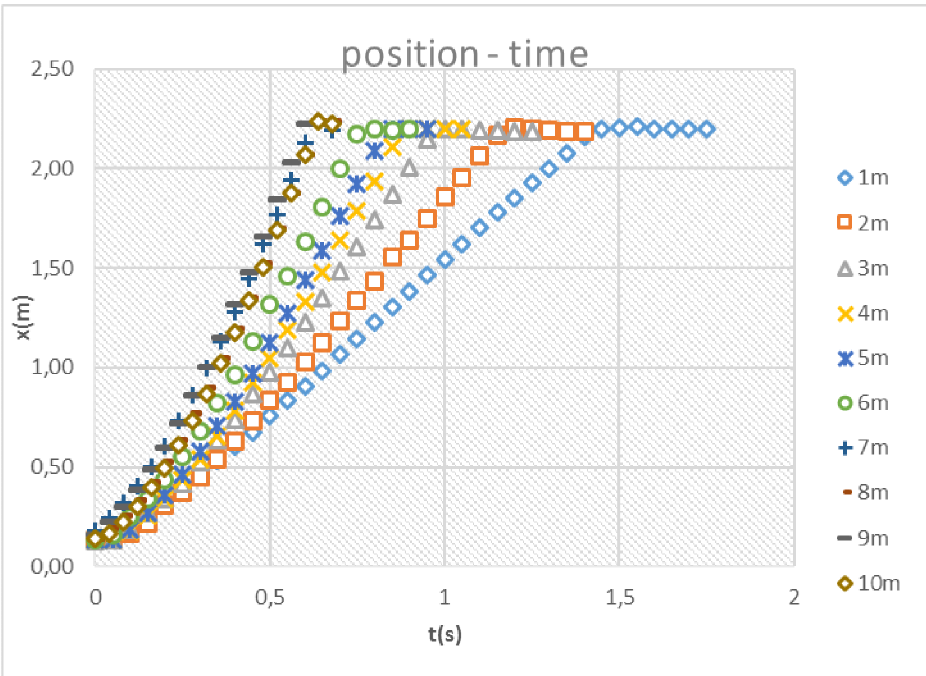

Figure 2 x-t graph for 1, 2, 3 ..10 pieces in the stack

If we analyse the Figure 2 graph we see that quite quickly x-t points define a straight line which indicate an uniform motion. The terminal velocity is calculated by fitting x-t data graph (on a linear portion) using the least-squares method with a first-degree function (see Table 1). In the third column of the table the Pearson's R - correlation coefficient is calculated. A value close to 1 indicate a strong positive correlation between x and t variable.

To see which of relations (2) or (7) regarding the air resistance force is verified in our experiment we must plot terminal velocity as a function of mass. If the dependence is linear then relation (2) fits, otherwise we must try to use an order 2 polynomial function. The results is shown in Figure 4. The fit with first order degree function generates a R correlation coefficient of 0,84 while using a polynomial function of two degree generates a R about of 0,99. On the other hand if we performed a χ^2 test we have 8,2 value for the straight line and 1,9 for the parabola. We conclude that relation (7) means Newton's law is better to parametrized the air resistance force in our case. An other way to test Stokes' law versus Newton's law is to observe that we are looking for a power law relation of type $m \sim kv^n$. Therefore we can plot $\ln(m)$ versus $\ln(kv^n)$, n is equal with 1 in case of Stokes' law and 2 in case of Newton's law. If we find the slope of $\ln(m)$ vs $\ln(kv^n)$ we can conclude about one of the two situations.

Table 1. Terminal velocity

m	v(m/s)	R^2
1	1,56	0,9999
2	2,05	0,9998
3	2,54	0,9995
4	2,92	0,9991
5	3,20	0,9994
6	3,42	0,9987
7	4,13	0,9996
8	4,44	-
9	4,52	-

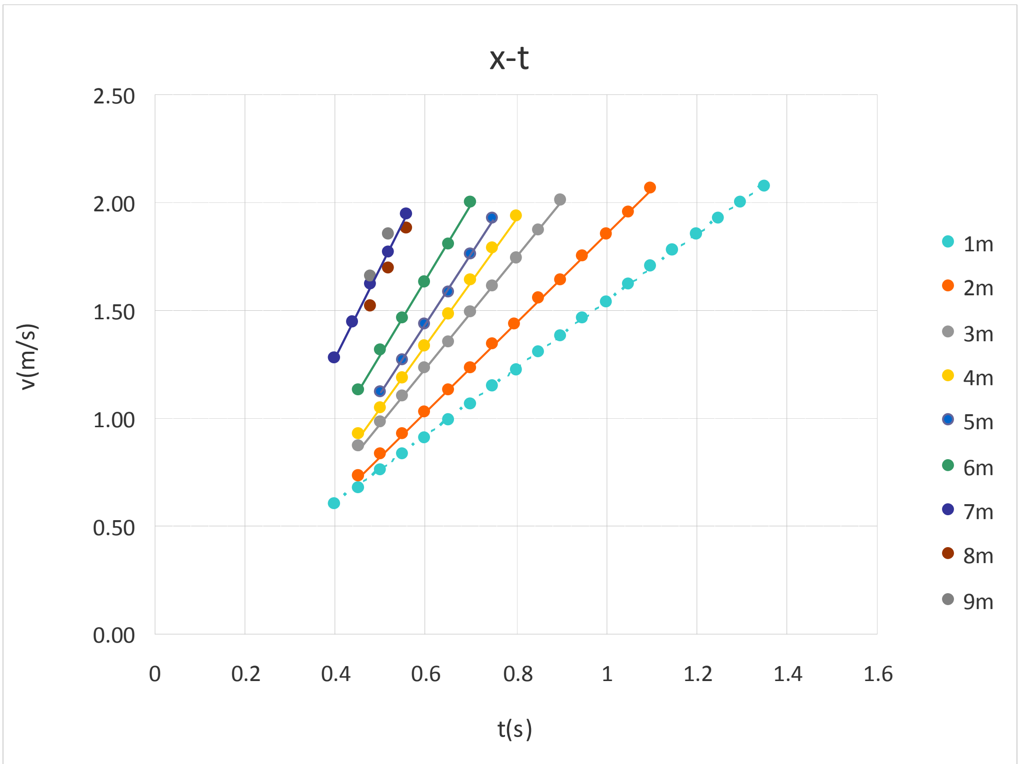

Figure 3 terminal velocity graph

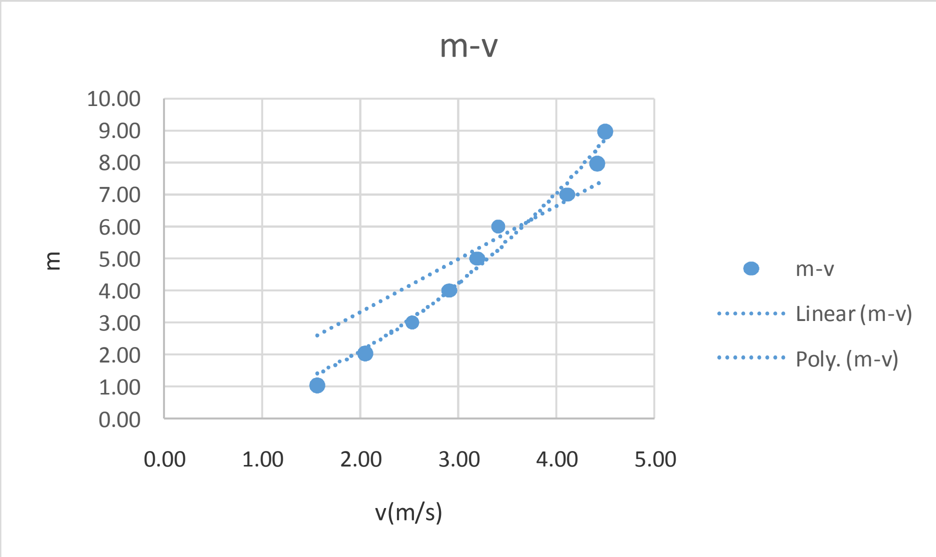

Figure 4 mass-terminal velocity graph

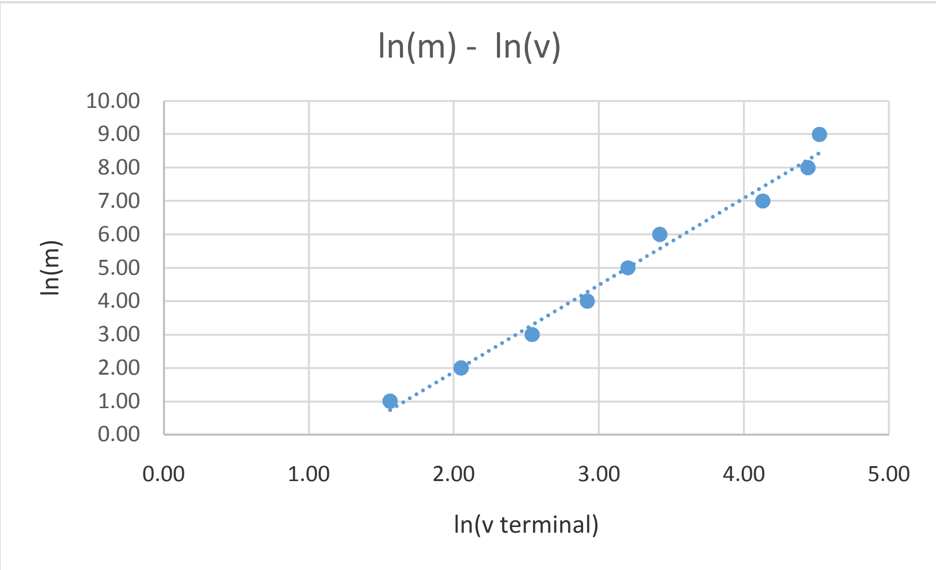

Figure 5 ln(mass) versus ln(terminal velocity) graph

The data from Table 1 are plotted in form of Figure 5. If we fit the points with the least square method we obtain the following value for *n* exponent,

$$n = 2{,}6 \pm 0{,}1. \qquad (13)$$

This value is not 1, consequently is not consistent with Stokes' law. Even is higher than 2 we can take into account the use of Newton's law.

4. CONLCLUSIONS

We have shown that using a sensor of motion detector we can perform measurements and analyse data regarding the free fall of a stack of small cake forms of different masses in a viscous medium. The results are consistent with a resistive force rather proportional with the square of the velocity.

5. ACKNOWLEDGMENTS

Many thanks to Mihaela Turturică for helping us with laboratory work.

6. REFERENCES

[1] HRISTEV, A., *Mecanică si Acustică, Editura disctică si Pedagogică*, Bucuresti, 1984
[2] YOUNG, H.D., FREEDMAN, R.A, *Sears and Zemansky s University Physics 13th Edition*, Addinson Wesley, 2012
[3] VERNIER SOFTWARE & TECHNOLOGY, http://www.vernier.com/
[4] EXCEL MICROSOFT OFFICE https://products.office.com/en-us/excel

THE ROLE OF THE TRAFFIC COEFFICIENT IN THE ANALYSIS OF INFORMATION PROCESSES IN A SEAPORT

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ABSTRACT

In this paper, we will analyse the traffic coefficient and its role in optimizing information processes in a maritime port. A particularly important role in analysing and optimizing information processes in the port activity is played by the Queuing Theory, in particular the Theory of the queuing systems with priorities. As demonstrated recently, the serving with priority appears as optimal serving in the class of all serving legalities. Furthermore, the diversification of the informational traffic into priority classes becomes an inevitable procedure even in the activity of the informational flow within the seaport.

Keywords: *traffic coefficient, optimizing information processes*

1. INTRODUCTION

The Queuing theory is one of the most interesting within the optimization and efficiency phenomena of a company.

The main advantage of the queuing theory is that it provides us with crucial information about waiting times that appear in the system, based on minimal data about the features of arrivals in the system, features of serving stations and the system discipline.

The performances of waiting systems under overload conditions play an important role regarding the consumer's perception on the service quality. Waiting times and delays are inevitable within those queuing systems that respond to some random requests; the appearance in time and space of these requests is governed by certain probability laws, known or unknown. To provide, in a queuing system, serving capabilities sufficient to avoid waiting under absolutely any circumstances, involves huge costs. For this reason, the aim of the queuing theory is to assist us in the design of serving systems, where there is a balance between operating costs and the waiting times of system users.

From theoretical perspective, the study of queuing contains three distinct stages, namely: the first stage deals with the type of distribution of arrivals and services, in the second stage, the model indicators are determined, and in the third stage, a criterion is determined, under which an improvement decision must be made.

In practice, the material resources invested in creating or improving a queuing system are limited and it is wishful for them to be used economically and scientifically justified. From this point of view, we can say that the main application problem of the queuing theory consists in establishing and justifying material costs necessary to achieve a given level of service quality in queuing phenomena of mass character. It follows that an important role is played by the service quality indicators: queue length, the volume of serving achieved in a time unit and others.

2. THE DESCRIPTION OF A QUEUING SYSTEM

We will briefly mention some of the most important features that appear in the analysis of queuing systems.

2.1 Distribution of the number of requests in the system

We note by X the number of requests in the system. Obviously that X is a discrete random variable, its set of values $\{ x_i \}$ is $0,1,2,\dots,m$. We note by P_n the distribution of this variable $P_n = P\{ X = n \}$. The determination of P_n is important for several reasons. For example, P_0 will indicate the probability that the system is free, if X is the number of requests in the queue, then P_n will be the distribution of the waiting queue length.

The average value of the queue length can, for example, be easily determined:

$$M(X) = \sum_n nP_n \tag{1}$$

The generating function $P(z)$ of probabilities is:

$$P_n : P(z) = \sum_n z^n P_n , \tag{2}$$

where $0 \le z \le 1$.

2.2 The period of occupancy

It shows the time period when the system is busy and is working without interruption. More specifically, the period of occupancy is the period of time beginning with the arrival of the request in the free system and ending with the next moment, when the system becomes free again. Obviously that we will note the period of occupancy by Π, which is a continuous random variable.

The period of occupancy is an essential factor in finalizing the traffic coefficient.

2.3 The waiting time of the service's beginning. The staying time in the system

We will note by v_n the entire time of presence of request n in the system, and the distribution function by $V_n(t) = P\{v_n < t\}$. Obviously, the staying time in the system is closely connected to the waiting time $v_n = w_n + B$. The traffic coefficient is, of course, a very important feature in the evolution of serving systems.

A queuing system is a generic model consisting of the next three elements:

- customers (consumers) requesting a service;
- service station which has the purpose to fulfil the customers' requests; in a queuing system, the serving station can have only one position or there may be several identical positions (finite or infinite) working in parallel;
- the waiting line or queue that is formed if consumers have to wait.

The models in the queuing theory differentiate between them in terms of:

- probability laws governing the arrival and serving of customers;
- the number of positions in the serving station;
- the queue discipline;
- the structure of the consumer population (finite or infinite number of consumers).

Since the serving system has a limited capacity for processing requests and requests arrive irregularly, then a queue is periodically formed, and sometimes the system is inactive, and requests are pending. Thus, the system has expenses or losses.

To determine whether the system is operating normally or is overloaded, it appears the need to define a performance indicator that we will call *traffic coefficient* and note ρ.

Let z_k be the interval between two consecutive arrivals in the system.

The average value of the serving time is:

$$M(B) = \int_0^\infty t dB(t) \tag{3}$$

The average value of the interval between two consecutive arrivals in the system is:

$$M(z_k) = \int_0^\infty t dA_k(t) \tag{4}$$

The distribution functions of the Poisson flow are:

$$A(x) = P\{z_k < x\} \qquad B(x) = P\{B < x\} \tag{5}$$

The traffic coefficient allows us to relate the initial parameters of the system, for example, formalized in Kendall's notations such as the distribution of time between arrivals and serving parameters with system development in time. In addition, based on the traffic coefficient, stationary conditions can be established and, therefore, operation strategies of the system without an overload regime can be determined.

The traffic coefficient is, generally calculated as the ratio between the average value of serving time and the average value of consecutive arrivals of requests, in the system.

$$\rho = \frac{M(B)}{M(z_k)} \tag{6}$$

It is obvious that if the average value of the service time is less than the average time between two consecutive arrivals of two requests ($\rho < 1$), then the core of the network where information is processed will work under normal conditions (without overloading). If the average value of serving a request is greater than the average time between two consecutive requests ($\rho > 1$), then a queue that extends to infinity is formed, and the system is overloaded. The case $\rho = 1$ is a delicate case involving a special research and opens a wide field of research.

So $\rho < 1$ will indicate us the situation that the system works in a normal regime, while the condition $\rho \geq 1$ will indicate an overloaded regime.

Such traffic coefficient has a very definite applicative aspect; it describes the system overloading and is of fundamental importance because, once established the distribution of the serving time, all features of the model studied are expressed in terms of this parameter.

3. THE M/G/1 CLASSIC SYSTEM

Further, we will consider the M/G/1 classic system with exponential distribution $x \geq Exp(\lambda)$.

Definition. Let X be a random variable. The exponential distribution is noted by $Exp(\lambda)$ and is equal to:

$$F(x) = \begin{cases} 0, & x < 0 \\ 1 - e^{-\lambda x}, & x > 0 \end{cases} \tag{7}$$

The exponential distribution has the density distribution:

$$f(x) = \lambda e^{-\lambda x}, \quad x > 0, \quad \lambda > 0 \tag{8}$$

The average value is:

$$M(X) = \int_0^\infty x \lambda e^{-\lambda x} dx = \frac{1}{\lambda} \tag{9}$$

The dispersion is:

$$D(X)=\frac{1}{\lambda^2} \tag{10}$$

Laplace transform of the exponential distribution is:

$$f(s)=\int_0^\infty e^{-sx}\lambda e^{-\lambda x}dx=\frac{\lambda}{s+\lambda} \tag{11}$$

We consider λ the intensity of the Poisson input flow, μ the average number of vessels processed in a time unit and $B(t)=P\{B\le t\}$ the distribution function of serving.

Let $\Pi(t)$ be the distribution function of the period of occupancy and the Laplace-Stieltjes transforms of functions $\Pi(t)$ and $B(t)$:

$$\pi(s)=\int_0^\infty e^{-st}d\Pi(t) \tag{12}$$

and

$$\beta(s)=\int_0^\infty e^{-st}dB(t)=\int_0^\infty e^{-st}d[1-e^{-bt}] \tag{13}$$

In this case, $\beta(s)=\frac{1}{1+bs}$ and $\pi(s)$ are determined from the following theorem.

Kendall's theorem. Laplace-Stieltjes transform $\pi(s)$ of the distribution function of the period of occupancy is uniquely determined from the functional equation

$$\pi(s)=\beta(s+\lambda-\lambda\pi(s)). \tag{14}$$

If $\lambda\beta_1<1$, then

$$\pi_1=\frac{\beta_1}{1-\lambda\beta_1} \tag{15}$$

$$\pi_2=\frac{\beta_2}{(1-\lambda\beta_1)^3} \tag{16}$$

where by $\pi_1,\pi_2,\beta_1,\beta_2$ are denoted the first and second stage of variables Π and B:

$$\pi_1=\int_0^\infty t\,d\Pi(t),\ \pi_2=\int_0^\infty t^2 d\Pi(t) \tag{17}$$

$$\beta_1=\int_0^\infty t\,dB(t),\ \beta_2=\int_0^\infty t^2 dB(t) \tag{18}$$

Proof:

We believe that independently from the system evolution, few "catastrophes" that form a Poisson flow with parameter $s>0$, can occur. Then the Laplace Stieltjes transform of the period of occupancy

$$\pi(s)=\int_0^\infty e^{-sx}d\Pi(x), \tag{19}$$

is the probability that during the „life" of the "busy period, „the catastrophe did not occur". On the other hand, it is necessary and sufficient that

$$\pi(s)=\sum_{k\ge 0}[\pi(s)]^k\int_0^\infty e^{sx}\frac{(\lambda x)^k}{k!}e^{-\lambda x}dB(x). \tag{20}$$

In order for Π *to* happen without "catastrophe", it is necessary and sufficient that while serving B, the "catastrophe" event does not occur (the probability of this event is $e^{-sx}dB(x)$), in the periods of occupancy associated with those *k≥0* incoming messages during the serving of the first message (the probability is $\frac{(\lambda x)^k}{k!}e^{-\lambda x}$), such a "catastrophe "(the probability is $[\pi(s)]^k$) not to occur.

From (20) it follows

$$\pi(s)=\sum_{k\ge 0}\int_0^\infty e^{-(s+\lambda)x}\frac{(\lambda\pi(s)x)^k}{k!}dB(x)=$$

$$=\int_0^\infty e^{-(s+\lambda-\lambda\pi(s))x}dB(x)=\beta(s+\lambda-\lambda\pi(s)$$

We will demonstrate formula (15). We see that deriving after *s*, both parties in equation (19), we obtain

$$\pi'(s)=-\int_0^\infty xe^{-sx}d\Pi(x).$$

Considering in the last expression $s=0$, we have

$$\pi'(0)=-\int_0^\infty x\,d\Pi(x)=-\pi_1 \tag{21}$$

Thus, we have obtained a simple procedure for calculating the average value of the random variable having only its Laplace-Stieltjes transform. Next, we will apply (21) to obtain (15). We have

$$\pi'(s)=(1-\lambda\pi'(s))\beta'(s+\lambda-\lambda\pi(s)).$$

Considering $s=0$, we get

$$\pi'(0)=(1-\lambda\pi'(0))\beta'(0),$$

because $\pi(0)=1$, or $\pi_1=(1+\lambda\pi_1)\beta_1$, hence it results (15).

The traffic coefficient is:

$$\rho=\lambda M[B(t)] \tag{22}$$

The stationary condition of the system is

$$\rho=\lambda M[B(t)]<1 \tag{23}$$

For this system, we will calculate:

The average value of the occupancy period:

$$M_1=\frac{\rho}{1-\rho}=\frac{\lambda M(B)}{1-\lambda M(B)} \tag{24}$$

The average number of vessels from the queue:

$$M_2=\frac{\rho^2}{1-\rho} \tag{25}$$

The average time of ship's queuing in the system:

$$M_3=\frac{1}{\mu-\lambda} \tag{26}$$

The average waiting time of the ship in the queue:

$$M_4=\frac{\rho}{\mu-\lambda} \tag{27}$$

4. EXAMPLE

We suppose that in a seaport, ships are arriving at random, and if they cannot be taken immediately to a berth, they are waiting, and thereby a queue is formed. We assume that we know the average number of ships arriving in the port in a unit of time (λ) and the average number of ships served in a unit of time (μ). The inverse value $1/\lambda$ is the average time between two consecutive arrivals of ships, and the inverse value $1/\mu$ is the average serving time of a ship.

$$M(B)=\frac{1}{\mu}$$

and

$$M(z_k)=\frac{1}{\lambda}$$

We assume that the average interval between the arrivals of ships in the port for all 4 berths is 5 minutes, and the average time of service of a ship is of: 8 hours, 6 hours, 4.5 hours, 3 hours for each berth.

Table 1. Analysis of the traffic coefficient

Features of the terminal	Berth 1	Berth 2	Berth 3	Berth 4
$M(z_k$	5 hours	5 hours	5 hours	5 hours
$M(B$	8 hours	6 hours	4,5 hours	3 hours
μ	0,12	0,16	0,22	0,33
λ	0,2	0,2	0,2	0,2
ρ	1,6	1,2	0,9	0,6
M_1	-2,6	-6	9	1,5
M_2	-4,3	-7,2	8,1	0,9
M_3	-12,5	-25	50	7,7
M_4	-20	-30	45	4,6

From the analysis of Table 1, we see that the first two options of berths are not viable because the waiting queue will grow unlimitedly since $\rho>1$, while the last two berths have the traffic coefficient less than 1.

5. CONCLUSIONS

The Queuing theory is established as a branch of operational research which has as object the mathematical approach of queues or waiting lines. Waiting lines and the queuing theory have found application in various fields such as telecommunications, traffic control, forecasting computers performances, medical services (planning beds in a hospital), sale of goods, air traffic, ports traffic etc.

The Queuing theory is the main tool used in the study of congestion phenomena which occur when the number of requests exceeds the capacity of serving. In practice, the queuing theory is, in particular, used to highlight existing problems in an operational system and to show directions to streamline its functioning by indicating values that have to meet certain system variables in order to reach a satisfactory level of performance.

6. REFERENCES

[1] MIHOC, GH. ; CIUCU, C. ; MUJA, A., *Modele matematice ale asteptarii,* Editura Academiei Republicii Socialiste Romana, Bucureşti, 1973

[2] ALLEN, A.O., *Probability, Statistics and Queueing Theory,* Springer, Berlin, 1978

[3] ASMUSSEN, S., *Applied Probability and Queues,* Springer, 1987

SOME EXISTENCE THEOREMS FOR GENERALIZED A-PROPER MAPPINGS

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ABSTRACT

The topological degree of a mapping is well known to be a powerful tool in establishing existence theorems for nonlinear equations be they integral or partial differential ones. Related to the approximation-solvability of operator equations, F.E. Browder and W.V. Petryshyn [1] have introduced a topological degree for A-proper mappings.

Although, it may not be singleton, it appear as a natural extension of Brouwer's finite-dimensional degree. We shall introduce the class of quasi A-proper mappings, for which a similar generalized degree is defined, to investigate existence results for new types of nonlinear operator equations.

Considering maximal monotone mappings, of type (M) and of type (S), we give conditions for a sum mappings to be A-proper or quasi-A-proper.

Keywords: *Approximation schemes, topological degree, pseudo-A-proper mappings.*

1. INTRODUCTION

Most problems for ordinary, partial differential and integral equations can be rewritten in the form:

$$Tu = f, \quad (1)$$

where T be (possibly nonlinear) operator, $T: D \subseteq X \to Y, D$ a subset of X , X and Y real Banach spaces.

We are concern in a constructive approach of solutions of the infinite-dimensional problem (1) as either strong or the weak limits of solutions of simpler finite-dimensional problems:

$$T_n u_n = f_n \quad (2)$$

2. COMPLETE PROJECTIONAL SCHEMES. PSEUDO-A-PROPER MAPPINGS

2.1 Complete projectional scheme and A-proper mappings

To this aim, we consider $\{X_n\} \subset X$ and $\{Y_n\} \subset Y$ two sequences of monotonically increasing finite-dimensional subspaces. If $Q_n: Y \to Y_n$ is a linear projection, the equation (1) have the associated sequence of finite-dimensional equations (2).

We intend to give an admissible approximation scheme in the sense of Petryshyn.

We denote henceforth by "$\to$" and "$\rightharpoonup$" strong and weak convergence, respectively

In the following development we have in mind the case of spaces with basis:

Recall that a sequence $\{e_n\} \subseteq X$ is said to be a basis for X in every $x \in X$ has a unique convergent expansion $x = \sum_{i\geq 1} x_i e_i$, $x_i \in R$.

If X^* and Y^* are the dual space of X, respectively Y, we define the coefficients functionals $e_i^* \in X^*$ by means of $e_i^*(e_j) = \delta_{ij}$ (the Kronecker's symbol), then $x_i = e_i^*(x)$.

It is useful to introduce the projections $P_n: X \to X_n = span\{e_1, e_2, \ldots, e_n\}$ and the remainders $R_n: X \to span\{e_{n+1}, \ldots\}$ defined by:

$$P_n(x) = \sum_{i\geq 1} e_i^*(x) e_i$$

and

$$R_n(x) = \sum_{i\geq n+1} e_i^*(x) e_i.$$

Then

$$x = P_n x + R_n x$$

while $P_n x \to x$ and $R_n x \to 0$ as $n \to \infty$, for every $x \in X$.

More general, let $\{P_n\}$ be a sequence of linear continuous projections $P_n: X \to X_n$ such that $P_n x \to x$ for every $x \in X$ as $n \to \infty$.

Definition 1. The couple of sequences $\{X_n, P_n\}$ with the above properties is called a projection scheme of X. Clearly, such a space is separable since $\overline{\cup_{n\geq 1} X_n}$ and we have $\sup_n \|P_n\| = \alpha$ by the uniform boundedness principle; always $1 \leq \alpha < \infty$.

Example 1. In the case of Banach space with base $\{e_n\}$, the sequences $\{X_n\}$, $\{P_n\}$ were defined above, we have $X_n \subset X_{n+1}$ and $P_n P_m = \min(n, m)$.

Example 2. Let X be a reflexive Banach space with a projection scheme $\{X_n, P_n\}$ such that $P_n P_m = P_{\min(n,m)}$. Then $(P_n^* X^*, X^*)$ is a projectional scheme for the dual space X^*; here $P_n^* f$ is defined by

$$(P_n^* f, x) = (f, P_n x)$$

or

$$P_n^*(f) = f(P_n x) \text{ for all } f \in X^*, x \in X$$

To see this, observe that

$$P_n^* P_n^* f(x) = f(P_n^2 x) = P_n^* f(x)$$

on X, whence $P_n^*: X^* \to Y_n = P_n^* X^*$ is a projection. Thus, we only have to show that $P_n^* f \to f$ for every $f \in X^*$, equivalent to $X^* = \overline{\cup_{n\geq 1} Y_n}$. Otherwise,if the union of Y_n were not dense, since $X^{**} = X$, there would find $x \in X\{0\}$ which annihlates all the Y_n. For such an element x and $f \in X^*$ we have $0 = (P_n^* f, x) = (f, P_n x)$ for all n. As f is arbitrary, $P_n x = 0$ for all n. Since $P_n x \to x$, we have $x = 0$ which is contradiction. Next, by hypothesis, $P_n P_m = P_n$ for $m \geq n$, Taking adjoints, we have $P_m^* P_n^* = P_n^*$ which implies $Y_n \subset Y_m$ for $m \geq n$.

Finally, given $f \in X^*$ and $\varepsilon > 0$, we may choose n and $g \in Y_n$ such that $\|f - g\| < \varepsilon$ to obtain

$$\|P_m^* f - f\| \le \|P_m^*(f - g)\| + \|f - g\| \le (c+1)\varepsilon$$

for $m \ge n$, showing that $P_m^* f \to f$ on X^*.

Let X, Y be real banach spaces with projection schemes $\{X_n, P_n\}$ and $\{Y_n, Q_n\}$, respectively. For the approximation-solvaility of (1.1) we associate with $T: D \subseteq X \to Y$ an approximation scheme $\Gamma = (\{X_n\}, \{P_n\}, \{Y_n\}, \{Q_n\})$.

Let X and Y be real Banach spaces with projection schemes $\{X_n, P_n\}$ and $\{Y_n, Q_n\}$. For the approximation-solvability of (1) we associate with $T: D \subseteq X \to Y$ an approximation scheme $\Gamma = (\{X_n\}, \{P_n\}, \{Y_n\}, \{Q_n\})$.

Definition 2. The scheme

$$\Gamma = (\{X_n\}, \{P_n\}, \{Y_n\}, \{Q_n\})$$

is said to be a *complete projection scheme* for (X, Y) if $\dim X_n = \dim Y_n$ for each n.

We can give now:

Definition 3. An operator $T: D \subseteq X \to Y$ is said to be *A-proper* at a point $f \in Y$ with respect to a complete projectional scheme $\Gamma = (\{X_n\}, \{P_n\}, \{Y_n\}, \{Q_n\})$ if the restrictions $T_n: D \cap X_n \to Y_n$ are continuous and whenever $\{u_m\} \subset \{u_n\}$ is a bounded subsequence with $u_m \in D_m$ such that $T_m u_m \to f$ for some $f \in Y$ there exists a further subsequence $\{u_k\} \subset \{u_m\}$ which converges to $u \in D$ and $Tu = f$.

2.2 A generalized degree for A-proper mappings

We define a generalized degree of an A-proper mapping and some of its properties will be reviewed.

The interesting feature of this degree is that it is multivalued function which, however, possesses most of the properties of the Brouwer degree.

P.M. Fitzpatrick [2] developed a generalized degree theory for a class of operators $T: \overline{\Omega} \to Y$, (Ω a bounded subset of X) which are the uniform limit of A-proper mappings.

Our goal is to prove the existence of a solution to equation (1), where T is the uniform limit of A-proper mappings $T_t: \overline{\Omega} \cap D \to Y$, $D \subset X$ arbitrary, and $\Omega \subset X$ an open and bounded subset of X with closure $\overline{\Omega}$ and boundary $\partial\Omega$. We define: $\Omega_D := \Omega \cap D$, $\overline{\Omega}_D := \overline{\Omega} \subset D$, and $\partial\Omega_D := \partial\Omega \cap D$. We remark that $\overline{\Omega}_D$ (respectively $\partial\Omega_D$) is not the closure (respectivey, boundary) of Ω_D. For all n we denote

$$\Omega_n := \Omega \cap X_n \subset \Omega_D,$$
$$\overline{\Omega}_n := \overline{\Omega} \cap X_n \subset \overline{\Omega}_D$$
$$\partial\Omega_n := \partial\Omega \cap X_n \subset \partial\Omega_D \text{ for all } n.$$

and observe that Ω_n is an open bounded subset of X_n with closure $\overline{\Omega}_n$ and boundary $\partial\Omega_n$.

To define the generalized degree we need the following:

Lemma 1. Let $0 \le \beta < \alpha < \infty$. Suppose that for all $t \in [\beta, \alpha]$, $T_t: \overline{\Omega}_D \to Y$ is A-proper with respect to the scheme $\Gamma = (\{X_n\}, \{P_n\}, \{Y_n\}, \{Q_n\})$ and $T_t u \ne f$ for all $u \in \partial\Omega_D$ and all $t \in [\beta, \alpha]$. Let $T_t u$ be continuous on $[\beta, \alpha]$ uniformly for all $u \in \overline{\Omega}_D$. Then there exists an integer $n_0 > 0$ and a constant $d > 0$ such that

$$\|Q_n T_t u_n - Q_n f\| \ge d$$

for all $u \in \partial\Omega_n$, all $t \in [\beta, \alpha]$ and each $n \ge n_0$.

Proof. Suppose that the assertion of Lemma 2.1 is false, then there exists a sequence $\{n_j\}$ of positive integers with $n_j \to \infty$, a sequence $\{u_{n_j}; u_{n_j} \in \partial\Omega_{n_j}\}$, and a sequence $\{t_j\}$ with $t_j \in [\beta, \alpha]$ such that

$$\left\| Q_{n_j} T_{t_j} u_{n_j} - Q_{n_j} f \right\| \to 0$$

Because $t_j \in [\beta, \alpha]$ there exists a subsequence (also denoted by t_j) and a number $t \in [\beta, \alpha]$ such that $t_j \to t$.

Thus we have by assumption of the lemma according to $u_{n_j} \in \partial\Omega_{n_j} \subset \partial\Omega_D \subset \overline{\Omega}_D$

$$\left\| Q_{n_j} T_t u_{n_j} - Q_{n_j} f \right\| \le \left\| Q_{n_j} T_t u_{n_j} - Q_{n_j} T_{t_j} u_{n_j} \right\| + \\ + \left\| Q_{n_j} T_{t_j} u_{n_j} - Q_{n_j} f \right\| \le K \left\| T_t u_{n_j} - T_{t_j} u_{n_j} \right\| + \\ \left\| Q_{n_j} T_{t_j} u_{n_j} - Q_{n_j} f \right\|$$

for $j \to \infty$, i.e., $Q_{n_j} T_t u_{n_j} \to f$.

Because T_t is A-proper with respect to the approximation scheme Γ there exists a subsequence $\{u_{n_j}\}$ and an element $u \in \overline{\Omega}_D$ such that $u_{n_j} \to u$ and $T_t u = f$. By $u_{n_j} \in \partial\Omega_{n_j} \subset \partial\Omega$ there follows $u \in \partial\Omega$, i. e., $u \in \partial\Omega \cap \overline{\Omega}_D = \partial\Omega_D$ contradicting our initial assumption. □

Definition 4. Let $T: \overline{\Omega}_D \to Y$ be an A-proper mapping with respect to the scheme Γ and let $T_n := Q_n T|_{\overline{\Omega}_n} : \overline{\Omega}_n \to Q_n Y$ be continuous foe each n. Let $Z' = Z \cup \{\pm\infty\}$. Furthermore let $f \notin T(\partial\Omega_D)$; then we define $Deg_\Gamma(T, \Omega_D, f)$ to be the subset of Z' defined as follows:

(a) The integer m lies in $Deg_\Gamma(T, \Omega_D, f)$ provided there exists a sequence $\{n_j\}$ such that $deg\left(T_{n_j}, \Omega_{n_j}, Q_{n_j}, f\right)$ is defined and equals m for all j;

(b) $+\infty[-\infty] \in Deg_\Gamma(T, \Omega_D, f)$ provided there exists a sequence $\{n_j\}$ such that $deg\left(T_{n_j}, \Omega_{n_j}, Q_{n_j}, f\right)$ is defined for all j and

$$\lim_j deg\left(T_{n_j}, \Omega_{n_j}, Q_{n_j}, f\right) = \infty[-\infty].$$

The degree $deg\left(T_{n_j}, \Omega_{n_j}, Q_{n_j}, f\right)$ used in Definition 4 is the classical Brouwer degree for mappings of oriented finite-dimensional spaces of the same dimension.

Using the properties of the Brouwer degree and of A-proper mappings, it was shown that the generalized degree $Deg_\Gamma(T, \Omega_D, f)$ enjoys most of the useful properties of the Brouwer topological degree, as the following theorem shows:

Theorem 1. Let $T: \overline{\Omega}_D \subset X \to Y$ be A-proper w.r.t. Γ and $f \notin T(\partial\Omega_D)$. Then:

(1) There exists $n_0 \in Z_+$ such that $deg(T_n, \Omega_n, Q_n f)$ is well defined for each $n \geq n_0$ and, in particular, $Deg_\Gamma(T, \Omega_D, f)$ is a nonempty subset of Z'.

(2) If $Deg_\Gamma(T, \Omega_D, f) \neq \{0\}$, there is $u \in \Omega_D$ such that $Tu = f$. Moreover, there exists $r > 0$ such that $B(f, r) \subset T(\Omega_D)$

(the existence property).

(3) If $H: [0,1] \times \Omega_D \to Y$ is an A-proper homotopy and $f \notin H(t, \partial\Omega_D)$ for $t \in [0,1]$, then $Deg_\Gamma(H(t,\cdot), \Omega_D, f)$ is constant in $t \in [0,1]$

(the homotopy invariance).

(4) If $\Omega_{D_1} \subset \Omega_D$ is open and, then $f \notin T(\overline{\Omega_D} \setminus \Omega_{D_1})$, then

$$Deg_\Gamma(T, \Omega_D, f) = Deg_\Gamma(T, \Omega_{D_1} f),$$

(the excision property).

(5) If

$$\Omega_D = \Omega_{D_1} \cup \Omega_{D_2},$$
$$\Omega'_D = (\Omega_{D_1} \cap \Omega_{D_2}) \cup \partial\Omega_{D_1} \cup \partial\Omega_{D_2} \text{ and}$$
$$f \notin T(\Omega'_D),$$

then

$$Deg_\Gamma(T, \Omega_D, f) \subseteq Deg_\Gamma(T, \Omega_{D_1}, f) + Deg_\Gamma(T, \Omega_{D_2}, f)$$

with the equality holding if either $Deg_\Gamma(T, \Omega_{D_1}, f)$ or $Deg_\Gamma(T, \Omega_{D_2}, f)$ is singled valued. (If $A_1, A_2 \subset Z'$, then $A_1 + A_2 = \{a | a = a_1 + a_2, a_1 \in A_1, a_2 \in A_2\}$ and we use the convention $+\infty(-\infty) = Z'$

(Additivity with respect to the domain)

(6) Let $0 \in \Omega_D$ and let Ω_D also be symmetric about 0. If $T: \overline{\Omega_D} \to Y$ is odd on $\partial\Omega_D$ (i.e., $T(-u) = -Tu$ for all $u \in \partial\Omega_D$) and $0 \notin T(\partial\Omega_D)$, then $Deg_\Gamma(T, \Omega_D, 0)$ is odd (i.e., $2m \notin Deg_\Gamma(T, \Omega_D, 0)$ for any m) and, in particular, $0 \notin Deg_\Gamma(T, \Omega_D, 0)$, so that $Tu = 0$ is feebly approximation solvable with respect to Γ

(the Borsuk theorem).

We recall that if *M* is any subset of *X*, then $H: [0,1] \times M \to Y$ is called an *A-proper homotopy* with respect to Γ if $H_n = Q_n H$, $H_n: [0,1] \times M_n \to Y_n$ is continuous for each *n* and if $\{t_{n_j}\} \subset [0,1]$, $\{u_{n_j} | u_{n_j} \in M_{n_j}\}$ is bounded, and $Q_{n_j} H(t_{n_j}, u_{n_j}) - Q_{n_j} f \to 0$ in *Y* for some $f \in Y$, then there exists further subsequences $\{t_{n_k}\}$ and $\{u_{n_k}\}$ such that $t_{n_k} \to t_0 \in [0,1]$, $u_{n_k} \to u_0 \in M$, and $H(t_0, u_0) = f$.

We present some existence theorems to equation (1) for mappings $T: \overline{\Omega_D} \to Y$.

Theorem 2.

(a) Let the assumption of Lemma 1 (with $\beta = 0, \alpha = 1$) be satisfied. Let $Q_n T_t u$ be a continuous mapping of $[0,1] \times \overline{\Omega}_n$ into $Q_n Y$ for all *n*.

(b) Suppose that $Deg_\Gamma(T, \Omega_D, f) \neq \{0\}$. Then there exists at least one $u_0 \in \Omega_D$ such that $T_0 u_0 = f$.

Proof. According to Lemma 1 there exists an integer $n_0 > 0$ and a constant $d > 0$ such that $\|Q_n T_t u - Q_n f\| \geq d$ for all $u \in \partial\Omega_n$, all $t \in [0,1]$ and each $n \geq n_0$. In virtue of $Deg_\Gamma(T_1, \Omega_D, f) \neq \{0\}$ there exists $\{n_k\}$ such that $deg(Q_{n_k} T_1, \Omega_{n_k}, Q_{n_k} f) \neq 0$.

Hence by the classical degree theory we have for $n_k \geq n_0$,

$$deg(Q_{n_k} T_0, \Omega_{n_k}, Q_{n_k} f) = deg(Q_{n_k} T_1, \Omega_{n_k}, Q_{n_k} f) \neq 0$$

,

i.e., there exists $u_{n_k} \in \Omega_{n_k}$ such that $Q_{n_k} T_0 \Omega_{n_k} = Q_{n_k} f$. For $k \to \infty$ we have $Q_{n_k} f \to f$. Therefore in virtue that $T_0: \overline{\Omega}_D \to Y$ is A-proper, it follows the existence of a subsequence $\{u_{n'_k}\}$ and an element $u_0 \in \overline{\Omega}_D$ such that $u_{n'_k} \to u_0$ and $T_0 u_0 = f$. By assumption $u_0 \notin \partial\Omega_D$, i.e., $u_0 \in \Omega_D$, proving theorem.

2.3 Pseudo-A-proper mappings

We recall the definition of pseudo-A-proper mappings:

Definition 5. A mapping $T: D \subseteq X \to Y$ is said to be *pseudo-A-proper* if $T_n: D_n \to Y_n$ is continuous and T satisfies condition

(h) for any bounded subsequence $\{u_m | u_m \in D_m\}$ such that $T_m u_m \to f$ for some $f \in Y$, there exists $u \in D$ such that $Tu = f$.

Let us consider the new class generalizing Definition 5:

Definition 6. A mapping $T: \overline{\Omega}_D \to Y$ is said to be *quasi A-proper* if and only if for any sequence $u_n \subset \Omega_D$, such that $Tu_n \to f$ for some $f \in Y$, there exists an element $u \in \overline{\Omega}_D$ such that $Tu = f$.

We are in position to establish the following results:

Theorem 3. Let $T_t: \overline{\Omega}_D \to Y$ be A-proper with respect to the scheme Γ for all $t \in (0,1]$ such that $T_t u$ be a continuous mapping of $[0,1]$ into *Y* uniformly for all $u \in \overline{\Omega}_D$, and $Q_n T_t u$ be continuous mapping of $[0,1] \times \overline{\Omega}_n$ into $Q_n Y$ for all *n*. Assume that $T_0: \overline{\Omega}_D \to Y$ is quasi A-proper. Suppose that

(a) $T_t u \neq f$, $u \in \partial\Omega_D$ and $t \in (0,1]$;

(b) $Deg_\Gamma(T_1, \Omega_D, f) \neq \{0\}$

Then there exist at least one element $u_0 \in \overline{\Omega}_D$ such that $T_0 u_0 = f$.

Proof. Let $\{t_n\} \subset [0,1]$ be a monotonically decreasing sequence such that $t_n \to 0$. Then, for $t \in [t_n, 1]$ and $u \in \overline{\Omega}_D$, $T_t u$ satisfies the assumptions of Theorem. Therefore there exists for every *n* an element $u_n \in \Omega_D$ such that $T_{t_n} u_n = f$. Hence by

$$T_0 u_n = (T_0 u_n - T_{t_n} u_n) + f$$

and the uniform continuity of $T_t u$ with respect to $u \in \overline{\Omega}_D$ the right-hand side converges to *f* for $k \to \infty$. By our conditions on T_0 there exists an element $u_0 \in \overline{\Omega}_D$ such that $T_0 u_0 = f$.

Let the assumption of the Lemma 1 satisfied and

Proposition 1. Let $T: \overline{\Omega}_D \to Y$ be quasi A-proper such that

$$\|Tu - f\| \geq d$$

for all , $u \in \partial\Omega_D$ with some constant $d > 0$. Suppose that, for all *n*, $Q_n T$ is continuous from $\overline{\Omega}_n$ to $u \in Q_n Y$.

Let $S:\overline{\Omega}\to Y$ be continuous and bounded[3], and for all $t\in(0,1]$, let $T_t:=tS+T$ be A-proper with respect to Γ. Suppose $Deg_\Gamma(T_1,\Omega_D,f)\neq\{0\}$. Then there exists at least one element $u_0\in\overline{\Omega}_D$ such that $Tu_0=f$.

Proof. We apply Theorem 2. It sufficient to prove $T_tu\neq f$, for all $u\in\partial\Omega_D$ and all $t\in[0,1]$. By the assumption of the Theorem it follows

$$\|T_tu-f\|\geq\|Tu-f\|-t\|Su\|\geq d-\frac{d}{2}=\frac{d}{2}$$

for all $u\in\partial\Omega_D$ and all $t\in[0,1]$.

If $f=0$, the condition (b) can be replaced by the oddness of T_1 on $\partial\Omega_D$.

Proposition 2. Let $\overline{\Omega}_D$ be symmetric relative to $0\in\Omega_D$, i.e., $u\in\overline{\Omega}_D$ it follows that $-u\in\overline{\Omega}_D$. Suppose that Assumption (a) of Theorem 2 is satisfied and

$$T_1u=-T_1(-u),\ u\in\partial\Omega_D$$

Then it exists an element $u_0\in\Omega_D$ such that

$$T_0u_0=0.$$

Proof. We apply Theorem 2. It is sufficient to prove $Deg_\Gamma(T_1,\Omega_D,f)\neq\{0\}$. By the conditions of the theorem it follows that

$$Q_nT_1u=-Q_nT_1(-u),$$

for all $u\in\partial\Omega_n$ and all *n*.

Furthermore, by lemma 1 there exists an integer $n_0\geq0$ and a constant $d>0$ such that

$$\|Q_nT_1u\|\geq d$$

for all $u\in\partial\Omega_n$ and all $n\geq n_0$. Hence by the classical Borsuk theory $deg(Q_nT_1,\Omega_n,0)$ is an odd integer; therefore

$$Deg_\Gamma(Q_nT_1,\Omega_D,f)\neq\{0\}.\ \square$$

Proposition 3. Let $\overline{\Omega}_D$ be symmetric such that $0\in\Omega_D$. Suppose that assumption (a) of Theorem 3 is satisfied with $f=0$. Furthermore, let $T_1u=-T_1(-u)$, for all $u\in\partial\Omega_D$. Then it exists an element $u_0\in\overline{\Omega}_D$ such that $T_0u_0=0$.

Proof. We apply Theorem 3. It is sufficient to prove $Deg_\Gamma(T_1,\Omega_D,f)\neq\{0\}$ which follows as in the proof of proposition 2.

We will give now sufficient conditions on $T:\overline{\Omega}_D\to Y$ to be A-proper, respectively quasi A-proper, with respect to an approximation scheme Γ.

Assumption 1. Let *H* be a real Hilbert space with inner product $(\cdot,\cdot)$ and let $\{H_n\}$ be a sequence of closed linear finite-dimensional subspaces of *H* such that $H_n\subset H_{n+1}$ and $\bigcup_{n=1}^{\infty}H_n$ is dense in *H*. Let P_n be the projection of *H* onto H_n. Suppose that *D* is a linear subset of *H* such that $H_n\subset D$ for all *n*. Suppose that $\Omega=\{u\in H:\|u\|<r\}$ with some $r>0$.

It follows that $\Gamma=(\{X_n\},\{P_n\})$ is an approximation scheme for mapping from *H* to *H*.

Definition 7. Let *A* be a mapping with domain $D(A)\subset H$ and range $R(A)\subset H$. Then *A* is said to be

(i) *monotone*, if for all $x,y\in D(A)$

$$(Ax-Ay,x-y)\geq0;$$

(ii) *strictly monotone*, if there exists a constant $c>0$ such that for all $x,y\in D(A)$

$$(Ax-Ay,x-y)\geq\|x-y\|^2.$$

Definition 8. An operator *A* with $D(A)\subset H$ and $R(A)\subset H$ is said to be (*maximal*) *m-monotonic* if and only if

(i) *A* is monotone;

(ii) $R(I+A)=H$.

By Definition 8(i) it follows that $(I+A)^{-1}$ exists on $R(I+A)$ and is Lipschitz continuous.

Assumption 2. Let $A_1:\overline{\Omega}_D\to H$ such that $A_1u=A_0(u,u)$ satisfying the following conditions:

(i) for all $u\in D$, $A_0(\cdot,u):\overline{\Omega}\to H$ is continuous from the weak to the strong topology;

(ii) for all $u\epsilon\overline{\Omega}$, $A_0(u,\cdot):\mathrm{D}\to H$ is *m*-monotonic.

Assumption 3. Let $A_1u=A_0(u,u)$ with $A_0:\overline{\Omega}\times\mathrm{D}\to H$ such that

$$A_0(u_n,P_nv)\to A_0(u_0,v)$$

for all $v\in D$ and all sequences $\{u_n\}$ satisfying $u_n\in\overline{\Omega}_n$ and $u_n\rightharpoonup u_0\in\overline{\Omega}_n$.

Theorem 4. Let $T:=A_1+A_2$ where Assumption 1.2(A1) and 3(A1) are satisfied. Suppose that, $A_0(u,\cdot)$ is strictly monotone for all $u\in\overline{\Omega}_\mathrm{D}$ and $A_2:\overline{\Omega}_\mathrm{D}\to H$ is compact and continuous. Then $T:\overline{\Omega}_\mathrm{D}\to H$ is *A*-proper with respect to $\Gamma=(\{H_n\},\{P_n\})$.

Proof. Let $\{u_n\}$ be a sequence such that $u_n\in\Omega_n$ and $P_nTu_n\to f$ for some $f\in H$ then we obtain by the conditions on A_2 that $P_{n'}Tu_{n'}\to f_1$ for some n' (with suitable $f_1\in H$). By the boundedness of $\{u_{n'}\}$ there exists a subsequence (also denoted by $\{u_{n'}\}$ and an element $u_0\in\overline{\Omega}$ such that $u_{n'}\rightharpoonup u_0$. Let $v\in D$; then by the conditions on A_0,

$$\begin{aligned}0&\leq(A_0(u_{n'},u_{n'})-A_0(u_{n'},P_{n'}v),u_{n'}-P_{n'}v)=\\&=(A_0(u_{n'},u_{n'})-A_0(u_{n'},P_{n'}v),P_{n'}(u_{n'}-v))=\\&=(P_{n'}A_1u_{n'}-P_{n'}A_0(u_{n'},P_{n'}v),u_{n'}-v)\to\\&\to(f_1-A_0(u_0,v),u_0-v)\end{aligned}$$

for $n'\to\infty$.

Hence

$$(f_1-A_0(u_0,v),u_0-v)\geq0\text{ for all }v\in D.$$

Therefore

$$\begin{aligned}\|u_0-v\|^2&\leq(u_0-v,u_0-v)+(f_1-A_0(u_0,v),u_0-v)\leq\\&\leq(u_0-v+f_1-A_0(u_0,v),u_0-v).\end{aligned}$$

By Assumption 2(ii) there exists a unique $v_0\in D$ such that

$$v_0+A_0(u_0,v_0)=u_0+f_1.$$

Hence $\|u_0-v_0\|=0$, i.e., $u_0\in\overline{\Omega}\cap\mathrm{D}=\overline{\Omega}_\mathrm{D}$ and $A_0(u_0,v_0)=f_1$.

By the conditions on A_0,

$$\begin{aligned}c\|u_{n'}-P_{n'}u_0\|^2&=\\&=(A_0(u_{n'},u_{n'})-A_0(u_{n'},P_{n'}u_0),u_{n'}-P_{n'}u_0)\leq\\&\leq(P_{n'}A_0(u_{n'},u_{n'})-A_0(u_{n'},P_{n'}u_0),u_{n'}-P_{n'}u_0)\to0\end{aligned}$$

for $n'\to\infty$, i.e., $u_{n'}\to u_0$.

Hence we obtain by definition of *T*,

$$A_0(u_0,u_0)+A_2u_0=Tu_0=f,$$

[3] We may assume without loss of generality that $sup_{u\in\overline{\Omega}}\|Su\|\leq d/2$

proving the assertion of theorem.

We can also show

Theorem 5. Let $T := A_1 + A_2$ such that the Assumption 1 and 2(A1) are satisfied and $A_2 : \bar{\Omega}_D \to H$ is compact and weakly continuous. Then $T : \bar{\Omega}_D \to H$ is quasi A-proper.

Proof. The proof follows as in Theorem 4. Let $\{u_n\} \subset \bar{\Omega}_D$ such that $Tu_n \to f$ for some $f \in H$; then by the boundedness of $\{u_n\}$ and the condition on A_2 there exists a subsequence $\{u_{n'}\}$ and an element $u_0 \in \bar{\Omega}$ such that $u_{n'} \rightharpoonup u_0$ and $T_1 u_{n'} \to f_1$ with a suitable $f_1 \in H$. By the conditions on A_1 we have for all $v \in D$

$$0 \le (A_0(u_{n'}, u_{n'}) - A_0(u_{n'}, v), u_{n'} - v) \to$$
$$\to (f_1 - A_0(u_0, v), u_0 - v)$$

for $n' \to \infty$. Hence, as in the proof of Theorem 4, we obtain $u_0 \in \bar{\Omega}_D$ and $A_1 u_0 = f_1$. By the weak continuity of the mapping $A_2 : \bar{\Omega}_D \to H$ the assertion of Theorem 5 follows.

As a consequence of the last two results, we have

Proposition 4. Let *H* be a real Hilbert space, which satisfies Assumption 1. For $t \in [0,1]$, let $T_t u := tu + B_1 u$ such that B_1 satisfies Assumptions 2(B1) and 3(B1). Then, for $t \in [0,1]$, T_t is *A*-proper with respect to Γ and T_0 is weakly-A-proper.

Proof. The second part of the proposition follows directly by Theorem 5. The first part follows by Theorem 4, by setting $A_0(u, v) := tv + B_0(u, v)$ and the remark that a mapping $A : D \to H$ being *m* monotonic yields $tI + A$ (with $t > 0$) is *m* monotonic and strictly monotone. □

2.4 Maximal monotone mappings, of type (M) and of type (S)

Moreover, let us consider another class of mappings of monotone type:

Definition 9. A mapping $A : \bar{\Omega} \to \mathrm{H}$ is said to *satisfies condition* (M) provided following condition hold: if $\{u_n\} \subset \bar{\Omega}$ is such that $u_n \rightharpoonup u_0$, $Tu_n \rightharpoonup f$ and

$$\limsup_n (Tu_n, u_n - u_0) \le 0,$$

then $Tu_0 = f$.

Definition 10. A mapping $A : \bar{\Omega} \to \mathrm{H}$ is said to be $(S)_+$ provided that whenever $\{u_n\} \subset \bar{\Omega}$ is such that $u_n \rightharpoonup u_0$ and

$$\limsup_n (Tu_n, u_n - u_0) \le 0, \text{ then } u_n \to u_0.$$

The definition of a mapping of type (*M*) given above is slightly different then that given by Brezis [3], we don't suppose the continuity of the finite-dimensional restrictions. Mappings with property $(S)_+$ have been introduced by Browder in the study of nonlinear eigenvalue problems.

Theorem 6. Let $T := A_1 + A_2$ such that the Assumption 1,2(A1) and 3(A1) are satisfied. Suppose that $A_2 : \bar{\Omega}_D \to H$ is of type (*M*) , bounded, and satisfies condition $(S)_+$. Then T is A-proper with respect to $\Gamma = (\{H_n\}, \{P_n\})$.

Proof. Let $\{u_n\}$ be a sequence such that $u_n \in \Omega_n$ and $P_n T u_n \to f$ for some $f \in H$; then there exists a subsequence $\{u_{n'}\}$ and an element $u_0 \in \bar{\Omega}$ such that $u_{n'} \rightharpoonup u_0$. Let $v \in D$; then by the conditions on A_1,

$$F_{n'} := (P_{n'} A_0(u_{n'}, u_{n'}) - A_0(u_{n'}, P_{n'} v) + P_{n'} A_2 u_{n'}, u_{n'} - v) \to$$
$$\to (f_1 - A_0(u_0, v), u_0 - v)$$

Furthermore, we obtain

$$F_{n'} := (A_0(u_{n'}, u_{n'}) - A_0(u_{n'}, P_{n'} v) + A_2 u_{n'}, u_{n'} - P_{n'} v) +$$
$$+ A_0(u_{n'}, P_{n'} v), v - P_{n'} v \ge$$
$$\ge (A_2 u_{n'}, u_{n'} - v) + (A_2 u_{n'}, v - P_{n'} v) +$$
$$+ (A_0(u_{n'}, P_{n'} v), v - P_{n'} v) \ge$$
$$\ge (A_2 u_{n'}, u_{n'} - v) - \|A_2 u_{n'}\| \cdot \|v - P_{n'} v\| +$$
$$+ (A_0(u_{n'}, P_{n'} v), v - P_{n'} v).$$

Hence, by the boundedness of A_2, and the conditions on A_0,

$$limsup_n F_{n'} \ge limsup_n (A_2 u_{n'}, u_{n'} - v).$$

Therefore, we have for all $v \in D$,

$$limsup_n (A_2 u_{n'}, u_{n'} - v) \le (f - A_0(u_0, v), u_0 - v).$$

There exists a subsequence (also denoted by n') such that $A_2 u_{n'} \rightharpoonup g$.

From the last inequality we obtain for all $v \in D$

$$\|u_0 - v_0\|^2 + limsup_n (A_2 u_{n'}, u_{n'} - v) -$$
$$-(g, u_0 - v) \le (f + u_0 - v - A_0(u_0, v), u_0 - v).$$

By Assumption 2(ii) there exists a unique $v_0 \in D$ such that $v_0 + A_0(u_0, v_0) = f + u_0 - g$.

Hence we have

$$\|u_0 - v_0\|^2 + limsup_{n'} (A_2 u_{n'}, u_{n'} - v_0) \le$$
$$\le (g, u_0 - v_0),$$

from which follows

$$limsup_{n'} (A_2 u_{n'}, u_{n'}) \le (g, u_0)$$

Therefore, by the continuity on A_2, we have $A_2 u_0 = g$, i.e.,

$$limsup_{n'} (A_2 u_{n'}, u_{n'}) \le (A_2 u_0, u_0)$$

from which

$$limsup_{n'} (A_2 u_{n'}, u_{n'} - u_0) =$$
$$= limsup_{n'} (A_2 u_{n'}, u_{n'}) - (g, u_0) \le$$
$$\le (A_2 u_0, u_0) - (A_2 u_0, u_0) = 0.$$

Hence, by the conditions on A_2, $u_{n'} \to u_0$. Therefore, by the above inequality we obtain

$$\|u_0 - v_0\|^2 + (g, u_0 - v_0) \le (g, u_0 - v_0)$$

which implies $u_0 = v_0 \in \bar{\Omega}_D$. Furthermore, we obtain

$$Tu_0 = (A_0 u_0, u_0) + A_2 u_0 = f,$$

proving Theorem 6.

5. CONCLUSIONS

The concept of A-properness generalizes in the field of numerical functional analysis existing ideas for linear problems to such a large extent that it seems to be advisable to translate usual numerical procedure into the abstract formulation and to check consistency or stability by general functional criteria, as a pre-numerical step. To cover more concrete methods, a broad approximation schemes were been defined.

In corresponding papers on linear problems we usually found sufficient conditions which are quite natural in the nonlinear case.

The results of this paper generalize in one sense results of Petryshyn [4] on *A*-proper mappings.

6. REFERENCES

[1] F. E. BROWDER, W. V. PETRYSHYN, *Approximation methods and the generalized topological degree for nonlinear mappings in Banach spaces*, J. Funct. Ana3, 1969, 217-245

[2] J. M. FITZPATRICK, *A generalized degree for uniform limits of A-proper mappings*, J. Math. Anal. Appl.35 (1971), 536-552

[3] H. BREZIS, *Equations et inequations non-lineaires dans les espaces vectoriels en dualite*, Ann. Inst. Fourier 18, 1968, 115-176

[4] W. V. PETRYSHYN, *Generalized Topological Degree and Semilinear Equations,* Cambridge Tracts in Math. 117, Cambridge Univ. Press, 1995

[5] F. E. BROWDER, W. V. PETRYSHYN, *Approximation methods and the generalized topological degree for nonlinear mappings in Banach spaces*, J. Funct. Ana3, 1969, 217-245

[6] D. PASCALI, *An introduction to Numerical Functional Analysis: Petryshyn's A-proper mapping theory*, Courant Inst., New York, 2002

[7] Y. C. ZHAO, *On the topological degree for the sum of maximal monotone operator and generalized pseudomonotone operator*, Chinese Ann. Math. Ser. B 4 (1983), 241-253

SECTION V

ENGLISH FOR SPECIFIC PURPOSES

CROSS-DISTRIBUTION OF MARITIME ENGLISH WORDS

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ABSTRACT

The significance of the sea becomes transparent at a mere glance for either English or French and German or for any other language for that matter. The entire Western civilization originates from the area surrounding the Mediterranean and the North Sea. The language used by the people living by the sea has always been permeated with nautical phrases which became a universal language understood by various cultures. Many nautical terms originate in the days of sailing ships. German, Dutch and French are languages spoken by European nations with a long sea faring tradition of their own, and they have also brought their own contribution. This paper aims at shedding some light on the linguistic sector of the maritime environment in English, French and German. Their respective etymology bears out both their linguistic imprint and their social function. For instance Mayday is the internationally recognized radio signal for ships and people in serious trouble at sea and it derives from the French *m'aidez* which means "help me". Our purpose is to provide potential readers and researchers with some clues and interesting linguistic connections

Keywords: *maritime linguistic area, French borrowings, Germanic roots, maritime English*

1. INTRODUCTION

The present paper focuses on some borrowings from French and German into maritime English. We have started from the assumption that these are related languages in a sense, because French is a Latin language with English influences, while English is a Germanic language with Latin and French influences. Therefore, there are some similarities between them, most notably the same alphabet and a number of true cognates.

The significance of the sea becomes transparent at a mere glance for either English or French and German or for any other language for that matter. The entire Western civilization originates from the area surrounding the Mediterranean and the North Sea. The language used by the people living by the sea has always been permeated with nautical phrases which became sort of a universal language understood by various cultures. Many nautical phrases and terms have their origins from the days of sailing ships. Since both England and the United States have shared a long maritime history as well as a common language, it goes without saying that many of these have survived to the present day. German, Dutch and French are languages spoken by European nations with a long sea faring tradition of their own, and they have brought their own contribution.

Nevertheless, there are a number of differences, both major and minor, between French, German and English. Still, we need to discriminate between German and Germanic. "The Germanic languages are a branch of the Indo-European language family. The West Germanic branch includes the two most widely spoken Germanic languages: English, with approximately 300–400 million native speakers, and German, with over 100 million native speakers." [1] "English is a West Germanic language originating in England, and the first language for most people in Australia, Canada, the Commonwealth Caribbean, Ireland, New Zealand, the United Kingdom and the United States (also commonly known as the Anglosphere). One of the consequences of the French influence due to the Norman Conquest in the Middle Ages is that the vocabulary of the English language contains a massive number of non-Germanic words, i.e., Latin-derived words that entered the lexicon after the invasion. English vocabulary is, to an extent divided between Germanic words (mostly Old English) and "Latinate" words (Latin-derived, directly from Norman French or other Romance languages). For instance, pairs of words such as ask and question (the first verb being Germanic and the second Latinate) show the division between Germanic and Latinate lexemes that compose Modern English vocabulary. The structure of the English language, however, has remained unequivocally Germanic." [2]

Although the majority of Germanic words have an Indo-European origin, a substantial part of the fundamental vocabulary appears to be non-Indo-European, most likely inherited from the indigenous pre-Bronze-Age inhabitants of Scandinavia and/or North Germany.

2. BORROWINGS

The so-called borrowed words have invaded the English language throughout the centuries. During the evolution of English history, many thousands of words were taken over from French mainly because of the ongoing uninvited arrival of invaders onto the island.

One might considers lexical borrowings as testimonials to our mental laziness yet a perfect physical shape. From this perspective, the British should win a medal. It is all due to or because of the invaders who came to England and brought along their own language, dialects and customs and more importantly, they transformed both the written form and the spoken form of the words used by the English. The English residents were perfectly able to adjust to the newly formed language by means of assimilation of borrowed words.

In his book "Growth and Structure of the English Language", Otto Jespersen [3] highlights the fact that modern English is but a chain of borrowings as a result of the various conquests of Britain. The invaders brought along their own languages being, at the same time, unable to fully impose their languages on the British. What happened actually was that the languages of the foreigners were intermixed with the words of the natives.

The Romans were the first and, together with their occupation of England, they introduced Latin to some inhabitants yet not to all of them.

Afterwards, in the 6th century there was the Christianization of the country and many more inhabitants were forced thereby to assimilate Latin words and phrases into their language through the Church. These borrowed Latin words were used primarily by the upper classes whereas "every educated Englishman spoke and wrote Latin as easily as he spoke and wrote his mother tongue", as George Lyman Kittredge and James Bradstreet Greenough claim in their book "Words and their Ways in English Speech" [4]. These educated men and women were able to use the borrowed words both in conversation and in writing.

English as we know it today is Germanic with a massive French influence. There were three invasions which shaped the history of the English language: Scandinavian (namely the Vikings), Teutonic, and, the Norman invasion of 1066.

The Normans, led by Guillaume le Conquérant (William the Conqueror) were speaking French and given the fact that the Norman occupation lasted for about three hundred years the amount of loan words, according to Jespersen was tremendous

To be more precise, the Normans reconfigured the institutional structures of England from the legal system to religion empowering themselves as masters of the island. The British inhabitants were somewhat forced to absorb the borrowings both form Latin and French.

What actually happened is that the borrowing process was fragmented because of the difference in social class meaning that the conquered nobles had no objection to adopting the language of the invaders whereas the peasants stuck obstinately to the use of the Germanic tongue. This linguistic division was to remain effective until the moment when the native tongue remainders and the borrowings were blended into Middle English.

Members of the nobility who were familiar with the French culture readily adopted and sometimes adapted the words that had been borrowed form French into the English language. The trigger for this process was a necessity to communicate.

Since the dominant power was represented by the French/Latin speakers, the Island was forced to take a new lease of life and a new way of living. In addition, since the newcomers wanted to get rid of the English synonyms, some of them have been dating for centuries.

As Gervaise of Tilbury once said, there was a time when the French language was a must for the English nobles as they were sending their children to France so they should lose it. The "perfidious Albion", as it was called, still reigned in royal courts until the fifteenth century. There has to be noted that almost all the documents related to prominent historic figures such as John Balliol or Robert Bruce were written in French. According to the aforementioned Gervaise of Tilbury, the Scots who came to Paris were bewildered by the fact that the beggars were seeking alms in French. Similarly, the very first worry of William the Conqueror (Guillaume le Conquerant), after the conquest of 1066, was to outlaw the Anglo-Saxon in court and in every school where the teaching process was in French. Although it was primarily the nobility which gladly adopted French, even the rural residents kept mingling continually French words into their British conversation.

Another aspect worth mentioning is that the so-called La Sorbonne, i.e. the University of Paris had a tremendous and powerful contribution to the spread French in the most distant places on Earth. The University of Paris, where people came to study from all parts of Europe, contributed powerfully to spread the knowledge of the language in the most remote countries.

Eichborn, a renowned writer from contemporary Germany, claimed in his book "A General History of Civilization and Literature" that: "The France of the Middle Ages served as the first example of modern peoples. From the Mediterranean to the Baltic, we imitated its chivalry and tournaments; on one half of the globe they spoke its language, not only in Christian Europe, but even in Constantinople, in Morea, Syria, Palestine and Cyprus. Its minstrels, travelling from one country to another, carried along their novels, their fables, their tales; they sang in the courts, in the cloisters, in cities and hamlets. Throughout the globe, their poems were translated and served as models. Italy and Spain imitated the French poets of the south; Germany and northern peoples imitated those of the Northern provinces; finally, even England for several centuries, and Italy for some time, rhymed in the idiom of northern France." [5]

To conclude, we should reinforce once more the fact that French was the language of high society in most European countries for many centuries, and is spoken exclusively or is very widespread (alongside German) among the populations of the following regions and countries: Belgium, the Grand Duchy of Luxembourg, the Anglo- Norman Archipelago, the Swiss cantons of Berne, Neuchatel, Fribourg, Vaud, Geneva, Lower Valais, Savoie and Val d'Aosta.

Last but not least French is still spoken in the ancient French maritime possessions such as Ile de France and its dependencies, the islands of Wind, St. Lucia, Sous-le-Vent islands, Santo Domingo and especially in Canada. In New Orleans, for instance, all the proclamations and the newspapers are printed in two columns, in English on one side, French on the other: travellers who are going west, to the interior of America, have a very great need to know French to be understood by people of French origin, and to communicate with the locals.

3. SHARING COMMON ROOTS

Firstly, English has been shaped by a number of other languages over the centuries, and many English speakers know that Latin and German were two of the most important. What many people do not realize is how much the French language has influenced English.

Without going into too much detail, we shall provide a brief insight on the French words which were lent to English. English was born out of the dialects of three German tribes: The Angles, The Jutes, and The Saxons who settled in Britain in about 450 A.D. This group of dialects forms what linguists refer to as Anglo-Saxon, and at some point this language developed into what we know as Old English. This Germanic base was influenced in varying degrees by Celtic, Latin, and Scandinavian which were the languages spoken by invading armies.

Bill Bryson calls the Norman conquest of 1066 the "final cataclysm (which) awaited the English language." [6], [7] When William the Conqueror became king of England, French took over as the language of the court, administration, and culture - and stayed there for 300 years. Meanwhile, English was somehow demoted to everyday, unprestigious uses. These two languages existed side by side in England with no noticeable difficulties; in fact, since English was essentially ignored by grammarians during this time, it took advantage of its lowly status to become a grammatically simpler language and, after only 70 or 80 years existing side-by-side with French, Old English derived into Middle English.

In terms of vocabulary we should bear in mind the fact that during the Norman occupation about 10,000 French words were adopted into English, some three-fourths of which are still in use today. This French vocabulary is found in every domain, from government and law to art and literature. More than a third of all English words are derived directly or indirectly from French, and it is estimated that English speakers who have never studied French already know 15,000 French words.

The Norman invasion of England in 1066 had a major impact not only on the country, but also on the English language. William the Conqueror and his Normans brought with them Norman French, which became the language of the court, government and the upper class for the next three centuries. English continued to be used by ordinary people, and Latin was the language of the church.

As far as contemporary language is concerned, Alan Ray, in his book "Essays on Terminology" provides a very clear discrimination between the similarities and differences between English, German and French in terms of borrowings adapted to the very structure of each language: "In science and especially in technology, terminological units in several languages (English, French, Italian, Spanish) take the form of noun phrases. Their structure is constant: one element, a noun or a noun phrase and a determiner in the form of one or several adjectives or prepositional complements. [...] This structure is the same for phrases or compound nouns. According to the morphological freedom of a language, some form compounds, other build phrases with the additional cost in length of letters, phonemes or syllables this involves. In this sense modern French with its limited morphological freedom contrasts sharply with German and less so with English. Examples:

- transmission factor = Transmissionsgrad = facteur de transmission
- contrasting filter = Kontrastfilter = filtre de contraste
- neutral filter = Neutralfilter = filtre neutre
- ball lightning = Kugelblitz = foudre globulaire
- anafront = Anafront = front anabolique
- catafront = Katafront = front catabolique

The semantic structures are similar, so are the formal structures, with the difference that in English and German the determiner precedes and in French follows the nucleus and, what is of interest here, in German it is directly linked to the determinant to form a complex lexical unit. The German term gains in cohesion and economy but loses motivation. " [8]

4. MARITIME WORDS

As far as the maritime environment is concerned, it has become more than obvious that words were borrowed to and fro but more importantly there are English maritime terms of French and Germanic origin which are yet another proof of the aforementioned. Although the origin of sailing terms is not always clear, many are derived from old Dutch, Norse, and Germanic languages. These peoples were accomplished sailors from ancient times, so their impact on the language of sailing in today's English is not at all surprising. While most of the nautical terms in English are of Germanic origin, some are French. The Norse element preceeds the Norman Conquest.

The following examples are meant to clarify all of the above:

The word *ship* itself is of Germanic origin: Old English *scip* (noun), late Old English *scipian* (verb), of Germanic origin; related to Dutch *schip* and German *Schiff* [9]

The word *mast* was borrowed into French in the form of *mat* where we can clearly see the reminiscence of the consonant *s* preserved in the shape of the circumflex accent. On the website http://www.straightdope.com/columns/read/2950/whats-the-origin-of-nautical-terms-like-jibe-tack-etcms-like-jibe-tack-etc, Matt Craver, Straight Dope Science Advisory Board, explains the origin of various nautical terms derived into English either from Old French or Old German. As such, the word *mast* is defined as a vertical spar to support booms, rigging and sails. In other words, the long pointy thing sticking straight up from the deck. The term started out as the Indo-European **mazdos*, "pole, rod," and evolved into the early Germanic *mæst*, meaning what it does today. [10]

Bow – The front of a boat or ship, deriving from *bog* in Low German, Dutch and Danish meaning "shoulder or arm." We still use the derivative form "*bough*" to mean the limb of a tree. The term was adapted for nautical use in Middle English to refer to the "shoulders" of a boat's hull.

Starboard – The right side of the boat as you look toward the bow. From the Old English *steorbord*, "the side on which the boat is steered." Equivalents existed in other Germanic languages such as Middle Dutch, Middle High German, Old Icelandic, Swedish and Danish.

Tack – 1. (noun) The direction of a sailing vessel relative to the wind. If the wind is coming from starboard (your right), you are on a starboard tack. A port tack means the wind is coming from port (your left). 2. (verb) When heading upwind, to change direction so that the wind shifts from one side of the vessel to the other. Both senses come from Old North French *tache*, "nail, pin," which may have roots in older German words meaning "pointed thing." The use of this word to mean "to hold the corner of a sail in place" starts in 1481 and by 1614 it meant "to sail across or diagonally to the wind."

Hull – The part of the boat between the deck and the keel that keeps out the water. The origin of this word has more to do with seeds than boats. The Old English hulu, "seed covering", traces back to the Germanic *hülle*, "covering." Whether the word was applied to ships because both boat and seed hulls keep out water or because some people thought a ship's hull looked like a peapod is a matter of speculation. I find this strange because, unlike most of these other words, "hull" entered English late, first turning up in 1551.

Spars – All the booms, masts, yardarms, etc., that support the sails and rigging. Spars used to be wooden but today can also be metal or carbon fiber. The term comes from the Middle Dutch *sparre*/*spaer* or Middle Low German *sparre*/*spare*, "stout pole" and ultimately from the Indo-European base **sper-*, "spear, pole." Nautical use in the "stout pole" sense dates from 1640.

Rig - from Early Modern English *rygge*, probably of North Germanic origin. Likewise, Norwegian *rigge* ("to bind up; wrap around; rig; equip"), Swedish dialectal *rigga* ("to rig a horse"), Old English **wrīhan, wrīohan, wrēohan, wrēon* ("to bind; wrap up; cover").

Windlass - device for raising weights by winding a rope round a cylinder. 1825, from the verb "to wind". Earlier, "an apparatus for winding," late 14c., in which use perhaps from a North Sea Germanic word, such as Middle Dutch, Middle Low German *winde* "windlass."

Ladder - Old English *hlæder* "ladder, steps," from Proto-Germanic **khlaidri* (cognates: Old Frisian hledere, Middle Dutch *ledere*, Old High German *leitara*, German *Leiter*)

Halyard – A rope used to haul the sail up the mast, from the Old French *halier*, "haul," plus "yard" as described above. So a "halyard" was a rope that hauls the yard up the mast. In vessels without yardarms, the word was applied to hauling the sail itself rather than the yard it was attached to.

Demurrage - from old French *demorage*. The term *demurrage* originated in vessel chartering and refers to the period when the charterer remains in possession of the vessel after the period normally allowed to load and unload cargo refered to as laytime.

Demise - a term from mid-15th century, from Middle French *demise*, past participle of *démettre* meaning *dismiss*, *put away*, from des- *away* (from Latin dis-) and Middle French mettre *put* from Latin *mittere* meaning *let go, send*. Originally it meant "transfer of estate by will" meaning extended in 1754 to „death" because that is when this happens. *Demise*, in its original meaning, is an Anglo-Norman legal term used to render the denotation of transfer of an estate, especially by lease.

Aboard - late 14th century, probably in most cases from Old French *à bord*, from *à* meaning *on* and *bord* (board) from the French word *bord* or a similar Germanic source. The usual Middle English expression was *within shippes borde*. The call *all aboard!* as a warning to passengers is attested from 1838.

Vessel - from Old French vessel (French *vaisseau* "container") from Latin *vascellum* meaning small vase or urn also from ship diminutive of *vasculum*, itself a diminutive of vessel.. The sense of ship, boat is found in English around the year 1300. The association between hollow utensils and boats appears in all languages. The meaning of canal or duct of the body (especially for carrying blood) is attested from late 14th century.

Port holes **-** The word "port hole" originated during the reign of Henry V of England. King Henry insisted on mounting guns too large for his ship and the traditional methods of securing these weapons on the forecastle and aftcastle could not be used. A French shipbuilder named James Baker was commissioned to solve the problem. He put small doors in the side of the ship and mounted the cannon inside the ship. These doors protected the cannon from weather and were opened when the cannon were to be used. The French word for "door" is *porte* which was later Anglicized to "port" and later went on to mean any opening in the ship's side, whether for cannon or not.

Maritime - 1540s, meaning "of or pertaining to the sea", from Middle French *maritime* (16th century) or directly from Latin *maritimus* meaning "of the sea, near the sea," from *mare* (genitive *maris*) and the Latin ending *-timus*, originally a superlative suffix (cf. *intimus* "inmost", *ultimus* „last"), here denoting "close association with".

Mariner - early 15th century, meaning "pertaining to the sea", from Middle French *marin*, from Old French *marin* and from Latin *marinus* "of the sea" that is from *mare* "sea, the sea, seawater", from *mori* "body of water, lake".

Bilge – 1510s, meaning "lowest internal part of a ship" also used of the foulness which collects there; variant of *bulge* "ship's hull" also "leather bag" from Old North French *boulge* meaning "leather sack" from Late Latin *bulga* "leather sack".

Capstan - late 14th century, from Old French *cabestant*, from Old Provençal *cabestan*, from *capestre* "pulley cord" coming from Latin *capistrum* "halter" meaning "to hold, take".

Pan-pan - The French word *panne* nominally refers to a mechanical failure or breakdown of any kind. A three-letter backronym, "Possible Assistance Needed" or "Pay Attention Now", is derived from "*pan*". It is used on various maritime and aeronautical radio communications courses as an aide-mémoire to radio/communications operators, specifically to reaffirm the important difference between Mayday and Pan-Pan emergency communications.

May day - The Mayday call sign originated in 1923 by Frederick Stanley Mockford (1897–1962). A senior radio officer at Croydon Airport in London, Mockford was asked to think of a word that would indicate distress and would easily be understood by all pilots and ground staff in an emergency. Since much of the traffic at the time was between Croydon and Le Bourget Airport in

Paris, he proposed the word Mayday from the French *m'aider*. "*Venez m'aider*" means "come help me."

An aspect worth mentioning is the evolution of the word *amidships* the meaning of which in maritime English refers to the center of the ship, more precisely the vertical line in a ship midway between the forward and aft perpendiculars. The word *amidships* was borrowed into French where it initially preserves its original meaning. Yet, there has been an alteration in the long run due to that fact that the word describes an area where the movements of rolling and pitching are most felt, and consequently, it is the most propitious spot where young seamen, who are about to get their sea legs, are accommodated. Strangely enough, the French attributed a feminine form to this noun namely *midshipette*. Vernacular French even has a verb synonym of *oublier* (to forget) which is *midshiper,* coming precisely from the English word *midship.*

Another interesting word is *barratry* meaning a fraud committed by a master of a ship or a member of the crew at the expense of the owners of the ship or its cargo. It dates from the early 15th century and it defines a "sale of ecclesiastical or state offices," from Old French *baraterie* namely "deceit, guile, trickery", coming from *barat* "malpractice, fraud, deceit, trickery" of unknown origin, perhaps from Celtic. In marine law, it refers to a "wrongful conduct by a ship's crew or officer, resulting in loss to owners" as of 1620s. The meaning "offense of habitually starting legal suits" dates from the 1640s. The latter is a sense somewhat confused with that of Middle English *baratri* standing for "combat, fighting" (used around the year 1400), springing from Old Norse *baratta* meaning "fight, contest". This was an active word in Middle English, with forms such as *baraten* "to disturb the peac" (mid-15th century); *baratour* "inciter to riot, bully" (late 14th century). Barataria Bay, from Louisiana, the United States, is a proper name coming from Spanish *baratear* meaning "to cheat, to deceive", a cognate of the French word; the bay so called in reference to the difficulty of its entry passages.

Another fascinating lexical borrowing is *aloft* which has a German origin. It comes from the German word "Luft" (meaning *air*) and, strangely enough, it was combined with the French preposition *à* meaning "go to". The mixture of the two borrowings produced "a luft" which became *aloft* in Old English (meaning "to go into the air" or "climb the mast").

Avast is yet another instance of a French borrowing, in this case it was the product of a contraction between two French words "haud" and "fast" meaning "to hold fast" or in other words "steady and hold what you are doing".

In the hope that all these examples have helped potential readers and alleged amateurs in linguistics, we wish to have given a taste of the most exquisite linguistic merge between maritime English and French.

4. REFERENCES

[1] http://en.wikipedia.org/wiki/Germanic_languages
[2]http://en.wikipedia.org/wiki/Germanic-speaking_Europe
[3] Jespersen, J. O. H., *Growth and structure of the English language*, Leipzig, 1912
[4] Greenough, J. B.; Kittredge, G. L., *Words and their ways in English speech*, The Macmillan Company, London, 1901
[5] Eichborn von, R., *A General History of Civilization and Literature*, Frankfurt, 1993
[6] Bryson Bill, *The Mother Tongue: English and How It Got That Way*, Publisher: William Morrow Paperbacks; Reissue edition 2001
[7] Bryson Bill, *Made in America: An Informal History of the English Language in the United States,* Publisher William Morrow Paperbacks, reprint edition 2001
[8] Rey, Alain, *Essays on Terminology / Alain Rey; translated and edited by Juan C. Sager; introduction by Bruno de Bessé.*, John Benjamins Publishing Company, Amsterdam. Philadelphia, 1995
[9] www.google.com
[10]http://www.straightdope.com/columns/read/2950/whats-the-origin-of-nautical-terms-like-jibe-tack-etc

5. FURTHER REFERENCE AND WEBOGRAPHY

Katzner K., *The Languages of the World*, Routledge Publishing House, 2002
Walter H., *French Inside Out: The Worldwide Development of the French Language in the Past, the Present and the Future,* Routledge Publishing House, 1993
Walter H., *Honni soit qui mal y pense : L'incroyable histoire d'amour entre le français et l'anglais,* Editeur Robert Laffont, 2001
The American Heritage Dictionary of the English Language, Publisher Houghton Mifflin Harcourt; 4th edition, 2006

http://www.sailorschoice.com
http://www.anglik.net/englishlanguagehistory.htm
http://www.ruf.rice.edu/kemmer/Words/loanwords.html
http://www.marineterms.com/
http://www.etymonline.com

COMMUNICATION AND CULTURAL AWARENESS – ENGINES THAT CAN POWER THE SHIPPING BUSINESS THROUGH SCYLLA AND CHARYBDIS SITUATIONS

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ABSTRACT

The 21st century has predominantly added a new ingredient to the education and training of those who are attracted by sea adventures. The modern seafarer usually sails in ships with multicultural crews whose nationality mix may vary from season to season, one voyage to the next, depending on the policy of shipping/crewing companies. Under these circumstances, a language course demands that the learner should get as close as possible to the people that will populate the merchant ships, the way they feel, think and act.

The paper presents the growing importance of building up the cross-cultural competency of our students. But reaching this goal depends on the G3 (industry, IMO-STCW, and academia) to make sure the right course is steered. The people responsible for this business should not ignore the new realities, it is better to change than to wait. Some corrections will have to be made regarding the requirements of crewing agencies, tailoring of the curriculum, and cross-cultural information to be presented in non-passive ways.

Keywords: communication skills, cultural awareness, maritime professionals, particular meanings, training

1. INTRODUCTION

The profile of the international maritime industry encompasses a significant variation of cultural diversity. Gone are the days when Romanian seafarers rubbed elbows and exchanged ideas with guys speaking the same language. More pointedly, a culturally diverse milieu of officers and ratings is becoming more of the norm for contemporary maritime shipping ventures. Unlike the planned cohabitation of mixed cultures that were known to be tolerant and compatible of each other, the current mixing of diverse nationalities on board merchant cargo vessels appears to be occurring at an unprecedented rate. This recent trend is partially explained by the larger percentage of mixed crews on foreign flagged ships. Regardless of the causes, however, there can be no doubt that the maritime environment has become multi-cultured, dynamic, fast paced and laden with liability. But provided the crew can make themselves understood, with English as lingua franca, the arrangement can work as well as single nationality crews (*Kahveci. & Sampson*, 2001).

Now all the actors on the stage of shipping, as well as in any other business, should take a step towards cross-cultural management in the maritime profession as there is strong interrelation between the level of quality of offered services by a ship operator, and the concern on cultural awareness, cultural sensitivity, diversity and negotiating skills. We have to understand and make other people understand that culture awareness is good for the business, or our training ship may be soon put out of commission.

2. APPROACHES TO CROSS-CULTURAL MANAGEMENT

Some writers, faced with the problem of an encyclopaedic definition, have tried to reduce the vast and amorphous nature of the culture concept to a manageable proportion by preparing lists of items. Several surveys have highlighted the different implications of this trend; some distinguish between (a) information culture, (b) behavioural culture, and (c) achievement culture (Hammerly, 1982), or with a special focus on the implementation of strategies related to decision making accepted by a diversity of seafarers (Moreby, 1990; Horck, 2004; Theotokas and Progoulaki, 2007), stereotyping and stereotype avoidance (Lieberman, *et all, 2003),* culture's influence on teamwork (Estlund, 2003), the working and living conditions onboard ships manned with mixed nationality crew (Kahveci and Sampson, 2001), and the effective communication of multi-lingual and multi-cultural crew (Iakovaki and Progoulaki, 2010; Noble,et al, 2011). In an attempt to help improve maritime crew operational effectiveness and avert losses, relative importance of cross-cultural competency should be examined. Competency includes those characteristics - knowledge, skills, mindsets, thought patterns, and the like - that when used whether singularly or in various combinations, result in successful performance. To what degree should maritime professionals (i.e. active and future employees in maritime transportation, either on board or at shore-based positions) be able to work and communicate effectively and safely in the highly multicultural environment that they experience not only on board, but also on shore? Obviously, even in cases where shipping companies employ single nation and/ or foreign/ native crews, often both the vessel and the office are involved in relations and communication with foreign third parties, such as port authorities, pilots, inspectors, and other (Progoulaki et al, 2013).

With a few exceptions the maritime professionals do not have the skills and training to work with a multicultural workforce, and cultural studies assume the role of optimizing their skill in conflict resolution, communication, team building, and decision making-competencies that are vital to ship and crew safety at sea. The trainers' task is to look closely at the current status and trends regarding cross-cultural training in maritime education and training systems, and to identify gaps, needs and challenges to be addressed in maritime education specific to cross-cultural competence.

3. FACTORS THAT CAN BRING CROSSCULTURAL ISSUES TO THE FOREGROUND

a. Shipping industry

As a survey of the shipping companies aimed at examining their values, policies and career strategies is very hard to make, I turned to a much easier way, i.e. company sites. These sites have a cornucopia of information, and, for instance, AB Crewing claims to be 'among the leading crewing agencies in our region because of a growing number of satisfied customers who repeatedly approaches them for their requirements.' The site also reads, 'We are committed to consistently monitor and upgrade our quality management objectives and systems, and make the necessary changes in our resolve to help our clients achieve their business objectives.' And the grand finale is "we regularly monitor client satisfaction levels through customer feedback and perception analysis, and take corrective measures where we notice gaps between our services and client aspirations."

It is quite obvious that forward-thinking vessel owners and ship management companies are already looking at ways to attract more and better trained graduates of the maritime institutions. Some of the ways are promoting a positive image of the industry among young seafarers, awarding grants to undergraduates, e.g. NYK Company, improving work and living conditions. That is an excellent policy, but cultural issues are completely missing. If they do analyse the feedback, it means that nobody requires cultural competence as a condition to getting a job.

b. IMO STCW resolutions

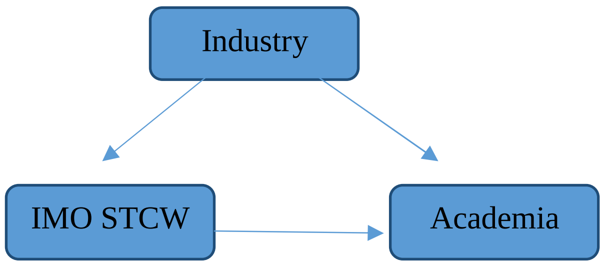
The licensure documents and maritime labour-related regulations and other accepted industry documents show that at the moment licensure is not connected to the development of cross-cultural competency. Even the recent Manila Amendments to STCW, while they emphasize the important of training in leadership and teamwork, no clear or direct statement is made with regard to cross-cultural competency development. Supporters of this approach are strongly in favour of making cross-cultural competency an IMO/STCW requirement.

c. Academic institutions

Cross-cultural competency appears to be a human resources' competitive advantage over the long term. While maritime institutions are not presently obliged to implement cross-cultural competency as a programmatic requirement across curriculums, it is imperative to pay attention to trends in the external environment. Even if it appears that there is a consensus regarding the importance of multiculturalism, some of the teaching staff express concern with additional training placed in an already full curriculum and that the word competency should be replaced with awareness as competency will be difficult to measure in light of the multiplicity of cultural milieu in the maritime sector. Unfortunately no one can blame them as this training will place other disciplines out of the curricula. This implies endless talks, disputes and negotiations.

There may be a time when 'clients' will knock on your door trying to find an institution that can do better than others. If the maritime universities are willing to have an eye on the market, they may leave the equation and take their progress in their hands. If they take action and stop waiting for others to tailor the curriculum, they will give the labour market graduates with n+1 competencies. Sooner or later this will make the difference and should any mishaps occur, even minor ones, the shipping managers will think of culture study, which is now on the weather deck and to the windward side of their priorities. The students will have not only the skill to make bridges in any eclectic crew but also find a ladder rigged on the leeside to board a ship after the graduation ceremony. Under the circumstances, Horck's warning –"if courses in cultural awareness do not become mandatory and if ships" crews English is not improved the International Ship Management Code will be a farce' (Horck, 2008) – will no longer sound so fatalistic.

The relation between the G-3 is as follows:



4. PREPARATIONS FOR CULTURAL STUDIES

The singular or united efforts of the institutions directly or indirectly involved in the shipping business will eventually impose cross cultural competency as a licensure requirement. But it is only the tip of the iceberg. This must be followed by an extensive field work, most of it outside library walls. It is almost impossible for one person, or a small team to compile the information needed by the trainers who take the road to building up cultural competency.

The topic is so vast that it cannot be tackled unless we have some guiding elements, and most important are the objectives of implementing cultural studies. Fortunately, this issue was widely under scrutiny and most writers agree that the overall goals of cultural teaching are cross-cultural understanding and cross-cultural communication. Even if the concept of culture is somehow vague, cultural goals can be expressed in clear and unambiguous terms that can be made operational in the classroom work. Following is a selection of the essential and attainable goals, described as a number of skills to be developed in the learner (Tomalin & Stempleski, 1993):

1. *The sense of culturally conditioned behaviour*. The student should demonstrate an understanding that people generally act the way they do because they are using options the society allows for satisfying basic physical and psychological needs.

2. *Interaction of language and social variables*. The student should demonstrate an understanding that social variables such as age, sex, social class, even place of residence affect the way people speak and behave.

3. *Conventional behaviour in common situations*. The student should demonstrate an understanding of the role convention plays in shaping behaviour by demonstrating how people act in common mundane and crisis situations in the target culture.

4. *Understanding of cultural values*. The student should be able to interpret both the target culture and his own culture.

The next step is identifying and compiling training materials that represent or can represent the major cross-cultural and national diversities that maritime professionals are likely to encounter. The handiest way is long hours of library research. Then you can try to find foreigners willing to fill in the right column of a task sheet such as that given below:

Romania	My country
1. At an informal party, people don't wait to be introduced. They introduce themselves.	……
2. When …..	……
3. When ….	……

If you get feedback from people representing several cultures then you have a wonderful starter. Even better is multiple twinning, i.e. notes on Romanian cultural values are passed on to foreign experts. The outcome must be a textbook in which cultural facts from different countries are presented, compared and differences highlighted. For these last two methods shipping companies or their branches may provide names and addresses of competent people in the field of cultural variables.

5. CONCLUSIONS

Communication and cultural awareness can influence each other especially now that ships are manned with younger people. With all the schooling and training of today the new wave of seafarers speak good English and this helps overcome cultural differences. Although it is true that good communication can smooth the edges of cultural walls, cross-cultural competency is considered an important asset, as companies that emphasize these competencies through training are generally considered high quality service providers.

If no maritime international body specifically requires cross-cultural skills for current and future maritime professionals, academic institutions can act without specific standing orders and thus become "the tail" that "wags the dog" in the realm of cross-cultural competency going forward.

The culture study should be integrated throughout the curriculum, to varied extents, and not just for the licensed programs. The ships are not manned only by officers, so attention should be given to the other members of the 'onboard family' and this can create mutual understanding among the crew and officers on the sailing vessel as well as potentially pave the way to alleviate social discrimination among seafarers and other maritime personnel.

In order to achieve our goal we will leave no stone unturned in order to find and produce good materials that can be adapted to the needs and resources of the maritime institution. Even so, this endeavor implies a trial and error method, which means that cross-cultural competency will increase in time, step by step, and training should be considered a work in progress.

6. REFERENCES

[1] Estlund, C., *Working together* (2003), Oxford University Press, Inc., ISBN 0-19-515828-8

[2] Hammerly, H. (1982). *Synthesis in Second Language Teaching*. Blaine, Washington: Second Language Publications

[3] Horck, J. (2004), *An analysis of decision-making processes in multicultural maritime scenarios. Maritime Policy and Management*, 31(1), pp. 15-29.

[4] Horck, J. (2008) *Cultural and gender diversities affecting the ship/port interface. Maritime education and training efforts to bridge diversity gaps*. ISPIC, Bremen 19-21 May.

[5] Iakovaki, H. and Progoulaki, M. (2010), *Language in Use versus Language as Taught: lingual and cultural issues in the Teaching and Use of English as a Workplace Language in the Maritime World*. Proceedings of the 22nd International Maritime English Conference (IMEC) 22, Alexandria, Egypt, pp. 141-158.

[6] Kahveci, *E. &* Sampson, H. (2001), *A Shipboard-Based Study of Mixed-Nationality Crews*, Seafarers' International Research Centre Lieberman, S., Simons, *G. and* Berardo, K. (2003) – *Putting diversity to work, ISBN*: 1-56052-695-5

[7] Moreby, D.H. (1990), Communication problems inherent in a cross-cultural manning environment. Maritime Policy and Management, 17(3), 199-205.

[8] Noble, A., Vangehuchten, L. and Van Parys, W. (2011), *Intercultural Competence and Effective Communication at Sea: An Invitation to Celebrate Diversity on Board*. Proceedings of the 23Rd

International Maritime English Conference, October 10-14, (Constanta, Romania: Nautica), pp 131-149

[9] Progoulaki, M. Potoker, E. Parsons, J. (2013), *An international survey on cross-cultural competency for maritime professionals through education and training*, 20th International Conference on "Managing complexity in shipping and port markets: firms' business models, co-operative games and innovative public-private interactions.

[10] Theotokas, I. and Progoulaki, M. (2007), Cultural diversity, manning strategies and management practices in Greek-shipping. Maritime Policy and Management, 34(4), 383-403.

[11]Tomalin, B & Stempleski, S. (1993). *Cultural Awareness* Oxford University Press

A MOTIVATIONAL LETTER AND SPEECH ABOUT LEARNING AND SCIENCE FOR MY DAUGHTER ANDREEA BUT ALSO FOR SOME OF MY STUDENTS

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ABSTRACT

The paper aims to realize a motivation for learning and research for those not seeing and not understanding the aim and scope of the science. It also analyzes what in the exact sciences happens and what are the exact sciences good for, by comparing them with some of the humanistic sciences, mainly related to economics and business, and the goals of them. It also shows how important the objectives and their induced forces, acting in one’s life are, in the sense that they can somehow attract or repel science, but it also deals with the connection between curiosity, science and money.

Keywords: *motivation, sciences, money.*

1. INTRODUCTION

The paper is structured in two parts, where the first part provides perspective on the non-productive way to approach learning and science, as sought through the eyes and personal experience of the author. The second part of the paper deals with aspects related to the motivation for learning and scientific research, going from the inner motivations and objectives of persons.

2. MOTIVATIONAL LETTER

2.1 A short history at the beginning

All begins with a very personal experience dated many years ago.

Some twenty-two years ago, when I was still a student at Politehnica University of Bucharest, one of the fields of study I had was the so-called “Leistungselektronik”. It seemed, I don’t know anymore the reasons, rather boring discipline to study. With that mind that I had, I believed that I dislike the professor and I will not use the respective information, falsely considering it as useless.

That is why, I haven’t attended the courses and when I had to present myself for the examination, after a long “white-night” of “learning and preparing” the exam, I barely passed the examination.

It was one of my poorest results as a student, which I am not very proud of.

Nowadays, after 22 years, I need for my present work activity, the very same knowledge from the field of study of “Leistungselektronik”. What should I do? I will revert and I will learn and study the discipline I haven’t studied at the proper time.

So, at present, I rhetorically ask my students: “When do you think I had more time and availability to study the knowledge I need now? During the student time, when I had more time and twenty-two years younger neurons in my brain, or now when I have family life with wife and daughter?”

I also say to them: “My dear students, if you don’t want to experience what I have experienced, don’t waste your time for study during your student-time, and learn and study as much as you can, when still at school and have the best opportunities for study. Because, if you throw away and waste perhaps the most useful period of your life, you may later lack the knowledge that you will once need and unfortunately you will do not possess. You may never know where life brings you and it is very probable that some time you will have to use even that information and knowledge, which you disregarded during your study”

2.2 Motivation for learning and scientific research

To be completely honest, the present paper aimed at first much higher, before writed it. It was initially meant to be a motivation for the scientific research but it turned out to be only a simply motivational letter to my daughter, on the one hand because of the presented personal history and on the other hand from resons of utility of this writing. For those who have an ideea about science there is no motivation needed.

In addition to this, the interest and passion for study and scientific research is a more complex matter than the speech for my daughter or my students, reason for which I am a too unimportant author, to write about. Therefore I live that priviledge to more experienced scientists than me.

So, we will remain further to my daugther and students, in order to not annoy or upset someone.

For the sake of the problem statement, I also say to my students, that the choice to study or not, depends only on their own personal goals and objectives of their life. So, before making this choice, everyone should ask himself the question: „What are my main long term objectives of my own life? I want to discover and better understand the world and life, or I want to get rich and make money?

In order to understand the world we live in, I represent the opinion that every little thing learned throughout the life is usefull and similarly to the Law of conservation, in natural sciences, nothing gets lost, nothing is unusable for those who seek to understand more of the life and world that surrounds us. The author is also representing the opinion that all small pieces of knowledge, everything learned and studied, marvelously connects, combines and joins together and to eachother, forming the base of and also fostering our big picture and representation to understand and think what happens around us, thus helping us to understand a small part of the order of things and the miracle of our own world.

So, in that sense everything we have learned and all we know is usefull to apprehend, comprehend and understand the world, life and most of the processes taking place therein.

So, if your goal is to understand what happens around you, you may be with sciences in the right place.

On the other hand if you choose money, you may be wrong with the exact sciences. For money and success in running a business there are other „abilities" and „capabilities" that should be gained and trained, this time less abstract and more applied and practical; but in order to be a successful businessman understanding and study of some other humanistic disciplines such as economics, psychology a.s.o. is also required. This brings us thus back again somehow, this time, to „more usefull and digestible sciences", the humanistic sciences intended for the person interested in becoming a succesful businessman. Anyhow, this fact stresses the importance of all sciences for anybody.

Reverting now to the choice of exact sciences which is at the same time the choice for a better understanding of the world and life, there is a certain contradiction between that and the choice of richness and money.

In fact, in the history of mankind, there were rather few examples for scientists, mainly in the capitalist system, who get rich from science and it was mainly not the science that made them rich, but rather their ability to use and apply science for commercial purposes and for the needs of the economic life of their times and the period afterwards.

But as already stated by some other authors in other papers and strongly sustained by the author of the present paper, the science should be always meant to be human and in direct connection and relation with the human beings and the unsolved problems of men.

Thus, the application of science in the human life even though for commercial purposes, may be the most useful application of science, made in order to help humans to progress and evolve.

In this above regard, the benefits of application of science for human beings, is in the opinion of the author, by far the most important feature of science, exceeding by far any other utilities of science, among which is also the aforementioned utility of science for those who aim to understand the world, life and man.

Continuing the ideea of science and money, poor and rich, the author makes the observation that the science resembles in its both aspects with the facts stated in the angler's curse.

The author is of belief that there is also a „science curse", that similarly to angler's curse, it may sound in his opinion „nobody can have enough from science and neither will get reach out of science".

For those who don't know, the angler's curse says that you will never get full from eating fish and the angler shall not become rich from practicing the fishing activity.

The vast majority of the few rich scientists, exceptions confirming the rule, were merely interested in apply and use their ideas in practice and reality. These few rich scientific researchers had either business backgrounds or were simply lucky to win money with their scientific results.

They had in both cases, a certain amount of double-luck, the luck of discovering new things and the luck of earning money out of it.

3. CONCLUSIONS

First conclusion which can be made is that the human beings are continuously changing, in very variously ways, depending on their lifes and their lifes' needs or change of view occured during their life span. No one can know what to expect from life or where the one's life shall carry him on the path of life.

This is one of the main reasons in order to strive to know as much as possible.

The second reason for learning, studying and scientific research is, as it has been shown, the burning and perhaps for some people „strange" desire to understand the world, or at least the visible part of it, through science.

The third important reason, but in the author's view the most improbable, would be the aim of becoming rich from science. This shall require, as previously presented the existence of the aforementioned double-luck which is the luck for both: science and business.

Although the main purpose of science is its utility for men and should be both, designed and designated to help people and to make the human life easier, we cannot neglect either the aforementioned eager desire of knowing our world and existence or the reality that few results are born out of the desire to improve man's life.

The obvious fact that on the one hand the man is striving to understand the world, sometimes clearly not aiming to use or not targeting eventual scientific results but only striving to understand things and on the other hand the fact that out of his such „unefficiently economical" endeavours it results very much of useable science and useful applications of science in human life, it clearly shows the significant interrelation, higly correlation and strong interraction, between the self-induced need for science of the curious, eager-to-know scientist and the numerous commercial, useful science applications, for humans.

4. REFERENCES

Much of the author's beliefs mainly based on observations and experience, but also on some processed scientific and non-scientific literature read throughout the years.

Reference

O mare parte din convingerile autorului se bazează în principal pe observații și experiențe, dar și pe unele literatura științifică și non-științifice prelucrate si citite de-a lungul anilor.

SECTION VI

TRANSPORT ECONOMICS

POLITICAL CHANGES INFLUENCE IN THE BLACK SEA BASIN ON THE ROMANIAN CRUISE MARKETING

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ABSTRACT

At present the Black Sea riparian countries have different political and military orientations. The annexation of the Crimean peninsula, belonging to Ukraine, by Russia, has changed profoundly the political, economic and military relations in the area, with regional, continental and global influence. Sustainable economic development plans of the Black Sea countries are seriously affected, and their adjustment is required. The Black Sea cruise market refocused, and early specialized marketing studies show how this economic activity can grow, on the Romanian Black Sea coast, in a sustainable way.

Keywords: *The Black Sea, marketing, politics, cruises market, cruise ship.*

1. INTRODUCTION

Since antiquity, The Black Sea has aroused the interest of the Mediterranean civilizations who built here fortresses - towns which have survived to the present by their names and local tradition.

Today, The Black Sea is, besides a semi - enclosed sea, a geographical, political, economic, social, cultural, military and a geopolitical complex reality, with a much greater inclusion and importance than its geographical definition. In recent years, in this area, were held outstanding political, economic, diplomatic, military, scientific, sporting and cultural international activities being attended not only by representatives of the riparian countries, but also, by representatives of other countries, irrespective of their geographical position, i.e. close or remote. This is strong evidence for the ever increasing geopolitical interest in the Black Sea basin.

At the Black Sea, there are six riparian countries with different military-political affiliations: Romania, Bulgaria, Turkey, Georgia, Russian Federation and Ukraine.

2. MILITARY AND GEOPOLITICAL CHANGES IN THE BLACK SEA AND THEIR INFLUENCE ON THE SUSTAINABLE DEVELOPMENT OF THE AREA

The geopolitical importance of the Black Sea region has been proved by numerous political and military actions conducted throughout history until today. Small countries wanted to gain access to the sea, while big countries wanted to extend their political and economic influence in the region; at present, the political, military and economic interests of the riparian countries lead both to divergent actions, in order to secure the best possible representation in the area, and to convergent actions, within political, military and economic organizations expected to promote their interests, particularly the economic ones. All these actions are taking place in the middle of the confrontations of the great geopolitical „actors", (USA, Germany, France, Russia, China and India) which are supported in their actions on by five pivots (Ukraine, Azerbaijan, Turkey, Iran, South Korea); it is worth noting that three of the countries listed above are Black Sea riparian countries.

The importance of the Black Sea in the international shipping evolution is emphasized by the need to reactivate the old "Silk Road", so as to establish transport links between Europe, the Caucasus, Central Asia and the Middle East, with particular influence on the economic development of the areas crossed. The new "economic bridge" Europe - Asia envisages linking the Port of Liayun , and other Chinese ports on the east coast of China (through the Longhai - Lauxiu railway, The Alta Pass, Central Asia, and the Caucasus) to the south – eastern European ports, and then to the rest of Europe, on three routes: via Kazakhstan / Uzbekistan - Turkmenistan - Iran - Turkey, Europe; via Kazakhstan / Uzbekistan - Turkmenistan – The Caspian Sea - Ajerbaidjan - Georgia – The Black Sea - Romania - Eastern and Northern Europe; via Kazakhstan to Moscow, and further to Western Europe.

There are five European transport routes and corridors which link the Black Sea neighbouring countries to European and Asian regions: the route Dresden / Nuremberg - Prague-Vienna / Bratislava – Budapest – Constanta – Sofia/Tessalonik/Plovdiv – Istanbul; corridor VII The Danube; the route Durres – Tirana – Sofia –Plovdiv- Burgas – Vama; the route Helsinki - Saint Petersburg - Moscow - Kiev - Chisinau - Bucharest – Alexandroupolis; the corridor X North-West- Ljubljana / Budapest - Belgrade / CIS and Sofia/ Tessalonik; the corridor TRACECA: Europe - Caucasus - Asia.

The project for pan-European transport corridors development was launched by the EU in the early 90s, in order to achieve the integration of the eastern Europe into the European market. This strategic project includes land, water, and air communication routes (18 000 km of highway, 20 000 km of roads, 38 airports, 13 seaports, 49 inland ports, oil and gas pipelines). These transport corridors are considered the strategic highways of the future, the competition for their control is open between the great powers The USA, Russia and the EU, with the participation of transit or neighbouring states.

This competition is intended to control the corridors, as follow: corridor IV, which connects Germany and Austria with the oil, gas and minerals of Asia through the port of Constanta; corridor V, that connects Italy and Slovenia and Hungary with Ukraine; corridor VIII, which connects the east with the west, via Italy and Albania, through the port of Burgas; corridor X that realizes the link with corridor VIII, from Skopje, via Kosovo, Belgrade, Zagreb, Ljubljana, up to Germany.

Although the seaborne trade volume decreased after 1990, with a slight increase after 2013, there still are strong commercial links between the ports of the riparian countries, and The Black Sea neighbourhood. However, large ports like Constanta, Novorosijsk, Odessa, Burgas, Poti, Batumi need investment for their modernization.

The maritime, river, and river freight traffic is very important because of the navigable rivers (The Danube,the Dnieper, the Don) and of the different channels , thus ensuring trade links with Northern and Western Europe. When analysing the importance and the future development of this corridors we should also consider, as a very important point, the passenger traffic adjacent to some of them.

Although the development strategies of these transport corridors (some with important maritime segments) are very generous, little has been done to improve them; some have stagnated or even appear to be abandoned due to geopolitical changes in these areas.

The marketing analysis on sustainable development of the Black Sea area, with cruises market developments application, includes, among others: the maritime power of the riparian countries, materialized in the length of their coastline, ports, military political affiliation, riparian countries population.

The analysis of the military and geopolitical changes in the Black Sea was based on geographical, political and military data, taken before and after the annexation, by the Russian Federation, of the Crimean peninsula, in 2014, an action which was condemned and not recognized internationally. Before 2014 the legal situation of the coastline belonging to the riparian countries was the following: the Romanian coast line measured 225 km, from Gura Musura to Vama Veche; the Bulgarian coast line measured 378 km, from Vama Veche to the mouth of the Rezovka river; the Turkish coast line measured 1695 km, from the mouth of the Rezovka river to the mouth of Chorotka river; the Georgian coast line measured 310 km, from the mouth of the Chorotka river, to the mouth of the river Psou; the Russian coast line measured 239 km, from the mouth of the river Psou to the Kerch Strait; the Ukrainian coast line measured 1200 km, from the Kerch Strait to Gura Musura (figure 1).

After the illegal annexation of the Crimean Peninsula, by the Russian Federation, the ratio of the Black Sea coastline length, of the riparian countries, has changed as follows:The Russian Federation took about 600 km from Ukraine; thus, Ukraine's loss was of about 600 km, thus, remaining with about 600 km of shoreline; the data for the other riparian countries have not changed. In this way, Russia has become, after Turkey, the country with the longest shores to the Black Sea and The Sea of Azov (about 839 km).

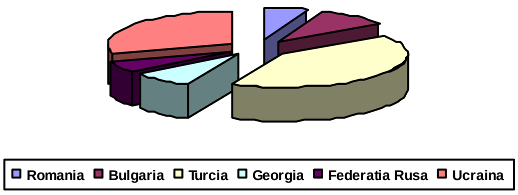

Figure 1 The ratio of the Black Sea coastline length of the riparian countries before 2014

Most important is the fact that Russia, through the military facilities (including the naval bases in Crimeea) has military control over the Black Sea Basin, including the possibility of action on the east Mediterranean basin.

With regard to the military-political affiliation, the situation of riparian countries has not changed: Romania, Bulgaria and Turkey are members of NATO, Romania and Bulgaria are members of the European Union, Ukraine oscillated between EU and the CIS, today reaffirming their desire to be part of Europe. Also, Georgia has expressed their desire to join Europe. Turkey is a candidate for the EU. In this geopolitical equation the Republic of Moldova should be included, since they stated their desire to join the European Union, in 2014. Regarding manpower report we can show the balance between Russia (141.1 million people) and the other countries bordering the Black Sea (137 100 000 inhabitants) (Table 1).

Table 1. The population of the Black Sea riparian countries in 2010 (mil. inhabitants)

Country	Population (milion inhabitants)
Romania	20,0
Bulgaria	8.0
Georgia	5.5
Russian Federation	141.1
Turkey	74.6
Ukraine	49.0

Sourses: Countries National Annual Statistics 2010

3. GLOBAL CRUISE INDUSTRY MARKETING ANALYSIS

A cruise can be defined as a pleasure voyage at sea; it is an attractive alternative to a "classic" holiday on land, since it can offer a different approach to spending a vacatoin; aboard cruise ships there is a special atmosphere, with specific products and services, adapted to different categories of passengers, depending on the requirements, preferences, interests, knoledge or age.

Since the 80s, the choice of a cruise as a way of spending the holidays at sea was one of the largest segments of the tourism development, with the North American tourist market as a starting point. Statistics published by the International Association of Cruise Lines CLIA (Cruise Lines International Association) show that, in 2012, with only one of the CLIA member companies approximately 17.2 million passengers were vacationing, compared with the year 2000 when a number of 7.2 million passangers were peresent on cruise ships, i.e. an annual increase of 7.2%, for the year 2012. CLIA shows, for example, that the cruise industry is still in its beginnings, and represents approximately 12% of the tourism market in North America. Also, judging by the number of berths for passenger ships, or the number of cabins, the cruise industry is, relatively, in its infancy compared with the classic tourism industry.

The cruise market addresses a broad spectrum of passengers, practically to all age groups. According to CLIA market study on the tourist profile, carried out in 2011, the North American cruise market targets are families aged 25, and over, with an income of $ 40,000 or above, i.e.

3.1 European cruise market

In this paper the European market is analyzed in terms of development of ports, and especially those ports which are specialized in passenger transport. The maritime port is a piece of land and an aquatorium for vessels to moor, or anchor, for cargo handling operations, for storage of goods, for boarding and disembarking passengers and crew, and also for economic and industrial activities. For all these activities ports are equipped with facilities and specific equipment (cranes, conveyors, storage, etc.) and specialized terminals (oil, minerals, container, grain, etc.). The European maritime states had a dominant role in the international sea trade development, beginning with the age of the great geographical discoveries. Today, the maritime port is a modern economy complex, developing a very high surplus - value and. It can create the possibility of high integration of various industrial and economic activities, with highly qualified expertise and specialized management. European ports are part of the unique multimodal trans-European transport net. Most of the goods for export and import are carried out by the European Union European seaports.

Passenger terminals are specialized in receiving, boarding and disembarking passengers. Passenger traffic is made by the help of installations, specially constructed walkways to and from the "Maritime Station" where legal formalities, customs, are solved, etc.

The cruise industry has a wide range of European destinations in northern and western Europe, Western Mediterranean and the Eastern Mediterranean and the Black Sea (table 2 and figure 1). Many European ports are considered „must see" destinations. Other ports, many of which, very important harbors have the advantage of having a strategic location, i.e. access to major airports and accommodation facilities, before boarding passengers on board. Tour organizers include them in their itineraries.These advantages include them in the category of home ports.

Table 2. Passenger traffic in the main European ports in 2011-2013

Home port	Country	2011	2012	2013
Mediteraneean ports (passagers/year)				
Barcelona	Spain	2642493	2408960	2599232
Civita-vecchia	Italy	2577438	2394423	2538259
Veneția	Italy	1788416	1739501	1815823
Pireu (Atena)	Greece	1566500	1290300	1302,581
Palma de Mallorca	Spain	1419502	984785	1245856
Marseille	France	826000	890124	1188031
Genova	Italy	798521	797239	1051015
Savona	Italy	948459	810097	939038
North European ports (passagers/year)				
Southampton	UK	1455245	1577790	1646000
Copenhaven	Denmark	820222	840000	800500
Kiel	Germany	377205	348180	363476
Dover	UK	223825	207820	255137
Hamburg	Germany	314494	430329	552359
Amsterdam	Hollande	258576	289757	276912

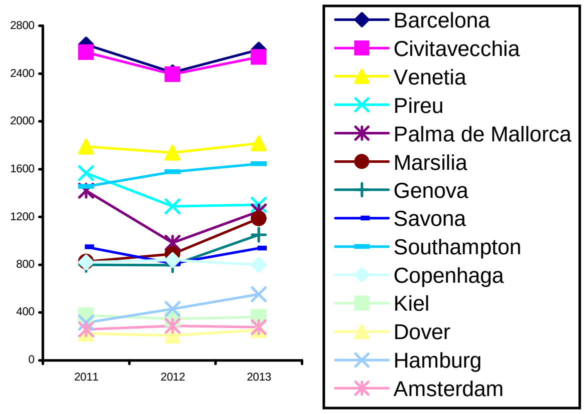

Figure 2 Passenger traffic in the main European ports 2011-2013

Source: Annual Reports of the port administrations concerned for the years 2011, 2012, 2013

In 2013 the top 10 Mediterranean ports were visited by 14.992 million passengers, and the top 10 North European ports were visited by a number of 6,449,000 passengers (Table 3).

Table 3. The main European passengers ports in 2013 (thousands of passengers)

Port	Embarked passengers	Disembarked passengers	Ports of call	Total
Mediteraneen top 10 ports				
Barcelona	754	752	1,093	2,599
Civita-vecchia	496	494	1,548	2,538
Venice	752	761	303	1,815
Pireus	149	160	994	1,303
Palma de Majorca	245	246	755	1,246
Marsilia	191	191	807	1,188
Napoli	58	52	1,064	1,175
Dubrovnik	12	12	1,112	1,137
Genova	327	324	401	1,051
Savona	337	333	269	939
Nord European Top 10 ports				
Southampton	796	796	54	1646

Copenhaga	224	224	352	800
Lisabona	24	26	507	558
Hamburg	261	259	32	552
St. Petersburg	-	-	524	524
Tallin	8	8	503	519
Cadiz	2	2	487	491
Stockholm	32	32	421	486
Bergen	-	-	453	453
Helsinki	-	-	419	420

Source: *MedCruise, Cruise Europe* and the official data of port authorities, 2013

Passenger traffic through the main ports of call (ports of call) in the Mediterranean Sea and Northern Europe for 2011-2013 is shown in the table below (Table 4).

Table 4. Passenger traffic by large European ports of call in 2011-2013

Port of call	Country	2011	2012	2013
Mediteraneen ports				
Marsilia	France	826000	890124	1188031
Napoli	Italy	1297236	1228651	1175018
Dubrovnik	Croatia	985398	950791	1136,663
Santorini	Greece	962000	838899	750000
Corfu	Greece	453000	655764	744651
Livorno	Italy	982928	1037849	744651
Cote d'Azur*	France	666082	702080	736516
Bari	Italy	586848	618882	613218
Mykonos	Greece	684000	657511	604781
Tunis	Tunisie	313267	582601	520000
Messina	Italy	500636	438379	511065
Valletta	Malte	566042	611757	501316
Valencia	Spain	378463	480233	477759
Palermo	Italy	567049	354399	473114
Malaga	Spain	638845	651517	397064
Toulon/Saint Tropez	France	265000	311072	385971
Nord europenean ports				
Lisabona	Portugal	502644	522604	558040
Saint Petersburg	Russia	455476	452000	523525
Tallin	Estonia	437517	440504	519319
Cadiz	Spain	376000	334266	461112
Stockholm	Suede	452000	467000	485858
Rostock/ Warnemunde	Germany	257300	382000	483000
Bergen	Norvege	350248	446906	453015
Helsinki	Finland	385000	368000	420000
Stavanger	Norvege	215026	277000	343500
Geiranger	Norvege	229220	312136	314867
Oslo	Norvege	312859	303386	298403
Flam	Norvege	156907	199875	248945
Le Havre	France	185194	212825	242000
Zeebrugge	Belgium	142444	151930	224000

Sourses: MedCruise, Cruise Europe, ports authorities official statistics

3.2 Companies and passenger ships on international and European routes

Passenger ships are defined as ships carrying more than 12 passengers and comply with international standards for ships, navigation and passenger safety .The STCW Manila 2010, include specific training requirements for crew members on board passenger ships, such as, inter alia, training in crowd management, in emergency situations.

Worldwide there are large, medium, and small cruise companies. They offer cruises on various lines / routes all around the world. Depending on the season, big companies reposition their ships in areas with favorable weather conditions to achieve successful cruises. In the summer season, many companies reposition some vessels on routes in Europe. Among companies that have significant passenger ships in the Black Sea the following are included: *Azamara Club Cruises* founded in 2007 ,and relaunched in 2009, that operates two ships: *Azamara Journey and Azamara Quest*, each with a capacity of 700 passengers, *Regent Seven Sea Cruises, Seabourn, Swan Hellenic, Windstar, Fred. Olsen Cruise Lines* which owns 4 ships (800-1300 passengers each), Holland America Line fleet of 15 vessels with an offering nearly 500 cruises to 415 ports in more than 98 countries, *Louis Cruises* which are operating seven ships, an and bein operattive in Eastern Mediterranean cruises, *MSC Cruises*, which after several years of unprecedented growth, is the market leader in passenger transport industry in the Mediterranean, South Africa and Brazil, *P & O Cruises and Thomson*. The large passenger ships voyages in the Black Sea will include: *Holland America, Princess, MSC Sinfonia and MSC Opera.*

4. CASE STUDY - BLACK SEA CRUISE MARKET

The modern marketing concept is based on the client and not on products. It uses tools to scientifically investigate the market and the consumer needs, for decisions optimization. From of all marketing modern tools we will detail the Black Sea cruises market promoting policy. The most important actions are: online advertising through websites, Facebook and other social networks, specialized articles and advertisements in national and international journals, specially trained agents who go to company for completion and improvement contracts, television and radio commercials, specialized domestic or international trade fairs and exhibitions, working with chambers of commerce. From the authors undertaken studies about the Black Sea cruises recent years market public information (in libraries, on internet, on public professional associations reports, company annual reports of cruise ships, port authorities reports) provided very little information, lack conclusive data, expert studies and reports, which allowed us to draw an empirical conclusion, that, bibliographic research should be intensified or market itself has not yet aroused particular interest for scientific research (Table 5, figures 3, 4 and table 6).

Table 5. Passengers traffic through the port of Constanta in 2008-2013

Year	2008	2009	2010	2011	2012	2013
Passengers	30948	15891	21286	23878	34010	54614
Passagers ships	82	46	58	43	52	69

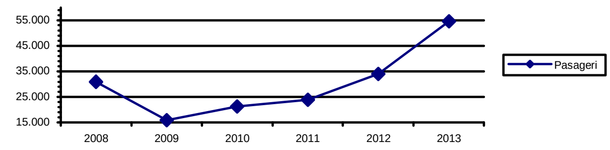

Figure 3 Passengers traffic thought the port of Constanta in 2008-2013

Tabel 6. Passengers traffic thought the port of Varna in 2008-2013

Year	2008	2009	2010	2011	2012	2013
Passengers	20569	12948	7039	11975	10695	2997

In 2014, as a result of the situation in eastern Ukraine, passenger ship companies have changed their itineraries for 2015, seemingly avoiding, in part, ports of Odessa, Sevastopol and Yalta. Instead, some ports in Turkey, Romania, Bulgaria and Georgia are preferred: Amasra, Batumi, Constanta, Istanbul, Nessebar, Sochi, Trabzon (Williamson, J. 2015) (Figure 5).

Figure 5 processed after the main figure from Bulgarian Center for Not-for-Profit Law, http://blacksea.bcnl.org/

The cruise companyes online offers, in the Black Sea for the period 2015-2016 showed that *Amazara Club Cruises* does not yet have a firm offer for cruises in the Black Sea, and other companies have a few offers for the first half of 2015. The Constanta National Company "*Maritime Ports Administration*" SA presents, on its website, the announcement that the port of Constanta has become a port of embarkation on cruise ships, since 2013; also, the website presents the list of passenger ships expected to arrive in 2015 (March to November). Hence, there results that there will be a total of 81 arrivals, of which 72 ships maritime ships (more than in 2013), and 9 river cruise ships, totaling over 110 days of stay in port.

If the number of passengers is estimated according to the type of ships that will arrive in Constanta in 2015 (eg *Prinsendam* ship with a capacity of 740 passengers and 460 crew, ship *Europe* with a capacity of 408 passengers and 275 crew, ship *Costa neoclassic* with a capacity of 1600 passengers and 622 crew, ship *Albatros* with a capacity of 812 passengers and 500 crew, ship *Deutschland* with a capacity of 520 passengers and 300 crew, ship *Silver Wind* with a capacity of 296 passengers and 212 crew, ship *Star Pride* with a capacity of 208 passengers and 164 crew, ship *Seabourn Odyssey* with a capacity of 450 passengers and 335 crew, *Emerald Princess* with a capacity of 3080 passengers and 1200 crew, *Tere Moana* vessel with a capacity of 90 passengers and 60 crew, ship *Thomson Spirit* with a capacity of 1,350 passengers and 520 crew, the ship *MSC Opera* with a capacity of 1712 passengers and 740 crew, ship *Azamara Journey* with a capacity of 694 passengers and 407 crew, ship *SeaDream II* with a capacity of 110 passengers and 95 crew, *Artemis* with a capacity of 1,260 passengers and 537 passenger, ship *Seven Seas Mariners* with a capacity of 700 passengers and 445 crew, *Riviera* with a capacity of 1250 passengers and 800 crew, *Zenith* with a capacity of 1828 passengers and 620 crew, *MSC Sinfonia* with a capacity of 2223 passengers and 710 crew, ship Island Sky with a capacity of 114 passengers, we can calculate with sufficient precision the current value of the cruise market in Romania. According to statistics provided by CLIA we can estimate the daily amount of money spent by passengers and crew when landing in ports, i.e. about 100 Euro. Doing a simple calculation, 110 days spent in Constanta port by 60,000 passengers and 10,000 crew members, result in a total of 700 visitors /day x 100 Euro/day/person and hence the amount spent is 70,000 Euro/day x 110 days = minimum Euro 7.7 million / year, plus port and supply costs. The Black Sea cruise market in 2015 will be about 150,000…200,000 passengers x aprox. 2,000 EUROs/cruise
cost = 300,000,000…400,000,000 EUROs.

4. CONCLUSIONS

The analysis of the Black Sea political changes influence on the cruise industry of the Romanian seaside is a first attempt to a a marketing analyze on the Black Sea cruises market, applied to the Romanian cruise market.

The small amount of information concerning the Black Sea cruise industry, and Romania's cruise market, in general, the limited space allowed by this study impeded a deeper application on this field; further research will be done in the future, in an extended study.

The cruise market, both globally and regionally, in Europe and in the Black Sea, is still in its beginnigs (2-3% of the potential, *CLIA* 2013), but it has a huge growth potential, which must be taken seriously. It should be made known and exploited.

For Romania, represented by government authorities in the field, companies and businesses in tourism and related activities, and also for the educational and professional institutions, it is of great importance to create a national trend of professional approach to this field, with high perspectives, due to its economic value, although some consider this domain a niche one, which is completely wrong.

We propose: the establishment of a national program for the cruise tourism in accordance with the new European policy in the field; development of management and marketing thorough studies in this field, useful for decision-making at the state level, and also in the private business level (our bibliography shows that there is no analysis of the articles on cruises, written by Romanian authors, compared to those signed by authors existing in the whole area of the Black Sea); organizing exchanges at national and local level with representatives of local and central authorities, and with bussines persons, too, from countries and companies with tradition in the field; establishment of modern and efficient campaigns, others than the classical and obsolete on, to promote the touristic values of the Black Sea coast, and of the entire country through tourism exhibitions, and other activities, be them online, to the end of creating attractive routes in the Black Sea, and even in the Mediterranean; now, the port of Constanta port fails to attract annually more than 40000-50000, compared to the Mediterranean ports, where the multiplier indicator is 10-20 times higher). If we only multiply by two the number of passengers and of the days of stay in the Romanian ports, we can reach a significant increase of the revenues, and also, a healthy advertising effect, directly from person to person, for the Romanian business field. Romania must understand and use this opportunity window created in the shipping industry, as a result of new geopolitical realities in the Black Sea. How this issue is (not) understood can seen in the totally inadequate response of the Minister for SMEs, Business Environment and Tourism, given in an interpellation made in the Chamber of Deputies (www.cdep.ro/interpel/2014/r3469A.pdf) on the new EU strategy on maritime and coastal tourism, calling upon a vague national master plan for tourism development in Romania, for 2007-2026 (where they speak on not more than 2 pages, out of 163, about the seaside tourism); reference is made to a project, Odyseea, from 2001, and to support actions, and aspects of cross-cutting European Commission policy, etc.

5. REFERENCES

[1] BOŞNEAGU, R., *Geographic Conditions Influence on the Maritime Trade Routes in the Black Sea Basin (West Sector)*, Cartea Universitară Publishing House, Bucureşti, 2004

[2] BOŞNEAGU, R., *Maritime Navigation*, DHM Publishing House, Constanța, 2011

[3] BOŞNEAGU, R., *Navigation and Marine Equipments*, ANMB Publishing House, Constanța, 2012

[4] BOŞNEAGU, R., COCA, E., C., SORESCU, FL., *World Economy and World Seaborne Trade in the 2005-2013 Period*, The 9th Edition of the International Conference, European Integration Realities and Perspectives, EIRP, 2014

[5] POPA, C., C., HĂULICĂ, D., *Organizarea transporturilor navale*, Editura ANMB, Constanța, 2008

[6] SORESCU, FL., BOŞNEAGU, R., COCA, E., C., *Strategic research on the maritime market*, Acta Universitatis Danubius Administratio, vol 5, no 1, 2013

[7]WILLIAMSON, J., *Cruise Critic contributor*, http://www.cruisecritic.com/articles. cfm ?ID =1288, 2015

[8]http://ec.europa.eu/enterprise/initiatives/cosme/index_en.htm

[9] http://blacksea.bcnl.org/

[10] http://www.cnadnr.ro/proiecte.php?tip=95

[11] http://www.europecruiseexperts.com/ports.aspx

[12]http://ec.europa.eu/maritimeaffairs/atlas/seabasins/blacksea/long/index_en.htm

[13] http://www.qclub.org.ua/en/articles/ru-turciya-i-novaya-energeticheskaya-politika-chernomorskogo-regional/

[14] http://www.iglucruise.com/black-sea-cruises/dates

[15]http://www.portofconstantza.com/apmc/portal/static.do?package_id=lr_con_pasagere&x=load

[16]http://www.mt.ro/web14/documente/strategie/strategii_sectoriale/strategie_de_transport_intermodal_text.pdf

[17]http://www.mt.ro/web14/documente/strategie/strategii_sectoriale/strategie_dezvoltare_durabila_noua_ultima_forma.pdf

[18]http://www.minind.ro/strategia_export/SNE_2014_2020.pdf

[19]http://www.mdlpl.ro/_documente/turism/studii_strategii/masterplan_partea1.pdf

[20]https://www.academia.edu/10341994/Aplicatiile_marketingului_modern_in_transportul_mari tim

[21]http://www.ashcroftandassociates.com/downloads/ECC-Report-2012-2013.pdf-European Cruise Council 2012-2013 Report

[22]http://www.cliaeurope.eu/images/downloads/reports/CLIA_2014.pdf-CLIA's Cruise Industry Magazine – Annual Economic Contribution Report

[23]http://www.cruising.org/

[24]http://www.port.odessa.ua/index.php/en/infrastructure/passenger-terminal

[25]http://www.traceca-org.org/en/home/the-silk-road-of-the-21st-century/

[26]http://www.cdep.ro/interpel/2014/r3469A.pdf

[27]*** UNCTAD Review of Maritime Transport 2011

[28]*** UNCTAD Review of Maritime Transport 2012

[29]*** UNCTAD Review of Maritime Transport 2013

[30]*** UNCTAD Review of Maritime Transport 2014

THE DEVELOPMENT OF SHORT SEA SHIPPING IN THE FRAMEWORK OF EUROPEAN INTERMODAL TRANSPORT

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ABSTRACT

Intermodal transport represents a vital element for the world trade, which tries to integrate in the most efficient way various modes of transport. In order to develop this type of transport, the European Union promotes short sea shipping as a highly efficient form of transport when referring to energy conservation and environmental performance. Within our study we have tried to highlight its importance for the European transport system by presenting a statistical overview of short sea shipping in Europe, as a sustainable part of the intermodal transport.

Keywords: *intermodal transport, sustainable transport, ports, short sea shipping, European transport*

1. INTRODUCTION

When referring to European Union's competitiveness there is a key element that is needed in order to achieve socio-economic and environmental sustainability, an efficient transport system. Taking into consideration that the overall efficiency of a transport system can be accomplished only through a door-to-door transport chain, there was introduced the concept of intermodality. Its main goal refers to the integration between modes that should improve in the end the overall efficiency of the transport systems. The standard definition of intermodal transport according to the UN/ECE 2001, attest that it tries to use the best benefits from every type of transport modes in one integrated transport chain (Flodén, 2007), using at least two modes of transport to transfer the goods in a single loading unit or vehicle.

As roads become more congested and trade increases, most European ports and traders tried to find an alternative to move the goods out of ports and closer to their final destinations. One efficient alternative that was introduced in order to accommodate freight without increasing road congestion was short sea shipping, seen as an essential part of the multimodal European transport system. Studies have shown that intermodality is the key needed to develop short sea shipping, a priority of the European Union transport policy since 1995.

2. LITERATURE REVIEW

Before the definition of the European Union, Balduini (1982) presented short sea shipping as: ”a maritime transport between ports of a nation as well as between a nation's port and the ports of adjacent countries''. Later, the European Commission presented its definition regarding short sea shipping, as the movement of cargo and passengers by sea between ports situated in geographical Europe or between those ports and ports situated in non-European countries having a coastline on the enclosed seas bordering Europe. According to this definition short sea shipping includes domestic and international maritime transport and it extends to maritime transport between the Member States of the Union and Norway and Iceland and other States on the Baltic Sea, the Black Sea and the Mediterranean (Commission of the European Communities, 1999).

According to the European Short Sea Network, short sea shipping (SSS) is the intermodal transport of Intra-European cargo on a door-to-door basis, usually in containers (of 20 ft, 30 ft, 40 ft and 45 ft) or trailers. On brief we can say that it is the movement of cargo and passengers by sea between ports that does not involve an ocean crossing (Johnson and Styhre, 2015).

The European Commission's White Paper “Roadmap to a single European transport area- Towards a competitive and resource-efficient transport system” (COM (2011) 144 final of 28 March 2011) sets some important strategies regarding intermodal transport, for which short sea shipping is a vital component, due to the fact that an adequate port infrastructure and good performance of port services are very important for European Union's growth. The new Trans-European Transport Network also refers to short sea shipping as a key element, especially the Atlantic Corridor one of the 9 Core Network corridors, which sets it as one of its major objectives as an alternative to saturated land routes. The main objective of Short Sea Shipping policy in Europe is built around the “Motorways of the Sea”, which according to the European Transport Policy for 2010: Time to decide, white paper, COM (2001), are door to door regular (with high frequency) services including a short sea leg allowing a significant modal shift from the road (Douet and Cappuccilli, 2011). The “Motorways of the Sea” are seen as a good substitute of the motorway of land, needed to avoid congested land corridors and to give access to countries separated from the European Union mainland.

Many studies were conducted referring to short sea shipping's efficiency, ones that used case studies (Torbianelli, 2000), cost-benefits analysis compared to land-transport modes and its environmental contribution (Lombardo, 2004) and the general European shipping policy (Paixao and Marlow, 2001). Studies have shown that without huge investments in infrastructure and in intermodal transfer points, short sea shipping will not be fully integrated as an alternative mean of freight movement, which in the end could reduce the social costs and the number of trucks which daily congest about 4000 km of road networks (Douet and Cappuccilli, 2011).

3. OBSTACLES AND ADVANTAGES TO SHORT SEA SHIPPING

As stated in 2009 by the European Union, after analyzing the 2003 Programme for the Promotion of Short Sea Shipping, there were identified some obstacles that stops the optimal development of short sea shipping:

- It has not yet been fully integrated in the door-to-door supply chain;
- It requires good hinterland accessibility and also higher port efficiency;
- It involves complex administrative procedures.

In order to overcome these obstacles the European Union has put in place some actions (that describes legislative, technical and operational initiatives such as standardization of intermodal loading units, a guide to customs procedures for short sea shipping, maintaining the efficient operation and guidance of Short Sea Promotion Centers, new routes, construction of infrastructures or feasibility studies) that are aimed at developing its efficiency at EU, national, regional and industry levels, so that it can remain on the political agenda as a key element. Industries are considered to be the most important ones for the implementation of short sea shipping.

There are many arguments that highlight the role of short sea shipping for the European transport system. As stated by the ECASBA (European Community Association of Ship Brokers and Agents), it could represent the most efficient and environmentally friendly mode of transport if it will be used at its full potential.

- First of all its development could help to reduce the growth of road transport and restore the balance between modes of transport, by passing in the end the bottlenecks.
- It also reduces the impact of transport on the environment, promoting a sustainable transport system; its external costs are lower than other mode of transport.
- Compared with inland transport, short sea shipping uses no-cost infrastructure, the sea. In terms of constructions and maintenance, the sea lanes and port infrastructure require smaller investment budgets than other transport mode.
- It is able to reach some regions like Ireland, Norway, regions on the Baltic Sea, the Black Sea and the Eastern Mediterranean that are impossible or difficult to reach by other modes, this is why short-sea- shipping is seen as the leading mode of transport for trade in goods between Eastern and Western Europe (OECD, 2001). It can also contribute to the development of remote and peripheral regions.
- It offers one contact throughout the total door-to-door transport and it is cheaper than road transport and also more reliable.
- Due to its role and to the fact that it develops a logistics business, it requires highly specialized employees; either we refer to shipyards, brokerage, insurance or freight forwarding sectors.

Taking into consideration all this advantages we can say that short sea shipping could offer shippers a rapid, regular and above all secure service, by using standardized equipment (such as pallets or containers) as part of the intermodal transport system (OECD, 2002).

4. STATISTICAL OVERVIEW OF SHORT SEA SHIPPING IN EUROPEAN UNION

Data analysis revealed that cargo volumes in the short sea shipping sector are growing faster than road haulage, short sea shipping currently accounting nearly 40% of all freight moved in Europe and the volumes have increased over the years while the market share has been stable (EC, 2012), with some 10,000 ships operating solely within Continental waters.

The table below shows us that the volume of freight transported by short sea shipping have increased by 12.923 thousand tons yearly. Calculating the growth rate over previous period we have obtained small increases from one year to another and the highest negative value in 2009, due to the effects of economic crisis.

Table 1. Evolution of gross weight of goods transported to/from main ports in EU28 in the period 2005-2013

Year	Unit (thousand tons)	Growth rate over previous period (t/t-1)
2005	2.901.741	-
2006	2.989.144	3,01
2007	3.076.280	2,91
2008	3.105.201	0,94
2009	2.730.655	-12,06
2010	2.876.437	5,33
2011	2.997.159	4,19
2012	2.992.036	-0,17
2013	3.005.125	0,43

Source: [12]

Considering the type of cargo in short sea shipping, table 2 presents a picture of gross weight of goods transported to/from main ports. Liquid bulk goods have the biggest share in total (44,77% in 2013) in comparison with dry bulk goods – 19,54% and large containers – 14,28%. Despite this fact, liquid bulk goods have recorded a rate of decline by 14,48% in 2013 compared to 2005.

Table 2. Gross weight of goods transported to/from main ports, by type of cargo in EU28

-thousand tons-

	2005	2007	2009	2011	2013
Total	1.808.019	1.865.243	1.691.734	1.787.838	1.746.426
Dry bulk goods	352.233	364.340	340.203	359.489	341.352
Liquid bulk goods	914.345	903.814	843.880	829.128	781.966

Large containers	183.425	209.299	196.613	232.203	249.401

Source: [12]

During the present study we stressed the importance of short sea shipping for regions like Ireland, Norway, regions on the Baltic Sea, the Black Sea and the Eastern Mediterranean that are impossible or difficult to reach by other modes of transport.

Having in view the statistical data from the table below, Mediterranean Sea ranks the first place from the sea regions, with an annual rate of increase by 435 thousand tons. North Sea and Black Sea recorded rates of decrease in the period analyzed (-7475,75 thousand tons annually for North Sea and -561,625 thousand tons annually for Black Sea).

The differences between the trend of evolution of these sea regions in the period 2005-2013 can be observed better in a graph (see the figure below).

Table 3. Gross weight of goods transported to/from main ports, by sea region of partner ports in EU28 in the period 2005-2013

-thousand tons-

Year	North Sea	Mediterranean Sea	Black Sea
2005	558.035	566.839	132.957
2006	560.757	570.286	139.025
2007	567.815	592.593	134.886
2008	562.659	596.566	136.656
2009	504.078	571.586	126.753
2010	527.324	580.728	128.050
2011	523.810	552.699	133.599
2012	505.985	577.869	127.479
2013	498.229	570.319	128.464

Source: [12]

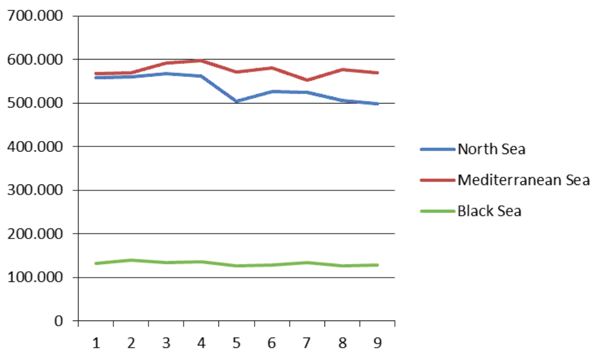

Figure 1. Evolution of Gross weight of goods transported to/from main ports, by sea region in EU28 in the period 2005-2013

A good example of port in North Sea region is Rotterdam, which has developed and promoted strong short sea services. This fact has happened due to its good and frequent connections with other ports and to its efficient handling operations. Also, the port of Rotterdam is a leader in the transshipment of oil products, containers, fruit, coal and so on. It is the most important economic and industrial centres of Western Europe and it can be reached within 24 hours. Scandinavia, the United Kingdom and Italy can be considered part of Rotterdam's hinterland, due to their maritime connections. All these benefits and development stimulate the main goal –"to promote business activities in a European perspective based on the concept of a safe, clean, sustainable port." [13]

5. BEST PRACTICE EXAMPLES OF PROMOTING SHORT SEA SHIPPING IN EUROPE

Almost unknown a decade ago, Short sea shipping is a fast-evolving activity; it changes the world of transport and logistics.

In the last years some issues are to be considered:

„- A wave of take-overs and joint ventures among shipping companies has turned some of them into larger and more substantial players.

- The shippers firmly believe in the further development of short sea shipping: they invest in new ships and increase their capacity and range by deploying extra vessels.
- The ports continue to develop their hub function: larger *round-the world* players can only be attracted if they are convinced that their cargo can be conveyed through a network of maritime links".[14]

Short sea shipping is a sustainable part of intermodal transport and more often shippers prefer to use it. A good example of transport modes combination – road haulage, rail, inland navigation and short sea shipping – is the intermodal transport of household appliances for Bosch/Siemens Household Appliances made by ACB group to the UK. The group invested in 72 pallet-wide 45' high cube containers with a special height of 3 meters. Since November 2006 the freight from Southern Germany has increased to 9 containers per day, which is the equivalent of some 2,200 lorries per year.[14]

Another good example is that of the short sea shipping used in the transport of refrigerated freight. European Food Transport (E.F.T.) demonstrates that a short sea-road combination is perfectly feasible. E.F.T. uses ro-ro and ferry solutions for the transport of its lorries. This particular haulier uses short sea services to Helsinki (5 containers a week), to Göteborg (12-15 containers a week), to Norway (4 containers a week) and to the UK (10-15 containers a week). From the United Kingdom empty pallets and end products such as fruit juice are already taken along.[14] So, in this case the synergies between road transport and short sea shipping are beneficial for the preservation of sensible-temperature goods and for their „just-in-time" arrival.

More and more companies activating in transportation field or in other areas of activity, have chosen short sea shipping to avoid the congestion of road transport and to preserve the environment. For example, Hoboken-based construction company Smulders has used short sea shipping to transport 11,000 tons of foundation elements for a windmill park to the Irish Sea.[14] Specially adapted coasters have loaded the heavy elements on the river Scheldt and have transported them to their discharging place.

Shortsea Promotion Center Flanders stated that „in recent years pure hauliers also have found their way towards short sea, in most cases as a consequence of the ever congesting European road network".

6. CONCLUSIONS

The statistical overview carried out in the research on short sea shipping emphasizes that, due to its advantages and the fact that it is a good way of avoiding congestion of road transport and of preserving the environment, short sea shipping is seen as the most suitable mode of transport chosen by shippers. Even if in Europe short sea shipping consists mainly of transport between European countries, it seems to be a good way of performing door-to-door transport.

When referring to long distance it is clear that maritime transport is highly competitive, but for shorter journeys studies have shown that short sea shipping has become the most attractive alternative. By using pallets or containers, short sea shipping offers a fast, regular and secure service to shippers involved in the intermodal transport system.

7. REFERENCES

[1] Balduini, G., *Short-sea Shipping in the Economy of Inland Transport in Europe*, A Report of the Sixtieth Round Table on Transport Economics Held in Gothenburg, Sweden. OECD Publications and Information Centre, Washington, DC (April 1–2), pp. 37–65, 1982

[2] Commission of the European Communities, *The Development of Short Sea Shipping in Europe: A Dynamic Alternative in a Sustainable Transport Chain*, Second Two-yearly Progress Report, COM, Brussels, p. 317 Final, 1999

[3] Douet M., Cappuccilli J. F., *A review of Short Sea Shipping policy in the European Union*, Journal of Transport Geography 19, pp. 968–976, 2011

[4] Flodén, J., *Modelling Intermodal Freight Transport - The Potential of Combined Transport in Sweden*, Department of Business Administration. Gøteborg University, 2007

[5] Johnson H., Styhre L., *Increased energy efficiency in short sea shipping through decreased time in port*, Transportation Research Part A 71, pp. 167–178, 2015

[6] Lombardo, G.A., *Short Sea Shipping: Practices, Opportunities and Challenges*, Transport logistics, 2004

[7] OECD, *Short Sea shipping in Europe*, European Conference of Ministers of Transport (ECMT), 2001

[8] OECD, *The benefits of multimodal transport chains and the growing role of specialised transhipment ports*, Workshop on maritime transport, 2002

[9] Paixao, A.C., Marlow, P.B., *A review of the European Union shipping policy*, Maritime Policy and Management 28 (2), pp. 187–198, 2001

[10] Torbianelli, V.A., *When the road controls the sea: a case study of Ro–Ro transport in the Mediterranean*, Maritime Policy and Management 27 (4), pp. 375– 389, 2000

[11] http://www.shortsea.info

[12] http://ec.europa.eu/eurostat/data/database

[13] http://eurift.eu/index.php/page/EIA

[14] http://www.shortsea.be

LIQUIDITY RISKS

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ABSTRACT

The expectancy theory is a branch of operations research that has as an objective the mathematical approach of,, staying in line/waiting in line" or of the expectancy strings. Concerning risk, the main characteristic of the payment system in real time gross settlement (RTGS) is that it offers the possibility of removing the system risk, which is very important for the central bank for assuring and maintaining financial stability. This result from a daily substantial reduction of interchange displays by implementing liquidity facilities using the "waiting in line" method.

Keywords: *Risk management, liquidity, payment.*

1. INTRODUCTION

The expectancy theory is the main instrument used in studying congestion phenomenon, which appear when the demands number overwhelms the offer. In Romanian language we use the term ''coada" which comes from the Latin word ''coda'' and it means a layout as a string of awaiting requirements. The expectancy strings and the expectancy theory were applied in various areas like telecommunications, traffic control, medical service, air traffic, plane tickets sells. Once the new digital technologies were involved in the banking system this theory is applied in order to make the payment system more efficient.

2. PAYMENT INSTRUCTIONS

The payment instructions are processed in order of arrival. In case of insufficient funds from the settlement account, the payment instruction is ordered in a waiting line, managed by the system. Payments are ordered in the waiting line depending on the class priority attached and on the time they were assigned.

The administration principle of the by-pass line FIFO is respecting the class priority (the system makes payments in chronological order ''first in- first out"; if this is not possible, the bank will make the first following payment for which there are sufficient funds. Payments will not be made from a class priority, as long as in the waiting line there are payments from a superior class). In the ReGIS system, the payment instructions can have priorities between 0 (the lowest level) and 99 (the highest level). The priorities from 51 to 99 are defined by the system for specific purposes and they cannot be assigns by the participants. The participants, except the organizers that provide compensation and discount services, can assign process priorities between 0 and 50, for the instructions processed by them.

The payment instructions initiated for BNR by the participants have priority number 57. A very important aspect in analysing the ways and the solutions chosen for implementing the waiting lines is represented by the possibility to cancel the instructions that are at the end of the waiting line. During the operation day, the central bank, as a system administrator, can decide to cancel any payment instruction from the end of the waiting line, if the initiator participant requests so. Exceptions to this rule are the payments instructions initiated by the organizations that provide services of discount and compensation. Their payment instructions cannot be cancelled from the waiting line at the request of the initiator participant.

3. THE UNLOCKING MECHANISM

Another very important aspect concerning the implementation method of the waiting lines consists in the fact that the electronic payment system has an adequate algorithm of detecting and solving the "gridlock" situations. When it comes to the discount of the payment instructions of certain participants, the ReGis system assures an automatically breakout that follows the concomitant discount of as many as possible instructions of certain participants

The unlocking mechanism can be released in a manual manner by the central bank in its administrative quality system. For this purpose, BNR is monitoring the discount accounts and the payment instructions situation of each participant that stands in the waiting line.

4. ASSURING THE RISK MANAGEMENT

In the gross settlement system, ReGIS, the risk management is assured by:

a) Providing intraday liquidity based on guaranties as government securities;

b) Monitoring the system by competent authorities and adopting the necessary measures.

In order to provide an efficient liquidity management, the ReGIS system offers to the participants a series of facilities that are meant to assure the framework and the tools for a proper management of their own liquidities and of the financial risk that may come, such as:

- The liquidity facility during the day given by the National Bank of Romania that offers the participants the possibility to obtain credit intraday in order to smooth the discounts in the ReGIS system
- The waiting in line mechanism, which offer the participants the possibility to allocate the payment

instructions that were developed in the ReGIS system processing priorities suitable for their own needs

- Facilities for fund reservations, in order to assure the discount of the payments priorities that were initiated by compensation and discount systems, funds that are blocked until the participants have the possibility of building anytime during the operation day a general and cash reserve, for a better management of their own resources and cash operations
- The mechanism of solving gridlocks which helps to unlock the payment instruction discount of two or more participants that are in the waiting line due to the lack of funds in the discount accounts of those certain participants
- Facilities for discount accounts miniaturisation in real time. In order to obtain the necessary information for a better management of their own resources, this allows the participants to manage their own activities, offering them information facilities in real time concerning their cash accounts situations.

Concerning risk management in the net settlement system, we must take into account that the majority of interchange payments are developing through this system which proved to be the most efficient.

The risk management in net settlement system can be achieved by:

a) the existence of a hedging system of risk;

b) monitoring the system.

The hedging system of risk is based on guarantees development of the participants in favour of ACH government securities systems, SaFIR, and through the voluntary reservation of liquidities for discounting the net amounts resulted from the compensation made through ACH. The participants can send for compensation, for every cycle, payment instructions, so that the payment amount won't overcome the guarantees level established by the system. Using this guarantee scheme we can make sure that the multilateral net debit position of each participant is covered in every moment by the guarantee cap developed by certain participant.

5. THE FINAL DISCOUNT

The final discount of the net dispositions of the participants will be achieved through ReGIS.

There will be 3 compensation cycles per day in order to deliver liquidity in ReGIS necessary to the final discount and necessary for reducing the levels of guarantees required

The guarantee cap is calculated in SENT on communication data by the ReGIS and SaFIR , as an amount between two guarantees:

a) as blocked funds in the SENT reserve from the ReGIS system;
b) as eligible financial instruments in the SaFIR system

Systems as ReGIS and SaFIR are communicating with this values for every session as a response to SENT.

The guarantees are disposed by National Bank of Romania as a discount agent, by each participant, and they can only be used for discounting their own net debtor position.

Concerning risk management in the third subsystem of the electronic payment system we must highlight the fact that the first mechanism of managing risks is the mechanism based on the principle "delivery against payment". Its implementation is based on the interdependence between the fond transfer and the financial instruments fond.

This way, the final transfer of the financial instruments takes place only if the final transfer of funds can be made. A way of reducing risk is the real time discount model by eliminating the extra processing time, restricting the risk of unfortunate events that make the discount process to "stumble". Also, the gross discount settlement eliminates the uncertainties on legal and operational matter.

Among the mechanisms described above we can add the discount caps for the participants that don't have a discount account in ReGIS system, the ,,waiting in line" managing system .

The credit institutions that take part to the SaFIR system have the possibility to take from the National Bank of Romania the necessary liquidity during the day for continuing the discounts in this system using repo operations.

6. CONCLUSION

In practice, the expectancy theory is especially used to highlight the dysfunctions inside of a functional system and its purpose is to correct the system functioning by showing the values that must be achieved for reaching a satisfying level of performances.

5. REFERENCES

[1] Basno, C., Dardac, N., „Management bancar", Ed. Economică, Bucureşti, 2002

[2] Cristea Viorela- Georgiana, Olteanu Ana Cornelia, (2012), "Price stability", Analele Universităţii Maritme din Constanţa, Volume 18, pp. 327-330, ISSN 1582-3601

[3] Dănilă, N., Anghel, L., C., Dănilă, M., I., „Managementul lichidităţii bancare", Ed.Economică, Bucureşti, 2002

[4] Dedu, V., „Gestiune şi audit bancar", Ed. Economică, Bucureşti, 2003

[5] Mihai, I., „Tehnica şi managementul operaţiunilor bancare", Ed. Expert, Bucureşti, 2003

[6] Olteanu, A., „Management bancar – caracteristici, strategii, studii de caz", Ed. Dareco, 2003

[7] Stoica, M., „Management bancar", Ed. Economică, Bucureşti, 1999

PREPARING FOR CONTROL DATA CONCERNING PAYMENT OBLIGATIONS TO THE STATE BUDGET

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ABSTRACT

When referring to the budget process in Romania we need to highlight the importance of the Constitution and the Law of Public Finance, the one that underlies this process. This act includes all activities related to the budget process including the elaboration of the draft budget, approving the state budget, budget execution and budget control. As stated in this paper the budget process in considered a cycle one, that contains data collected through the Declaration on payment.

Keywords: *State budget, payment, taxes.*

1. INTRODUCTION

The preparation for control of the declared payment obligations to the state budget data is made by consulting the Order of the President of the National Agency for Fiscal Administration nr. 101 form 21st of January 2008 concerning the approval of content and model of forms used for declaring taxes and contributions with a self-assessment regime.

The Declaration on payment obligations to the state budget can be completed and submitted by the tax-payer who have this kind of obligations specified in the Nomenclature of payment obligations to the state budget.

2. RESPECTING NOTIFIABLE CONDITIONS

The declaration term of the payment obligations to the state budget differs depending on types of obligations:

Monthly – until the 25th day of the current month, representing:

- With holding tax according to the legislation concerning personal income tax;
- Salary income tax;
- Tax on income from intellectual property rights;
- Tax on financial accounting expertise, on juridical and extra juridical expertise;
- Tax on incomes that come from activities performed under civil contracts concluded according to the Civil Code;
- Tax on incomes from activities performed under contracts of agent, commission or commercial mandate;
- Tax on income from dividends distributed to individuals;
- Tax on interest income;
- Tax on pension income;
- Tax on income from prizes and gambling;
- Tax on income from transfer of real estate from the personal property;
- Other income tax on individuals;
  - ➢ tax on crude oil from internal production;
  - ➢ tax on dividends distributed to legal entities;
  - ➢ tax on incomes obtained from Romania by non-residents, individuals or legal entities;
  - ➢ payment shall from legal entities for disabled individuals;
  - ➢ social stamp tax on gambling;
  - ➢ social stamp duty on imported new vehicles with a minimum displacement of 2000 cm.

Payments can be made quarterly until the 25th day of the month following the reporting period for payment obligations, representing:

- Prepay in annual income tax, owed by banking companies, Romanian legal entities;
- Income tax, payable by Romanian legal entities;
- Income tax from associations, owed to individuals;
- Income tax owed by foreign entities, other than the ones mentioned above:
  - ➢ income tax owed by foreign entities that are developing their activities and have a permanent location in Romania;
  - ➢ income tax, from associations without legal personality;
  - ➢ income tax, owed by foreign legal entities that sell or assign real estate properties located in Romania.
- Microenterprises income tax;
- Income tax on microenterprises that come from associations, owed to individuals;
- Salary income tax;
- Mining and oil royalties;
- Tax incentives stipulated in art. 38 of 571/2003 law;

Another option to make payments is the half-yearly payment, until the 25th day of the month following the reporting period for the obligations of tax payments on income from wages and withholding tax.

Other terms:

- Until December 25 of the current year for tax payment obligations representing the activity of prospecting, exploration and exploitation of mineral resources;
- Until the 25th of the month in which the payment obligation is provided, for gambling tax;

- Until the 25th of the month following the month in which the legal deadline for submission of the balance sheet is provided, if the special law doesn't provide otherwise, for the payment obligations – representing payments shall from the net profile of autonomous administrations , national companies and firms;
- Until the payment deadline stipulated by law, for the next payment obligations:
  - Tax on dividends, tax on dividends, if the dividends distributed were not paid by the end of the year in which annual financial statements were approved;
  - Tax on interest income, for incomes based on civil contracts;
  - Tax revenues from the liquidation of legal entities;
  - Tax on the gain from transferring legal property rights over securities, in case of closed companies.

The declaration concerning payment obligations shall be submitted to the tax authority in whose fiscal record the taxpayer is registered. The declaration concerning payments at the state budget is completed using the assistance program.

The form is submitted on paper format, signed and stamped as the law provides, encoding the information with the barcode.

Large taxpayers submit the form via electronic means of distance transmission through national electronic system, as the law provides.

Taxpayers who own a digital certificate can submit the form via electronic means of distance transmission, on the Ministry of Economy and Finance site, National Agency for Fiscal Administration portal.

3. CHECKING THE REPORTING PERIOD

The obligation month number is checked, or the number of the last month of the reporting period (eg.: 01 for January or 03 for the first quarter). Also the year for which is completed the statement is checked.

4. VERIFICATION OF PAYER IDENTIFICATION DATA

The taxpayer that is preparing for future control actions is checking the fairness of the tax identification code assigned to him, as the law provides.

The name of the payer is checked, along with his address.

5. PREPARING DATA CONTROL FOR TAX RECEIVABLE

For every tax in the Nomenclature of payment obligations, for which there are declarative obligations in the reporting period, must be completed in the same form a table generated by the assistance program, registering amounts representing the obligations established in the reporting period to which the return relates, in accordance with the instructions below.

The payment obligations that were wrongly declared in the form can be corrected.

Preparatory aspects in order to verify the control accuracy will consider the following types of data:

- Name of the payment obligation, according to the Nomenclature of payment obligations to the state budget;
- The amount owed that represents the tax in the reporting period;
- The payment amount;
- The amount that must be recovered
- Total payment obligations;
- Amount representing payment obligations to the state budget for the reporting period, respectively the total amounts claimed for each tax.

6. SPECIFIC ASPECTS OF DATA VERIFICATION CONCERNING VARIOUSTYPES OF TAXES

For the taxes that can be found at 1,5-32 and 35 positions in the Nomenclature of payment obligations to the state budget, the taxpayer must verify the correctness of the following data:

- The amount owed, representing the amount of tax during the reporting period;
- The payment amount.

For prepayment in annual profit tax account, set to position 1in the Nomenclature of payment obligations to the state budget, the 100th form must be completed quarterly periods of time in accordance with art. 34 of Law 571/2003, with the specific modifications, as it follow:

- The amount owed, amount representing a quarter of the income tax due for the previous year;
- The payment amount.

For the taxes that can be found at 2-4 positions in the Nomenclature of payment obligations to the state budget, aims accuracy of the data on:

- The amount owed. This amount represents the income tax due for the reporting period, calculated as the difference between the income tax due to cumulative from the beginning of the year and the income tax due;
- The payment amount.

The following taxpayers don't complete the form:

- Non-profit organizations;
- Taxpayers who derive income mainly from cereals and industrial crops, fruits and viticulture.

Just in case the payer of income is not a Romanian legal person, the obligation of declaring the income tax goes to the foreign legal entity that derives the income mentioned in para. 1 of Art. 30 of law no. 571/2003.

In case the tax payer is a Romanian legal entity, the payment obligations belong to the income tax payer. In case of associations without legal personality, the amount that must be recovered is checked, meaning the amount representing recoverable income tax for the reporting payment period.

7. CONCLUSIONS

As a conclusion, we consider that the state budget is an important element referring to Romania's economy, due to the fact that it appears as a financial action plan of the state.

8. REFERENCES

[1] Ord. Presedintelui ANAF NR.101 DIN 21.01.2008
[2] Codul Civil
[3] Legea 571/2003 privind Codul fiscal
[4] O.G. 64/2001 privind repartizarea profitului
[5] Legea 769/2001, cu modificarile si completarile ulterioare, prevazuta la pozitia 32 din Nomenclatorul obligatiilor de plata la bugetul de stat
[6] Ord MFP 600/2004

THE CONNECTION BETWEEN PREVENTIVE FINANCIAL CONTROL AND BUDGETARY EXECUTION

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ABSTRACT

Budget execution is the process of monitoring, adjusting, and reporting on the current year's budget. In every country, including Romania, this task must be accomplished by the Government, more exactly by the minister of finances. The concern on legal administration and performance of public resources determinates the government to take measures for perfecting financial control on intern public funds and on extern funds.

Keywords: *Expenditure, financial control, payment.*

1. INTRODUCTION

Taking into consideration both the requirements of the European Union and of the International Monetary System, the World Bank, the European Bank and OECD, in Romania there was adopted for all public entities the accrual accounting system in the public sector.

One of the measures that our government took at the beginning of 2003 was to determine public institutions to respect the four stages of budget execution, more exactly the commitment, validation, order and payment of expenditure, and also to organize, to lead and to report the budgetary and legal arrangements.

The four stages of budget execution are presented in the table below, which shows their similarity in three different groups of countries (commonwealth, francophone and transition economies), taking into consideration their specific terminology.

Table 1. Stages of budget execution

Stage	Commonwealth	Francophone	Transition Economies
Commitment	Contract signed, order placed. Information not recorded in central accounting system.	Contract signed, order placed. Authorized by the ministry of finance or financial comptroller.	Order is placed, often no contracts. Typically no record is made at this stage.
Validation	Bill is received. Work is verified as complete or supply delivered in full.	Bill is received. Work is verified as complete or supply delivered in full.	Bill is received. Work is verified as complete or supply is delivered in full. Some use of preaudits by control departments.
Orders	Treasury processes orders and issues checks; or done directly by line ministries.	The specific part of the Ministry of Finance and Economy, processes orders and issues checks or an entry is made in deferred payments account.	Unless system has been reformed, the central bank processes payment orders and transfers are made between accounts electronically. No issuing of checks.
Payment	Checks are cashed.	Checks are cashed.	Not applicable.

Source: International Monetary Fund

The Ministry of Finance elaborated methodological procedures which, despite the fact that it refers in detail at the modalities of implementing the obligations mentioned in the public financial law, it creates lots of difficulties in applying them which made it difficult for public institutions, even after four years, to understand very well how to apply them.

Anyway, there are many workers in the domain that claim simplifying the procedures, the number of documents that must be written and the number of persons that contribute.

In our opinion, the regulation from 2002 (Public Financial Law and the Ministry of Finances order Nr. 1792/ 2002 for approving the methodological norms that refer to faze evidence of the budgetary execution) has positive sides but it also has some week points that makes it inefficient.

The bright side consists in involving more persons or responsibility factors in exercising preventive financial control, preventing and following, evidencing and reporting obligations that conduct to a higher responsibility on spending public funds.

We must agree on the fact that a much to bigger number of paper work that must be drawn for every payment operation, the necessity to assure the proper staff that must take part at the budgetary execution and the variety of interpretations of the treasury units on legal clauses – aren't helping the budgetary execution process.

Which is the connection between preventive financial control and budgetary execution phases? How can this positively influence the quality of growth of the budgetary execution process? If the preventive financial control, but also the concomitant control and the subsequent control are implied in the unwinding of the budgetary execution phases, the quality of this process will grow.

2. COMMITMENT OF EXPENDITURE

The first phase of the budgetary execution is the commitment of expenditure, which, according to law, it represents the beginning of institution commitments spread in two phases: the legal commitment and the budgetary commitment which are global and individual.

By legal commitment we understand any document with juridical effect from which it results or it could result an obligation on public funds or public patrimony (laws, contracts, other juridical laws).

The budgetary commitment represents the administrative procedure which reserves the budgetary credit for full payment of a payment obligation that results from an ulterior execution of a legal obligation.

When we talk about the global budgetary obligation we must take into account that this is a budgetary obligation associated with a legal commitment which relates to current functioning administrative expenses, like:

- Travel expenses;
- Protocol expenses;
- Maintenance expenses;
- Assurance expenses, etc.

In contrast with those, the individual budgetary commitment refers to a commitment specific to a new operation that is to be made. The commitment of expenditure considers documents with legal value that give obligations to the organizations or institutions.

Those documents that hire the institution in making commitments must receive the acceptance of the preventive financial control.

According to law, the control object in this phase is having budgetary clauses and account reserves. Otherwise, law sanctions the commitment of expenditure if those conditions are not respected.

Therefore, the connection between preventive financial control and the commitment of expenditure phase is direct – so that any organization commitment – legal or budgetary – must be controlled on the objectives of preventive financial control.

3. VALIDATION OF EXPENDITURE

Validation of expenditure is the second phase of the budgetary execution in which the existence of commitment is verified, the amount of sum that must be paid back is checked and the conditions in which the legal commitment is made is also verified, based on the supporting documents that validates the operation.

As a rule, for this activity are named different persons from those who are implied in giving approval for preventive control. A signature of the person responsible with checking the fulfilment of requirements asked by validation of expenditure is also required.

4. EXPENDITURE ORDERS

Expenditure order is the budget execution phase where delivery of goods and payment of other debts are confirmed so that the payment can be made. These objectives must be followed, according to law, by the persons who signs the document named ,,expenditure order”.

Because of the fact that the approval for the preventive financial control is necessary for every payment operation, the expenditure order must be prepared in every case where we have payment operations.

This procedure implies an extra work volume, insistently reported by the domain workers, which is not always justified, especially when we take into account medium and small entities that make payments with values that are not significant enough to make preventive control necessary.

That is why, in this situation, we believe that is important to let the credit release authorities to decide the value limits that determine the necessity of receiving the acceptance regarding preventive financial control.

5. EXPENDITURE PAYMENT

Expenditure payment is the final phase of the budgetary execution. In this phase the public institution is released by its obligations to creditors. The expenditure payment is made by authorized persons, that, according to law, are named accountants. They have the obligation to make payments in the limit of budgetary credits and in the limit of destinations approved by legal dispositions through treasury and public accounting units. Exceptions to the rule are payments made in currency by banks or other payments that, according to legal dispositions must be made through bank. These payments can be made by the accountant only if the documents and operations respect certain conditions.

Those conditions are:

- The expenditures that must be paid went through all the budgetary execution phases;
- There are open or assigned budgetary credits or cash in escrow accounts;
- The approved budget subdivisions correspond to the nature of expenditure concerned;
- All the supporting documents that justify the payment exist;
- The signatures on the supporting documents belong to the credit release authority;
- The amount beneficiary is the one entitled, according to the documents that certify the service performed;
- The amount owed to the beneficiary is corrected;
- The documents are prepared with all the data the form requires;
- Other terms required by the law.

The law also establishes concrete conditions in which payments cannot be made, as the following situations:

- When there are no open or assigned budgetary credits or there are insufficient funds;
- When there is no confirmation of the performed service and the documents are not approved for a “good payment” situation;
- When the beneficiary is not the one for whom the institution has obligations for;
- When there is no approval for the preventive financial control on the order of payment and

the authorization the law demands is also inexistent.

The person that has the power to give approval for preventive financial control is usually the head of financial accounting department or the financial director. This authorized person that gives the approval for the preventive financial control is, according to law, in an incompatibility situation if he makes payments that were approved by the preventive financial control that he also performed.

As a result, the payments must be entrusted to others that are authorized to give preventive financial control approval so that it can be made an objective examination of the documents and situations.

The head- accountant or the authorized person that is entitled to give approval for preventive financial control wants to find out if the objectives provided by law are performed.

We believe that the person who makes payments should not be the same person that gives the approval for the preventive financial control in order to avoid a possible subjective interpretation. A proper person for this operation could be the head of financial accounting department.

On the other hand, the responsibilities that this person has must be simplified and reduced to the real level of his practical possibilities of decision making.

In practice, it was very easy for the law courts to sanction, unjustly sometimes, this kind of persons that had no decision power in their units, but had overwhelming responsibilities established by our relevant legislation

6. CONCLUSIONS

As a conclusion, we consider that, if the only responsibility for the person that makes payments is to verify the signatures of all persons that are implied in the budgetary execution process and in the preventive financial control, the superposition between the assignments each person has would vanish, the process would be more clear and the time spend to complete all the phases would be less.

5. REFERENCES

[1] DOMNISORU S., *Audit statutar si comunicare fianciara*, Editura Economica, Bucuresti 2011

[2] FLOREA I., CHERSAN I.C. , FLOREA R., *Controlul Economic Finaciar si Gestionar*, Editia A II-a, Editura CECCAR, Bucuresti, 2011

[3] International Monetary Fund, https://www.imf.org/external/pubs/ft/expend/guide4.htm

[4] Legea nr. 500/2002 – Privind Finantele Publice

[5] MUNTEANU V., *Control si audit contabil*, Editura Luminalex , Bucuresti 2003

[6] O.U.G. nr. 146/2002, Ordonanta de urgenta privind formarea si utilizarea resurselor derulate prin trezoreria statului, republicata 2008

[7] O.G. 119/1999 – Prvind controlul intern si controlul financiar preventive

[8] ORDINUL MFP nr. 522/2003 – Control Financiar Preventiv

[9] Regulamentul financiar nr. 1605/2002 al Consiliului Europ

[10] TIRON TUDOR, ADRIANA, *The Reform of the Romanian Local Public Governments Accounting in the Context of the European Integration* (April 2, 2006). Available at SSRN: http://ssrn.com/abstract=924100 or http://dx.doi.org/10.2139/ssrn.924100

MEASURES OF TRANSFORMING SUMMATIVE ASSESSMENT IN FORMATIVE ASSESSMENT IN EVALUATION STUDENTS ACTIVITIES IN CONSTANTA MARITIME UNIVERSITY. CONSIDERATIONS ABOUT FORMATIVE FEEDBACK

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ABSTRACT

Traditionally and within theoretically approaches, examiner's report on courses' final exam in the universities consists of two components: firstly, there is a summative assessment where a judgment is made about whether the thesis has met the standards established by the discipline for the award of the degree; second there is a conception about the development and the formative aspects of the exam, where examiners provide feedback to assist the students to improve their learning tasks. The main objective of this paper is to determine if periodically exams of students are primarily assessment or feedback? In this paper we used term feedback referring on the trajectory of reports professor-student, in an effort to distinguish it clearly form summative assessment. Our small-scale study of four examiner reports aimed at identifying the nature of examiners' reports and whether the reports provided primarily summative assessment or feedback.

Keywords: *feedback, assessment, evaluation process, quality in education*

1 THEORETICAL BACKGROUND: ASSESSMENT AND FEEDBACK

Educational process and training processes could not be evaluated and focused on performance without feedback. Feedback is considered the most important factor within the learning process (Clynes and Raftery, 2008). Without feedback, the chances that student to progress, to close the gap between current and desired performance and to attain the level needed to become a member of the academic community are lower (Strake and Kumar, 2011).

A stronger focus on feedback would improve, for all stakeholders involved in the educational process, the quality of the higher education.

We built out some literature review investigations regarding to the definitions and interpretations of feedback. Usually, the common definition is that feedback is an interactive process which aims to provide learners with insight into their performance.

Notwithstanding the evidence that feedback is a determinant component of the student learning process we made a review of the literature reveals regarding barriers to giving and receiving feedback, personal relationships between professor and students and how the preparing feedback process looks.

There are some factors which influences the understanding the student response to feedback. Students self-esteem, relationships in the workplace and the expectations of the learners, are factors which influences the receiving of feedback (Young, 2000). Teachers as trainers need to be cognizant of the relationship between self-esteem and receipt of feedback. Studies relate that students with high self-esteem have the ability to appreciate constructive comments and understand that the information relates to performance. Conversely students with lower self-esteem tend to interpret constructive messages as negative communication strokes and perceive them as personal messages.

One of the main consideration in communication is that given feedback is not always the same with the feedback received (Eraut, 2006; Koh, 2007). The information that professors regards as a comment on performance may be perceived by the student as a personal slight. In order to assess how the information has been received by students during feedback session, it may useful to have a summary discussion during which students are encouraged to reflect on the feedback and to outline their interpretation into this context. The relationship and the category of stimulus transferred between the sender professor and the receiver teacher are influenced by the relationship between two of them. When students respect and appreciate the professors' activity, they are likely to value the information (Giilespe, 2002). In addition, this type of relationship professor/student may encourage the student to seek feedback regularly. Jerome (1995) describes feedback process as delivering in four different stages. Initially, teacher and student have to work together to establish learning objectives as feedback will eventually based on these. Wherever professors have to deliver negative feedback, they have to use sandwich technique (Dohrenwend, 2002). This method consists of providing negative feedback sandwiches between two specific pieces of positive feedback. The method consists of providing negative feedback sandwiched between two specific positions of positive feedback (Clynes&Raftery, 2008); is particularly useful when working with junior students and with students with low self-esteem. In an effective communication between professor and student it is not always essential that all praise and criticism needs to be sandwiched and on occasion it may be more appropriate to offer praise and criticism independently. Mature students do not appear to be overly concerned with the manner in which feedback is given; younger students, regarding to studies, seem to be more sensitive to criticism. Wiggins (1998) describes the importance of the specific character of feedback: being well descriptive and actually occurred. Information presented to students should be clear and offered in terms of specific targets and standards. Feedback should focus on evaluating behavior and work performance and not on the students different characters (Russel, 1994; Dohrenwend, 2002).

The process of delivering feedback is considerably easier for the professors' activity, when the student identifies their own practice limitations (Clynes, 2004). That's why student's should implement their own self assessment before giving feedback; we should not underestimate in educational process students' ability in evaluating their own performance. The process of delivering feedback is always easier when students identify their own theoretical and practical limitations.

1.1 Assessment and evaluation process activities in relationship professor-student. Summative assessment

Examiners may consider the examination as a gate keeping task or/and as an opportunity to provide developmental experiences to the candidate. Examiners encourage developmental experiences in the form of feedback (Kiley, 2009) and usually make a summative judgment within the examination process. Professors prepare in evaluation activities a summative assessment where examiners make a judgment as to whether the thesis has met the standards established by the discipline and the university in order to award of degree. There is another important element in activity professor-student, a development and formative one, where examiners provide feedback to assist student to revise and improve his work in future evaluations (Strake&Kumar, 2011).

A conceptual definition of assessment refers to how much learning has taken place as a result of teaching (Gibbs& Simpson,2004; Kumar& Stracke, 2011). Assessments are considered learning outcomes, which are whether the outcomes meet the standards that have been established. In this sense, assessment provides information about a performance. The performance standards are usually listed as assessment criteria or usually classified as guidelines for examiners. Examiners verify if certain learning outcomes have been met. One of the learning outcomes of the students is the capacity to make an original interpretation of the course's information and to consult scientific literature indicated for the course. If the student has promoted this criterion, the assumption is that the objective of this outcome has been met. Even if the examination criteria are made available to the examiners, examiners may interpret the criteria based on their own scholarly understanding and interpretation. These elements are influenced by the notion of hidden curriculum by which examiners assess the learning outcomes. Professors should be evaluated on the atmosphere they create in the classes and the degree of trust they have established with their students. The hidden curriculum of an university starts in each individual class. Faculty should have the opportunity to discuss their school's hidden curriculum at length, as a whole group, because it will bring them closer to alignment with their core ethical values and agreed practice on the ground.

Another different conceptual understanding of assessment emphasizes the view of assessment as educational measurement; it has been developed the concept that assessment is a measure of competence. The notion of assessment refers to any appraisal, whatever we call it judgment or evaluation (Sadler, 1989), and it supposed to serve two purposes: summative and formative.

Summative assessments are those assessments given at the end of semester/program or mid-semester with the sole purpose of grading or evaluation progress. Summative assessment indicates to professors and students if the learning goals have been achieved. If we report results of summative assessment to performance, is a passive measure of improving performance, because it doesn't have a direct impact of learning (Sadler, 1989).

In contrast with summative assessment there is formative assessment, which is given with an opportunity to direct improve the task of learning. Formative assessment incorporates different components:

- Diagnosis students difficulties
- Measuring improvement over time
- Providing information to improve tasks of learning.

One of the main objectives of this article is to improve students' assessment in Constanta Maritime University and to transform summative assessment in a formative one; formative assessment is active in the sense that it triggers and provides a sense of direction to achieve learning goals. The distinction between summative and formative evaluation could be very clear interpreted: summative assessment make a judgment call on learning outcomes while formative assessment provide a sense and a direction to achieve unattained goals.

1.2 Formative assessment/feedback in students' evaluation process

One of the proper interpretation of the feedback is that provides developmental experiences and encourages self-regulated learning. The main aim of feed-back is to reduce discrepancies between current understandings, performance and a goal.

Feedback is a fundamental aspect of teaching and learning. Authors like Rowntree (Rowntree, 1997) describe it as "lifeblood of learning". One of the aims of this article is to outline the nature and the importance of feedback in formative learning environment.

Formative feedback in exam's evaluation of students is an unbiased, analytical reflection of what was occurred. Both formal and informal methods of delivering feedback to the student exist. Ideally a combination of these methods should be used in order to ensure offering of correct information. One informal method of feedback is to on-the-spot comments, which are made during practice. These could be used especially for the practical aspects which were evaluated by professor. We can call this opportunistic feedback, which is a vital experience for the formative learning experience.

A second informal method of feedback provided by the professor is general conversation with students away from the job. While this technique may enhance collegiality, its value is uncertain.

The distinction between summative and formative assessment is clear: summative assessment makes a judgment call on learning outcomes, while formative assessment provides a sense of direction to achieve unattained goals. If the information which professors send to students has a direct impact on the learning tasks established within the analytical program of the discipline, it can be considered feedback or formative assessment. If information sent by professors does not have an immediate impact on learning, it is summative assessment. So, we can define feedback as a trajectory move towards attainment of a learning goal.

In our study, we proposed to improve formative feedback in the students' evaluation process within Constanta Maritime University. The central goal is a proposed data base, accessed by each students, where they can find the summative assessment for each discipline and advices for improve quality of learning, starting from the learning tasks which haven't been reached. (o fraza de legatura cu testele).

John Burton defines a series of eight human needs that are based on the idea of feedback from others. The human needs are :

¬ need response from others (and therefore consistency)

¬ need for stimulation

¬ need for security

¬ need for recognition (by the individual obtain social confirmation that the his reactions to stimulation coming from the company are relevant and approved)

¬ need specific judgment (not enough that the answers it receives only individual to be consistent , they must be consistent with the experiences and expectations)

¬ need to be perceived as a rational person (which stems from the need for consistency of response that an individual receives from others , rationality points out that there are the others need a consistent behavior)

¬ understand the need for consistent response received

¬ need for control

Based on Maslow 's idea that the threat of unmet need creates considerable tension in the individual , to imagine what can cause in organizational neglect by both the employer and the employee of these human needs based on feedback .

People are attracted to the idea of the whole, complete, will understand the events that happen every day and have principles that gives order and therefore predictability. The activity of a component depends not only employed "to do", but component "evaluate" and "improve".

If you work out an employee is not evaluated and the result of evaluation is not communicated in a comprehensive manner the employee, it may experience a voltage generated by unmet need for response from his boss. If this lack of response persists, depending on personality, the employee may manifest as: outbreak ("explosion") or toward the attack itself inwards ("implosion ").

In both cases we are dealing with a frustrated employee who , over time, can become very irritable (without being able to name the exact cause of his state of irritability) and that will end the relationship with the employer or organization physically leaving or staying , but " absent " from the point of view of its participation (especially of the creative) .

Lack feedback place an employee in a state of stagnation confused he does not know if his efforts are adequate enough or if there are necessary for the boss to notice .

When the employee receives feedback, whether positive, negative or neutral, it is already placed in an environment more secure than when the feedback is not known. He feels free to choose his next move and has the feeling of belonging to a transparent working environment, the predictability of actions do not free feed the tension/stress. The idea of feedback inhibition may create unjustified. Many who should provide feedback forget or do not understand that feedback means a sentence like: "You did a great job! Thank you! "Or "During the meeting, you made the transition from one topic to another, not sure if anyone has additional comments made", and concludes that result from the complex evaluation process. It is very important for the employee to feel that his work is recognized in any form and that this recognition has continuity.

If repeated , the employer shall give his employees positive feedback , it should lead naturally and a gratification of his efforts , expressed as a change of function, by assigning new responsibilities and increased compensation or even form of performance-based bonuses .

Without this continuity of feedback, not estimated employee may feel ignored or even useless for the company where they work. It is true that it is very difficult to give negative feedback and also it is hard to get.

Most times, the poor performance of an employee can have many causes and both partners in question must be aware of this and, if possible, eliminate them.

There is, however, a solution to avoid negative feedback if it is just for avoiding stagnation means, and this hinders the development of solving / improvement.

Feedback should be provided when performance is of a certain level, be it negative or positive. There are employees who, in the absence of feedback, especially in the absence of negative, imagine that their work stems from the standards required by the employer.

It's a lack of respect for the employee to claim at the end of a year of activity, the performance was low, as long as during that year no one warned about the quality of his service. Speaking of feedback, talk about attention that an employer knows or not to grant his employee and thus attention manifests or employee to employer.

The employee becomes increasingly "invisible" for the employer; the chances of it to seek satisfaction of this need to be noted in another company grow.

Most times, chiefs defend against this threat through lack of time, her business paying more attention to itself than its people.

Here the need for formative evaluation, feedback, is present not only in assessing the student teacher, but also the management processes in relations manager – subordinate.

2.PERFORMANCE MEASUREMENT IN TEACHING PROCESS

2.1. Assessment in the Educational Act

Assessment, within the instructive-educational process, is necessary to be considered an attempt to know own students, to find out the nature and the quality of what they learn, strengths and weak points of the educational act, but also students' aversions and interests or even their style to learn. From here we can interpret that the result of the assesment represents knowing of the student. The way this result can be interpreted and used, it is the problem where we seek answer in the following argumentation.

The main objective of the assesment ist o give feedback in the students and teachers process. Generally, this aspect is given less importance, especially from teachers, even though this part is one of the most important within in the educational process, indicating the way student perceived the educative process and its The learning assesment involves student's performances. In a learning process there are three types of assesment like: formative assesment, summative assesment and diagnostic asesment.

The formative assesment is realized during the learning process. Its purpose is to assess the student's progress during this process development. This can be made on account of a continuous assesment.

Summative assesment represents the general assesment of the way the objectives of the education act have been achieved. This type of assesment is used at the end of a stage within the learning process (written or oral examinations, practice strategies). As far as this type of assesment is concerned, we will refer tom ost common assesment ways: assesment through multiple choice tests and tests with questions demanding a developed answer.

As far the diagnostic assesment is concerned, it positions the student according to the knowledge at the beginning of the learning stage. Within the summative assesment, we can realize, according to the results if our purposes have been accomplished. Now it can be established if a multiple choice test is correctly accomplished, helping to achieve the teacher's purpose, if it can be improved, if any sequence, any question or any subject contributes to the wrong answers of the students, if the teacher's activity can lead to wrong answers. In this respect, the analysis techniques of the subjects can help t ogive answers form this point of view. metodelor statistice care să identifice întrebările testului care lasă de dorit sau pe cale care sunt.

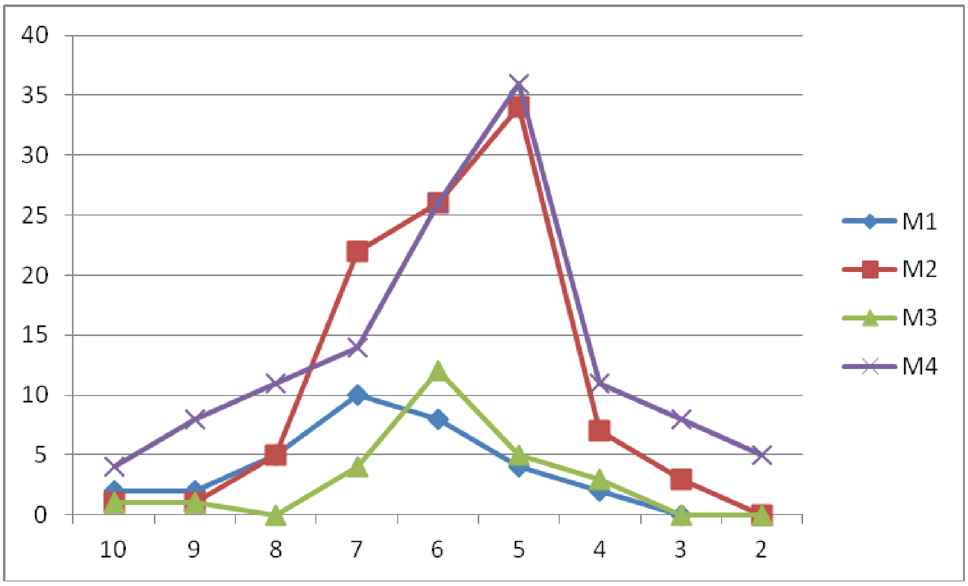
Revising the multiple choice tests involves the use of statistic methods with an ambiguous use. Generally, these methods are used to assess the assesment efficiency through the observing of the difficulty level of questions and of elements producing error.

We will use statistical methods to identify improper construction of the tests used in assessing students at the Constanta Maritime University specialization Economic Engineering in Transport. Thus the methods used will help in evaluating students, trying to formulate the end, based on the results and some suggestions for teachers that make their training.

The study was conducted on a sample of 100 students pursuing courses of this specialization following the results of these four disciplines covered by them.

First we will try for the four disciplines to establish an indicator hereinafter: Difficulty level = Number of wrong answers / total number of responses

In the figure below the subjects were summarized in note intervals obtained for the sample analyzed

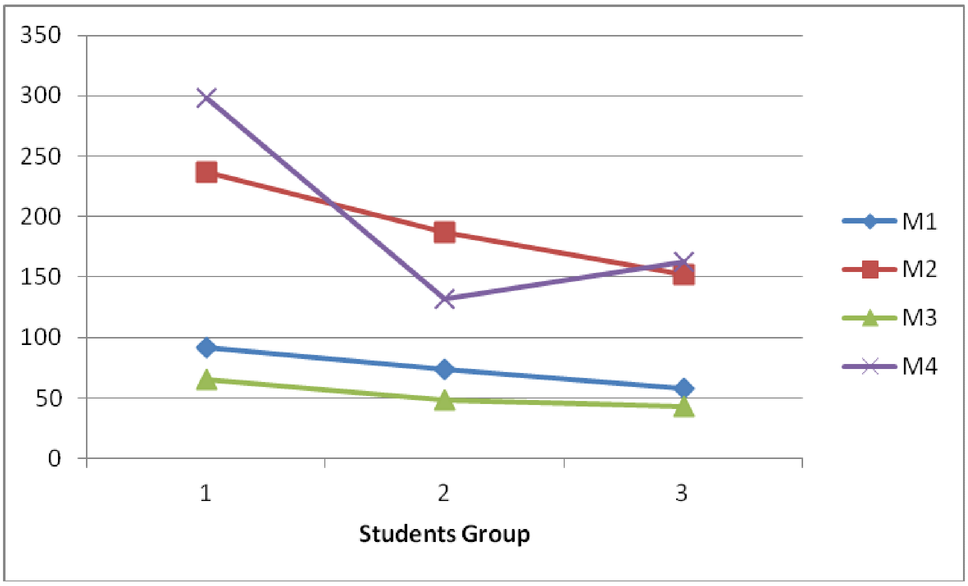


A difficulty of over 70% can be considered an answer to a difficult question while a difficulty below 30 % is considered an answer to a trivia question. Such difficulty levels obtained at disciplines analyzed varies between 7% and 20 % (GM1= 6.9 % , GM2 = 10.2 % GM3 = 11.6 %, GM4 = 19.6 %). This indicates that either the students are very well prepared either tests were well prepared or so they were able to achieve satisfactory results

The difficulty of questions within a test can affect the discriminatory power of the test. Such tests in which questions are strongly related questions have a discriminatory power of 50 %, and it is recommended that the questions in the questionnaire have a difficulty level between 20 and 80 % and the lightest in terms of motivation to positioned at the beginning of the tests. For cases of a small sample (30 %) the results may be quite inaccurate so it is recommended to supplement these without having any influence on them, as

$$W\,W = \sum w_i \,.$$

Next, they built a second indicator called in the following index indicates discrimination of splitting the sample analyzed in two categories: students well trained and less qualified students. It will use all the results of students who performed the analysis for the four subjects studied by them. Initial test results are arranged in groups of grades and subjects, and are divided into groups of equal size (about one third) of their total number. Thus for each question: Discrimination index = (score of well-trained students - score of less qualified students) / Number of students in the group of well-trained or poorly trained people



This index D can take values between 1 and -1 indicating that a test can be divided into two categories weak students and well trained is crucial for the whole test. Entire test is taken as a criterion of the assumption that broader sampling of content and educational objectives will provide a better shootout between students well trained and weak students. Also discriminate the index can be determined using a score for the entire test.

The results of analysis are summarized in the table below:

D_{M1}	D_{M2}	D_{M3}	D_{M4}
0.309091	0.257575758	0.244444	0.329268293

Thus obtaining a value above 0.4 for the index of discrimination is considered effective in time 0.2 values are inefficiency.

Indicators previously calculated G and D are used for building reliable and valid tests, considering the degree of difficulty is also strongly affected the credibility factor and distracters, which should be removed if possible.

Improvement of the test questionnaires can be achieved in efficiency analysis distracters, their choice is independent of students' interest, and so good distracters may be of interest much higher for poor students from the most qualified and also be chosen and corresponding proportion of students who are divided into categories.

Examination of difficulty, efficiency and discrimination distracters allows the teacher to identify and correct weaknesses or give to that question. Such questions allow the teacher to analyze and improve the ability to build tests , evaluating the effectiveness of testing methods for evaluating teacher and student strengths and weaknesses as well as future creates valuable questions that can be used in evaluating students.

A performance criterion that indicates learning or not mainly depend professional experience of the teacher evaluator (so subjective!) And generally can be used criterion score. In general the results of these tests are between 70-80 %, and if certain tests they have to be above 50 % generally between 60-90 %. Professional skills of the teacher evaluator dependent processes mentioned above, the level of feed -back as well as his experience in the evaluation of the course and its subjects.

Correlation is defined as a measure of the strength of association between two variables, where I researched survey correlation exists between the 4 materials to verify the hypothesis that if students get high marks for a subject they will get satisfactory results for other material. The correlation coefficient is within the range - 1 and 1, and can help interpret the graphs and indicating the degree of scattering between variables (subjects) analysis.

Analysis of correlations between the subjects studied by students as part of the sample is shown in the table below, and used as an indicator Pearson product correlation coefficient

Pearson				
m1		0.692789	0.577466	0.565696
m2	0.692788533		0.769556	0.894671
m3	0.57746589	0.769556		0.720836
m4	0.565695653	0.894671	0.720836	

As noted in the table above for all possible combinations of the materials studied are obtained positive values for Pearson correlation coefficient which can interpret the by the fact that obtaining satisfactory results unsatisfactory for field automatically generates same results and other matters .

Standard score

In general training and educational institutions used for marking the trained scale between 0 and 100 points, and the promotion is done if you get more than 50 points. Thus , if the results from one discipline compares with the results of other disciplines is important that they provide signals scattered in the same direction, otherwise the comparison is not justified because of eg 50 % of a test can be much higher than 80 % of other test.

Equalization spread of results obtained by different sample subjects most often done using the normal distribution method

	M1	M2	M3	M4
10	0.060606061	0.010101	0.038462	0.03252
9	0.060606061	0.010101	0.038462	0.065041
8	0.151515152	0.050505	0	0.089431
7	0.303030303	0.222222	0.153846	0.113821
6	0.242424242	0.262626	0.461538	0.211382
5	0.121212121	0.343434	0.192308	0.292683
4	0.060606061	0.070707	0.115385	0.089431
3	0	0.030303	0	0.065041
2	0	0	0	0.04065
	1	1	1	1
Mean	6.787878788	5.818182	6	5.788618
Std dev	1.494940964	1.248376	1.356466	1.856544

Above mentioned method results are presented in the table above. Thus to say that a student who obtains a score with a standard deviation above average (for an example if material M1 where the average is 6.79) will get better results than 88% of students examined

	M1		M2		m3		m4	
Point	Point	rank	Point	rank	Point	rank	Point	rank
10	20	4	10	6	10	5	40	7
9	18	5	9	7	9	6	72	5
8	40	3	40	4	0	7	88	4
7	70	1	154	3	28	2	98	3
6	48	2	156	2	72	1	156	2

5	20	4	170	1	25	3	180	1
4	8	6	28	5	12	4	44	6
3	0	7	9	7	0	7	24	8
2	0	7	0	0	0	7	10	9
mean	24.88888889		64		17.33333333		79.11111111	
std dev	22.15322622		73.08727659		22.95103484		58.25900026	
z-score	-0.220685188		-0.73884269		-0.31952081		-0.671331656	
	-0.310965492		-0.75252496		-0.36309183		-0.122060301	
	0.682117853		-0.32837453		-0.75523101		0.152575376	
	2.036322414		1.231404482		0.464757548		0.324222675	
	1.043239069		1.258769026		2.381882432		1.319777005	
	-0.220685188		1.450320835		0.334044487		1.731730521	
	-0.762367012		-0.49256179		-0.23237877		-0.602672736	
	-1.123488229		-0.75252496		-0.75523101		-0.945967333	
	-1.123488229		-0.87566541		-0.75523101		-1.186273551	
mean	4.93432E-17		2.46716E-17		4.93432E-17		-7.40149E-17	
std dev	1.060660172		1		1		1	

Next was built called Z-score indicator which indicates the performance of students in the subjects studied by them, which causes the score expressed by the standard deviation from the mean.

Thus Z-score = (score-average) / standard deviation

As can be seen from the data previously obtained the main disadvantage of this indicator is that its average is 0, yielding even negative values of the scores. So it is necessary to build another indicator to correct this shortcoming, with a mean and a standard deviation preset. Newly created pointer will cause multiplying the Z-score with the average standard deviation and adding their values fell up to the teacher examiner.

Thus Standard Score = Z-score * 15 +50

Standard score	46.68972218		38.91735966		45.20718779		39.93002516	
	45.33551762		38.71212558		44.55362249		48.16909548	
	60.2317678		45.07438207		38.67153478		52.28863064	
	80.54483622		68.47106724		56.97136322		54.86334012	
	65.64858604		68.8815354		85.72823648		69.79665508	
	46.68972218		71.75481252		55.01066731		75.97595782	
	38.56449482		42.61157311		46.51431839		40.95990895	
	33.14767657		38.71212558		38.67153478		35.81049	
	33.14767657		36.86501886		38.67153478		32.20589674	
Mean	50		50		50		50	
std dev	15.90990258		15		15		15	

So as we can see the results can be compared. Comparing the results with standard tests can convey very different perceptions of reality.

We can say that the teacher give high marks for encouraging students to attend that course.

5. FINAL CONSIDERATIONS: ASSESMENT THROUGH MULTIPLE CHOICE TEST VS ASSESMENT THROUGH QUESTIONS WITH DEVELOPED ANSWER

The problem of subjectivity (or the lack of objectivity) concerning the assesment process will not be completely removed, but it can be kept within acceptable limits, through the establishment of clear grading criteria, a lack of objectivity in valuing a paperwork or the subjectivity of an accurate presentation or not. Another problem appearing in this assesment form the situation where there are two or more assessors of a paperwork and between their appreciations there are inconsistencies.

As far as the assesment through multiple choice tests there must be realized the fact that an efficient assesment is hard to conceive, as it is required a careful accomplishment of the questionnaire, an accurate target-group, an efficient implementation and an elaborate analysis of the results. In the assesment process the multiple choice tests must be used occasionally, they must be short and simple. In order that such tests be efficient, they have to be submitted to the following criteria: the asked questions must be essential; the questions must be easy to understand; an emphasis upon closed questions to lead a choice of more alternative answers; avoinding subjective answers, the questions must be short and precise.

Moreover, an efficient asessment test must take into account the following criteria: avoid figure results, eliminate irrelevant questions, avoid vague and unclear questions, it should not contain exaggerate questions, avoid ambiguous questions, to give student enough time to offer feedback.

The assessment represents a necessary on standard deviation, an element of the instructive-educative process. It gives account of the availability of the educative-instructive process and leads to performance accomplishment. In this respect, the assessment process must have a careful and efficient analysis.

This analysis involves taking into account a series of elements functioning as measurement factors of this process. Among these elements we can have: the power to makes a difference of a question, the discrimination index, misleading elements, normal distribution.

The success of every educational and instructive activity is measure through the assessment process interpretation, that is why it is imposed the need of adequate understanding and correct interpretation of this process, leading to performance, that will be translated in visible results and within the job that the student-a future employee will play in the work field.

Transforming summative assessments in formative assessment is an objective of implementing quality management in Constanta Maritime University. Positioning students in the center of the educational process can be achieved only under conditions in which students perceive that they are learning objectives that they have mastered and which ones should be reviewed. The two types of needs: the need for recognition (by the student obtain social confirmation of the fact that his reactions to stimulation coming from the company are relevant and approved) and the need for specific judgment (not enough that the answers it receives student just be consistent, they must be consistent with the experiences and expectations) cannot be satisfaction than by implementing formative assessments, feed-back.

6. REFERENCES

[1] Clynes, M.P., Reftery, S.E.C.*(2008). Feedback: an essential element of student learning in clinical practice*. Nurse Education in Practice, 8, 405-411

[2] Clynes, M., (2008). *Providing feedback on clinical performance to students nurses in children’s nursing: challenges facing preceptors.* Journal of children’s and young people’s nursing 2(1), 29-35

[3] Dohrenwend, A.,(2002). *Serving up the feedback sandwich*. Family Practice Management 9(10), 43-49] Eraut, M., *Feedback.* Learning in health and social care 5(3), 111-118

[4] Gibbs, G. & Habeshow, S. & Habeshow, T. (1988). *53 Interesting ways to assess your student*. Technical and Educational Service, Bristol.

[5] Gibbs, G., & Simpson, C.(2004-05). *Conditions under which assessment supports students’ leraning.* Learning and teaching in higher education,1,3-29, Retrieved on 11 December 2013 from http://resources.glos.ac.uk

[6] Gillespie, M., (2002). *Student-teaching connection in clinical nursing education*. Journal of advanced nursing 37(6), 566-576

[7] Gronlund, N. E. (1985). *Measurement and Evaluation in Teaching*, McGraw-Hill, London.

Jerome, P.J., (1995).*Coaching through effective feedback*, Kogan, London

[8] Kiley, M.,(2009). You don’t want a smart Alec’: Selecting examiners to assess doctoral dissertations. Studies in higher education, 34(8), 889-903

[9] Koh, L.C.,(2007). *Refocusing formative feedback to enhance learning in pre-registration nurse education*. Nurse Education in practice.doi: 10.1016/ j.nepr.2007.08.00

[10] Kumar, V., Stracke, E.,9(2011). *Examiner’s reports in theses: feedback or assessment*?. Journal of English for Academic Purposes 10(2011)211-222

[11] Munhead, Peter (1997). *Learning from students – Feedback and Evaluation* in *Maritime Education and Training*. The Nautical Institute, London, pp. 222 – 228.

Russel, T., (1994), *Effective feedback skills*, Kogan, London

[12] Sadler,D.T.,(1989). *Formative assessment and the design of the instructional systems*. Instructional Science, 18, 119-144

[13] Wiersma, W and Juus, S. G. (1990). *Educational Measurement and Testing*, Ed. II, Allyn and Bacon, Boston.

[14] Wiggins, G.P., (1998). *Educative assessment. Designing assessment to inform and improve student performance*, Jossey- Bass, San Francisco

[15] Young, P.,2000. *I might as well give up: self-esteem and mature students feelings about feedback on assignments*. Journal of Further and Higher Education 24(3), 409-418

HUMAN ELEMENT IN SHIPPING

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ABSTARCT

In the maritime context, the term human element embraces anything that influences the interaction between a human and any other human or system or machine aboard ship.

The human element has been with us since time immemorial, but it is the humans, systems and machines that have changed, not only through the increase in technology, but also because of the need for operators to maintain the competitive edge by reducing running costs, which has resulted in a reduction in manning scales and the employment of multi-national, multi- cultural and multi-lingual crews. Build a crew for a ship efficiently is more difficult because it may happen that the ship owner, ship manager or crewing agency have different views on management, and many members of the crew may find their stay on board is just a transitional period if there is not a long-term relationship involving loyalty and accountability of crew members.

Keywords: *human element, Safe & secure working, competence, human relationships, moral values, habitability, survivability, quality of input, familiarization, work force*.

1. THE IMPORTANCE OF PEOPLE

People are important and ships need good, qualified, and motivated seafarers to operate well. Hitherto, little emphasis has been placed on honing the personal attributes of the seafarer, yet the quality of the end product depends not only on the standard of education and training provided, but also on the basic human needs of the Mind, the Body and the Spirit.

There is no accepted international definition of the human element. In the maritime context, it can be taken to embrace anything that influences the interaction between a human and any other human, system or machine on board ship. The "human element" refers to human behavior and psychology factors, in various aspects.

The human element is a complex multi-dimensional issue that affects maritime safety and marine environmental protection. It involves the entire spectrum of human activities performed by ships' crews, shore based management, regulatory bodies, recognized organizations, shipyards, legislators, and other relevant parties, all of whom need to cooperate to address human element issues effectively.

Improved technical standards, including more demanding survey regimes and stronger regulation enforced through a rigorous port state control system, have had a strong positive influence on safety. However there is a limit to how much additional improvement is possible if attention is only focused on the structural, mechanical, electrical and electronic components. Further improvements will require a focus on the way that a ship is used; in other words, considering the overall ship system. This can't ignore the people operating it, often known as the 'human element'.

The term 'Garbage In, Garbage Out' (GIGO) is one of the great proverbs of the computer age, which says that if invalid, inaccurate or inappropriate data is entered into a system, the resulting output will be invalid, inaccurate or inappropriate. In other words, the quality of the output is directly dependent on the quality of the input. In terms of the Mind, the Body and the Spirit, therefore, the personal output of the mariner is dependent on 7 needs:

- Competence. The seafarer's level of competence will depend not only on good and effective education and training and realistic competencies, but also on aptitude – the ability to absorb knowledge and to understand the subject – and on his own skill and proficiency.
- Attitude. The seafarer's attitude towards education and training will be driven by his mental ability, intelligence, personality, character and sensitivity. Self-awareness and self-evaluation are the key drivers.
- Motivation. Motivation is driven by good communication, direction, teamwork, empowerment and character building in order to provide the seafarer with a sense of leadership, interoperability and adaptability.
- Happy & healthy lifestyle. A happy and healthy lifestyle through the encouragement of a balanced diet, good hygiene, exercise, rest and recreation, together with acceptable standards of habitability and regular medical screening, including drug and alcohol testing, will ensure that the seafarer has the energy, physical fitness, physical strength, stamina and a sense of wellbeing to enable him to do the job.

• Safe & secure working environment. Good ergonomics, safe working practices, the provision of protective equipment, together with proper physical security will lead to an improved safety culture and greater security awareness.
• Self-actualisation. Personal ethics, conscience, cultural integration and leadership, together with proper supervision and adequate remuneration can generate a sense of pride and purpose, identity, conviction, trust, expectation, realisation, belonging, loyalty, esteem, fellowship and personal security.
• Moral values. Moral values are equally important; an awareness of the various religious beliefs, together with one's personal faith and self-discipline are drivers towards cultural awareness.

Some of these attributes can be taught, and some are developed through self-education, while others fall to the shipowner or shipmanager who has a duty to provide a safe and secure working environment, decent working and living conditions and fair terms of employment.

2. THE HUMAN INFLUENCE

About 75-96% of marine casualties are caused, at least in part, by some form of human error. Studies have shown that human error contributes to:
• • 84-88% of tanker accidents [1]
• • 79% of towing vessel groundings[2]
• • 89-96% of collisions[3], [4]
• • 75% of allisions[3]
• • 75% of fires and explosions[3]

Therefore, if we want to make greater strides towards reducing marine casualties, we must begin to focus on the types of human errors that cause casualties.

The causes of maritime incidents can be linked to a number of contributory factors:
• Poor ship or system design;
• Equipment failure through poor maintenance;
• Fatigue;
• Ineffective communication;
• Lack of attention to rules, regulations and procedures;
• Inadequate training in the operation of equipments;
• Unawareness of the vulnerabilities of electronic systems;
• Complacency.

Crew competence does not feature in this list; indeed, rarely does an accident investigation report cite crew incompetence as a cause.

3. HUMAN FACTORS

Human Factors, or The Human Factor, are terms that are often misinterpreted and are used as covers for the human element or even human error. Human Factors are defined as the body of scientific knowledge relating about people and how they interact with their environment, especially when working.

YEAR	lower	Human error/Total cases Percentages	upper
1995	50,80%	69,00%	82,70%
1996	43,60%	60,00%	74,40%
1997	51,50%	70,40%	84,10%
1998	39,10%	57,10%	73,50%
1999	33,50%	52,00%	70,00%
2000	29,00%	50,00%	71,00%
2001	30,70%	50,00%	69,30%
2002	49,70%	76,90%	91,80%
2003	23,30%	40,90%	61,30%
2004	24,50%	42,90%	63,50%
2005	38,80%	64,30%	83,70%
2006	26,80%	50,00%	73,20%
2007	25,50%	50,00%	74,50%
2008	16,93%	42,86%	68,78%
2009	21,71%	50,00%	78,29%
2010	16,03%	45,45%	74,88%
2011	9,64%	40,00%	70,36%
Total	51,10%	54,98%	62,90%

Table 1 Percentages of human-error / total cases .

In the Figure 1, was given Graphical presentation of the trends and the trend line of the percentages of human-error/ total cases over the years from 1995 to 2011 with statistical 95% confidence limits for dataset depicted in Table 1.

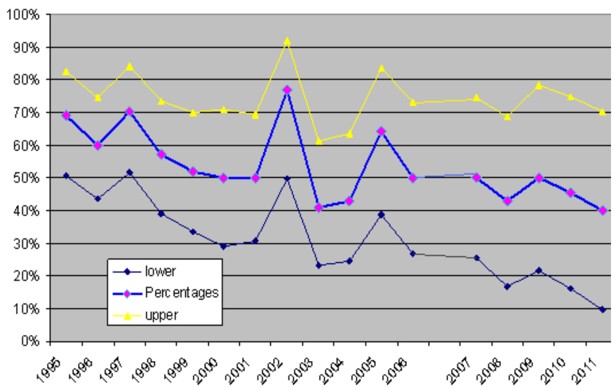

Figure 1 Trend line of the percentages of human-error/total cases (1995-2011).

Perhaps the most distinct accidents that involved a big number of lives lost are sinking of the Titanic in 1912 when 1,502 people were killed and the foundering of the Costa Concordia in 2012 when 32 people lost their lives. In both cases, the cruise ships were involved. Despite the technological progress and ship modernization, there are still human and organizational reasons for the occurrence of accidents that should be precisely analyzed. Regarding accidents, the human error and organizational reason have played the main role [5]. Besides the cases of the sinking of the Titanic and the foundering of the Costa Concordia, in 2011 an accident happened with the riverboat Sergei Abramov Russian.

The sources, namely, reported fire on a passenger ship moored at a Moscow river port. Four people onboard were injured and one crew member was missing. The reason for such an accident was that the fire might have been caused by defective electric wiring or fire-safety violations. The human factor also caused the incident that happened with the cruise ship Oriana P&O in 2011. The ship had a sizeable dent in the stern after finishing into a solid stone quay at her last port of call, Kristiansand in Norway. The incident resulted in the following consequences: a water pipe and an optical cable on the quay were damaged and the ship's stern was stowed in.

Obviously, the number of sinkings, collisions and groundings was decreasing while accidents caused by fires/explosions and other types of accidents were reported to increase during 2010. The minimum number of accidents during the considered period was 28 in 2009 and related to sinking. In the case of EU waters and if comparing the number of lives lost in marine accidents from 2007 to 2010. Almost the largest number of lives lost was in 2007 when 49 people died on other types of ships.

This represents around 18% of the total number of lives lost during the considered period. The statistics shows that 7% of the total number of people lost their lives on tankers, 1% on container ships, 28.9% on cargo ships, 9.7% on passenger ships, and finally, 53.4% on other types of ships.

More specifically, if analyzing the human error involved in marine accidents, some examples have to be highlighted. The first example is the collision between the ships Santa Cruz II and USCG Cutter Cuyahoga. The accident occurred at the moment when Cuyahoga passed close to the Santa Cruz II. The collision was inevitable and 11 people lost their lives. The second example was the grounding of the Torrey Canyon. It happened in the English Channel. The ship spilled 100,000 tons of oil. Considering both accidents, the only cause was related to human error [6].

Applying human factors to the design and operation of a ship or its systems means taking account of human capabilities, skills, limitations and needs. Human Factors should not be confused with the term Human Resources, which is a closely related activity that addresses the supply of suitably qualified and experienced staff. But, when considering the operation or design of any ship and its systems both of these domains should be considered – Human Resources for the selection and preparation of staff able to do the required work and Human Factors to account for the use of people as a component of the system.

4. SHIP/SYSTEM AND EQUIPMENT DESIGN AND OPERATION

A ship is unique in that it is not only a place of work, within which there are a number of workspaces - the bridge, the machinery control room, the engine room, the cargo control room, cargo holds, galley etc. - each of which may have different operational criteria, but also it is a 'home' to those who work onboard. Furthermore, it is a floating platform which can be affected by external and internal environmental conditions such as weather, temperature, humidity, noise, vibration and ship motion (pitching, rolling and slamming), any of which can also be detrimental to the safety and performance of those who work and live onboard.

For any ship to operate safely and effectively, therefore, it must be designed to support the people who work it, without detriment to their health, safety and overall performance particularly in respect of:

- Habitability. The provision of adequate and comfortable accommodation - including furnishings and washing facilities - galleys, mess rooms and recreational spaces, having due regard for the variations in the size, shape and gender of the seafarer, and for the various environmental stressors such as noise, heat and vibration.
- Maintainability. Designing operational maintenance tasks to be rapid, safe and effective to allow equipment and systems to achieve a specified level of performance. This includes consideration of access, removal routes, tools, expertise, disposal and through-life support.
- Workability. Due consideration must be given to the context of use - the users, tasks, equipment (hardware, software and materials) and the physical and social environments in which a 'system' is used. The level and amount of information provided in handbooks must be appropriate to the required technical skills of the user and be written in his/her native language.
- Controllability. Designing the layout of ship control centers, machinery control rooms, cargo control rooms etc., bearing in mind the integration of people with equipment, systems and interfaces, such as communication, controls, displays, alarms, video-display units and computer workstations.
- Maneuverability. Having the most appropriate maneuvering capabilities consistent with the intended role, manning and operating pattern of the ship. These should include type, number and power of propulsion systems, steering systems and thrusters, all having due regard for the environment and fuel economy.
- Survivability. The provision of adequate firefighting, damage control and lifesaving facilities (including manpower) and security arrangements to ensure the safety and security of the crew, visitors and passengers.

The human element, therefore, is a critical feature of all aspects of ship or system design and operation. User-input is essential to ensure that the operational parameters and the layout and procedures for the operation of shipboard systems are being optimized for the specific role or trade of the ship.

Those who are involved in the design build and updating of ships and their systems and in their operation need to be aware of the problems associated with onboard operations not only in terms of workplace design but also in respect to crew habitability and the education and training needs of the seafarer.

There is now a worrying trend towards recruiting non- seafarers into the industry in operational posts, such as the employment of naval architects etc. as ship surveyors and superintendents, which has been brought about by the decline in the number of former seafarers available to fill these positions. In principle, this should not present a problem, provided that they are sufficiently educated in 'the ways of the sea'.

Naval architects and designers, for example would benefit from periods at sea, in a variety of ship types, both early in, and on occasions throughout their careers in order to understand the various design and operational problems that the seafarer is faced with.

5. MAINTENANCE

According to the International Association of Classification Societies, shipboard maintenance is the least-developed and weakest element in many of even the most well intentioned companies [5].

That responsibility starts from the top managers of the company, who should be committed to direct efforts, resources and investments to ensure that their ships are properly maintained and operated by qualified and competent crew.

6. FATIGUE

The issue of fatigue features in many accident reports, albeit mainly relating to minimum manned short sea shipping. According to the IMO, fatigue is an important issue that has hitherto been discounted as a potential cause of or contributor to human error6. It had been suggested that fatigue could be prevented through some of the characteristics described in the context of personal attributes articulated above. But, if the seafarer is unable to identify the causes of fatigue, he will be unable to take measures to prevent it.

The IMO Guidelines on Fatigue[8] are comprehensive and provide advice to all the various stakeholders - including training institutions and management personnel in charge of training - on how to combat fatigue. However, it is important to recognize that fatigue is not just about working hours and minimum manning levels.

The US Coastguard's Crew Endurance Management Program[9] (CEM) takes the IMO Guidelines one step further in identifying the various environmental, operational, physiological, and psychological factors that can affect crew endurance, and addresses the specific endurance risks pertinent to ship operations. It looks at the science behind, and effects of, fifteen interrelated risk factors, which include those of temperature, motion, vibrations, intensity of lighting, and other physical considerations aboard a ship.

Although current IMO thinking [10] is that training in fatigue management should be addressed through voluntary guidance rather than mandatory requirements, fatigue now poses a major problem in terms of safety of life at sea.

7. COMMUNICATION

In the maritime world, the ability to communicate at all levels by a variety of means is essential. Communication is about the transmission of information through a common system of symbols, signs, behavior, speech, writing, or signals.

8. CONVEYING INFORMATION

The ability to properly convey information by word of mouth, whether directly or indirectly (by the use of technology) is important to the safety of ships' crews, visitors and passengers. Multi-national crews are a common feature aboard more than 65% of the ships of the world's merchant fleet, of which some 10% of crews are made up of five or more nationalities.

The commonly used language onboard may not be the native language of the majority of the crew. This can lead to communication problems, which may be exacerbated by the unwillingness of individuals to admit their difficulty in understanding and communicating.

9. INFORMATION EXCHANGE

Increasing paperwork can sidetrack the mariner (especially the master and the chief engineer) from his primary purpose of working the ship. 'Routine clerical or administrative work' is one dictionary's definition, but it would seem that in the maritime world it is becoming far more than simply routine.

Electronic paperwork (especially e-mail correspondence) seems to have increased the burden on the ship's master. For example, the master of a 15000gt LPG tanker11 (managed by a very reputable company) reports that he spends on average 3 to 4 hours a day on sending and receiving information by e-mail. He adds that on the tankers there are plenty of inspections, where the inspectors are looking for checklists.

10. SHARING AND COMING TOGETHER

Breakdowns in communication and teamwork are common factors in many major P&I claims.12 There is no place today for the 'autocratic shipmaster' – he needs the support both of management and of his crew to ensure the safe conduct of his ship and the safe and timely arrival of its cargo. Good communication is the key to the successful operation of any ship; in this context, communication is about empowerment, inclusion, leadership and teamwork. The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) recognizes the importance of establishing detailed mandatory standards of competence necessary to ensure that all mariners are properly educated and trained, adequately experienced, skilled and competent to perform their duties. However, in the way of all international Codes, the standards of competency set out in STCW are a minimum set. Furthermore, the maritime workforce is now multinational and multicultural. This may allow differing interpretations of international guidelines and inconsistent standards in training and education. Indeed, there are still numerous reports, mainly anecdotal, of poor standards of education and training in the maritime sector. In fairness, there are owners, managers and manning agents who invest in the education and training of their mariners to beyond the minimum criteria set out within the STCW Code - but they are in the minority.

Decisions are made using knowledge rather than information alone, and it is the management and processing of data and information, which needs to be designed and trained for. Accident investigation reports suggest that some junior bridge watch keepers are so absorbed in technology that their awareness of the situation around them is confined to the display rather than looking out of the window. Furthermore, there is an increasing tendency for some seafarers to become over reliant on electronic systems with scant regard for the vulnerability of those systems in terms of their accuracy, reliability, availability, and integrity.

Today's seafarers need to be trained on new technology and equipment; they should not be expected to pick it up after they have joined the vessel, or to undergo familiarization by other staff onboard, who themselves have no formal training or qualifications in the use of such equipment. In fairness, the more responsible companies do invest in the training of their key staff in the use of integrated systems, before they join a vessel that is so fitted, and then allow them some time for familiarization onboard before they are permitted to work with those systems.

It was concluded that that there is a need to raise awareness across the industry – designers, engineers, owners/managers, trainers/educators, insurers, regulators etc. - of human element issues related to the use of technology and automation, particularly in regard to training.

11. CONCLUSION

For any ship or system to operate safely and effectively, not only must it be designed to support the people who work it, without detriment to their health, safety and overall performance, but also those people must be sufficiently educated and trained to be able to operate it.

A ship is unique in that it is not only a place of work, within which there are a number of workstations, each of which may have different operational criteria, but also it is a 'home' to those who work onboard. It is also a floating platform which can be affected by external and internal environmental conditions such as weather, temperature, humidity, noise, vibration and ship motion (pitching, rolling and slamming), any of which can also be detrimental to the safety and performance of those who work and live onboard.

12. REFERENCES

[1] Transportation Safety Board of Canada. (1994) Working Paper on Tankers Involved in Shipping Accidents 1975-1992.
[2] Cormier P.J. (1994) Towing Vessel Safety: Analysis of Congressional and Coast Guard Investigative Response to Operator Involvement in Casualties Where a Presumption of Negligence Exists. Master's Thesis, University of Rhode Island.
[3] Bryant D.T. (1991) The Human Element in Shipping Casualties. Report prepared for the Dept. of Transport, Marine Directorate, United Kingdom.
[4] U.K. P&I Club (1992). The United Kingdom Mutual Steam Ship Assurance Association (Bermuda) Limited. Analysis of Major Claims.
[5] Jens-Uwe Schröder-Hinrichs, J-U., Hollnagel, E., Baldauf, M.: From Titanic to Costa Concordia — a century of lessons not learned, WMU J Marit Affairs, Vol. 11, 2012, pp. 151–167
[6] Perrow C.: Normal Accidents: Living with High-Risk Technologies. Basic Books, 1984.
[7] MSC/Circ.1014 dated 12 June 2001 - Guidance on Fatigue Mitigation and Management (International Maritime Organisation).
[8] Crew Endurance Management Practices: A Guide for Maritime Operations. (http://www.he-alert.com/documents/published/ HE00265.pdf).
[10] STW 34/14, 14 March 2003.

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