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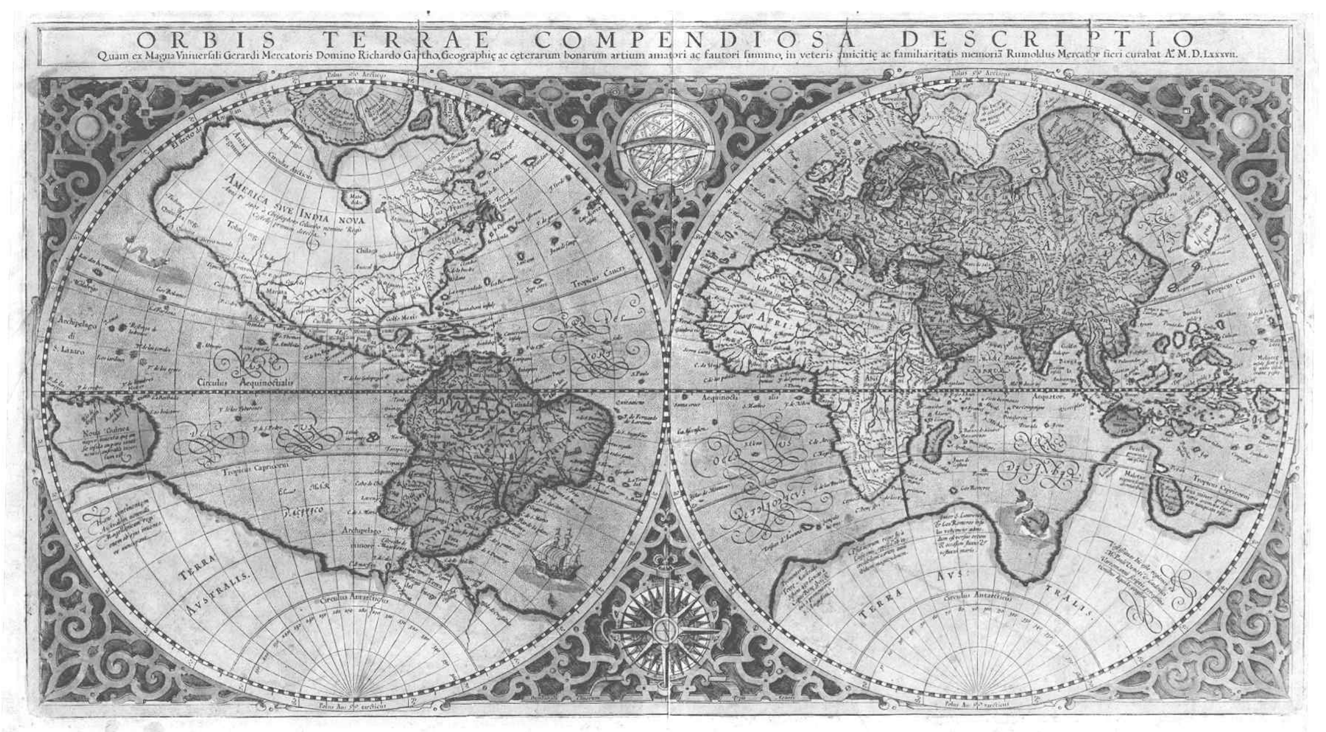
# ANNALS

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# SCIENTIFIC COMMITTEE

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# SECTION I

## NAVIGATION AND MARITIME TRANSPORT

# MINIMIZING THE HEAT FLOW LOST BY A BALLAST TANK USING INSULATION

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**ABSTRACT**

The main purpose of treating ballast water in naval transport is killing the organisms and microorganisms. One of the treating methods is based on heating ballast water at a specified temperature. After heating the ballast water we should keep it at that level for a shorter or longer period of time, depending on organism nature.

This paper presents the heat flow lost by a ballast tank and analyses the methods for minimizing it. We chose an insulating material and three ways of applying it.

**Keywords:** *heating ballast water, flow lost.*

## 1. INTRODUCTION

To heat the ballast water we should use a heat exchanger. For choosing the right heat exchanger we need the thermal agent characteristics including the total flow. We also should consider the heat lost by convection and conduction. These terms could be presented in the following mode:

- Q1 – the heat flows lost due to the vaporisation process,
- Q2 – the heat flows due to convection at the surfaces of the water medium,
- Q2 – the heat flows lost due to conduction through the walls.

In order to provide stability to the ship, the ballast tanks are almost all the time pressurised. This is to avoid the free water surfaces that could rapidly move the centre of gravity, causing ships' overthrow. So, we will neglect the first components and we will calculate the flows lost by the walls. The heat flows lost through the walls is different for the external wall to the other internal walls. The most important quantity of heat lost is represented by the external wall of the tank.

## 2. THE MATHEMATICAL MODEL OF THE HEAT FLOW LOST

This study presents the heat losses by a ballast tank after heating it at different levels of temperature. We consider that the ship navigates in various condition of temperature, the ballast tank is a rectangular one, situated in double hull, and the total volume is $700m^3$. It is situated under the water line, so the temperature of the external side of the tank is in permanent contact with the sea water (WWB5- Wing Water Ballast 5). The dimensions of the ballast tank: L = 44m, l = 2m, H = 8m.

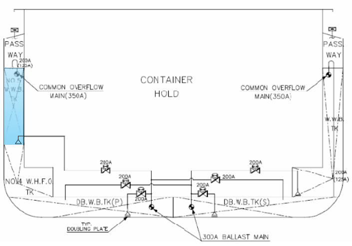


Figure 1 Ballast tank location

Considering that the ship navigates in aria where the marine environment temperature could be from 5 to 25°C, we will calculate the flow lost by the external wall while the ballast water temperature inside the tank is 45°C. The total area of the external wall is $A = 352m^2$, so in the following we present the heat flow through this aria. The heat transfer rate is:

$$Q_w = q \cdot A_w \text{ [W]} \quad (1)$$

$$Q = k \cdot (t_{in} - t_{out}) \text{ [W/m}^2\text{]} \quad (2)$$

where:

- k – the overall heat transfer coefficient through the external wall $[W/(m^2*K)]$
- $A_w$ – aria of the wall, $[m^2]$
- $t_{in}$ – ballast water temperature, inside the tank, [°C]
- $t_{out}$ – sea water temperature of the marine environment, [°C]
- q – the heat flow per unit, $[W/m^2]$

$$k = 1/(1/\alpha_1 + \Sigma\delta/\lambda + 1/\alpha_2) \quad (3)$$

where:

- $\delta$ – the wall thickness, [m]
- $\lambda$ – the thermal conductivity of the material of the wall, $[W/m \cdot K]$
- $\alpha_1$, $\alpha_2$ – the individual convection heat transfer coefficient for each material, [W/(m2*K)]

### *2.1 The mathematical model of heat flow lost for a non insulated ballast tank*

The following tables present the heat flow lost by a heated tank, depending on sea water temperature. We consider that the tank was heated at 46°C.

Table 1. The heat flow lost

| Eq. | Sea water temperature | | | | |
|---|---|---|---|---|---|
| | 5°C | 10°C | 15°C | 20°C | 25°C |
| T1 | 319.15 | 319.15 | 319.15 | 319.15 | 319.15 |
| T2 | 278.15 | 283.15 | 288.15 | 293.15 | 298.15 |
| α1 | 35 | 35 | 35 | 35 | 35 |
| α2 | 5000 | 5000 | 5000 | 5000 | 5000 |
| λ1 | 50 | 50 | 50 | 50 | 50 |
| δ1 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| S | 352 | 352 | 352 | 352 | 352 |
| q | 1405 | 1234.08 | 1062.68 | 891.28 | 719.88 |
| Q | 494730 | 434397 | 374064 | 313731 | 253398 |
| | 494.73 | 434.40 | 374.06 | 313.73 | 253.40 |

Because the heat flow lost obtained have a big value, we use an insulating material for the tank.

*2.2 The mathematical model of heat flow lost for an insulated ballast tank*

The insulation will be used only to insulate the wall that is in permanent contact with the sea water. The material that we chose for insulation is polycarbonate with 2cm thickness.

Polycarbonate can be mechanically bonded by standard methods. It can also be cemented by using a solvent such as methylene chloride or adhesives such as epoxy, urethane and silicone. The following tables present some of the technical data of the polycatbonate.

Table 2. Physical properties

| No | Property | Value | Unit | Test method |
|---|---|---|---|---|
| 1 | Appearance | Cellular plan sheets | - | EN 1013 - 4 :2000 |
| 2 | Colour | Various | - | EN 1013 - 4 :2000 |
| 3 | Thickness | 4, 6, 8, 10, 16, 20 | mm | EN 1013 - 4 :2000 |
| 4 | Density | 1,2 | g /cm$^3$ | SR EN ISO 1183 -1 /04 |

Table 3. Thermal properties

| No. | Property | Value | Unit | Test method |
|---|---|---|---|---|
| 1 | Thermal conductivity | 0.2 | W/mK | ISO 8302 |
| 2 | Coefficient of linear thermal expansion | 0,7 | 10-4 /K | ISO 11359-2 |
| 3 | Thermal deformation temperature | 135 | 0 C | SR EN ISO 75 – 1,2/2004 |
| 4 | Vicat point 50N;500C/h 50N;1200C/h | 143 144 | 0 C 0 C | SR EN ISO 306 / 2005 |
| 5 | Term U | 3,9 – 2 | W/m2.$^0$C | DIN 2612 |

We have three types of insulation using a different number of layers:

**Case 1**: 2cm polycarbonate, 2cm vide, applied on the steel wall of the ballast tank

$$q=(T_1-T_2)/(1/\alpha_1+\delta_1/\lambda_1+\delta_2/\lambda_2+\delta_3/\lambda_3+1/\alpha_2)\ [W/m^2] \quad (3)$$

Table 4. The heat flow lost, case 1

| Eq. | Sea water temperature | | | | |
|---|---|---|---|---|---|
| | 5°C | 10°C | 15°C | 20°C | 25°C |
| T1 | 319.15 | 319.15 | 319.15 | 319.15 | 319.15 |
| T2 | 278.15 | 283.15 | 288.15 | 293.15 | 298.15 |
| | | | | | |
| | | | | | |
| | | | | | |
| q | 42.20 | 37.51 | 32.46 | 28.36 | 23.290 |
| Q | 14856 | 13203 | 11426 | 9985 | 8198 |
| | 14.86 | 13.20 | 11.43 | 9.99 | 8.20 |

The temperature drop is represented in the figure 2, 3 and 4. They show the temperature lost by each layer of insulation material and also through the wall.

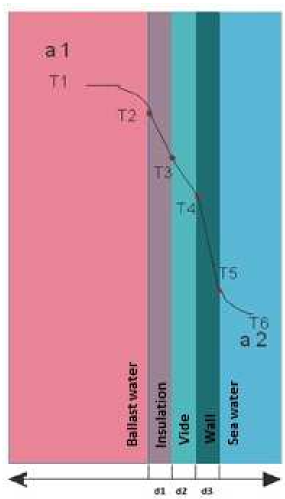


Figure 2 Insulated wall, case 1

**Case 2**: 2cm polycarbonate, 2cm vide, 2cm polycarbonate

$$q=(T_1-T_2)/(1/\alpha_1+\delta_1/\lambda_1+\delta_2/\lambda_2+\delta_3/\lambda_3+\delta_4/\lambda_4+1/\alpha_2)\ [W/m^2] \quad (4)$$

Table 5. The heat flow lost, case 2

| Eq. | Sea water temperature | | | | |
|---|---|---|---|---|---|
| | 5°C | 10°C | 15°C | 20°C | 25°C |
| T1 | 319.15 | 319.15 | 319.15 | 319.15 | 319.15 |
| T2 | 278.15 | 283.15 | 288.15 | 293.15 | 298.15 |
| | | | | | |
| | | | | | |
| | | | | | |
| q | 38.26 | 33.97 | 29.38 | 25.57 | 20.96 |
| Q | 13469 | 11957 | 10343 | 9002 | 7379 |
| | 13.47 | 11.96 | 10.34 | 9.00 | 7.38 |

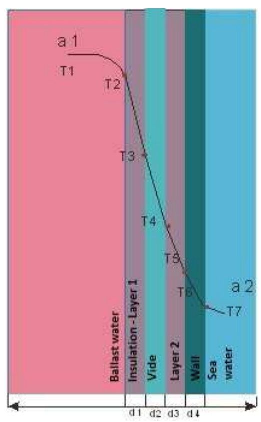


Figure 3 Insulated wall, case 3

**Case 3**: 4cm polycarbonate, 2cm vide, 2cm polycarbonate

The difference between Case 2 and Case 3 is the thickness of one of the layers.

Table 6. The heat flow lost, case 3

| Eq. | Sea water temperature | | | | |
|---|---|---|---|---|---|
| | 5°C | 10°C | 15°C | 20°C | 25°C |
| T1 | 319.15 | 319.15 | 319.15 | 319.15 | 319.15 |
| T2 | 278.15 | 283.15 | 288.15 | 293.15 | 298.15 |
| | | | | | |
| | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| q | 34.99 | 31.04 | 26.84 | 23.28 | 19.06 |
| Q | 12319 | 10926 | 9448 | 8196 | 6709 |
| | 12.32 | 10.93 | 9.45 | 8.20 | 6.71 |

The temperature drop for an insulated ballast tank

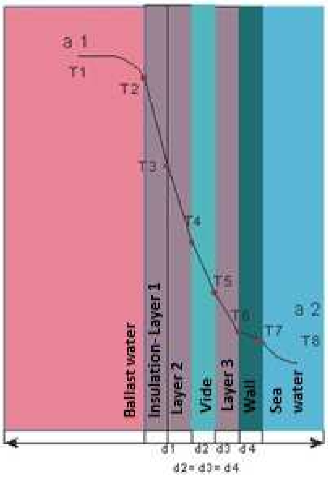


Figure 4 Insulated wall, case 3

In order to minimize the heat flow provided by the heat exchanger and the time for heating the water, we chose for insulating the tank the case 3. The following diagram presents dropping temperature for this situation. Temperature T1 is for the ballast water =45$^o$C and T8 is for the sea water, also known.

- T1 ballast water
- T2 on the layer 1, inside the tank
- T3 connection between layer 1 and 2
- T4 connection between layer 2 and vide layer
- T5 connection between vide layer and layer 3
- T6 connection between layer 3 and tank wall
- T7 on the tank wall outside the tank
- T8 sea water

The density of the heat flow was calculated before. So, we could calculate the temperature between layers using differential equation for temperature:

$$q=\lambda_1/\delta_1\cdot(T_1-T_2)=\lambda_i/\delta_i\cdot(T_i-T_{i+1}) \qquad (5)$$

$$T_2=T_1-q\cdot r_{T1}=T_1-q\cdot\delta_1/\lambda_1 \qquad (6)$$

Where:
$r_{T1}$ – thermal resistance

| T. | Temp. drop depending on sea water temp. | | | | |
|---|---|---|---|---|---|
| | 5$^o$C | 10$^o$C | 15$^o$C | 20$^o$C | 25$^o$C |
| T1 | 319.15 | 319.15 | 319.15 | 319.15 | 319.15 |
| T2 | 318.15 | 318.26 | 318.383 | 318.485 | 318.605 |
| T3 | 314.65 | 315.159 | 315.699 | 316.156 | 316.699 |
| T4 | 311.15 | 312.055 | 313.015 | 313.828 | 314.793 |
| T5 | 281.671 | 286.273 | 290.85 | 295.493 | 300.068 |
| T6 | 278.171 | 283.169 | 288.166 | 293.164 | 298.161 |
| T7 | 278.157 | 283.156 | 288.155 | 293.155 | 298.154 |
| T8 | 278.15 | 283.15 | 288.15 | 293.15 | 298.15 |

The figure 5 presents the influence of the insulation material and its thickness on the thermal flow lost through an aria A = 352m$^2$.

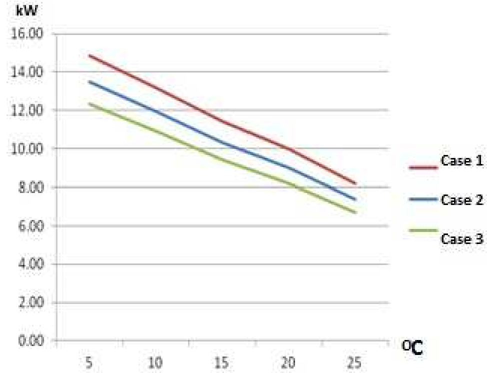


Figure 5 The comparative heat flow lost

## 3. CHOOSING THE RIGHT HEAT EXCHANGER

The heat flow that we need for heating the ballast water could be calculated using formula:

$Q_w = m_w\cdot c_w\,(t_w-t_{HE})$ [kW]
where:
$c_w$ – specific heat capacity of water, 4.1855 [kJ/(kg·K)]
$t_w$ – the temperature of the ballast water, 25…45$^o$C
$t_{hw}$ – the temperature necessary to be obtained, 47$^o$C
$m_w$ – the flow of the heated water

The ballast water from the tank will be heated using the heat exchanger. The selection was done using the Danfoss software.

Table 7. The heat exchanger characteristics

| Heat exchanger type | | XB 70-1 200 | |
|---|---|---|---|
| | | HEATING | |
| Danfoss Code | | 004B2499 | |
| Capacity | [kW] | 2768 | |
| | | Hot side | Cold side |
| Flowrate | [m3/h] | 46,02 | 100,00 |
| Temperature in | [°C] | 80 | 23 |
| Temperature out | [°C] | 28 | 47 |
| Real pr.flow/ret.temp. | [m3/h/°C] | 46,020 | 27,5 |
| LMTD | [°C] | 14,8 | 14,4 |
| Pressure drop | [kPa] | 7 | 16 |
| Velocity | [m/s] | 3,3 | 3,1 |
| PHYSICAL DIMENSIONS | | | |
| Number / elem | : | 99 | 100 |
| Water volume | [l] | 54,45 | 70,00 |
| Oversurfacing | [%] | 10,00 | |
| All heatsurface | [m2] | 47,32 | |
| Total weight | [kg] | 340 | |
| PHYSICAL PROPERTIES | | | |
| Hot Side flow | | Water | |
| Cold Side flow | | Water | |
| Heat capacity | [kJ/kgK] | 4,185 | 4,176 |

| | | | |
|---|---|---|---|
| Density | [kg/m3] | 986,2 | 994,1 |
| Viscosity | [mNs/m2] | 0,502 | 0,702 |
| Thermal conductivity | [W/mK] | 0,651 | 0,624 |

First, the ballast water is heated using the engine cooling system; the sea water that was used as a coolant agent for the main engine low temperature cooling system that is usually discharged overboard, we directed to the insulated tank. We use this water for filling the ballast tank with sea water at 25$^{o}$C. The temperature is not enough to kill the microorganism; so we will use a 20 percent of the flow from high temperature main engine cooling system at 80$^{o}$C temperature. This flow rate is directed by a heat exchanger that will heat the sea water from the ballast tank.

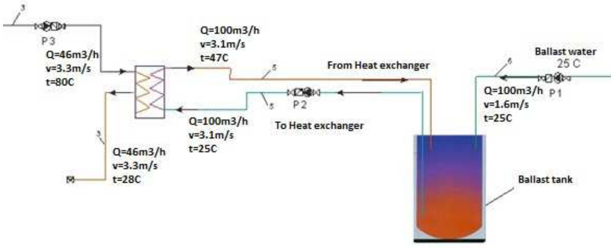


Figure 6 The functional diagram

This is a very efficient method because coolant water is necessary and would most likely be discharged into the ocean if it were not used to treat ballast water. Another benefit to this method is that there are no resulting chemical products.

## 4. CONCLUSIONS

Using this type of heat exchanger we will raise the temerature in the ballast tank from 25$^{o}$C to 45$^{o}$C in seven hours. Because for killing the microorgansims we need to maintain the high temperature for 4-5 hours it means that the heat exchanger will start after 35 minutes to rise the temperature at theone that we set before.

After treatment, the ballast water need to be directed to another ballast tank, uninsulated to let the insulated tank free to be filled with sea water that need treatment.

Because of this period of delay, the treatment method of ballast water by heating is suitable for those types of ships that have small quantities of ballast water to be treated, for example port-containers and general cargos, rather than the large ships like petroleum tanks that unload all the cargos once and need to fill most of the ballast tanks with sea water, almost at the same time.

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# A LEGAL ANALYSIS OF CIVIL LIABILITY FOR OIL POLLUTION DAMAGE

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**ABSTRACT**

A long series of maritime disasters that have caused major damage by oil pollution at sea have been the catalyst for developing a new international legislation. Stemming from the compromise between the interests of the shipping industry and the oil interests, the new statutory liability regime imposed on shipowners, introduces a series of legal innovations and serves as a model for developing legislation concerning liability in other areas. But the international system is divided between four international conventions and the regime adopted by the U.S. unilaterally by OPA Act 1990. UE., an ardent critic of the civil liability regime for oil pollution doesn't develop its own compensatory scheme but actively sustains the reforming of the international system and it designs initiatives related to maritime safety. The paper aims to examine the elements of the international civil liability regime for oil pollution damage. The conclusion is that despite the fact that it was designed for success the image is of a fragmented system, unable to provide adequate compensation and undermined by a number of key deficiencies: maintaining the limitation of liability, narrow definition of damage which excludes the environmental damages and the principle of channeling the liability exclusively to the shipowner or his insurer.

**Keywords:** *oil pollution damage; limitation of liability; channeling the liability; the 1992 Civil Liability Convention; the 1992 Fund Convention; the 2003 Supplementary Fund Protocol; STOPIA and TOPIA;*

## 1. INTRODUCTION

The 1967 Torrey Canion disaster has tested the adequacy of tort law based on negligence in the case of compensation for the damage created by the widespread pollution [1]. At the private law level, the 1969 International Convention on Civil Liability for Oil Pollution Damage (CLC) set up a compensatory regime that was far more generous than that allowed by the tort of negligence law [1]. 1969 CLC is still the essence of the marine oil pollution legislation in many countries of the world [2]. In this convention have been decided the basic principles for oil pollution compensation, mainly, setting up a strict liability on the shipowner limited to an amount that was approximately double the limits set under the 1957 International Convention Relating to the Limitation of the Liability of Owners of Sea-Going Ships [3].

This convention was followed by the 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (Fund Convention) [1]. This provided for a Fund financed by levies on oil industry to compensate victims of pollution who fell outside or were inadequately compensated by the new statutory regime imposed on shipowners in respect of oil pollution [1]. The 1992 Protocols updated both the CLC regime and the Fund Convention provisions [1]. A new Protocol to the 1992 Fund Convention was agreed in May 2003 for the creation of a voluntary third tier of liability for oil pollution damage [4].

The effectiveness of the international system of compensation was raised with each new incident of oil pollution at sea: Amoco Cadiz in 1978, Exxon Valdez (in the US) in 1989, Erika (off the coast of Brittany-France) in 1999 and Prestige (off the coast of Galicia-Spain) in 2002 [5]. It is true that these incidents were the catalyst for the development and the revision of the oil pollution liability regimes internationally as well as domestically [3]. However the regimes have inevitably limitations because they were formulated to address immediate problems exposed by the incidents as a compromise between conflicting interests, rather than being given sufficient importance and were, in particular, influenced by commercial interests [3]. Despite these issues, civil liability regime for marine oil pollution was the first international liability regime that extended compensation obligations beyond the provisions related to personal injury and property damage provisions to environmental impairment, and has served as a model for liability rule development for the carriage of dangerous goods, the maritime carriage of hazardous and noxious substances, and revisions to civil liability provisions for nuclear damage [6]. In addition, the method of compensation entitlement under these regime of strict liability (without the need to prove negligence) has become the norm everywhere for oil pollution damage liability rules [6]. It was also explained as an efficient and equitable way to incorporate polluter pays principle into the field of environmental liability [6].

## 2. LEGAL SYSTEM-AN OVERVIEW

The issue of liability for pollution and compensation has been addressed by the International Maritime Organization (IMO) with the help of the Comite Maritime International (CMI) which created the first international regime addressing liability for oil pollution damage and compensation [ ].

This regime was originally composed of the 1969 International Convention on Civil Liability for Oil Pollution Damage (CLC) and the 1971 International Convention on the Establishment of an International

Fund for Compensation for Oil Pollution Damage (Fund Convention) [3]. It was followed by the International Convention on Civil Liability for Oil Pollution Damage, 1992 and the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992. Finally a Protocol to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992 was established in 2003.

Among national regimes the most important is the regime developed by the US where there are both federal and State statutes relating to damage caused by oil pollution [8].

*2.1 Controversial aspects of the international conventions*

The 1969/1971 Fund Conventions apply exclusively to oil pollution damage, which took place in the territory including the territorial sea of a Contracting State and to preventive measures taken to prevent or minimise such damage[7]. There is no restriction regarding the jurisdictional zone in which the preventive measures have to be taken in order to be covered by the 1969 CLC [7]. The 1992 CLC/ Fund Conventions maintain similar provisions but their applicability has been extended in order to cover a new jurisdictional zone following the establishment of the Exclusive Economic Zone under the 1982 UNCLOS [7].

Apparently the 1992 CLC/Fund Convention regime would apply also to pollution damages caused on inland waters of a State Party provided that the ship in question is a sea-going vessel [8]. This issue was raised in October 2003 by the 1992 IOPC Fund Executive Comittee in the context of The Victoria Case, a vessel registered both for river and sea navigation, involved in an incident which occurred on the upper reaches of the Volga River, some 1.300 km from the Caspian Sea and Azov Sea [8]. In that case, the Fund Executive Comittee concluded that The Victoria is a ship within the meaning of the 1992 CLC and under general principles of international law the concept of the territory of the state covers inland waters, including rivers [8]. A different opinion was formulated by some delegations which expressed reservations about the applicability of the 1992 CLC/ Fund Conventions, drawing attention to the preamble of the 1992 CLC which referred specifically to pollution posed by the worldwide maritime carriage of oil and the exclusion of inland waters from the scope of the LOSC [8].

The CLC regime applies to any sea-going ship or any seaborne craft of any type whatsoever, constructed or adapted for carrying persistent hydrocarbon mineral oil in bulk as cargo, provided that such a ship capable of carrying oil and other cargoes to be regarded as a ship only when it is actually carrying the oil in bulk, as cargo, and during any voyage following such a carriage, unless it is proved that it has no residues of such carriage of oil in bulk aboard [11]. Spills from tankers during ballast voyages are not covered by the 1969 CLC/1971 Fund Conventions [9].

The 1992 CLC applies to oil tankers as well as oil spillage from Oil/Bulk/Ore Ships which fulfil the requirement to be constructed for the carriage of oil [7]. Oil pollution damages arising from barges without steering and propulsion ability or floating storage units-FSU as well as floating production, storage and offloading units-FPSO raises the question of applicability of the 1992 CLC [7]. While barges without steering and propulsion ability are to be treated as ships under UK law, such an answer is not so obvious for other types of crafts and is to be decided on a case by case basis [7]. In The Slopes (2000), the intergovernmental bodies of the 1992 Fund decided that the 1992 Fund's policy is to apply the 1992 Conventions to offshore crafts only when they carry oil as cargo on a voyage to or from a port or a terminal outside the oil field in which they normally operate [10]. Weather or not a relevant ship meet the criteria for being considered as a ship within the meaning assigned to the term in the definition of the 1992 CLC has been the subject of several decisions adopted by the 1992 Fund Assembly in a number of cases such Maritza Sayalero(1998), The Dolly(1999), The Al Jaziah(2000), The Slopes(2000)[8].

The interpretations offered by intergovernmental bodies of the 1992 Fund are not binding and the matter may be referred to national courts, but according to some authors, it constitute persuasive evidence of the meaning of the provisions and can be taken into account by the national courts [10].

All structures that fall under the definition of ship under article I(1) would be subject to the 1969/1992 CLC irrespective of their size [8]. The 1992 CLC does not apply to warships or to other government ships used for non-commercial activities [11].

Ecological damages are excluded from compensation [12]. Also, the regime does not recognize a right to compensation for a claimant whose claim is in essence of purely economic indirect/relational/secondary nature [8]; [10]; [12]. A trio of cases - Landcatch Ltd.v.International Oil Pollution Fund, P&O Scottish Ferries Ltd v. Braer Corp Times, The Sea Empress-considered these matter [1]. As a matter of principle it has been decided in *Sea Empress* that for an economic loss to be recoverable must be satisfied the requirement of a strong causal link between economic loss on one hand and the claimant's activity on the other hand with the polluted area [1]; [7].

Strict liability of the shipowner and channelling of liability were adopted at the Diplomatic Conference in 1969 due to the influence of the 60s nuclear conventions [15]. Claims for pollution damage under the Civil Liability Conventions can be made only against the registered owner of the ship concerned [17]. This does not preclude victims from claiming compensation outside the Conventions from persons other than the shipowner [8].

In the 1992 CLC the channelling as a principle was not abandoned, but it widens the category of people who are exempt from suit to now include in addition to the servants and agents of the shipowner, as originally specified in the 1969 CLC, the crew and pilots, together with charterers of any kind including demise charterers, operators, salvers, persons taking preventive measures and the servants or agents of any of these categories [9]; [15]. Claims against such persons are expressly prohibited unless the damage resulted from their personal act or omission committed with the intent to cause such damage or recklessly and with knowledge that such damage would probably result [8]. A right of recourse is given to the shipowner both against the persons covered by „channelling provisions" as against the third parties, i.e. port authorities [8].

Strict liability means that there is no need for the claimant to prove shipowner's fault and only limited exceptions are available to the shipowner [7]. The shipowner is defined as the „registered owner" or, in the absence of registration, the person(s) owing the ship at the time of the incident [7].

When an incident involving two or more ships occurs and pollution damage results there from, the owners of all ships concerned shall be jointly and severally liable for all such damage which is not reasonably separable [11].

A public law liability may arise under EC legislation that exceeds the amount of compensation payable according to the 1992 CLC/Fund Conventions [1]. Therefore, whenever victims will not be compensated to the full of then damage due to the existing international liability and compensation system, the European Court of Justice's ruling in *Commune de Mesquer v. Total France SA and Total International Ltd.* Case, allows them to turn to other persons involved in maritime transport, persons who cannot invoke the right to limit their liability: shipper, charterer and producer of waste [16].

The Court held that in this case of heavy fuel oil accidentally spilled at sea following the sinking of an oil tanker, it can be considered that the seller of the oil, also being the charterer of the ship carrying it, has „produced" waste if the seller-charterer contributed to the risk that the pollution caused by the shipwreck would occur [16]. His contribution to the risk of pollution would consist in failing to take measures to prevent such an incident, in this case measures such as concerning the choice of the carrying ship. In such circumstances, for the purposes of Directive 75/442/ EEC on waste, it will be possible to regard the seller-charterer as a previous holder of the waste and to make him responsible for bearing the cost of disposal and compensating the pollution damage [16]. The French Court de Cassation, by a Judgment of 17 December 2008, has fully endorsed the European Court of Justice's preliminary ruling in upholding the liability of the seller and charterer of the Total group companies [4].

### *2.2 International Fund for Compensation for Oil Pollution Damage, 1992 (1992 Fund)*

The 1992 Fund Convention materialise the undertaking of the oil pollution industry and in particular, oil importers to contribute to the compensation of oil pollution damage [7]. The 1992 Fund Convention has the following purposes: to provide compensation for pollution damage to the extent that the protection afforded by the 1992 Liability Convention is inadequate; and to give effect to the related purposes set out in the Convention [13].

*Rationae materiae*, the 1992 Fund Convention apply to pollution damage caused in the territory, including the territorial sea/ economic exclusive zone, of a Contracting State, and to preventive measures, wherever taken, to prevent or minimize such damage [13].

*Rationae personae* the 1992 Fund shall pay compensation to any person suffering pollution damage if such person has been unable to obtain full and adequate compensation for the damage under the terms of the 1992 CLC. The following reasons justify the compensation paid by the Fund: because no liability for the damage arises under the 1992 Liability Convention; because the owner liable for the damage under the 1992 CLC is financially incapable of meeting his obligations in full and any financial security that may be provided under Article VII of that Convention does not cover or is insufficient to satisfy the claims for compensation for the damage; because the damage exceeds the owner's liability under the 1992 CLC as limited pursuant to Article V, paragraph 1, of that Convention or under the terms of any other international Convention [13]. Thus, the Fund liability is secondary [8].

In situations were there is oil pollution damage but the ship responsible for oil spill hasn't been identified, the claimant can be compensate by the 1992 Fund if he can prove that the oil that caused the damage came from at least one ship [7]. Thus, the Fund is liable for compensation from „mistery oil spills" where the ship that caused the damage is not identified [7].

The shipowner's expenses for preventive measures falling under the definition of Article 6 of the 1992 CLC rank equally with oil pollution damage or clean-up claims by other parties [7].Therefore, to the extent the shipowner's liability limit is exceeded, these are recoverable from the 1992 Fund in the same way and to the same proportion as other claims [1]; [7].

The Fund shall incur no obligation if: it proves that the pollution damage resulted from an act of war, hostilities, civil war or insurrection or was caused by oil which has escaped or been discharged from a warship or other ship owned or operated by a State and used, at the time of the incident, only on Government non-commercial service; the claimant cannot prove that the damage resulted from an incident involving one or more ships [13]. The defences available to the 1992 Fund are more limited than those available to the shipowner [8]. In the specialized literature it was held that in such cases neither the shipowner nor the 1992 Fund have any liability under the 1992 Liability Convention and thus, the claimants will be have to try and recover against other parties [7]. The Fund may be exonerated wholly or partially from its obligation to pay compensation to such person, if proves that the pollution damage resulted wholly or partially either from an act or omission done with the intent to cause damage by the person who suffered the damage or from the negligence of that person [13]. There shall be no such exoneration of the Fund with regard to preventive measures [13].

The aggregate amount of compensation payable by the Fund was set at 203,000,000 units of account

[13].Time bar is similar to 1992 CLC but in addition the 1992 Fund Convention allow the claimant to make a notification about the said notification [13].

Where an action for compensation for pollution damage has been brought before a court competent under the 1992 Liability Convention, such court shall have exclusive jurisdictional competence over any action against the Fund for compensation in respect of the same damage. However, where an action for compensation for pollution damage under the 1992 Liability Convention has been brought before a court in a State Party to the 1992 Liability Convention but not to the 1992 Fund Convention, any action against the Fund shall be brought either before a court of the State where the Fund has its headquarters or before any court of a State Party to the Fund Convention competent under Article IX of the 1992 Liability Convention [13]. In the specialized literature it was emphasized that there are no provisions in the 1992 Liability Convention or the 1992 Fund Convention for multiple proceedings thus, the conflict of laws provisions for each contracting state would apply in such cases [7].

Any judgment given against the Fund shall, when it has become enforceable in the State of origin and is in that State no longer subject to ordinary forms of review, be recognized and enforceable in each Contracting State[13].

*2.3 The International Oil Pollution Compensation Supplementary Fund, 2003*

Threatened by the EU regional actions, the IMO quickly increased the financial caps (together with the compensation provided from the Fund) by 50.37% in 2000 through the adoption of two Amendments [5]. On May 2003 a new Protocol was approved which provided a third tier of compensation through a Fund [12]. The total sum of the amount of compensation payable under the Supplementary Fund together with the amount of compensation actually paid under the 1992 Liability Convention and the 1992 Fund Convention shall not exceed 750 million units of account [14].

No compensation shall be paid by the Supplementary Fund for pollution damage in the territory, territorial sea or exclusive economic zone or area of a Contracting State until the obligation to communicate to the Director of the Supplementary Fund on the quantities of oil received have been complied with in respect of that Contracting State for all years prior to the occurrence of that incident [14].

Provisions related to jurisdiction and the recognition and enforcement are similar to 1992 Fund Convention.

*2.4 The position of European Union*

In response to the Erika incident, the European Commission has adopted two sets of legislative proposals in March and December 2000 respectively, the so-called Erika I package and Erika II package [15].

The first set of proposals was launched in a Communication on the Safety of the Seaborne Oil Trade and provides for amendments to existing EC Directives on port state control and on classification societies as well as a Regulation on the accelerated phasing out of the single hull oil tankers [16].

In the second set of safety measures the Commission announced a proposal for a Directive establishing a Community monitoring, control and information system for maritime traffic, a proposal for a Regulation establishing a European Maritime Safety Agency (EMSA) as well as a proposal for a regulation on the establishment of an additional compensation fund [16].

The Fund for Compensation for Oil Pollution in European waters, known as the COPE Fund, would have an updated ceiling of 1 billion, instead of 200 million under the 1992 Conventions [15]. The Fund has never been established, the Council preferred to deliver the issue to the IMO as they considered that the issue, being international in scope, could be better addressed at international level [15].

The third maritime safety package consists of seven proposals for directives and regulations. These proposals demonstrated a clear intent to contribute and to participate in the international legal framework aimed at improving maritime safety and guaranteeing ample compensation for oil pollution victims [16].These position is a consequence of the dissatisfaction about the international scheme actually in force who could not provide adequate compensation due to existence of the limitation of liability and did not have a sufficient deterrent effect [15].

The UE has been an active supporter of reform, supporting the extension of liability to charterers, classification societies or flag states in the event of fault, as well as the amendment of the right to limit, aiming to revert the old test of „actual fault or privity” [8]. In a report to the UE Parliamentary Assembly dated 30 March 2005, the Committee on the Environment suggested that in case of repeated refusal of the IMO to consider these issues, a threat should be made together with EU member states to leave the CLC Convention [8].

*2.5 US regime*

The fundamental reason for the US unilateral approach to marine oil pollution is that US admiralty law was seldom harmonized with the international maritime conventions [5].

A series of direct reasons must be taken into account. First, coverage of the pollution costs from major oil spills under the 1969 CLC and the 1971 Fund Convention, was considered inadequate [5]. The liability limit under CLC was set at approximately $14 million, even though the US sought a minimum of $50–60 million [5]. Secondly, the ambiguous definition of the pollution damage under international conventions. The definition of pollution damage is a reflection of the different concepts over what constitutes damage [5]. These different concepts led to the adoption of a general definition which resulted in different interpretations among the national jurisdictions [5]. Thirdly, the political issue over whether the international convention shall prevail to the U.S. State Oil Pollution statutes states thus leaving open the possibility of claims for uncompensated damages in the event of major oil spills [5].

*2.6 STOPIA and TOPIA*

The decision to stop the review procedure of the 1992 Conventions was due the offer made by ship-owners through their P&I [8] Clubs to share the overall costs of the claims equally with the oil products receivers. Because the revision was abandoned, the Boards of International Group P&I agreed to implement a mechanism for increasing voluntary the minimum limit of ship-owner liability under the 1992 CLC in respect of small tankers (up to 29,548 GT) and this later has become known as Small Tanker Oil Pollution Indemnification Agreement (STOPIA). This agreement entered into force at the same time with the 2003 Protocol, namely on March 2005 [8]. In addition, the discussions and consultations that took place between the Fund Secretariat, OCIMF, P&I clubs Board, Intertanko and ICS resulted in a supplementary agreement by which the ship-owners will be contractually bound to indemnify the Supplementary Fund in respect of 50% of the amount of any claim falling on the Fund, so that additional burden imposed under the Supplementary Fund will be equally shared [8]. The agreement was entitled TOPIA (Tanker Oil Pollution Indemnification Agreement 2006) and in contrast to STOPIA it applies to all relevant tankers irrespective of their size [8].

Both STOPIA and TOPIA have particular importance in case of exorbitant damages from oil tankers in State Party of the 2003 Supplementary Fund. These arrangements do not affect the rights of claimants in relation to damages caused by pollution but only concern the agreements between shipowners and oil cargo interests on who contributes and how much in the compensation [7].

## 3. CRITICABLE ASPECTS OF THE LIABILITY REGIME

The international legal regime concerning the damage caused by oil pollution has undeniable merit to make the pass from a legal vacuum to an innovative scheme of compensation of the victims of oil pollution spills [3]. The international system had encountered many problems during its 20 years of application [2]. In addition to the problem of insufficient compensation, two other problems have been intrinsic to the international system: first, the refusal by the IOPC Fund to cover environmental damages and second, the lack of effective sanctions to the pollution-prevention system [2].

Finally, despite broadening of the geographical scope of the liability regime, its impact over transnational damages remain debatable in relation to high seas [6].

The refusal of the US to take part in the international regime has also posed an obstacle to the concerted international efforts aimed at controlling oil pollution by ship as well as handling the problem of the transnational oil pollution [2].

The necessity of updating and improving of the international system of liability for marine oil pollution generated much debates focused mainly on the following aspects: the limitation of liability; the narrow definition of the prejudice; channelling of the responsibility; broadening the scope of application.

## 4. CONCLUSIONS

Civil liability for oil pollution damages could not be effectivelly solved under the national law until the adoption of the 1969 Liability Convention, the first convention of the international liability regime. Considered an outstanding legal tool, it established the basic principles of compensation for oil pollution, mainly set of a strict liability for the shipowner up to a certain limit, a requirement of compulsory insurance as well as the channelling of liability exclusively to the shipowner and his insurer. To this principles, maintained by the 1992 Protocols, were added amendments in respect of limits of liability and compensation, enhanced protection for other persons than the shipowner, broadening of the scope of aplication. The norms of the convention regime become everywhere the rule for the law concerning liability for oil pollution. Finally, they served as a model for drafting of the legislation on liability in other fields too. The legal construction of the system of the international conventions is based on balancing of multiple economic and political interests of the shipping industry, on the one hand and oil interests on the other side. In fact, it constitutes an adaptation of the contractual model provided by the 1957 Limitation Convention where along with the shipowner and the cargo owner is brought a third party, the victim of the pollution damage. One can say that it is the „source of evil". The inadequacy of the international regime is primarily seen through the inadequate compensation. Following every major oil pollution incident the limits of compensation were raised through new amendments. This challenged the shipowner's limitation of liability. Another effect of the insufficient compensations is challenging the exclusive nature of liability under the international oil pollution conventions system. The "de-responsibilization" of an entire category of persons involved in the running of ship affects not only the level of compensations but also the interest in the prevention of the pollution incidents.

The international regime adressing liability for oil pollution is not unified. The refusal of the US to joyn the 1984 convention system leads to the development of its own national oil spill liability laws which are far beyond not only in respect of the level of compensations afforded to individual claimants, the functions of the Fund but also in respect of the scope of the recoverable damages. Its provisions which provide compensation for ecological damages remain only a simple goal for the system of the international conventions. The fragmentation of the international system of liability affects adequate compensation and leaves open the issue of the transbondary pollution.

The future of the international regime of liability for marine oil pollution depends on the interests of the parties involved but also implies more and more large human collectivities and areas perceived as marine common spaces. It is preferable in these circumstances that the emphasis should be placed on preventive measures, effective sanctions of the pollution prevention system and ecological restoration.

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# LIPARA AND MYLAE.
# THE FIRST NAVAL BATTLES IN THE WAR FOR SICILY (260 B.C.)

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**ABSTRACT**

In 261 B.C., the Roman Senate took the decision to build a powerful fleet of 20 triremes and 100 quinqueremes to be able to stand the Carthaginian one. The ambitious Roman project was finalized in 260 B.C., when the ships were launched at sea and equipped with crews trained on land. The new ships engaged immediately in two little confrontations, at Lipara and near the coast of Italy. The first one ended with the Carthaginian victory while the second was won by the Romans. The two confrontations were followed by an important naval battle at Mylae that ended with the Roman victory, due to the new fight technique that involved the use of a plank to link the ships together at sea.

**Keywords:** *Rome, Carthage, Gaius Duilius, corvus, Lipara, Mylae, quinqueremes*

## 1. INTRODUCTION

Between 264 B.C. and 261 B.C., the Roman legions from Sicily reputed noticeable successes, prompting Syracuse to conclude peace and conquering Agrigentum. Nevertheless, Carthage was still ruling over the Western part of Sicily, because of the military bases it had established in that area and of its fleet, which was dominating over the Sicilian waters. It became obvious that, in order to win the war, Rome needed war ships able to face the powerful fleet of Carthage. In 261 B.C., the Romans changed the military tactics they used in the War for Sicily and the Senate took the decision to build 120 war ships, 20 triremes and 100 quinqueremes [1].

## 2. THE BUILDING OF THE ROMAN FLEET

Putting the project into practice was not an easy task. Although the Roman navy was well developed, it was only made up of commercial ships and triremes. It lacked the quinqueremes, that were specific to the Carthaginian war fleet [2].

The Romans used a Carthaginian ship they captured in 264 B.C. as a model for their quinqueremes [3]. According to the literary sources, the Roman fleet would have been built in 60 days from the moment of cutting the trees [4]. The place where this happened could not be precisely identified. It seems that some ships were built at Ostia, where the Romans could survey the activity closely, and the other part of the fleet was assembled on the docks of the Greek cities in Italy. The ships built by the Greek craftsmen were paid and became the property of the Roman state [5].

A delicate problem was that of the crew necessary to equip the new fleet. A trireme was usually equipped with 200 persons, 170 of them being oarsmen [6]. In case of a quinquereme, the number of oarsmen raised to 300 [7]. Rome needed a great number of men for the crews of the newly built ships. It was almost impossible that the total number of persons to equip the 100 quinqueremes had been provided only by the *socii navales* from Italy. It seems that the crew of the fleet was heterogeneous, made of citizens from the *coloniae maritimae* of Ostia, Antium and Tarracina [8], also of Roman *proletarii*, citizens who had an income smaller than 400 *asses* [9], and people from the allied naval cities. The literary sources also mention the presence of the Samnite ethnics in the crews recruited for the great sea adventure [10].

According to Polybius, the crew was trained on land. The oarsmen had to sit on especially-built benches, in the same order as in the ships, and their leader was placed in the middle of them. The oarsmen bent on their back, at the same time bringing their hands to the chest, and then bent forward stretching their arms [11]. Some modern historians denied the possibility of training the oarsmen on land, but J. Thiel agrees with Polybius' record. He supports it with an account given by Polyaenus about the Athenian admiral Chabrias. He had to command 200 Egyptian triremes and trained the oarsmen on land, because they were young and unskilled [12]. Another argument to support Polybius' description is the major risk involved in embarking unskilled oarsmen. If Romans had taken aboard people with no previous training, the first naval experience would have ended in a disaster. The oars could have been broken, some sailors might have been wounded and the ships might have sunk [13].

## 3. THE BATTLE OF LIPARA

In 260 B.C., the consul Gnaeus Cornelius Scipio was given the command of the newly built fleet while his colleague, Gaius Duilius, was supposed to handle the land army in Sicily. Scipio sailed to Messana with 17 ships, to prepare the logistics for the Roman fleet that was to come [14]. Sailing towards Sicily, the consul learned there was an opportunity to seize the town of Lipara, that was under the control of the Carthaginians. This was the only harbor of a small archipelago at the north-east of the Sicily coast. The Carthaginian admiral Hannibal was at Panormus when he received the news regarding Scipio's activity. He dispatched Boödes to Lipara, with a squadron of 20 quinqueremes, to prevent the Romans from capturing the city. Boödes sailed by night, and appeared at the mouth of the harbour at dawn, taking Scipio by surprise. The Roman squadron was trapped, and, having no way out, Scipio surrendered without opposing any resistance [15]. The literary sources also offer another version on the capturing of the consul Gnaeus Cornelius Scipio. According to this records, the Carthaginians used a trick to capture the Roman magistrate: they invited the consul on the board of the flag-ship to negotiate the fate of Lipara and, once on the vessel, he was taken prisoner [16]. As a result of this failure Scipio was given the cognomen *Asina*. Later on, he was probably redeemed, because he got to the consular power once again in 254 B.C. [17].

To compensate for the loss of 17 ships, Rome asked for help from the allied cities. The Roman fleet was completed by the addition of ships from Massalia, Ostia, Naples and Rhegium [18]. While waiting for the finalization of the fleet preparations, the ships were training at sea near the Italian coasts. Hannibal learned of these maneuvers of the Roman fleet and directed his ships to Italy. The African squadron, composed of 50 vessels, attacked the Roman ships but the odds were on the Roman side. The Romans defeated the Carthaginians, which lost more ships than they had captured at Lipara [19]. After the first two naval fights the results were balanced, since each opponent enjoyed a small success.

## 4. THE BATTLE OF MYLAE

After Scipio was taken prisoner, the command of the fleet was given to Gaius Duilius. Shortly after he took the command, the consul started the fight preparations, because the enemy fleet was sailing near Messana.

The well-known and decisive method in a naval battle was to outrun the enemy ship and to pierce it with the iron spur at the bow [20]. The Romans realized that they did not have either fast ships or skilled commanders, and they equipped the bow with a mobile boarding device, called *corvus*, that could be lowered either in front of the ship or on both sides when an enemy vessel would have tried to use its iron spur. When the bridge was lowered over the enemy ship, the soldiers could have captured it, like in a land fight. In this way, the Roman infantry was given more importance in the naval battles [21].

In order to lure the Roman fleet, Hannibal decided to sail to Mylae, a city in the north of Sicily, near Messana, intending to plunder it. The Carthaginian admiral was confident about his victory, because he knew the Roman fleet, consisting of heavy ships, would have had no chance in front of the fast African vessels.

The Carthaginian fleet was made up of 130 vessels and a flagship, a heptares that belonged to the king Pyrrhus of Epirus [22]. W. Tarn showed that the Romans had about 143-145 ships, because they had possessed 160 ships before the battle of Mylae, but he also considered the vessels Scipio Asina had lost [23]. However, it is possible to complete the number of the Roman ships calculated by W. Tarn, because, in the battle near the Italian coast, the Carthaginians lost more vessels than the Romans at Lipara. Probably, Rome equipped the ships captured from the Carthaginians and thus their fleet reached the number of 160 vessels [24].

The Roman squadrons were made of quinqueremes, triremes and probably penteconters. Certainly, most of the fleet was made of quinqueremes, because the enemy had similar ships. The percentage of this type of ship in the Roman fleet was about 80-90% [25].

The presence of the Carthaginians near Mylae, with the intention to plunder it, determined the consul Duilius to give the command of the land troops in Sicily to the military tribunes and he ordered the departure of the fleet [26]. When the Roman ships were noticed by the Carthaginians, they realized that the Romans had difficulties in controlling them, due to their lack of experience. The admiral Hannibal was sure about his victory and attacked the Roman ships without any preparation in advance. When the Carthaginian ships came closer, with the intention to rip up the enemy vessels, they were assaulted on the boarding bridges that allowed the access of the Roman soldiers on their decks. The Carthaginian first line was defeated by the new technique and the naval battle looked more like a land fight. During the second stage of the battle, after the surprise effect had disappeared, the Carthaginians tried to adapt to the new situation and made use of their agility in maneuvering the ships, rotating around the enemy vessels to strike them. This attempt failed when the second line of the Roman fleet entered the fight. The battle of Mylae, from August 260 B.C., ended with the victory of a great land force against an incontestable sea power [27].

The losses in the Carthaginian fleet were considerable. Polybius related that the Carthaginians lost 50 ships, without indicating the number of captured or sunk vessels [28]. Eutropius mentioned that the Romans captured 31 ships and took 7,000 prisoners and other 14 ships had been sunk, with 3,000 persons on board [29]. The Roman losses seemed to be significantly smaller, estimated at only 10 triremes. This type of ship was more vulnerable since it did not have a *corvus*. The conclusions drawn, considering the Carthaginian losses, is that the boarding technique applied by the Romans was less destructive, the number of captured ships being bigger than that of the sunken ones [30].

The victory at Mylae meant a lot for the Romans' morale. Rome became over night a naval power and got the means to conclude the War for Sicily, that seemed not to end in the near future and threatened to ruin the Italian commerce. The consul Gaius Duilius, the commander at Mylae, was the first magistrate who was given the naval triumph at Rome [31].

## 5. THE BOARDING BRIDGE (*CORVUS)*

In 261 B.C, Romans needed only 60 days to launch their first important military fleet. The ships were still rudimentary and they could not be compared with the Carthaginian vessels, that were faster [32].

The Romans needed to compensate for the lack of naval experience of their commanders and crews and also for the lack of speed of their military ships. In order to reduce these disadvantages, they invented a boarding bridge, that was later named *corvus* (*kórax* in Greek) [33].

The technical data of the device used by the Roman naval forces are to be found in the *Histories* of Polybius. It seems that the historian from Megalopolis took the data offered by the Roman annalist Fabius Pictor [34]. The Polybian account relates that the badly build Roman ships were equipped with a device called “crow”. This was made of a long pole of 7.3 m long and 22-25 cm wide, placed vertically at the bow and having a pulley at its end. Around the pole there was a board of 11 m long and 1.2 m wide, with a hole in it. The board was making the bridge. It had a small parapet and a spike at its end, used to grip the enemy ship. This could be lowered in front and also on both sides of the ship [35].

The new device was functioning as it follows: when an enemy ship was coming closer to a Roman vessel prepared to pierce it, the soldiers on the deck lowered the bridge over the ship of the enemies using the pulley; the enemy ship was gripped and the Roman soldiers passed on the deck of the vessel, capturing it as in a land confrontation [36].

The Romans who were skilled in land battles added this bridge to the ship in order to compensate the difference between them and the Carthaginians and to take them by surprise. The Roman innovation also had another major advantage, because it considerably decreased the number of the sunk ships. Using this technique, the Romans captured 31 Carthaginian vessels in the battle of Mylae [37].

W. Tarn rejected the validity of the information offered by Polybius regarding the boarding bridge. He noted that it was impossible for a Roman ship to be equipped with such a device, because its weight would have sunk the vessel. According to his analysis, the Roman ships could have been equipped at the most with a hook [38].

H. Rose and J. Thiel accepted the presence of the boarding bridge on the Roman ships that participated in the First Punic War. They proved that in case the Romans had used a simple hook, it would have been impossible for the soldiers to pass on the deck of the enemy ship. Another strong argument prove the usage of the boarding bridge in the naval battles during the War for Sicily: the boarding technique was given up with the development of the naval constructions and the building of easier and faster ships and hence, later on, this device is not to be found on the Roman vessels [39].

## 6. CONCLUSIONS

The First Punic War broke in 264 B.C. and it opposed two different types of military powers: Rome was a great terrestrial power, which had just completed the conquest of Italy, while Carthage was a fearsome naval force, owning the most powerful fleet in the Western Mediterranean.

At the beginning of the conflict, an African admiral warned the Romans that they would not be able even to wash their hands in the sea unless the Carthaginians allowed them to do this [40]. The Romans needed 4 years to realize that it was not possible to win the war without a military fleet able to chase the Carthaginians away from the Sicilian waters.

Launched at sea in 260 B.C., the first Roman fleet defeated the Carthaginians in the great naval battle from Mylae, through the use of a boarding bridge fixed on the deck of the ships. By this victory, Rome opened its ways on the sea and became a noteworthy naval power.

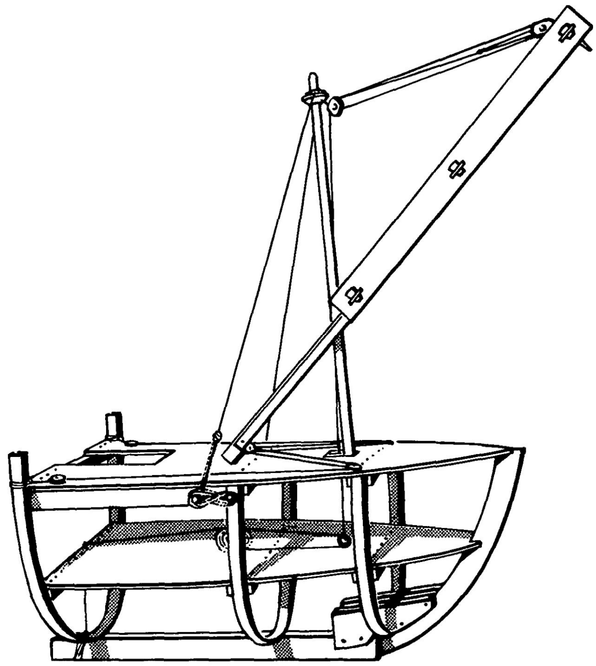

Figure 1 Roman *corvus*
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# CORRELATION BETWEEN SAFETY OF NAVIGATION AND PARAMETRIC ROLL OF SHIPS IN WAVES

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**ABSTRACT**

The present paper addresses the problems raised by the parametric rolling phenomenon on board vessels. The problems involving ships stability loss due to parametric rolling concerned the maritime community and researchers from early decades but more attention was paid at the time when this phenomenon was sighted in the late of 1990s on board a containership. Being a part of ship stability, the assessment of the parametric rolling is part of the safety of ships and safety of navigation. The necessity of paying more attention to this phenomenon and the possibility to be included into future stability criteria is of paramount importance.

**Keywords:** *parametric rolling, ship stability, stability criteria, righting moments, metacentric height, lever arm curves, capsize, safety, navigation.*

## 1. INTRODUCTION

Ship survivability against capsize in heavy seas has become one of the reasons of the areas of primary concern among ship stability researchers and designers in recent years. When a ship is subjected to the effect of large waves it may capsize according to a number of different scenarios, depending on the magnitude and direction of the wave excitation and the ship's own capability to resist such excitations. Resonant or breaking waves approaching a ship from the side ("beam seas") have a potential to excite large rolling which could result in capsize, especially if the intensive oscillation of the ship causes shift of cargo or, if a considerably quantity of water is shipped on the deck.

In practice, the ships could loose intact stability under the impact of waves and wind in several ways. Typically, it is a chain of events rather than a single event. For example, due to high or abnormal waves, a ship could sustain rudder failure or even more could loose power, which might then cause it to heavily rolling in beam seas, thus in turn leading to shift of cargo and dangerous list of the vessel. Moreover, huge amount of water is shipped on deck and the worst result is capsizing.

Another frequent scenario is when the wave produced important damage to ship structure, for example to hatch covers and/or coamings, deck equipment or the hull itself and the result is flooding of cargo holds or other compartments, loss of freeboard and eventual sinking. Failure of structural integrity is common to many loss scenarios so it is of paramount importance to find out the order of magnitude of stresses imposed by large waves.

More dangerous can be a group of steep and relatively long waves approaching a ship from the bow ("head seas") or from the stern ("following seas"). Waves of this kind are known to incur significant reductions in roll restoring capability (i.e. the tendency to return to the upright position) for many types of vessels and they instigate dangerous coupled motions.

Due to restoring levers alterations in waves, in head and following seas, a ship may loose her stability or may capsize in at least four different ways:

- Pure loss of stability, typically on a wave crest;
- Parametric rolling;
- Dead ship condition;
- Broaching and/or Surf-riding.

All these phenomena, which the nature is purely dynamic, usually occur in a sea state under the influence of arbitrary loads, which came from waves and/or wind.

The main objective of this article is to point out the importance of parametric roll phenomenon which is more and more encountered in practice on board vessels, especially on board containerships. The assessment of the parametric rolling is very important for the assessment of ship intact stability and therefore for safety of ship and safety of navigation. The idea came from a number of observations related to casualties involved containerships in heavy weather conditions which faced the challenge of parametric roll phenomenon, resulting in huge losses of cargo and damage to ships.

## 2. THE RESEARCHES OF PARAMETRIC ROLLING PHENOMENON

The research on parametric roll phenomenon has started in Germany in 1930's. The studies continued in 1950's, Kerwin (1955), Paulling and Rosenberg (1959) who studied a 1-DOF model based on Mathieu equation. France (2001) and Shin (2004) point out that a Mathieu type one degree of freedom model can easily be used to show when ships encounter parametric resonance used the same approach later. In 2006 Bulian came up with a 1.5 DOF model where the assumption of quasi-static heave and pitch leaded to an analytical description of the GZ curve. This model is valid for moderate ships speed in head seas and gives reasonable results for the prediction of parametric roll resonance.

To get an extensive analyze and understanding of the ship behavior, Neves (2007) derived a 3-DOF model where the motions of heave, roll and pitch were coupled.

Thus, the restoring forces and moments in heave, roll and pitch motions were described by using Taylor expansion up to second order. However, compared with experimental results, the roll angle predicted by this model was too large. Therefore, in 2005 Neves and Rodriguez expanded the model found in 2002 by using Taylor expansion to third order. In this model, the nonlinear coupling coefficients are derived as functions of the characteristics of the hull shape. Later on, using the third order model from Neves and Rodriguez, Holden (2007) made predictions of the roll angle of container vessels.

Despite the fact that parametric rolling was extensively investigated this fact was actually done only by mathematical modeling and laboratory experiments. For the first time when this phenomenon came into the attention, as a real incident scenario, was in late October 1998 when a laden Post-Panamax containership was overtaken by a violent storm in the North Pacific Ocean. In a completely confused and violent sea, the containership faced the storm for about 12 hours, during which the master attempted to steer the vessel into increasingly higher seas. The violence and magnitude of the seas, with waves up to 15 m, and extreme and violent motions of ships, with roll angles up to 40 degrees correlated with significant pitch amplitudes, was reported by deck officers. The result was catastrophic; with almost one-third from the 1300 on-deck loaded containers been lost overboard while another one-third were in various stages of damage and destruction.

From that time, an increased number of containers ships who faced rough weather conditions, with high seas and winds, and developed heavily rolling and pitching motions, were involved in incidents resulted in loss of containers overboard possible as a result of parametric roll.

## 3. WHAT IS PARAMETRIC ROLL?

Parametric roll is a mode of intact ship stability failure in heavy weather conditions. The stability of a ship depends on the waterline of the ship. The development of parametric rolling is caused by periodic stability changes occurring with certain frequency.

If the ship is rolled on the wave trough, due to a wide waterline, the restoring moment is increased over its magnitude in still water. There is more stability than in still water (this means that is need a bigger force to push the ship away from its equilibrium point) and the ships rolls to the other side with an increasing roll angle with time.

If at that time, the ship has the wave crest amidship, the stability is decreased and the ship will roll further to the opposite side because of the greater speed of rolling and less resistance to heeling. So, the push back force is smaller and the roll speed increases.

Finally, the vessel comes again with amidships section on the wave trough, where the stability is again large. This situation leads to a large push back force and the ship roll more over (because the roll speed was increased in previous step) which leads to a larger roll angle and the ship reaches its maximum amplitude roll. The scenarios repeats until the ship capsize or stabilize up to a certain roll angle. In this scenario, was one half of the roll cycle associated with the passing of an entire wave. So, there are two waves that pass during each roll period. That means the roll period is about twice that of the wave period.

In contrast with pure loss of stability, parametric roll is generated by a series of waves of certain frequency, therefore parametric roll cannot be considered as a one wave event.

One of the main reasons for parametric rolling is the variation in metacentric height and damping values from trough to crest conditions associated with bow flare immersion and pitch resonance in head sea conditions.

The occurrence of parametric roll phenomenon is related to the hull forms that experience large volumetric changes in the submerged portion during the wave passage, predominantly the ships with large bow, stern flares and fine underwater hull, such as new generation of containerships.

Today’s Post-Panamax container ship designs feature wide beam and large bow flares in order to carry more containers on deck while still minimize the resistance with the stream lined underwater hull. As wave travels down along hull, the stability varies as the wave crests travel along the hull. When the bow is down due to moderate pitching couple with slight roll, the large flare suddenly immersed in the wave crest. The restoring buoyancy force plus the wave excitation force would “push” the ship to the other side. Similar action will happen on the other side as the bow pitch down in the next cycle. These coupled synchronous motions could lead to large roll angles with short period in few cycles even with moderately high waves.

Many model tests carried out highlighted the major influence of two factors related to parametric rolling: the wave heading and the ship speed on the roll angle. Particularly, the wave heading influenced the amplitude of roll oscillations through speed reduction and through the variation of metacentric height, which in turn determined a roll damping degrease.

Thus, to cause the parametric roll resonance, is needed simultaneously to be involved environmental and physical factors:

- Parametric roll occurs when natural roll period is between 1.8 to 2.1 times the encounter period (normally associated with the pitching period):
- Shape of ship’s hull. This condition needs some more attention. The hull geometry is critical for occurrence of parametric roll resonance. Large flare the more likely is the parametric roll angle and wider range of resonance. These types of hull designs are based on years of investigation of what is the optimal design in respect of economical aspects, like for example maximum cargo and reduced water resistance. The result is a hull shape like a box in the middle and with large geometry gradients at the head and stern of the ship, which involves large difference in water plane area. This type of hull designs is common in container vessels and due to this shape these ships are susceptible to encounter parametric roll resonance.
- To be initiated the parametric roll; it requires a group of waves above the threshold or critical

height: $h_w > h_c$. The threshold depends on size and shape of the hull.

- The wave length is approximately equal to the ship length: $\lambda \approx L$. In this condition the ship needs to sail in head or stern seas. Only waves in such direction can reach such a length, especially for large container vessels.
- The ship's roll damping is low.

## 4. PARAMETRIC ROLL AND SHIP SAFETY

The main concern for all floating structures that have ever built was their stability. That's why since 1914 the Safety of Life at Sea (SOLAS) convention treated and deals with ship stability. The earliest regulatory recognition of this can be traced to Samuel Plimsoll in the 1860's.

A classical field of ship safety and safety to navigation is without any doubt the intact stability of the vessel. In regard to the safety of the vessel, the stability of a ship is of paramount concern. Times have moved on and stability regulations have come on a long way but the concern remains high.

Vessel's intact stability is a fundamental component of seaworthiness so it is in the interest of all owners/operators to learn about this topic and ensure that their vessel possesses a satisfactory level of stability in order to ensure its safety as well as that of the people on board the ship. Understanding ship's stability, trim, stress, and the basics of ship's construction is a key to keeping a ship seaworthy.

The first condition essential to seaworthiness is that the ship shall never be unstable when upright at the beginning or at the end of any given voyage while at sea. The second condition of seaworthiness is that the worst conjunction of wind and waves that can possible be encountered during the given voyage shall not cause the ship to roll beyond the safe effective range of heel. The lower limit of safety in service is reached when the ship becomes unstable in the upright position. Initial stability at sea is dangerous for two reasons, the ship is very easily inclined by wave and/or wind pressure, and if one course is held for a long time there is a great tendency for cargo to shift so that an angle of heel is accumulated which continually tends to become greater. In order to maintain this limiting degree of safety under actual service conditions, the vessel must sail with sufficient margin of metacentric height to cover any losses of stability which may occur during the voyage.

The safe effective range of stability depends partly upon the nature of the cargo carried, ship design and human factor. The other part of safety effective of stability range depends on environmental factors. Among the environmental factors that can affect the stability of a ship, extreme weather conditions are dominant. In particular, the combined effect of wind and waves can lead to an excess roll angle, water on deck, or motion of cargo. Thus, one of the contributory factors to safety at sea is the weather. Wind and sea forces may dominate the ship behavior or even overwhelm her physically, although a well designed, strongly built ship has a good chance of surviving the worst ravages of the open sea. However, the heavily rolling of modern ships in rough seas is a problem that has not been yet adequately addresses in international regulations.

## 5. PARAMETRIC ROLL SOLUTIONS

For the ships with particular designs found to be vulnerable to parametric rolling possible options to address this vulnerability may exist. In this context, the solution is to introduce a criterion to cover the phenomenon of parametric rolling that have to indicate the possibility of the occurrence of parametric rolling and the magnitude of stability change, as a minimum stability requirement and as additional criteria to the already existing one. These criteria should be made available in form of operating instructions and tools, including information that will define the combination of speed and course, sea state and load conditions that might be dangerous, and to be used for on board-guidance to master and navigation officers.

The possible solutions for parametric roll can be implementation of elements that may contribute to improving the vessel's roll damping characteristics. One of these solutions for reducing the risk of parametric roll is to install small anti-roll tanks (passive or active) to absorb the surplus energy collected during the parametric roll motions.

Installation of fin stabilizers that move to counteract the roll motions of the ship can be an alternative. Again, the key consideration in minimizing the risk of roll is to prevent the progressive accumulation of energy.

Finally, a possible solution for avoiding parametric rolling is by modifying the ship hull from the early design stage. This solution would be aimed at reducing the effect of large bow flare and flat stern lines, so the vessel has an improved volume distribution along its length and in this way the stability during the passage of the wave will be increased.

Of course, all those possible solutions of prevention show good promise but involve high expenses from the owner side and the possibility of introducing still remains as a prospect and based on the individual owner's preference. Moreover, all those solutions will have an impact on the vessel's terms of speed and cargo carrying capacity which are not negligible factors.

However, till reliable solutions will be available, the main responsibility remains in the hands of the master and navigation officers who must recognize very quickly the symptoms of parametric roll and to take action in due time, by using the only available means for the moment, to adjust the ship's course and / or speed, in order to minimize the risk of damage to ship and cargo.

## 6. CONCLUSIONS

The written information for handling of ships in heavy weather is of very little amount. The Admiralty Manual of Seamanship devotes some pages to the handling of ships in severe conditions and explains: „ *How best to handle a ship in heavy weather depends so much upon the type, size and capabilities of the particular ship that it would be unwise to lay down* *precise instructions as to how to act in various circumstances*.“

The seamanship practice indicates that the best way to survive heavy weather is to avoid it. This is borne out also by the development of weather routing systems such as Optimum Track Ship Routing (OTSR), a US Navy system that utilizes route selection and surveillance procedures based on short and extended range forecasting techniques. Seaman’s also use for long time ago weather forecasting and historical data to create routes of navigation that will both mitigate the weather risk and ensure mission success. Once in the vicinity of storm, the general advice is to minimize the risk and damage to the ship. For tropical storms, the doctrine is mainly concerned with avoiding the storm centre, depending on the ship’s location relative to it. Prudent ship operation dictates that severe sea conditions be avoided when possible; thus, ship operators often have limited experience in severe conditions.

Ship stability is significant concern and „secure for sea“, to reduce loss of stability on waves and free surface effects on taking on water as well as to reduce the possibility of cargo shifting.

The capability of the ship to withstand the rigors of the seas has influence on decisions regarding speed and heading in heavy weather. The ship that steaming into rough seas is exposed to extreme forces: the impact of waves against the bow and water breaking onto the ship, hogging, sagging and pounding forces caused by excessive pitch and roll motions. Slamming and associated loads are significantly influenced by a small reduction of speed. Running before the sea lessens the extreme forces but significantly increases the risk of broaching-to. Of course the risk of broaching-to can be minimized by reducing the ship speed in relation to wave speed, but this leads to the increase of the risk of being pooped. As the ship slows, relative to wave speed, the overtaking waves can wash along the upper decks from astern. This fact can cause a significant damage, and what is critically is that damage may not be noticed from the bridge.

Presently, the ship courses and speeds are chosen based on the general guidance provided in the references and on a subjective „feel“ for how the ship is handling the external forces. In particular, there is little information to guide the mariner who must brave extreme weather to achieve a vital mission.

For managing the ship capsize hazard, the traditional method was to adopt conservative methods. These include use of prescriptive stability criteria, based on data from past loses; and hurricane avoidance techniques that may not work well under operational conditions.

Establishing methods to aid vessel operators in identifying the onset of threatening ship motion conditions would allow time for changes to be made, thus altering the commanded response to environmental conditions and possibly reducing exposure to devastating ship motions or capsize. Therefore, it is of benefit to all sectors of the marine industry to develop methods which could provide ship’s officers with indicators of the onset of inclement ship motions.

The casualty reports indicates a number of areas where ships have been vulnerable to heavy weather damage due to parametric roll. These areas should have priority for improvement design.

Of course, not all the times the heavy weather conditions can be avoided. In this way, the necessity of establishing a set of stability criteria, to show the vulnerability and behavior of the vessel in such conditions, is of paramount importance. In the present, ships are meet heavy weather conditions but how will react in such conditions remain a big question mark.

While the phenomenon of parametric rolling of ships in regular waves has been extensively investigated and solid knowledge about this interesting phenomenon gained in recent years, the particular conditions for the occurrence of such resonance in case of irregular waves, which represent more realistic sailing conditions, are less clear. This type of investigations, with emphasis on the appearance of the phenomenon in head waves, gained significant scientific and practical interest in the last decade.

Due to unexpected nature of the motion as compared with synchronous roll in following or beam seas on smaller and finer ships, parametric roll is quite dangerous.

The phenomenon may induce costly ship operations problems. In the last decades serious accidents of parametric rolling were reported that have resulted in loss and damage of cargo. Apart from these, possible consequences may include machinery failure, structural damage, and even capsize.

It can be concluded that the most important phenomena leading to large rolling angles can be related to the changes of righting levers between the two conditions, crest and trough, to the minimum stability requirements in still water. In order that large rolling angles to be avoided, it is important to minimize the crest-trough alterations or to attain the minimum required stability values according to these alterations. A method for assessment the parametric roll may be related to the size of the instability area in irregular seas and a group wave approach seems to be promising.

An increased number of container ships recently suffered from parametric excitation with results in loosing and / or damaging the cargo, implied also the risk of capsizing. Not only the new designed container ships are susceptible to parametric excitation, but also Ro-Ro, Ro-Pax, Ro-Ferry and Cruise ships vessels.

The fact that most of them have not yet encountered such a dangerous situation can be considered only a matter of luck. This dangerous phenomenon as well as other dangerous and unfavorable seakeeping characteristics is not covered by currently intact stability rules. Very short roll periods leading to high accelerations (especially if combined with insufficient roll damping as well as insufficient course keeping capabilities in rough weather) for the Ro-Ro, Ro-Pax, Ferry, cruise and container ships made the vessels operators of such vessels to complain.

Because the main causes of these problems are rooted in hull geometry, from the early design stage is needed an increased awareness of the potential problems. However, due to additional constrains, sometimes these problems cannot be solved with design modifications. In this case, the risks posed by such behavior need to be evaluated and ship-specific operator guidance may be needed to help crew attempt to avoid dangerous situations where the ship may become dynamically unstable.

Due to these problems, which are not currently covered by stability criteria, a revision process has to begin. The new stability criteria should be completely revised with two major aims:

- all new criteria shall be formulated as performance based criteria,
- alternative direct assessment (via model test and/or numerical simulations) shall be possible.

Moreover, in the revision process the following steps have to be performed:

- Safety related situations / mechanisms endangering the intact ship have to be identified,
- Based on the intact stability criteria a development of a framework of performance is needed,
- The existing knowledge and further research related to physical phenomena endangering ship stability and safety as well as the assessment of ship performance in dangerous situations must be collected,
- Definition of criteria with appropriate standards.

For the future ship design, those developments are indispensable as empirical formulations will never be able to provide a sufficiently broad and fair evaluation basis to cover all possible new design developments.

The new stability criteria should take into consideration primarily three modes of stability failure:

- Restoring arm variation problems on wave crest such as parametric rolling and pure loss of stability,
- Stability under dead ship condition, and
- Maneuvering related problems in waves such as surf-riding and broaching.

This is reflected in the IMO decision towards development of performance based criteria and alternative direct assessment.

It is of first priority the development of criteria able to distinguish ships sensible to additional dangerous phenomena (to the present stability criteria) so that full calculations / testing can be limited to these ships.

The efforts to develop better criteria and standards must be continued, but it becomes more and more obvious that even the best criteria will not provide absolute safety. In practical terms, it seems impossible to design a ship to be absolutely stable in all wave and loading conditions, although designers should aim for this objective. Therefore, an important problem looks to be raised among researchers and designers: a change of ships designs or the development of ship-specific operational guidance.

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# SAILS AS ADDITIONAL MEANS OF PROPULSION

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**ABSTRACT**

If at the beginning of the era marked by the introduction of the steam engine and propeller to ships, the propeller was considered as an additional means of propulsion, since 1950, constructive ideas about ships equipped with sails began to appear, this time as an additional means of propulsion.

**Keywords:** *sails from cloth, rigid sails, the mechanical sail, hybrid sails*

## 1. INTRODUCTION

Since ancient times, man has used wind as a means of actively propelling boats, but a very long time man could not sail without bearing winds (in the stern area), since propelling sailing installations were primitive, and in those times, the modern system of sails construction and orientation had not been discovered yet. Thus, sails must be constructed so as to function according to the trajectory of the vessel and to the wind direction, on any of the borders, in order to allow, depending on the need, to change the course of the ship (the ascent or descent depending on the wind direction and the navigation in volts). This is a prerequisite for the design and construction of various types and forms of sails, because during their use, they should be able to keep up in the wind, in order to capture and efficiently consume all its energy.

Keeping up the sails in an efficient position through their support elements, relatively low, the masts, the fixed and mobile maneuvers, as well as other stiffening materials, offers the possibility for sails to be manufactured on templates as wing-type profiles, flexible, rigid or hybrid, their appearance becoming closer and closer to that of wings and less to that of classic sails.

The effectiveness of any sail is determined by its ability to generate a large aerodynamic bearing force with a minimal frontal resistance induced.

In setting optimization conditions for any sail, for a minimum frontal resistance induced, the criteria to start from are the next:

1. establishing limits on the bending moment (the height of the sailing center), by taking into account the stability of the hull and limits on the height of the sail;
2. the variation of the induced speed distribution, in order to minimize the frontal resistance induced, respecting the limit of the bending moment, and the determination of the load scale, from the distribution of the induced speed;
3. the choice of projects for sections, based on considerations on the viscous environment;
4. setting the combination between torsion and flat sail, given the distribution of the downward current, the angles of the attack bearing force zero of sections, and the coefficients of the maximum upward force;
5. the modification of the optimal plane form in order to get a form that can be practically built;
6. analyzing the final form for comparison with the optimal performance

## 2. TYPES OF SAILS

Sails can be classified by the shape and material that they are made from, as it follows:

### *2.1 Sails from cloth*

Ordinary cloth sails were first placed on large ships with conventional propulsion. Regarding the traditional sails, from sail material (soft sails), they were used successfully by shoners of the time, being considered very powerful ships. The Bermudian sail type is used also today to yachts and cutters. Waertsila Ab. Company conceived an automatic system of handling sails and designed the modern cruise sailing ships “Wind Star” (Figure 1), “Wind Song” and “Wind Sprits” between 1986 and 1988.

Figure 1 Modern cruise ship “Wind Star”, sails equipped

Since 1980, Nippon Kaiji Kyokai has registered ships of different types and displacements equipped with sails, as additional means of propulsion. Sails adopted by some ships were made from ordinary sailcloth, the role of the masts being taken during the march, by the installation of loading / unloading of the ship (ship cranes and sheers).

With only one improvised sail, after 14 days of bearing to the wind ward, the gain in the area covered will be of 336 mm, which means, to a vessel with a speed of 12 Nods, a gain in time, bigger than a day of march (28 hours of march) and, at a rate of 0.666 tons / hour (16 tons / day), a fuel saving of 18, 664 tons (without taking into account "a decrease in motor tasks" and the lubricants saving).

*2.2 Rigid sails*

Since 1955, in Germany, the project plan of the ship "Dynaship" (Figure. 2) began to investigate the possibilities of equipping ships with conventional propulsion and semi rigid square type sails. This project of sail type was not in the end built, but the concept can be considered the predecessor of the rigid sail made by Yamada, who together with NKK built the first rigid square sail.

Opening and handling the sail with angles corresponding to the wind dash are executed by hydraulic machinery.

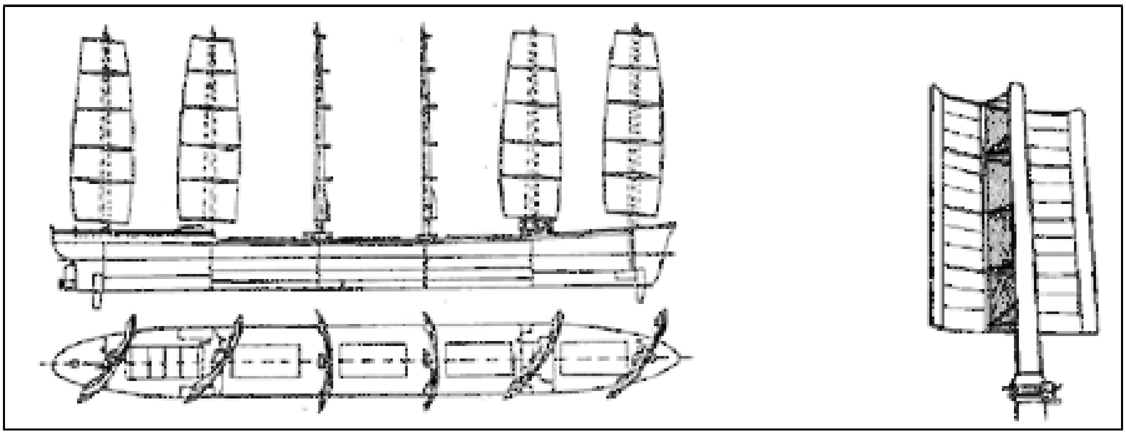

Figure 2 The general plan of the project of ship "Dynaship" equipped with rigid sails

*2.3 YAMADA-NKK type sails.*

These are rigid sails, which were located in the diametrical longitudinal plane, the first in the prow of the cargo store no. 1 and the second between stores 2 and 3, their handling being accomplished with an auxiliary motor controlled by a computer which calculates and controls their orientation angle, depending on the wind direction and on the force of the relative wind.

Figure 3 Tanker "Shin Aitoku Maru", the first modern ship equipped with rigid sails

As consequence of those features, the ship Shin Aitoku Maru, compared with a similar ship powered only with mechanical propulsion, achieved a fuel reduction by 30% -40% and the decreasing of the time planned for the voyage, by increasing the speed of the march. After 1980, more ships were equipped with rigid sails with aerodynamic profile, as auxiliary propulsion installation; only in Japan, 17 vessels were equipped with Yamada sails.

*2.4 The mechanical sail*

Mechanical sails can generate the highest coefficient of lift, significantly higher than that of the usual classic sail, but their drawback is that the sail is very heavy.

*2.5 The turbo sail*

The turbo sail has as functioning principle, the air capture and its drawing behind the sail body, by a powerful electric ventilator. Although hoping that it will be a sail with a high lift, it was only experimentally used on small boats.

In 1985, French maritime researcher Cousteau ordered a ship to be the successor of the famous ship “Calypso", called “Alcyone”, after which the ship “Calypso 2” will follow. Both vessels are equipped with the so-called “turbo-sails”. In reality, they are large wings resembling very much to Flettner's rotating cylinders, although they do not rotate. “Alcyone” ship has two turbo-sails, each with a height of 7 m. Currently, a team collects donations for “Calypso 2”, ship which will have a single turbo sail with a height of 24 m.

Figure 4 The ship “Calypso” equipped with Turbo sails

*2.6 The wing-type profile sails*

Keeping sails in an efficient functioning position, through their support elements, relatively low, such as: the masts, the fixed and mobile maneuvers, whales and other stiffening materials of the sails, provides the opportunity to conceive and build the profile of wing type, flexible, rigid or hybrid, and to be more effective; today, their appearance is closer to that of wings than to that of conventional sails (figure 5).

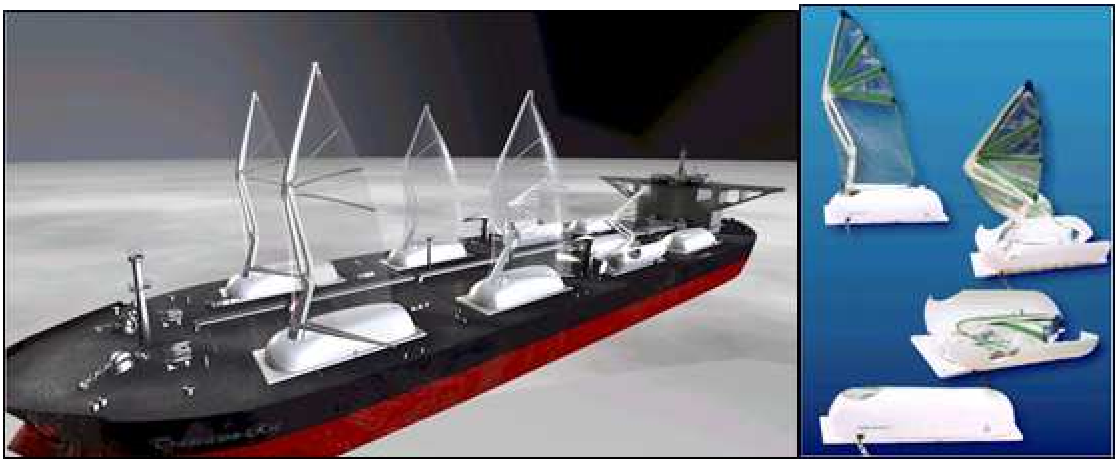

Figure 5 Flexible wing-type sails

The purpose of such installation is to use wind power for propulsion and to reduce fuel consumption and therefore the air pollution, eliminating, thus the need to use, exclusively, the engine propulsion. This type of modular sail offers the possibility to be lifted, if needed; the module cover is temporarily opened to allow the mast to extend up and closes around the base of the large sail for sealing.

*2.7 Hybrid sails*

The hybrid sail is patented to the State Office for Inventions and Trademarks, and consists of a rigid wing profile that will have also the role of mast, combined with a slit shutter, the mast being extended from the flow edge with a thin sail (soft material - from cloth).

The technical problem solved by the hybrid sail is the use of a sail made of two parts (one rigid – of rigid lightweight materials, plastics, aluminum, fiberglass, etc. and the other soft – from cloth), which provide both the classic appearance of flexibility and efficiency and the aspect of resistance in time.

Next to these considerations, are those related to the using of shaped masts, aircraft wing-type, which significantly reduce the longitudinal resistance to progress of the ensemble mast-sail, and a flap (little wing) of board for attack on the wing mast, device similar to the fire sail from sails boats.

Considering this type of complex sail determines the increase of the propulsion force of the boat or vessel and, just as in the case of aircraft, to a more rigorous control of the behavior of hybrid sail-wing in the air stream.

The advantages of this sail are benchmarks for further studying the construction of sails used for trans-oceanic ships and consist of:

1. the use of the hyper-sustention device (flap), which improves the lift of the hybrid sail due to the increase of the sail area, the change in march of the curvature of the sail profile, leaving the surface constant or not, the possession of the limit layer on the back of

the wing and the delay for angles of incidence bigger than the critical angle, of the separations on the back.

2. the lift coefficient increases almost simultaneously with the aspect of the sail ratio in experiments, and on the other hand, the coefficient of frontal resistance does not change significantly;

3. when using the flap, an improvement of the air flow on the back of the sail is found, especially when the flap is close enough to form a blower;

4. the influence of the flap and soft sail on aerodynamic characteristics was investigated through experiments and showed that the flap influence on the lift is very big, increasing it by approximately by 30-40%;

5. the effect of the flap and flexible wing of adaptable form of the current determines the increase almost twice of the maximum angle of incidence, from normal wings;

6. the sails system set from the main deck above has the advantage of adequate adaptation and using, at the masts, of devices and mechanisms from the loading/ downloading installations (sheers, cranes), but which, however, during the operation of the ship or for harbor maneuvers can be an impediment.

The achievement of this system is based on the consideration according to which, for the optimization of the sailing propulsion system of ships, the design of a sail consists actually of the control of the boundary layer of separation, by the distribution of pressure in order to lift the maximum bearing force of the section and reduce the frontal resistance in viscous environment.

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# WEATHER INFORMATION AND FORECASTING ON SHIPBOARD

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**ABSTRACT**

Seafarers have access to a variated documentation that can be used in order to realize an overview of existing meteorological situation and estimate the future trend of the weather conditions.

The first rule in forecasting at sea is that the weather will continue much the same unless you pass close to, or through, a front or a low.

There are, however, other methods of forecasting, of shorter or longer duration that seafarers can use in practice.

**Keywords:** *forecasting, analysis, weather maps, radiofacsimile, methods.*

## 1. INTRODUCTION

The seaman is necessarily an amateur meteorologist. Detailed knowledge of weather conditions helps to navigate safely, taking better decisions on their chosen route.

Seafarers have access to a diversified documentation that can be used in order to realize an overview of existing meteorological situation and estimate the future trend of the weather conditions.

There are several types of weather message broadcast by radio in most parts of the world:

- Weather warnings;
- Forecast messages;
- Analysis and prognosis messages;
- Synoptic messages.

They add weather maps via radiofacsimile received on board and INMARSAT and also those prepared to ship based on direct observations made by seafarers.

## 2. WEATHER MESSAGES

Weather warnings and forecast messages are in plain language.

Maritime weather forecasts include four types of severe weather warnings: small craft, gale, storm and hurricane force winds.

The meanings of these warnings are:

- Small Craft Warning: winds 20-33 knots and wave heights 2-3 m (7-10 ft.)
- Gale Warning: winds 34-47 knots and wave heights 6-9 m (20-30 ft.)
- Storm Warning: winds 48-63 knots and wave heights 9-16 m (30-52 ft.)
- Hurricane Force Warning: winds 64 knots and over and wave heights over 16 (52 ft.)

The Storm warnings are one of the most essential form of weather message. In these warnings are given the position of the low, or storm centre, the force or spees of the wind at different distances from the centre or in the several forecast or geographical areas affected and the expected movement of the centre in the immediate future.

Forecast messages are issued at least twice daily and include an expectation of wind and weather in advertised areas for a period of 12 to 24 hours.

An analysis gives nearly all you can want. When it is ploted you can immediately visualise the situation in any part of area covered.You can see just where any fronts are, where they will be during the next 12 or more hours and how bad the weather will be if and when on passes you. The deficiences of a forecast are removed in the analysis messages. The disadvantage is the time taken to plot it.

The analysis and prognosis messages and the synoptic messages are in 5-figure groups, the numeral codes used being almost universal and the same as those used by ships for coding their own weather reports. This is the IAC (International Analysis Code) FLEET Code, form in wich analysis and prognosis messages are transmited to ships, abridged for marine use.

It is advisable to plot two analysis messages a day, at 12 hourly intervals, because one is thereby using more up-to-date information.

Synoptic messages gives nearly all the information one could need. Unfortunately, this kind of message takes a long time to plot (about 2 hours for an amateur meteorologist) and a further 45 minutes or more to analyse.

## 3. WEATHER MAPS

A weather map displays various meteorological features across a particular area at a particular point in time and has various symbols which all have specific meanings. Such maps have been in use since the mid-19th century and are used for research and weather forecasting purposes. Maps using isotherms show temperature gradients, which can help locate weather fronts. Isotach maps, analyzing lines of equal wind speed, on a constant pressure surface of 300 mb or 250 mb show where the jet stream is located.

Use of constant pressure charts at the 700 and 500 hPa level can indicate tropical cyclone motion. Two-dimensional streamlines based on wind speeds at various levels show areas of convergence and divergence in the wind field, which are helpful in determining the location of features within the wind pattern. A popular type of surface weather map is the surface weather analysis, which plots isobars to depict areas of high pressure and low pressure. [5]

*3.1 Analysis maps*

Analysis maps are based on weather observations from which patterns of higs and lowsas well as the locations of weather fronts are drawn. Much of the accuracy of the charts depends on the skill of the meteorologist or analyst who draws the pattern bassed on his interpretation of the observation.

The surface weather analysis charts are going to be the most frequently use because they are the ones wich depict what the actual pattern looked like a certain time.

There are two important factors to keep in mind when using any surface analysis map.

First, the weather pattern over the ocean outside the major shipping lanes may be based on very few observations. Aboard ship we have no indication how many observation were used for each chart, so whether the analysis is precise or not has to be left to trust.

Second, the analysis chart is not showing the pattern as it exists at time of receipt aboard the ship, but is the pattern as it was some three to six hours earlier depending on wich maps we elect to copy. This will be important in those weather situation that are changing rapidly, such as deepending lows moving at 40 knots.

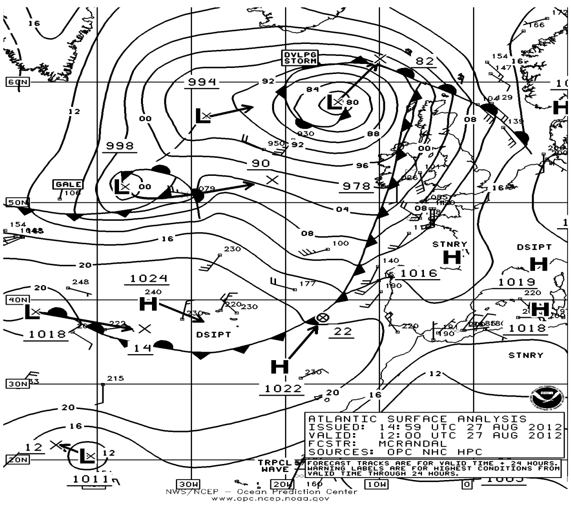


Figure 1 Analysis map
*(source: NOAA; http://www.noaa.gov/)*

*3.2.Prognosis charts*

Prognosis charts are maps which display what the weather is expected to be like at a future time; in other words, a forecast map.

The prognosis charts normally used are the Surface weather prognosis, the significant wave height prognosis and the 500 hPa prognosis.

There are also other prognosis charts, such as weather depictions charts showing the types of clouds and weather expected over the ocean.

Manual prognostic charts have special symbols which require a legend or previous knowledge which depict tropical cyclones, turbulence, weather fronts, rain and snow areas, precipitation type and coverage indicators, as well as centers of high and low pressure.

Atmospheric models are computer programs that produce meteorological information for future times at given locations and altitudes. Within any modern model is a set of equations, known as the primitive equations, used to predict the future state of the atmosphere.

The prognosis charts showing weather patterns at the surface and the 500 hPa level (about 4 800 to 6 200 meters about the earth`s surface) are produced by computers. As might be expected, the further into the future the prognosis, the more inaccurate it is likely to be. Thus, prognosis charts that predict for 12 to 48 hours agead will usually be more precise than ones that are for 72 hours, especially in fast changing weather situations.

Surface weather prognosis charts for seamen indicate the positions of high and low pressure areas, as well as frontal zones, up to five days into the future. Surface wind direction and speed is also forecast on this type of chart. Wave prognostic charts show the expected sea state at some future time.

For purposes of severe weather, prognostic charts can be issued to depict current weather watches, convective outlooks for thunderstorms multiple days into the future, and fire weather outlooks.

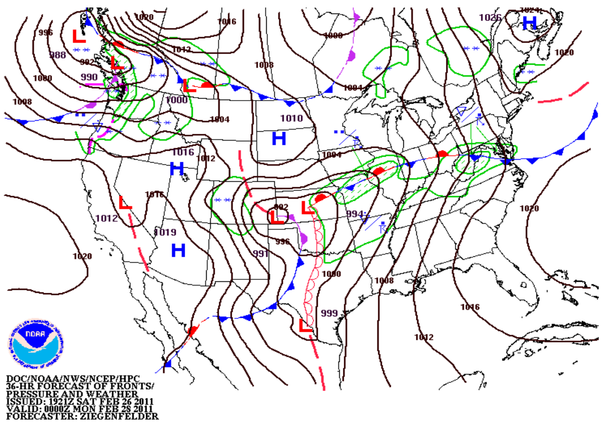


Figure 2 A manual prognosis chart of the weather 36 hours into the future
*(source: NOAA; http://www.noaa.gov/)*

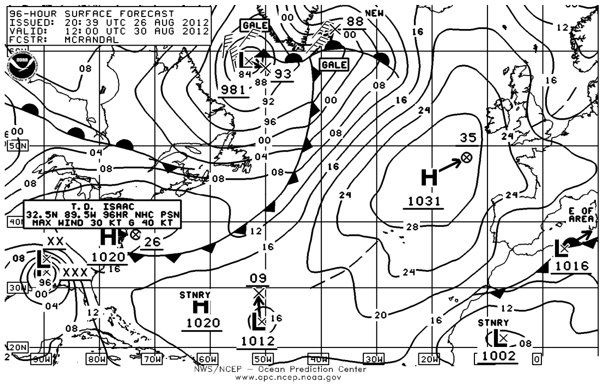


Figure 3 An automated prognostic chart of the 96-hour forecast
*(source: NOAA; http://www.noaa.gov/)*

## 4. FORECASTING TECHNIQUES AND METODS

### *4.1 Forecasting techniques*

The technique used with surfaces analysis charts in tracking the weather is based on the idea that the past is an indicator of the future. A minimum of two surfaces analysis charts received each day is recommended and more than this when the situation is rapidly changing or critical operations requiring the most up-to-date information are involved.

Take the latest map and the one previous to it and then plot the earlier locations of the high and low centers and fronts. Plot these on the latest chart. Based on the past movement between the two maps, project ahead by noting the positions of these features at 12 and 24 hours ino the future on the latest map. Another useful feature to advance in the region of closely spaced isobars in wich gale force ore stronger winds are likely.

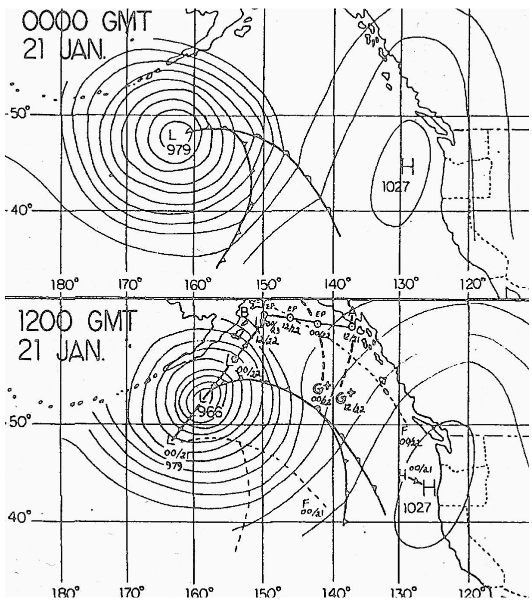


Figure 4 Forecasting positions of low and high centers, fronts and strong wind areas using two surface weather maps

### *4.2. Forecasting methods*

Forecasting based on history or <<Historical forecasting>>- predicting the weather by assuming that what hapened in the past will happened again this time- is one of the methods used to predict the tracks of hurricanes.

One of the simplest methods of forecasting the weather is to assume that it will not change for a little while. This technique, called <<persistence forecasting>> is often reliable over periods of minutes or hours. In most locations, persistence forecasting doesn`t work well for periods longer than a couple of hours, because the temperature and cloud cover often vary greatly between morning and afternoon, afternoon and evening and between day and night.

A more reliable and versatile method of short term forecasting involves the assumption that a current tendency or trend will continue or that observed cycle will repeat. This is known as <<trend forecasting>>. It is a form of extrapolation- extending a defined rated of change into the future.

Synoptic weather forecasting is done by assembling weather maps pf large regions from observed and reported data at numerous stations. The defining tool of synoptic forecasting is the weather map. At the temperate latitudes, major weather systems tend to move generally west to east at 20 to 30 kt. High pressure systems are usually associated with fair and warm weather, while low-pressure systems are associated with foul weather.

Synoptic forecasting can be comparated to analog communications, in wich variables can change continuosly. Numerical forecasting is more like digital communications, in wich the variables are broken up into small parcels or packets and the behavior of the whole system is deduced by brute force of calculation, based on the laws of physics.

The atmosphere and the oceans interact to produce weather on moment to moment basis. The motion of every single atom or molecule plays same role. The weather phenomena are the sum total of action of all these particles. Numerical forecasting has proven to be an excellent method of weather prediction for the short-term (a few hours) and the medium term (up to a few days).

Computer models have also been used to forecast weather trends for approaching months and season.

## 5. CONCLUSIONS

On board, seafarers have available a number of documents and maps able to provide meteorological information required for practicing a safe navigation.

How they manage to collect and manage information depends to a large extent on the experience they have gained. Realizing some proper correlation between data obtained from direct observations or from real data analysis, can get an overview into the future evolution of weather conditions and they can establish a convenient route accordingly.

It is therefore important to know what resources are available to inform about the weather and the way in which they can operate conveniently.

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# A CASE STUDY FOR REFLOATING A SHIP USING HER OWN ENGINE

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**ABSTRACT**

Over the past decades there has been a continuous increase in the public concern about general risk issues. The consequence of this trend is that whenever a catastrophic accident occurs - and receives media coverage - there is an immediate political and public demand for actions to prevent the same type of catastrophe in the future. Many of the past improvements in safety of marine structure have been triggered by disasters but there is a change in this trend. The maritime society is beginning, albeit slowly, to think and work in terms of safety assessment of individual ships instead of the very generalized prescriptive regulations which have evolved over the past 150 years. In line of these aspects it is clear that rational procedures for evaluating the consequences of accidental loads are highly desirable, not to say necessary. Within a reasonable time span this makes it impossible to draw cause and effect conclusions from statistics alone and attempts of doing so would most likely be highly reactionary with questionable effectiveness.

**Keywords:** *ship's grounding, refloating, simulation.*

## 1. INTRODUCTION

A grounded ship is in a position not intended by her designers, builders, or operators, and is subject to very different forces and conditions than when in normal service; she is more like a poorly designed, inadequately protected, and usually inappropriately placed breakwater than a ship at sea. Like a ship being drydocked, part of a stranded ship's weight is supported by the surrounding water, part by the ground. The portion of the ship's weight supported by the ground is *ground reaction* (*R*), or *tons aground*; it is equal to the lost buoyancy. The ground reaction distribution is uneven and unpredictable. There are four major effects of ground reaction:

- The loss of buoyancy alters hydrostatic characteristics and hull girder loading.
- The upward force of ground reaction at the keel causes a virtual rise in the centre of gravity.
- Extremely high local loading with damage or penetration of the hull can occur, particularly on rocky bottoms.
- Ground reaction holds the ship stationary; she cannot respond to or fall away from disturbing forces, such as waves, as she does when afloat.

The conditions of a stranding are seldom fully defined in the beginning and often are not completely defined during the salvage operation. The stranding condition and the environment are the principal sources of forces on a stranded ship. Stranding salvage is time-critical; environmental conditions may improve or worsen with time, but the condition of a stranded ship steadily deteriorates.

## 2. THE STRANDING CONDITION

The way the ship lies on the ground and her position relative to the seafloor and coastline influence the casualty in two ways:

- The way the ship lies on, and is supported by, the ground is a principal indicator of the effort required to free her.
- Distribution of the ship's weight between residual buoyancy and ground reaction affects stability and strength.
- The ship's position relative to the shore and underwater features can either intensify or mitigate environmental effects.

Specific considerations are:

- Magnitude and distribution of ground reaction.
- Changes in list and trim caused by the stranding.
- The area of the ship in contact with the bottom.
- Depth of water under and around the ship.
- Channel depth—depth of water between the ship and unobstructed deep water.
- Position and attitude of the ship relative to the ground and the shore.

An overall view on groundings categorize the accidents in two major groups:

- Grounding on soft sea beds, so-called Soft Groundings. The damage to the hull in terms of crushing at the point of ground contact is limited but the hull girder may fail in a global mode due to shear force and bending moment exceeding the hull girder capacity.
- Grounding on hard bottoms - so-called Hard Groundings. The primary concern here is the local crushing and tearing of the ship bottom due to a cutting rock.

In accordance with Pedersen, the starting point of the theoretical analysis is to divide the scenarios leading to grounding into four main categories:

- Ships following the ordinary direct route at normal speed. Accidents in this category are mainly due to human error, but may include ships subject to unexpected problems with the propulsion/steering system which occur in the vicinity of the fixed marine structure or the ground.
- Ships which failed to change course at a given turning point near the obstacle.

- Ships taking evasive actions near the obstacle and consequently run aground or collide with the object.
- All other track patterns than Cat. I, II and III, for example ships completely out of course due to loss of propulsion.

When a ship runs aground on a soft sea bed the principal energy absorbing mechanisms which stop the ship are normally:

- Deformation of the sea bed.
- Friction between sea bed and hull.
- Change of potential energy of the ship and the surrounding water.
- Deformation of the hull.
- Hydrodynamic damping.

## 3. REFLOATING STRANDED SHIPS

Stranded ships are refloated by the following actions:

- Moving the ship to water deep enough to float it at the draft corresponding to its weight (displacement).
- Deepening the water around the casualty.
- Reducing the required draft at the grounded portion by removing weight, lifting, or altering trim.

In practice, a combination of methods is normally used. In most cases, the stranded ship is lightened until the required freeing force is less than the available tractive forces, and then pulled into deeper water. It is often necessary to remove many tons of cargo, stores, or floodwater.

### *3.1 Moving Stranded Ships*

The force required to move a casualty over its strand is the sum of the forces required to:

- Overcome friction between the ship and seafloor.
- Move loose seafloor material that may be pushed ahead of the ship.
- Break or crush obstructions or impalements, such as rock outcroppings, coral heads, etc.
- Overcome suction on soft bottoms.

Friction is a function of ground reaction as modified by other factors, such as the coefficient of friction of the bottom, the area of the hull in contact with the bottom, and the casualty’s list and trim. Freeing force is reduced by decreasing the effects of these factors, as well as by decreasing ground reaction.

### *3.2 Increasing Water Depth*

Water depth under and around a casualty can be increased to:

- Obtain sufficient water depth to refloat the vessel.
- Reduce ground reaction by increasing buoyancy.
- Free one end of a vessel to allow it to be pivoted by other methods.

Water depth inside small coves or estuaries can be increased by closing the entrance with sheet-steel piles or cofferdams. In some navigable rivers and canals, water level can be controlled to some extent by lock gates and dams – it may be possible to raise water level by increasing flow past upstream dams. On very soft soils, it may be possible to increase the ship’s weight, by flooding or other means, so that she settles more deeply into the seafloor. After she has settled, the excess weight can be removed to allow her to float free. More commonly, water depth around a casualty is increased by removing ground from under it. Ground removal is accomplished by scouring or dredging soft bottoms, or by blasting hard bottoms. These methods can also be used to cut channels to deep water through bars or behind vessels stranded high and dry.

### *3.3 Temporary Reduction*

Dynamic friction is almost always less than the static friction between two objects. If freeing force can be reduced long enough for the pulling system to start the ship moving, it can usually be kept moving.

- Swells increase the buoyancy of the stranded ship and decrease the ground reaction as they pass. High seas or heavy swells running during a retraction decrease the pulling force required to refloat the ship. If the pulling force is enough to start the ship moving at the top of a swell when ground reaction is lowest, the coefficient of friction is lowered instantly to the dynamic level. The dynamic coefficient of friction may be low enough that freeing force stays less than pulling force after ground reaction increases again, and the ship keeps moving. When there are no natural swells, ships passing parallel to the beach at high speed create swells that act like the natural swell. Destroyers running a long racetrack pattern as close to the refloating operation as safety permits are ideal for this purpose.
- Jacking reduces freeing force by changing the nature of the ground reaction, rather than reducing it. Hydraulic jacks of 60 tons capacity or greater are employed to temporarily lift the ship. By taking up part of the ship’s weight on the jacks, the amount of weight bearing on the high friction interface between the ship’s bottom and seabed is decreased. The jacks are rigged on long spuds that can pivot at their bases, allowing the casualty to be moved when the friction force is sufficiently reduced. Jacks are placed symmetrically about the estimated position of the center of ground reaction and are secured with a retrieving line led to the deck. The jacks are raised to their maximum lift at the beginning of a pull. When the ship moves, the jacks will topple and must be reset for the next operation. Once the stranded ship is moving, it is often possible to keep it moving against the lower dynamic coefficient of friction, even if the ground reaction increases when the jacks trip. If not, the casualty is refloated by moving it seaward in a series of short steps. For jacking to be successful, the seafloor must be hard enough, or must be reinforced, to support the jacking forces. On rock seafloors, concrete rubble-filled beds or heavy timbers topped by steel plate are adequate foundations. On sediment seafloors, plate or timber mats are used to spread the load until the unit

pressure is less than the bearing capacity of the soil. Crushed coral, stone, shell, or gravel can be laid in to increase soil bearing strength. Similarly, the hull of the ship must be protected from the jacking forces. If these forces are not spread out along the hull, they will cause local damage at the point of application and may even rupture the hull. Steel weldments or heavy steel angles welded to the hull and padded with timbers are suitable jacking pads. The load is transmitted to the ship structure by shear stress in the welds and side plating.

*3.4 Explosives*

Explosive measures to reduce freeing force include:

- Judicious use of small charges to deepen the water around the casualty and cut channels through hard bottoms (explosive dredging).
- Explosively cutting or pulverizing coral or rock outcroppings that are impaling the casualty or blocking its retraction.
- Using small charges along the length of the casualty to cause vibration and fluid behavior in the seafloor under the casualty.
- Detonating moderate charges several hundred feet from the casualty to generate artificial swells to momentarily increase buoyancy.

Use of explosives requires skill and experience to avoid damaging the casualty.

## 4. SIMULATION OF REFLOATING A SHIP USING HER OWN ENGINE

During the simulation session, represented by the notation S1, using Transas Navi Trainer 5000 simulator, we've tried to analyze the possibility of refloating a ship by using her own means of propulsion, namely her main engine.

The ship, with her main characteristics and dimensions is presented below, a bulk-carrier, Figure 1, fully loaded and she runs aground on a soft muddy bottom, where the water depth is 15 metres.

The detailed actions taken to refloat the grounded ship only by using her main engine are presented in the figures below.

Figure 1 – The simulated bulk-carrier

Table 1 – The main characteristics and dimensions of the simulated ship

| **Type of engine** | **Diesel 1 x 14720 kW** |
|---|---|
| Type of ship | Bulk-carrier |
| Bowthruster | No |
| Sternthruster | No |
| Type of propeller | Fixed pitch propeller |
| Deadweight | 202000 DWT |
| Maximum speed | 14.6 Knots |
| Maximum Length | 290 m |
| Maximum Beam | 46 m |
| Bow draft | 17.7m |
| Stern draft | 18.7 m |

Due to the nature of the sea bottom, namely mud, the ship doesn't manage to refloat by using her own means of propulsion. The ship cannot manoeuvre astern because the pivot point or the gyration point (the point from where the bow and the stern can be seen gyrating with the same angular speed) changed its' position (at the stern of the number three hold as it can be seen in the picture) and thus it remains fixed in a position relatively close to 1/3 of the ship's length measured from the bow. It can be easily seen that approximately 100 m of the ship's length measured from the bow is 'stuck' in the mud, and the thickness of the bed is at least 1.5 – 2 metres if taking into account only the difference of draft.

Using the main engine at 'full speed astern', initially shows the fact that the ship's refloating could be possible but the motion vector with its' direction astern (although it has a certain value that indicates the ship's movement and its' possible refloating) indicates a lateral motion, a motion of gyration of the ship about the pivot point.

During the simulations, we have selected a series of pre-set parameters, like:

- bow/stern drafts
- transversal/longitudinal speeds
- vertical and longitudinal forces
- rolling moment, pitching moment, lateral moment

following their variation for different situations of refloating attempts.

Further on I am going to present in details the actions taken to refloat the ship, attempts made only by using the ship's main engine. It must be also taken into consideration that around the casualty there is no tide, wind and/or surface current.

Simulation S1 presents the ship's sailing with a constant speed of approximately 3.3 – 3.7 knots, on a direction that leads to the grounding area close to the coast line, where the fathom line in the chart indicates 15 metres.

In S1 – 1 it can be seen the ship's heading on a course of 044°, ship's backwater and wave formed at the ship's bow due to small depths. Usually, during low speeds, at the ship's bow there are no waves when there is enough depth below the ship's keel because the ship does not 'push' hard enough the quantity of water ahead. We made this remark because during the grounding, showed in S1 – 5, only the backwater of the ship is going to be seen, the propulsion machinery hasn't been stopped and the bow waves have disappeared completely.

The ship stays on its heading of 044°$_3$ - 044°$_7$ until she runs aground when a slight change of heading occurs (045°$_7$), (a change that is accepted in normal conditions of the ship's making way through water), as it can be seen in S1 – 1, S1 – 3.

Once the ship runs aground, the ship's speed drops suddenly, (S1 -4) from 3.7 knots to 0 knots, which indicates that the ship ran aground on a block mud bank which is 1.5 – 2 metres thick.

If the ship's speed dropped in steps, which indicates a progressive thickness of the mud bank, the chances for refloating the ship would have been higher, meaning that the grounded length would have been shorter and maybe, if using ballasting/de-ballasting bow and respectively stern tanks operations, the grounded length would have been wrenched from the mud.

By changing the values of the selected parameters, the ship's behaviour while aground can be observed.

The parameters for bow and stern draft and the parameters for the transversal speed are presented in S1 – 2. It can be seen that, due to the fact that the ship sails in a calm waters area, with no tides and currents, the value of the parameters used during the analyzed period before the grounding event, do not change.

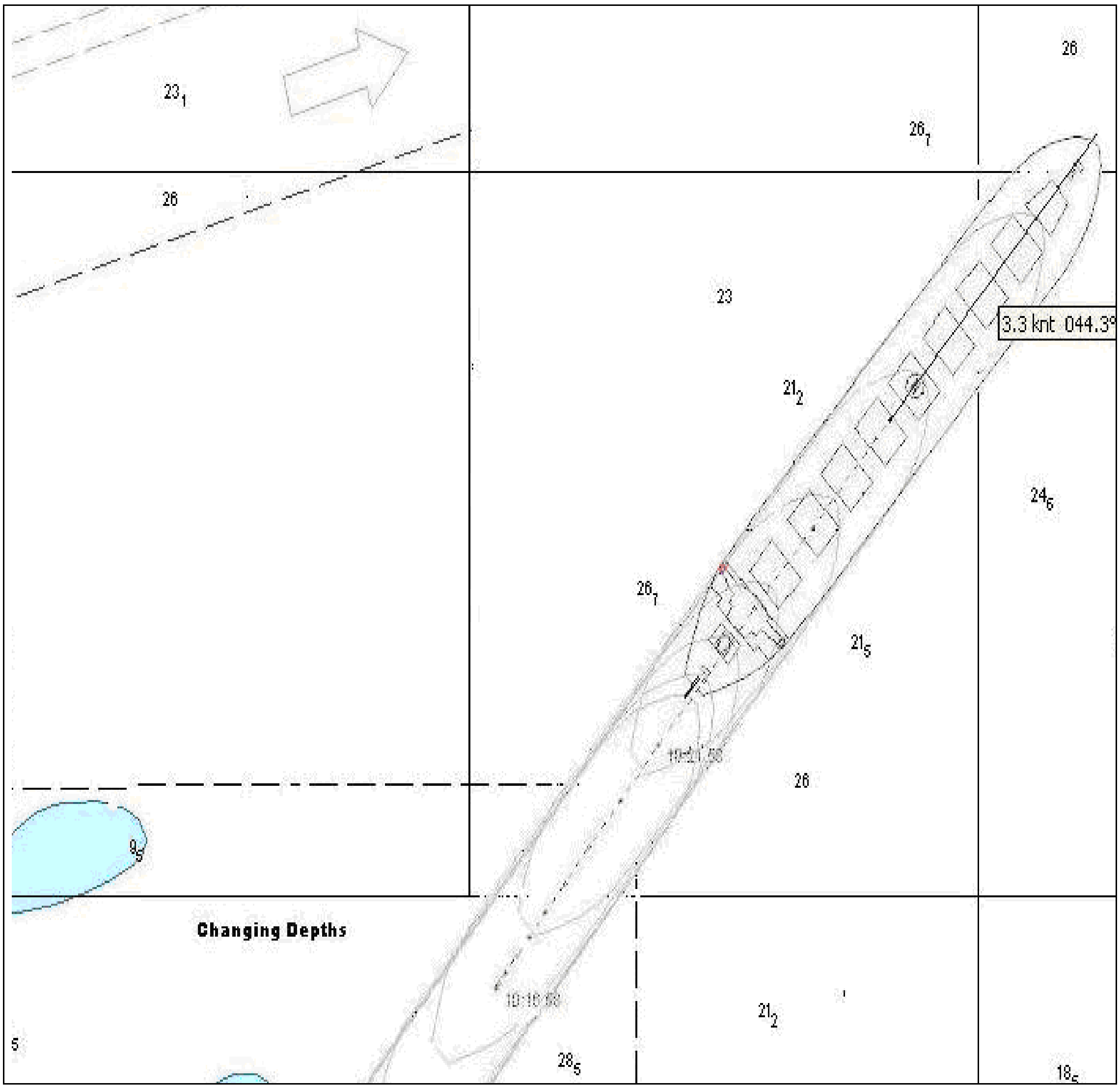

Figure 2 S1-1 Ship's heading towards shallow waters

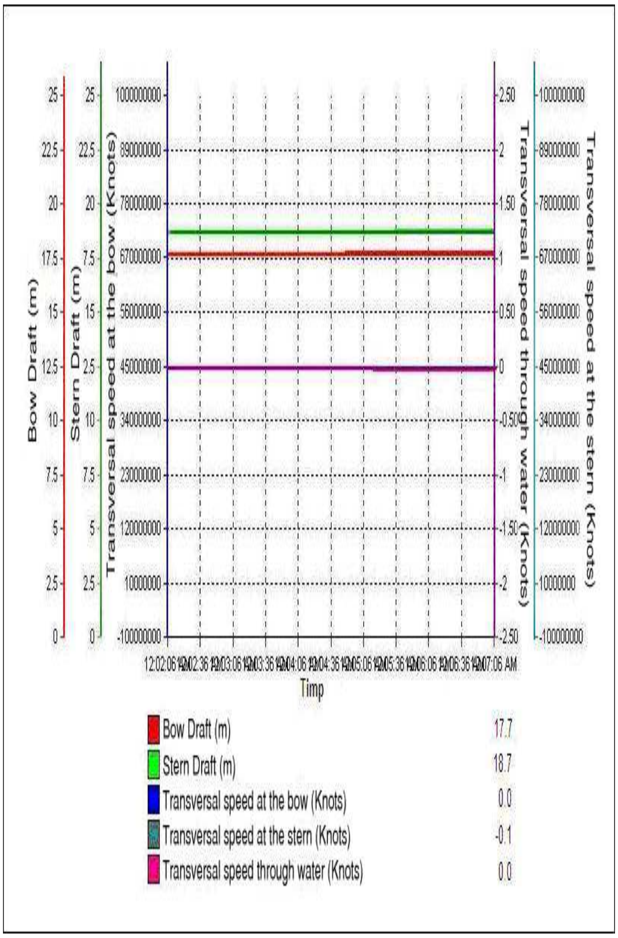


Figure 3 S1 – 2 The graphics of the parameters chosen for the selected case

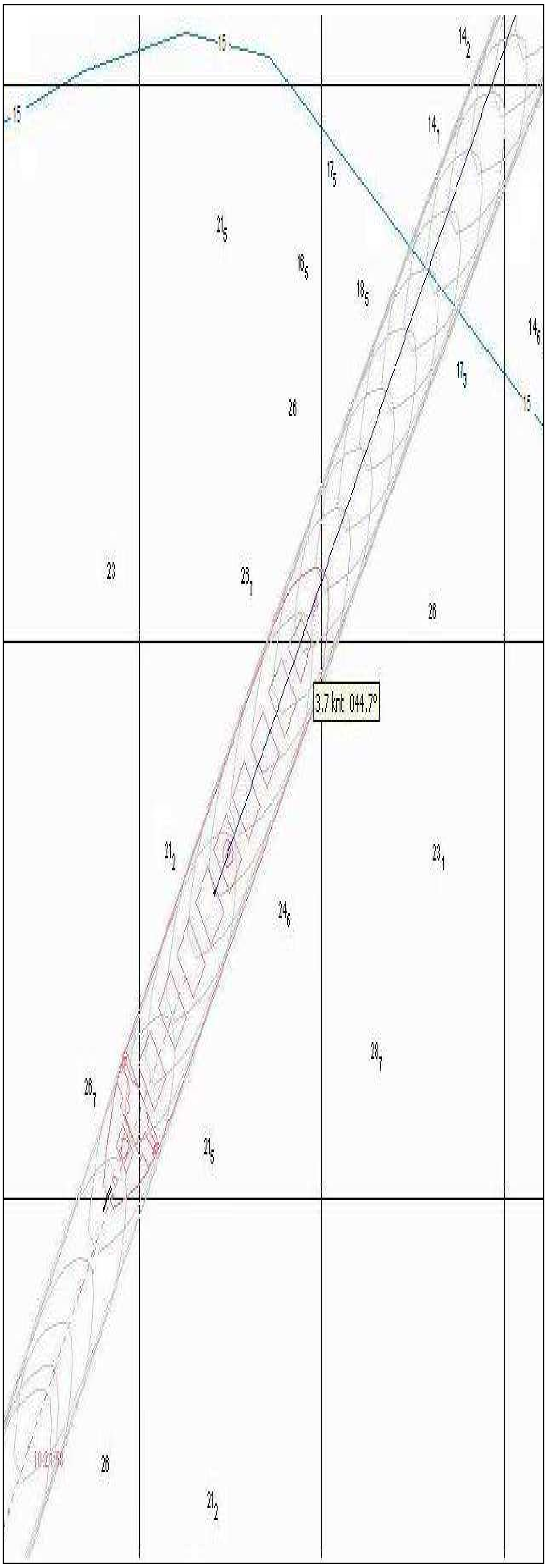


Figure 4 S1 – 3 The fathom line of 15 metres and the image of the future positions of the ship if she stays on the same heading

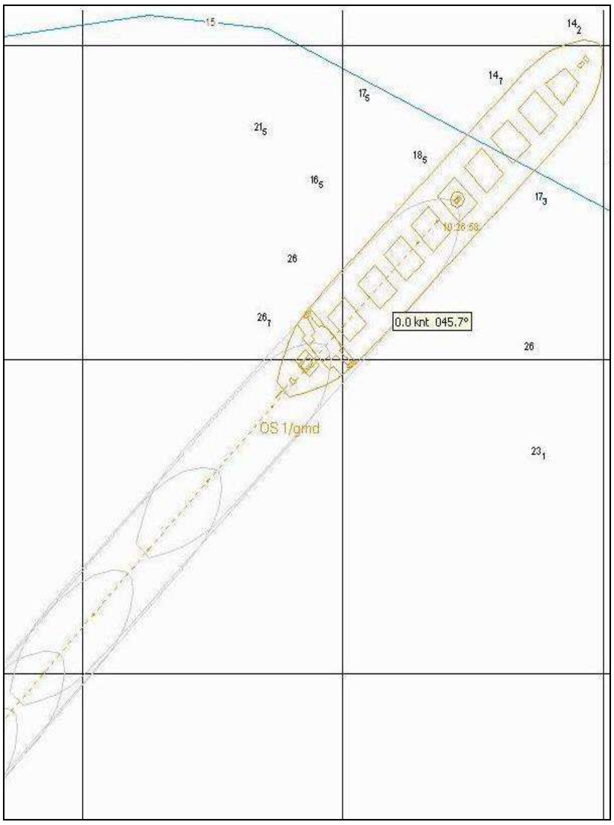


Figure 5 S1 – 4 Ship's grounding and sudden drop of the ship's speed

Figure 6 S1 – 5 The Grounded Ship

## 5. CONCLUSIONS

Despite all efforts, the ship does not manage to refloat herself and in this situation the only available solution is to move the cargo from the forward tanks to another ship.

The conditions of a stranding casualty are not completely defined in the beginning and they are not fully defined during the salvage operation. The stranding condition and the environment are the principal sources of forces on a stranded ship. The operations for refloating a stranded ship are time-critical and environmental conditions may improve or worsen with time, but the condition of a stranded ship steadily deteriorates. The first manoeuvre taken into consideration to be applied is represented by the attempt to refloat the ship by using the means present onboard (ship's own means of propulsions and ballast/de-ballast operations). These are the fastest manoeuvres available onboard and in the same time they are the cheapest ones. The longer the ship remains in a stranded position, the higher are the possibilities for a ship to suffer severe damages and a pollution event to occur. In this paper we are trying to analyse the possibility of refloating a ship by using her own means of propulsion, namely her main engine, in combination with ballasting and de-ballasting the stern tanks and the ones on the portside and starboard side. For this purpose we have performed several simulations using TransasNavi Trainer 5000 Simulator.

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# BULK HANDLING QUAY CRANES IN PORTS

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**ABSTRACT**

The paper analyzes bulk handling quay cranes with single-rope, two-rope and four-rope grabs and methods of grab calculation, including establishing the grab mass, geometry and kinematics and efforts in the grabs elements. A study case with Bocsa quay crane 18 t - 32 m is included, with two of the most defavourable case scenarios in exploitation.

**Keywords:** *quay crane, grab, port operator, cargo, maritime transport*

## 1. INTRODUCTION

Freight transport needs to have increased efficiency and for this is necessary the stationary time for loading or unloading of ships to be minimized. In this regard, a key element is the port equipment with sufficient equipments for mechanization and automation of port operations. [1]

Mechanized transshipment is rational only if the methods and apparatus used for transshipment of cargo are chosen accordingly to the work situation, type of cargo and depending on how the transshipment facilities are used rationally and are maintained properly in good condition. [2]

Using quay cranes with high productivity is required for loading and unloading cargo as quickly as possible, need of primary importance in operating activities of ships and ports.

Grabs are attachable equipment for cranes on tires or tracks, intended to load and unload bulk materials like grain, ore, sand, gravel, iron waste, wood waste, logs etc.

Mechanics parts of quay cranes with grabs malfunction and are out of service due to their accidental failure, or their failure due to wear.

Accidental failures are caused by poor design, manufacturing or exploitation problems, for example, gear teeth break due to incorrect coupling of the ballad wheel gearboxes, crankshafts break due to hidden defects beyond the control of the manufacturing stage or due to saturation, mobile subassemblies collide, working tools break as a result of irrational exploitation, chains and ropes break due to heavy lift, etc.

Wear processes are causing the most damage to mechanical components. Practically all mechanical parts of quay cranes are subject to abrasive wear processes, fatigue, corrosion or adhesion, which sometimes act independently or as a rule, simultaneously.

The most common are fatigue failures due to wear of the elements required in rolling friction (bearings, gears, rollers, etc.) and damage from abrasion wear (sliding and rolling bearings, working bodies, etc.)

## 2. GRAB TYPES

Depending on the action mode there are the following grabs types:

- cable grabs
- hydraulic grabs
- grabs with electromotor.

There are many constructive solutions for grabs, depending on their destination, i.e., depending on the materials with which it operates. For small and medium-grained materials (a <200 mm) are used bucket grabs, while for large materials (a > 200 mm) are used polyp grabs. [3]

The four-rope grab have a reduced dead weight with shorter closing times compared to motor grabs. Four-rope grabs manage a far better payload per move, have higher operating speeds and improved overall handling performance.

These cranes can out-perform a two-rope mobile harbor crane with a motor grab by up to 30%. One additional benefit of the four rope grab is its rigidity which makes it far less susceptible to knocks and damage when used in tough, nonstop operation and this result in reduced maintenance requirements and reduced downtimes. [4]

The advantages of a single-rope grabs are that they can be operated on every kind of crane and they are quiet robust. So they fit for areas or circumstances where is only low maintenance possible. Disadvantages are that this grabs are very slow and can appear problems with the working high, because of the length of the closing rope. In harbours with tide it can happen that during the time when the water is on the lowest point the grabs can not reach the top of the hoppers. Or at least the necessary time per cycle rises up, because the jib has to be lifted much more to reach the hopper on the shore- site.

The two-rope and four-rope grabs need a crane with 2, respectively 4 winches.

In the two rope grab case, one rope is the holding-rope, the other one is for closing and opening the grab.

A four- rope grab is working with the same mechanism, but he has 2 holding-ropes and two closing-ropes. The positions of the 4 ropes in the top of the grab has to correspond nearly with the position of the 4 winches in the jib-head. The closing force of all mechanical rope grab depends on their dead weight and how often the rope is folded inside the closing mechanism. The more often the rope is folded, the slower the grab is closing, but the more power it has. [5]

## 3. GRAB CALCULATION

Grab calculation involves determination of its mass, the elements that define the geometry and kinematics of the system and work forces and efforts necessary for strength calculations.

The only certain initial data are the usable volume ($V_{30}$) and the nature of the material. For this reason any calculation method is using empirical data obtained statistically. In addition, the designer may have reference models. These circumstances make the results to be approximate and their validity should be tested experimentally.

### *3.1 Establishing the grab mass.*

Mass of the grab should be correlated with material mass and properties as the process of filling is made by digging and traction effort in the closing cable can't exceed the grab weight. Mass of material is determined by the formula:

$$M_m = \frac{V_{30}}{k_v}\rho \quad (1)$$

where $V_{30}$ is the usable volume, ρ - material density, $K_v$ - filling and aeration complex coefficient of the material.

Physical characteristics of some representative materials are shown in table 1.

Table 1. Physical characteristics of some bulk materials

| Material | $k_0$ (maxim) | ρ kg/m³ | $q_0$ daN/m | $k_v$ (max) |
|---|---|---|---|---|
| Hard dry sand | 0,375 | 1600-1800 | 100 | 1.15 |
| Iron ore | 0,400 | 2200-2750 | 200 | 1.30 |
| Coal | 0,425 | 850-950 | 62 | 1.22 |
| Wheat | 0,450 | 700-800 | 36 | 1.15 |

where $q_0$ is specific resistance at digging.

At cranes equipped with grab, load capacity is:

$$Q = M_0 + M_m \quad (2)$$

where $M_0$ is the mass of the grab. This can be viewed as the fraction $k_0$ of the whole load capacity, ie

$$M_0 = k_0 \cdot Q \quad (3)$$

where $k_0$ takes the values shown in table 1. Eliminating Q from equations (2) and (3), we obtain the relation between $M_0$ and $M_m$:

$$M_0 = \frac{k_0}{1-k_0} M_m \quad (4)$$

or using (1):

$$M_0 = \frac{k_0}{1-k_0} \cdot \frac{V_{30}}{k_1}\rho \quad (5)$$

Own mass distribution on the grab constituent parts should be the following:

- top beam mass(including share of tyrants mass)
  $m_1 = 0.3\ M_0$
- buckets mass (including share of tyrants mass)
  $m_2 = 0.5\ M_0$
- lower beam mass
  $m_3 = 0.2\ M_0$

It is favorable that the lower beam mass is as small as possible, as its weight reduce the digging force that can be developed at the buckets teeth.

### *3.2 Geometry and kinematics.*

The main geometry of grabs is usually expressed by L which is the maximum opening of the buckets. This can be determined by the formula:

$$L = (2.2....2.6)\sqrt[3]{V_{30}} \quad (6)$$

(smaller values correspond to lighter materials).

It is recommended the following proportions:

- Bucket width
  B = (0.45 .... 0.55) L
- Tyrants length
  $l_B$ = (0.55 ... 0.7) L
- Joint coordinates:
  $l_1$ = 0.4L
  $l_2$ = (0.15 ... 0.25) L
  $e_1$ = (0.05 ... 0.06) L
  $e_2$ = (0 .... 0.05) L
- Maximum angular opening of the buckets:
  2β = 156 ... 160°

Values and similar relations are proposed by other authors like Vainson, Dukelski and Ernst.

### *3.3 Efforts in the grabs elements*

Efforts calculation in the grab elements is made for the position open, at the beginning of filling and for position closed after filling. It can be approached analytically by writing the equilibrium conditions of the main components: high beam, low beam, and bucket.

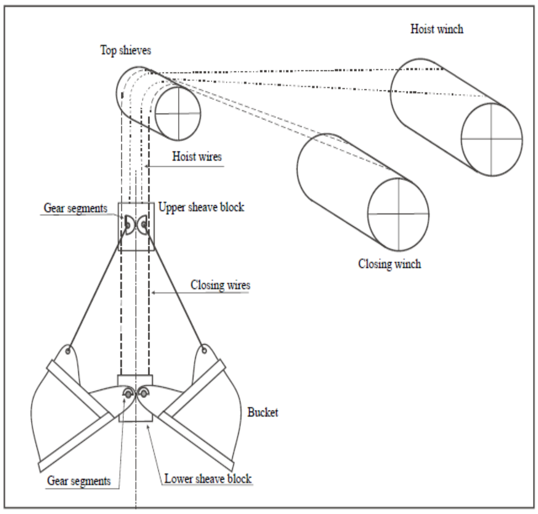


Figure 1 Hoisting system of cable cranes, Source: Wim Vlasblom, *Lecture Notes on Dredging Equipment and Technology [6]*

When the grab is empty, open, at begin of filling, it is considered that it is supported by the closing cables, while the lifting cables are loose. In this case the effort S from each of the two closing cables is

$$S = 0,5G_0-V \tag{7}$$

where $G_0$ is the weight of the empty grab and V is the normal component (oriented vertically upwards) of resistance to digging. From the formula is showed that S is maximum when V is zero. It is therefore reasonable for the calculation to consider V = 0, therefore:

$$S = 0.5\ G_0 = G_1 + G_2 + G_3 = (m_1 + m_2 + m_3)\ g \tag{8}$$

where $G_1$, $G_2$, $G_3$ are the weights of the elements concentrated in the grab joints. Noting with *i* the gear ratio and with $\eta$ the yield of closing hoist, vertical forces acting are:

$F_1 = G_1 + (i\eta-1)\ S$ on the upper beam;
$F_2 = G_2$ in joint bucket with bars;
$F_3 = G_3 + iS\eta$ on the lower beam.

Force $F_1$ is transmitted along the bar ($F_B$), therefore it appears H1 horizontal component whose value is determined graphically.

In point of articulation of the bar with bucket, forces $G_2$ and $F_B$ determine the resultant $R_2$, and in the joint of bucket with the lower beam forces $iS\eta$, G3 and $H_3$ determine resultant $R_3$. Therefore the bucket is under the action of $R_2$ and $R_3$ forces and $H_i$, resistance to digging, which should make the equilibrium.

Result these forces are concurrent, namely in the top of the bucket, where it acts force $H_i$. Force $H_i$ is assumed a priori horizontal, whereas under the hypothesis of calculation (8) the vertical weights forces are balanced by effort S.

For the full grab the force polygon is similar and at the buckets weight is added the weight of the material.

Analyzing the two cases it is showed that closing force $H_i$ is maximum when grab is open. It declines as the bucket close, being proportional to the weight of the grab and the gear ratio of the hoist. From this point of view is favorable a higher transmission report. At the same time it requires more cable wound around the drum, thus a longer closing time and a lower productivity.

The solution should be a compromise between the two conflicting requirements. [7]

## 4. BOCSA QUAY CRANE 18 T- 32 M STUDY CASE

The analyzed quay crane is a Bocsa crane in the propert of one of the largest cereals port operators from Constanta Port.

It usually loads and unloads:

- sunflower (aprox. $\rho = 0,45$ t/ $m^3$);
- wheat ($\rho = 0,75\ 45$ t/ $m^3$);
- corn ($\rho = 0,75\text{-}0,76$ t/ $m^3$) ;
- barley ($\rho = 0,63\text{-}0,68$ t/ $m^3$).

We analyze the forces that appear in the most defavourable case, when the crane operates corn. The grab capacity is 13 $m^3$ and the empty grab mass is 8 tons.

The load mass is 13 $m^3$ x 0,76 t/ $m^3$=9,88 t cargo.

The total mass of the loaded grab is 9,88 t + 8 t = 17,88 tons.

$$F=17,88 \text{ t x } 9,8 \text{ m/s} = 175,224 \text{ kN}.$$

Tension in the cable pressing on the 4 maneuver reels is:

$$T = \frac{Q + Ggraifar}{n \cdot n_{tr}} = \frac{175,22}{4 \cdot 0,97} = 45,16\ kN / reel$$

The most defavourable case is when the load is raised on 2 maneuver cables. This is a very frequent situation that happens to the port operator cranes.

In the particular case when the reel is blocked by dirt scum, appears the frictional force

$F_f = \mu \times T$ , where $\mu$ corresponds to the friction between iron and iron ($\mu = 0.16$). Frictional force is an additional force in the grab cable and is added at the tension force.

$$F_f = 0,16 \text{ x } 45,16 = 7,22.$$

Thus, traction force in the cable is

$$T + Ff = 45,16 + 7,22 = 52,38 \text{ kN}$$

## 5. CONCLUSIONS

Worldwide in ports, operating cargo depend highly on port handling equipments.

Unexpected malfunction of handling equipment is disturbing and sometimes total stop of the cargo handling process in a terminal port. For these reasons, the organization of port equipment repairs should be done with great care and discernment. Maintenance, no matter how well done, can not remove all effects of normal wear over a longer period of operation.

In the study case, the worst case scenarios of Bocsa 18 t - 32 m quay crane exploitation are when corn is loaded on two maneuver cables instead of four cables (a very common situation), and the reel is blocked with deposition of material (dust). In such cases we calculated friction forces and tension.

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# A NAVIGATOR'S LIFE ABOARD SHIP. THE EXPERIENCE OF THE FIRST VOYAGES

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**ABSTRACT**

In the present paper we show a few requests to strictly satisfy the professional discipline aboard ships, as well as the way to voluntarily involve every student to get the most of the training elements concerning his future professional activity.

From the very beginning we have to present the author's experience, gathered aboard "Somes" and "Neptune" ships and eventually we'll read some lines from the personal diary of the student Diana Moldoveanu, who graduated the Naval Academy "Mircea cel Batran" from Constanta, concerning the level of the willingness and personal involvement for learning from the beginning a largest ever experience from all the ship's districts.

We are positively convinced that this paper will be useful for all naval and marine students and is to contribute to increase the willingness level so much needed aboard ship, as well as for the own professional specific training.

**Keywords**: *Training student, practical activities aboard, watch service, deck service, engines service, psychological adaptation, professional activities relationship, activity discipline, etc.*

## 1. INTRODUCTION[1]

The navigation across the seas and the oceans of the world attired and will continue to do it only the people having an emphasized sense of responsibility, people with a physical capacity and an important nervous force, as well as a pronounced spirit of sacrifice near the limit between sacrifice and adventure.

But, for every single individual, the emotions and the feelings of the first voyages are to be definitely unforgotten.

The present exposal will try to partially reflect the feelings of the teacher aboard school ship in the instruction practical trips and the students aboard the same ship, too. More than that, we'll present a part of the diary of a graduated girl, embarked in her first voyages. We are sure the material will be received as very interesting for both the didactic personnel and the students in the Navy.

## 2. THE PLACE AND THE ROLE OF NAVAL PRACTICAL EXERCISES IN THE SPECIFIC PROCESS OF THE PROFESSIONAL FORMING OF THE NAVAL AND MARINE STUDENTS

The Naval practical activities, mostly the embarked students one, is an important didactical activity included responsibly in the educational plans of the Navy as a continuous and compulsory activity, due to the formation of the specific professionalism of the students, for their promotion and, finally, serving them to get the maritime officer licence.

As the possibility to act formatively by this discipline, the physical training, during the preparing hours of the students was severely restricted after 1990, a smaller number of the physical training **in the navy** (!!!) as in any other discipline, the transfer of the instructive-formative action, including them into the practical nautical exercises.

Developed on Mamaia Lake, at the seashore, including the coastal area of the Black Sea, in the Constanța and Midia-Năvodari harbors or aboard school ships on the seas and the oceans of the world, the naval exercises are in fact an important form to develop the didactical organizing acting to obtain specific psycho motional qualities, so needed in this socio-professional activity.

*The nautical practical activities* of the naval and marine students presents some special *features* we show a little further:

- it is a didactical activity, a little more ample, differentiated, but also submitted to all didactical and psycho-pedagogical laws, adapted to the naval education;
- this didactical activity has, at the same time, a larger specificity degree, needing the elaboration or the adaptation of some specific work methodologies for the naval students, either on Mamaia Lake, to row or swim in the open sea, or aboard school ships, or some specific criteria also specific to appreciate and evaluate the students. And these ones are stimulating and challenging.
- generally speaking, *the nautical practical activities* of the naval and marine students, as well as the embarked activities, represent a very serious didactical activity a little less known, developed in a relative isolation, in a permanent potentially dangerous status, far from the other people except the crew mates, in concrete conditions the students notice from the very beginning, a strictly abiding rules attitude, discipline in every respect.

[1] Mention the contribution in achieving this work of mr. col. (rs.), psiholog ***Dan NICOLAU***.

***OPRISAN Naie - The first voyage, aboard the fishing ship „Somes", from Tulcea harbor, on Sulina Canal, across the Black Sea, up to Constanța harbor.***

- in this activity of forming and training the students, the discipline is obviously emphasized aboard ships, no matter if they are civilian or military, professional navigators or students. All of them take part to every specific activity, facing the difficulties and the physical, psycho motional or psychical requests, no matter the weather conditions, the state of the ship, the naval traffic, etc. All these and many more others mean for all navigators, students and teachers as well, elements of the specific stress;


***The fishing ship „Somes". In anchor in the Midia-Năvodari harbor, was the first school ship of the civilian Navy, after 1989.***[2]

- **embarked practical activity** is one of the most expensive forms of the school activities, developing aboard a school ship that really ***navigates*** involving important expenses, meaning the general maintenance of the ship as to answer in an adequate manner to the security needs of a national ship: R.N.R. *("Romanian Naval Registry Book")* and of international security imposed by I.M.O. *("International Maritime Organisation)* and C.I.O.V.O.M. *("International Convention to Protect the Human Lives in the Open Sea).*

The expenses imposed by the fuel, oils, changing pieces, maintenance and cleaning materials, the daily food and water supplies, protection and salvation devices and equipments, as well as the payment (currency) for the personnel as the international laws and rule of the traffic establish;

- *the nautical practical activities* of the students represent a difficult didactical activity, involving a serious degree of *specific experience* for the ones to organize and work to fulfill.

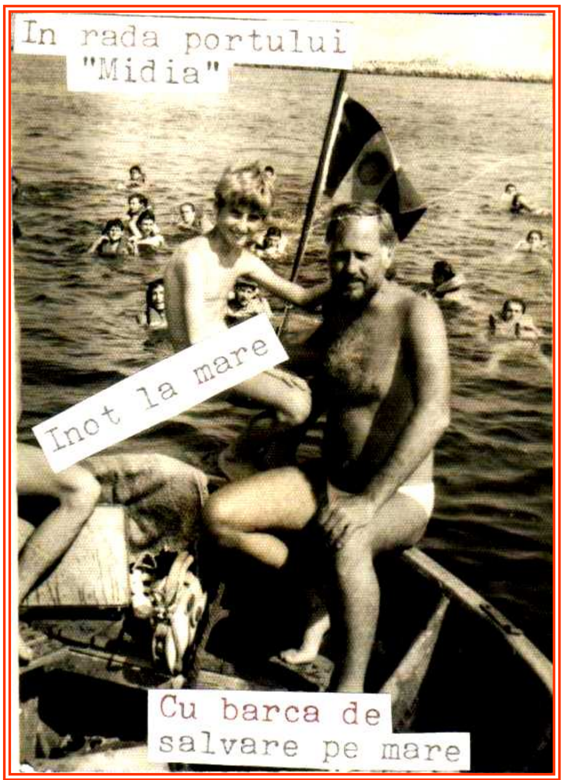

Developed on Mamaia Lake, combined with the swimming in the open sea (or closer to the shore), as well as the practical activities and exercises aboard, involve a superior involvement level, a conscious participation, sense of volunteering, correctness, professionalism, experience and exactingness from all the personnel involved.[3]

The specialists agree that aboard school ships they realize the mist efficient specific professional training.

[2] The fishing ship ***„Somes"*** was taken over, afterwards, by The Romanian Institute of Marine Researches (I.R.C.M.) Constanța, and renamed ***"Mare Nigrum".***

[3] The new level we, the teachers in physical training, reached was noticed in 1990, when we participated aboard school ships to do the training and the other professional activities our specialty includes in the Navy. Embarked by the naval and marine students and the professional navigators, we methodically studied the life, the challenges and the requests the life aboard ships raises. We directly act to form physical capabilities and specific psycho motional skills necessary in this kind of activity. We also implemented in the life and daily activity aboard ships, first of all another way of thinking another manner to treat things, some other habits and volunteering for everyone.


***The previous instructionof the naval and marine students on the rescue boat of „Somes" ship in the Midia-Năvodari harbor, Romania***




***Aboard rescue boat of the fishing ship „Somes" in the area of Midia-Năvodari harbor and…,***

*„An important part of the Romanian naval education was from its very beginnings, the instruction aboard school ships of the youngmen who had chosen this career.*

*As time goes by**, the importance of the school ships** and other ships fulfilling in different periods of practical exercises, appears as fundamental for the training of thousands navigators.*

***…swimming two miles away in the open sea.***

*The students acting this way aboard these ships as watch services on the upper deck, together with the older navigators, passing different roles in the voyages on the Black Sea or other seas and oceans or even on the Danube river, could check them up and consolidate their technical and navigation knowledge they acquired in the laboratories and the classrooms. They also developed this way the character, the loyalty to the ship and the ship crew, the discipline to face the worst challenges the sea could raise against them. By their instructing and formating role for the navigators", (...) "the school ships meant an important chapter in the Romanian Education evolution".*[4]

## 3. THE ANALYSIS OF THE SPECIALISTS' OPINIONS CONCERNING THE ROLE OF THE SPECIFIC PHYSICAL AND PSYCHO MOTIONAL TRAINING IN THE PROFESSIONAL FORMING OF THE NAVAL AND MARINE STUDENTS

The heuristic dialogue and the investigation questionnaire-type concerning the need to orientate the physical training to the challenges and professional requests of the navigation activity.

**a. The heuristic dialogue (discussion).** To find out the specialists' opinion concerning intimate, varied and specific aspects of this professional activity in **our** embarking conditions aboard ships, together with our students brought in a large quantity of specialty information and knowledge. We rapidly gathered anew personal; experience to whom we added scientific and theoretical elements offered by the specific literature.

[4] **BITULEANU Ion** - historian, writer, dr. Universitary professor in the "Mircea cel Batran" Naval Academy, Constanta; Eventually, he became Pro-rector of „Spiru Haret" University, Constanta;

All that was to complete an experience of over 30 years in the high level naval educational field, made us be certain in promoting these new experiences and treat our study with scientific arguments.


***Part of the professional navigators from aboard "Somes" volunteered in the Midia-Năvodari harbor to take part in the tests, studies and researches.***

The heuristic discussions near to the pedagogical experience constituted a permanent basis for our research. As general conclusions, we can mention the following:

1. As a principle, almost all the specialists in the domain are conscious knowing that our present level of specific psycho motional training of the navigators did not reach the real needs of the navigation activity; The number of the naval accidents, disasters, etc., the lost of lots of material goods could be far more reduced if this issue were treated more thoroughly at the level of the navigation personnel;

2. Everybody without any exception knows everyone will pay attention to abide the regulation concerning the periodical training courses, but mainly **theoretical** of the crew members to fulfill the ***„roles of the ship"***, and very rarely executing real actions. They resume most of the training on simulating actions, not on **practical** ones. And the formation of their skill deeply suffers;

3. Another part of the specialists acting in the navigation count a little bit too much on individual and collective rescue means and devices of the ship means, in spite all these were never launched on water, the moment the situation imposed this. So, they lost their efficiency remaining some ,,dead devices".

*„The moment the ship is sinking, the man imagines that the whole Universe is sinking, too. Not having the two wooden boards under him he loses his courage and the reason, too".*

*The moment he founds in that very second a rescuing boat, it doesn't mean he's saved at all, because he still stays stunned watchind frozen to the disaster. His life stops right now.*

*Covered by the night, caught by the water stream, whipped by the wind, horrified by the empty spaces between the wawes, by noise and silence he'll put an end to his life in less than three days. I know, victims of the wreckages you did not die because of the sea, because of starving or thirst, but rolled by the wawes you died of horror under the seagulls cries!*

***Exercising the rescuing from drowning in the area of Midia - Năvodari harbor, Romania***

*I got this way the certainty that many shipwrecked persons die long before the physiological or physical conditions become, by themselves, deadly".*[5]

***Exercising the rescuing from drowning in the area of Midia - Năvodari harbor, Romania***

The lack of the practical training, of the psychological training, of the experience and effective capacity to struggle to survive, because of the practical execice missing, is obvious;

4. We finally present another disarming opinion. Even if at a worldwide level , according to the statistics *„at every 90 minutes a ship suffers damages in the open*

[5] **ALAIN BOMBARD** - *„Shipwrecked by own will"*, Stress Publishing House, „ Graphic Art" S.A., 1991.

*sea”*, and *„at any 36 hours a ship suffers wreckage”*, that *„200,000 people die every year swallowed by the sea waters”*, another „bunch” of specialists, (actually they are not too many) have an alarming opinion, saying there is no use to make such an effort to train the skills and the knowledge of the navigators, the manner we exposed above, because those mentioned disasters ***maybe*** would never happen!!!

They are mainly the ones torn away from the practical activities, thinking from their large offices, letting God to solve those problems men could solve!

A little more sad is the fact that those persons reduce their activity just „checking off” the instruction and training actions in their „captain's logs”, marking figures, terms and OK-s. All that having decision power, organizing responsibilities...[6]

## 4. THE NAVIGATOR'S LIFE FROM THE PROFESSOR EMBARKED ABOARD THE SCHOOL SHIP PROSPECTIVE

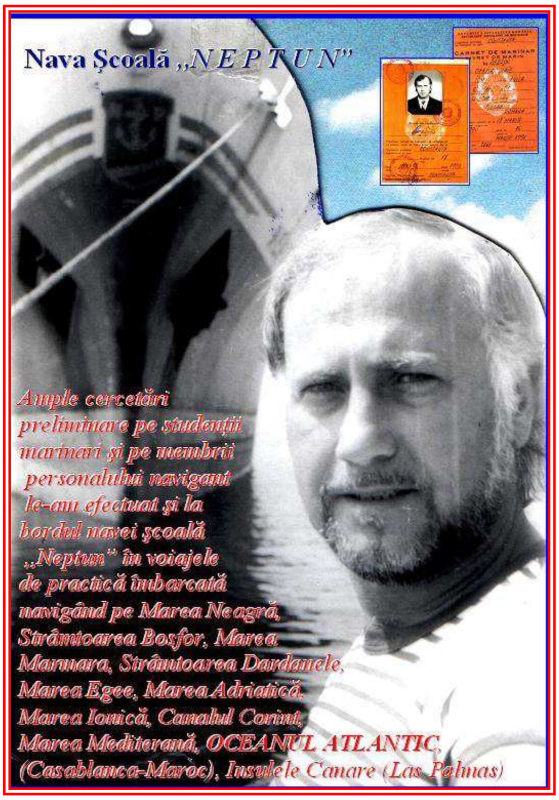
*4.1. The first voyages and the effective practical activities embarked for instruction and specific training aboard the school ship „Neptune”*

After the first voyage on ***„Someş”*** there followed some other voyages as *„**Teacher for the practical instruction**”* aboard the ship ***„Neptune”.***

**Voyage 1:** Constanța - Bandârma (Turkey); **Voyage 2:** Constanța -Aspra Spitia (Greece); **Voyage 3:** Constanța - Ilepsis (Greece);
**Voyage 4:** Constanța - Cavalas (Greece).

***I put back again in function the swimming pool abpard school ship „Neptune”***

Eventually, because of the interest we showed to fulfill at a highest level this kind of activity with the students, the Senate named me ***„Chief of embarked practical activities”*** aboard ***„Neptune”***, having 76 students aboard and 8 other professors from other specialties (navigation, electromechanics, communications) one of the most efficient and long voyages of practical activities.


***OPRISAN Naie - Chief ov embarked practical activities aboard school ship „Neptune”, 59 days***

During allalong two months (59 days) we had the following ittinerary: Black Sea, Bosphorus Sarrow Sea, Marmara Sea, Aegean Sea, Adriatic Sea, Ionic Sea, Corinth Canal, Mediteraneean Sea, Gibraltar Narrow

[6] The sea storm (tempest) or the naval sinister cannot choose its victims after the rank or responsibility. As a concrete example, Romanian ship *„Fălticeni”* sunk during a storm in the Aegeean Sea, part of the crew managed to save themselves, but the skipper the mechanic and even the captain drowned!

Sea, Canarias Islands (Gran Canarias - Las Palmas) and back.[7]

Together with our students and the professional navigators aboard, we learnt every moment, and completed our knowledge and experience so far, with everything we needed to know from the specific of the navigation activity.

***The Corinth Canal, splitting The Greece from the half island of Pelopones***

A second important action was our direct participation in the exercise alarms given by the captain of the school ship to accomplish ***„The roles of the ship"***: *„fire on board", „man overboard", waterhole", "abbandon ship".*

*4.2. A study we made aboard ship concerning the specific physical and psycho motional requests level of the professional activities of the professional navigators.*

Therefore, standing all these difficult periods, together with the agitated sea periods, some different restriction to the food and the water, the maintenance and the cleaning of the ship, „all for one", no matter if student navigator or professor, we gathered a valuable *specific practical experience*, which helped a lot in realizing the research.

*4.2.a. The determination of the specific psycho motional requests in current conditions of life and activity aboard ship*

The life and activity aboard ships involves from the navigators to have some important specific qualities, as well as psychological, psycho physiological, psycho temperamental, dictated by the different specific of the activities.

***The Corinth Canal***


***The school ship „Neptune" in anchor in Ilepsis harbor - Greece***

A main condition to make us able to use the general psycho pedagogy in our specific domain, and to try to treat the study through the image of the activities aboard, was the knowledge about the psycho physical particularities of the life and professional activities aboard the ship. And by doing all that we took into account the physical intellectual and psycho motional specific requests aboard ship.

The experience we directly gathered, the recent conclusions of the most recent pedagogical observations on the experiment made aboard ship, permitted us to take out the following specific aspects particularities from the navigation activity:

1. The professional gearing as well as the navigators psycho motional requests is often influenced by the way the ships were designed, they were built and are exploited as:

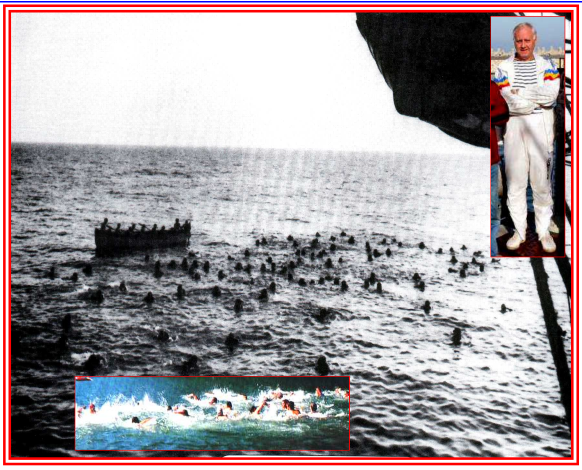
a. *The universality and the specialization*: *The universality* represents the specialists' tendency to design ships able to answer any multi-purpose activity having different specialized crews; *The specialization* is the way

[7] I was told I was lucky to pass the Corinth Canal, because a lot of old navigators reach the retiring age without passing this Canal !

to design a single purpose specialized ship, for a special kind of activity.

***Between the specific particulary aspects in our study, we based also on the specialty litterature we consulted very thoroughly*** [8]

As the specialists in the domain ( F. Sîntion, 1980) say, as *the specialization* impose some special constructions characteristics and the specialized devices to make performance in its domain, *the universality* make a various technical endowement in order to reach that mentioned multi purpose capability to respond a various pack of requests.



***The simulation of the ship abandon (the most complex role) and swimming in the sea, in the harbor area Casablanca - Maroc***

The psycho physiological effects of this first group of particularities (the universality and the specialization) are represented more in two phases:

a) the technical endowement of a modern ship impose *the existence of a large number of specialities* aboard with everything they mean concernind the specific training of the personnel, the selection of the personnel, the knowledge of the leaders aboard ship. All that means the introduction of a new methodology of selection and specislty training according to each specialty;

b) *the specific psycho motional and psycho physiological requests* the navigators have to answer during the voyages are very different, in a very large number and very intense most of the time. It imposes adequate instruction and training for the navigator personnel, in order to help them face all these challenges.

2. The interaction and the interdependence between the members of the crew by realizing aboard some complex functional relationship; we could mention here just the most important ones as: the relation specialist (man) as user of the technique the ship is endowed; the relation between the members of the same specialty; the relation between the different specialty members (between teams); the relation between the chief ( captain or department chief) and the members of the crew.

3. The particularities linked by the psycho-sociology of the ship crew. From this point of view, the crew can be considered a small group submitted to the cohesion rules, conformity, group motivation, simpathy or antipathy relations indiferrence, all of them influencing more or less the life and the activity on board.

Specifically, the crew is a closed group, having a small number of members. The life aboard is generally balanced as the weather is good. That means a wide, tight and good communication between all categories of the crew. The personal relations can develop in time:

a) *in a positive direction*, reaching a better knowledge, an increasing mutual confidence, a spirit of helping each other, a cohesion of the group. Now there is a good opportunity for the performance and skills to raise their level;

b) *in a negative direction*, one can reach an exhausted dialogue, with nothing to comment, no matter when on duty watch or the free time. There can occur this way non-compatibilities of psycho social origin, some intollerance towards the others, nervousness, conflicts, etc. They all do not have real external causes, but are bad enough to destroy the formerly mentioned balance and affecting of course the general efficiency.

c) As we already mentioned, the most important factor influencing the psycho physical state of the navigators and thus the capacity and the efficiency of the activity is the *ship instability* (the balance, the oscillations) of an agitated sea.

It is a very rare situation to navigate on a flat sea *(„flat calm”)*. The oscillation along the ship *(„rolling motion”)* is always combined with the oscillations created by the progress of the ship *(„rocking motion”)*, both being combined and having bad effects on all activities aboard. The effects are perceived by all personnel, only the intensity of perception being different. And this comes along the years with the experience.

So the walking on the ships becomes more difficult, the objects start to move, all the activities either training

[8] I. I. Alecsandrov, 1972; G. F. Keller, 1974; P. S. Siris, 1974; G. D. Gorbunov, 1979; I. L. Gancear, 1981; E. G. Milner, 1981; F. P. Iliin, 1983; V. L. Kneazicov şi colab. 1987; T. Orlick, 1986, 1990; M. Epuran, 1990; P. Bundsen, 1994; I. E. Unesthall, 1996; F. Sîntion, 1984, 1987, 1980, 1998; C. Voiculescu, 2003, 2004; V. Ene, 2003, 2004, etc.

or work are more and more difficult. That means a diminished work efficiency.

d) The behaviour and the psycho physical state of the navigators aboard the ship in march are also influenced by *the changing weather conditions* (*hydro meteorological),* having effects over the psychical balance. For example, when there is a foggy weather, some tensions may appear, some stress is noticed an extra attention and care is also very present, and sometimes illusions were reported. The ionizing of the atmosphere has strong effect on the physic and the psychic of the navigators.

5.The particularities linked of the specific factors appearing during long voyages.

Knowing all the issues we previously mentioned, makes it easier to orientate our scientific observations and the pedagogical experiment on the naval and marine students involved in the practical activities and training aboard ships.

We have to mention that at the end of every voyage, on the way back home, a relatively high spirit installs, but the time still moves too slowly.

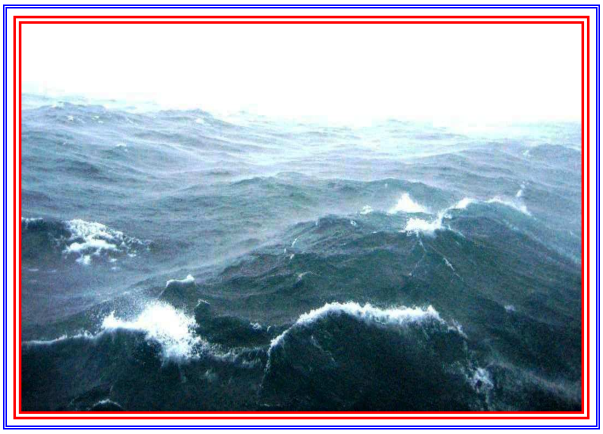
But, at the very same time, a profound and grand feeling of confidence of self evaluation, relatively objective appears. The duties aboard were carried out, mostly the difficult ones and all that because „my contribution".

From this moment, the navigator, especially the beginner, becomes another person, has a feeling of utility, has just made another step ahead.

In the same time superficiality can appear as a result of a self-overappreciation. It doesn't get over some limit.

**General expressions of the specific navigators stress during the storms on the sea.**

All changes produced to the internal human functions, determined by the ship oscillations on a whirling sea, are translated as ***„sea sickness"***.



At a reduced level of the sea agitation there appear only headaches, vertigo, nausea, sleepy states or even agitation. The capacity to select and act with the information lowers, selfish attitudes appear, as well as misconfidence, nervousness, undisciplined attitudes.

At a higher level of a whirling sea and a strong oscillation of the ship, man starts vomiting and he temporarily loses his capacity to work. He even suffers. During the storm the navigators become grumpy, sober, unsafe, less talkative, tensed but at the same time cooperant and more careful.

The fine physiological mechanisms that took out the evil under the form of „the sea sickness"are still studied in interdisciplinary researchesas: physiologists, psychologists, physiciasns, will find a complete answer.

For the very first time we lauhch **OUR HYPOTESIS** concerning the sea sickness as a result of neurovegetative functions perturbation, having as effect the stopping of the stomach normal functions, the perturbation of the digestion, the rottening of the alments in the stomach at the human body temperature ($37^o$ C), no acid in the gastric juice and, finally, vomiting and a bad, very bad, state.

## 5. THE NAVIGATOR LIFE ABOARD SHIP FROM THE PROSPECTIVE WHO MADE HER PRACTICAL CADET

As a woman, your first voyages are even more important than for a man. The woman status on board is still gathering shape.

A far more interesting situation is that one to be accepted in your first voyages aboard ships hang a multi national crew.

*„There's a difficult thing to be a woman aboard ship, I mean to impose to get the respect of the others to be taken seriously! But not impossible! The proof was a*

*III*[rd] *degree officer, in a voyage: A 26 years woman of German nationality.*

*To navigate together with the Germans was a good thing for sure. They say they are cold, but professional.They do not make differences between a man and a woman when working. It was something I needed by then. My first voyage meant accomodation, the learning of the ship, the basis of my job I was to do. The second one fixed my knowledge gathered in the faculty and during my first voyage.*

*Concerning the work on the deck. I learned to make the knots, to paint, to solder, I washed the deck (they say one has to start from below). I did not miss any manoeuver".*

***The activity of practical self instruction in the engines Hall***

Look then at the interest the new graduated of the Naval Academy „Mircea cel Bătrân", specialist in navigation, showed to the complete knowledge of all compartiment of the ship, of all depearament of the leadership and all the activities developed aboard.

*„I got down in almost all ballast tanks, spent a few days in the engines Hall to get used with all that stuff, to understand as much as possible".*

*„It was far more pleasant* ***in the command tower****. Any watch service started hading it over by the previous officer and.... the coffee preparing, not to forget.*

*During both voyages I worked all watch services in order to know what every officer had to do. What was he responsible of. I stressed on the work with the map and electronic map as a first stage as you graduate.*

*Sometimes I was feeling on my own, e.g. the moment first officer was letting me to decide to change the direction or was counting me on to make his papers.*

*From the busy traffic on the sea point of view, I do not feel I have too much experience, and I wish I could go to Asia before becoming an officer, because it is said to be the busiest zone. The most amazing stories come from out there.*

*Anyway I visited some nice places, closer or farer. I've been in Brasil, Argentina, South Africa, Germany or Canarias Islands.*

*We waited for 12 hours to 3 days in every harbor in the happiest cases. As a cadet I was working 4 hours and having 8 free hours, so I was having time enough to get out, visit and buy souvenirs".*

***Moldoveanu Diana***

*„The things didn't work very well all the time. For the very beginning was the most difficult, but it is quite important to think positive, to want to learn, more and more. Once you can handle the job no one will laugh at you, no matter man or woman !"*

This last image could be called ***„A beautiful dream !”*** - the dream of any navigator to lead such a ship.

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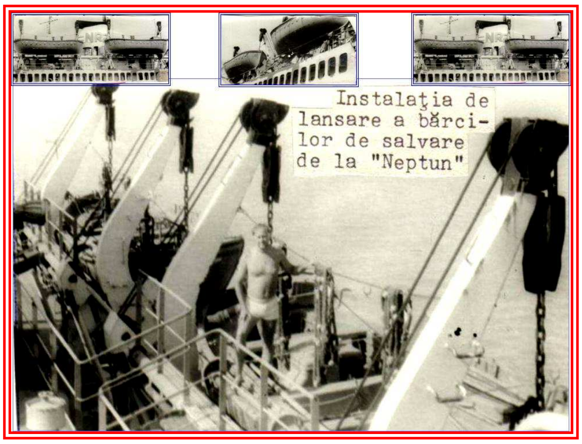
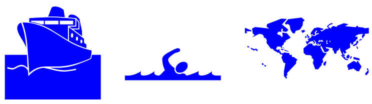



***The installations of launching the rescue boats („the crame”) ffom the base ship „Neptune”***



# ROMANIA-LNG IMPORT TERMINAL PROJECT

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**ABSTRACT**

Active studies have been made on the offshore LNG receiving terminal by many people around the world. LNG infrastructure consists primarily of tankers, import terminals, and inland storage plants. Many actual LNG receiving terminal projects are under progress and some are under engineering and construction stages. Considering most of the feed gas for LNG is imported via sea, it might be natural that many people in LNG industry would consider offshore LNG facilities as alternatives for the land-based ones. Two major sectors of the offshore LNG facility would be LNG FSRU (Floating Storage and Regasification Unit) and LNG FPSO (Floating Production Storage and Offloading).

**Keywords:** *LNG, terminal, project, regasification, FSRU, FPSO.*

## 1. INTRODUCTION

Romania's domestic gas production, although currently at approximately 12 Billion Cubic Meters (BCM) per year, is in decline and not expected to increase. Romania's current annual consumption is 17 Billion Cubic Meters, with Gazprom supplying most of the imports, and Romanian dependence on Russian gas is expected to grow. As such, plans to diversify the country's sources of energy supply should have broad political support especially from EU. Since Russian imports secure only gas via main pipe networks, a liquid form import via sea would be of huge benefits as it could provide the possibility to supply both ships, trucks and cars and domestic and industrial consumers after regasification process. State company Romgaz owned by Ministry of Energy asked for a grant from US for a feasibility study in 2008. The Grantee invites submission of qualifications and proposal data (collectively referred to as the "Proposal") from interested U.S. firms which are qualified on the basis of experience and capability to develop a Feasibility Study ("Study") that will assist Romgaz ("Grantee") in its planned implementation of a LNG import terminal at the Black Sea port of Constanta. The Grantee is Romania's state-owned gas exploration, production and storage company, and the largest gas producer in Europe.

The goal of this Feasibility Study is to assist the development a LNG import terminal on Romania's Black Sea coast. This terminal will augment the security and diversity of Romania's energy supply and increase the level of competition in the natural gas market.

We consider the FSRU solution most appropriate as it will secure fast supply, lower costs comparing to classical on shore storage tanks (250 mil euro versus 800 mil euros).

## 2. FLOATING STORAGE REGASIFICATION UNIT (FSRU)

A Floating Storage Regasification Unit (FSRU) is a special type of ship which is used for LNG transfer and a vital component required while transiting and transferring Liquefied Natural Gas (LNG) through the oceanic channels.


Figure 1: Floating Storage Regasification Unit (FSRU)

FSRUs can be equipped in two ways:

- as a separate unit aboard the LNG carrier;
- an old gas carrier can be converted into an independent unit and placed in a particular destination.

The fuel though is transported in a slushy state of -160° Celsius, at the required destination, needs to be heated up to its original gaseous state. This reheating needs to be carried out before the gas is pumped into its storage systems. The whole process of freezing and then re-heating the fuel is extremely expensive not to mention time-consuming. The resultant solution to this time-consuming process is the FSRU. A key advantage of the FSRU concept is that it can be moored in a wide range of water depths. In shallow waters (approximately 20 to 30 meters), a jacket based, soft yoke system can be used, in greater water depths a catenary based, turret mooring system can be employed. Both of these systems are allowing the FSRU barge's heading to rotate according to the vector of the local environmental forces. New ship orders remain robust as charter rates rise and demand for FSRUs expand. For example, Hyundai Heavy Industries has announced that it has agreed to a US$500 million construction contract for two FSRUs with an option for two more. Recently, Sovcomflot ordered two carriers with construction to be carried out by STX Offshore & Shipbuilding. Golar LNG announced a deal with Samsung to build four 160,000 cubic meter LNG carriers at a cost of some US$800 million. Higher charter rates are driving demand for new ships. Drewry Maritime Services stated on June 7 that charter rates for spot cargos had risen from US$35,000 per day in April 2010 to US$92,000 in April 2011. The firm reports a total of 37 vessels are on order. Thus far, prices have remained steady around US$200 million per unit. In addition to ships, markets continue to demand more import capacity. In India, developers are proposing East Coast terminals to compete with gas from the Krishna Godavari basin. Dhamra Port Company is advancing a plan to establish a receiving terminal south of Kolkata at an estimated cost of US$750 million. The project would benefit from the location's deepwater port. Indian Oil Corporation (IOC) also is progressing plans to establish a five million tonnes per annum project at Ennore, north of Chennai. IOC states that it is willing to establish the terminal even if it has to depend on spot markets for supplies. The announced terminals come as Reliance is reportedly delaying construction of two pipelines from the Krishna Godavari basin, India's most prolific gas basin. In Malaysia, Petronas has confirmed that it will proceed with the development of a planned 3.8 million tonnes per annum regasification terminal at Pengerang, Johore as part of the company's Refinery and Petrochemical Integrated Development Project. The proposed regas terminal is slated for 2016 and is likely to be constructed onshore. A second regas project, called Malaka LNG, which aims to speed development with the use of floating storage, is proposed next year at Sungai Udang Port.

## 3. LNG REGASIFICATION SYSTEM

The process of liquefying the natural gas involves compression and cooling of the gas to cryogenic temperatures (e.g. -160° Celsius). Prior to liquefaction the gas is first treated to remove contaminants, such as carbon dioxide, water and sulphur to avoid them freezing and damaging equipment when the gas is cooled. At this destination, the LNG is offloaded to special tanks onshore, before it is either transported by road or rail on LNG carrying vehicles or revaporized and transported by e.g. pipelines. In many instances more advantageous to revaporize the natural gas aboard the seagoing carrier before the gas is off-loaded into onshore pipelines.

LNG is sent from the tanks to the regasification skid situated forward. The regasification skid essentially comprises booster pumps and steam heated vaporizers.
The booster pumps will increase the pressure to about 90 bar, before the high pressure LNG is vaporised, after which the gas passes through a fiscal metering unit and is sent to the subsea pipeline via the gas swivel and flexible risers.

## 4. OFFSHORE TERMINAL CONCEPTS

Natural gas is rapidly being adopted as the fuel of choice for the 21st Century. Readily transported in the form of LNG, market demand for this product across the world is growing fast. Demand for LNG, is typically located near major population centres leading to a growing tension between the desire for it's beneficial qualities (clean, relatively inexpensive and easily distributed) and a persistent public perception of LNG as a 'dangerous' product. The FSRU barge is typically between 350 to 400 meters long by up to 70 meters wide and normally does not have a propulsion system. (It will be towed from the shipyard and installed at its operational site). The key drivers influencing the successfully implementation of any LNG import terminal are numerous, complex and varied whilst at the same time, advances in technology are offering a wider choice of options for the method of importation using both onshore and offshore technology. Regardless of which of these options is finally selected all are capital intensive and time consuming, and as the picture becomes increasingly complex, business developers are looking for ways to bring some structure to the decision making process, thereby increasing the chances that they will 'back the right concept' from day one. Regasification Unit (FSRU) it is possible for a 'virtual' LNG terminal to be created using the LNG carriers themselves. This so called 'Energy Bridge' or Converted LNG carrier scheme as initially proposed by El Paso makes use of the LNG carriers as storage vessels. This scheme has several attractive qualities, most appealing of which is the high operability offered by the internal turret mooring system. Using a submerged turret system it is possible for the LNG carrier to approach and safely connect to a subsea buoy in up to Hs 5.5 m waves. Once connected the mooring system can safely withstand even North Sea storm conditions (The APL STL system has been successfully deployed in the Offshore Oil and Gas sector in the North Sea region for many years).

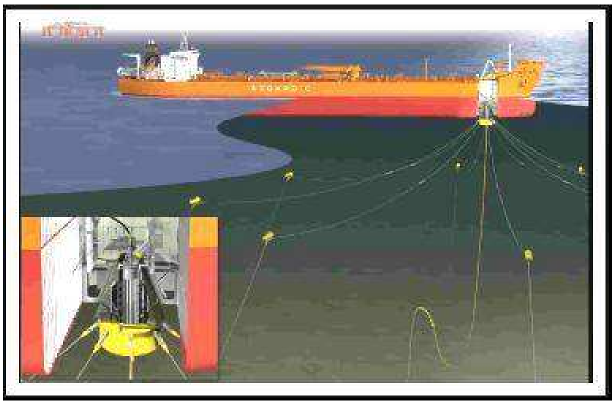

Figure 2: Illustration of APL Submerged Turret Loading System

A further alternative option for importing LNG exists in the form of direct regasification facilities. This option also makes use of the LNG carriers as storage vessels but this time instead of placing limited regasification facilities onboard each carrier as is the case with the converted carrier scheme, here one large regasification plant is located on an offshore platform. The carriers will still be required to remain in berth for a longer period than the normal 24 hour offloading period (hence incurring additional demurrage costs) but if the regasification capacity can be made high enough this additional duration can be limited to around 12 hours. Direct regasification as a concept is by no means applicable everywhere as it requires some very specific local characteristics to be in place but this in itself serves to emphasise the point that when considering these alternatives careful assessment of all existing local conditions is vital to match the optimum solution to each location.

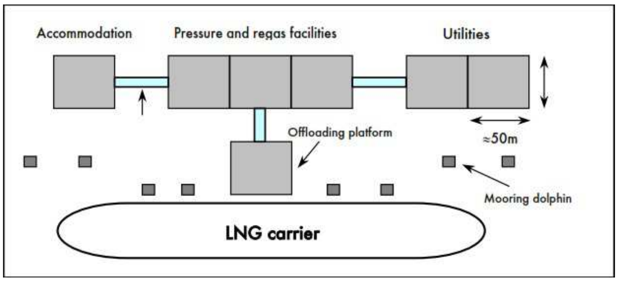


Figure 3: Offshore platforms

## 5. LNG SUPPLY

The global LNG industry continues to face high level of uncertainty in supply and demand forecasts. Rapid changes in the industry in the recent past including Japanese nuclear outage, recession in Europe, delays in Australian and African supply, the US liquefaction plans, raising concerns of shale gas, Europe nuclear phase out plans coupled with emergence of new markets are forcing companies and investors to reformulate their investment and LNG strategies. Actual LNG imports exceeded forecasts in 2011 driven by increased imports from traditional importers and developing economies. Coupled with this, relatively higher LNG prices over 2010 led to a rise in revenues for most LNG exporters. However, despite increase in revenues, sustainability of high revenues in near to medium future is yet un-certain. High prospects of LNG have encouraged most reserve rich countries, companies and investors to invest in liquefaction infrastructure. Globally, 12 countries including Australia, Papua New Guinea, the US, Russia and Venezuela are planning new terminals. If all the planned liquefaction terminals are realized, the industry will have large supply capacity, of 555 mtpa by 2020. Whereas LNG demand from existing markets will be much lower than this, which can lead to surplus LNG capacity. However, emergence of new imports markets will nullify the excess LNG. 17 new markets are likely to enter LNG trading, adding up to a regasification capacity of 65 mtpa. Further, uncertainty continues to prevail over LNG prices, probability of commencement of terminals and the impact of shale gas. Current recession in Europe coupled with lowered GDP growth rate in developing economies like India is also expected to impact LNG demand. Amidst such uncertainties, the new report from LNG Reports-"Global LNG Trends, Outlook and Business Prospects to 2020" provides realistic forecasts of supply and demand in near to long term future. It offers clear understanding of market dynamics, shift in trade flows, contracting patterns and LNG company strategies. It evaluates the pros and cons of investing in new projects and identifies potential investment markets. Further, opportunities in small and medium scale LNG and Floating LNG are evaluated. Backed up by strong quantitative data, insights in the report aid you in formulation of your expansion, retention strategies and in merger and acquisition decisions. Feasibility of new terminals, latest trends and challenges along with short and long term outlook of all exporting and importing countries is discussed in detail. Research and Analysis Highlights - Delays in realization of liquefaction capacity and widening scope of regasification will lead to a demand-supply gap of over 75 million tonnes in 2020.17 regasification countries will foray into LNG trade by 2020, resulting in a total capacity increase of 65 mtpa. Of 100 LNG terminals scheduled for operation between 2012 and 2020, 23% will be floating in offshore seas. Increasing LNG trade mandates addition of over 200 LNG carriers by 2020.

## 6. MATHEMATICAL SOLUTION OF LNG PROPULSION SYSTEM

The multi-billion dollar investment intensive LNG business is generally governed by risk sharing consortia as well as by 20–30 years long-term supply and ship charter contracts. Results of published studies are based on oil and gas prices (HFO, LNG purchasing and selling price).

[8]*LNG is purchased by the charterer at FOB price (or produced at FOB costs) and sold at a higher CIF price.* (a)

*PROFIT = Income – Expenses* (b)

$$[9]\left(\frac{FOBHFO}{FOBLNG}\right) < \frac{LNGADel - LNGBDel}{HFOABurnt - HFOBBurnt} \cdot \left(\frac{CIF\ LNG}{FOB\ LNG}\right) + \frac{LNGBDel - LNGADel}{HFOABurnt - HFOBBurnt} + \frac{LNGB\ Burnt - LNGA\ Burnt}{HFOA\ Burnt - HFOB\ Burnt} \qquad (1)$$

For a given class of LNG carrier design (cargo capacity) and transport distance the amount of consumed fuels and delivered cargos for two different LNG carrier propulsion technologies A and B (or two different fuel operation modes for a given propulsion system) is fixed and, hence, we can write:

$$\left(\frac{FOBHFO}{FOBLNG}\right) < C_1 \cdot \left(\frac{CIF\ LNG}{FOB\ LNG}\right) - C_1 + C_2 \qquad (2)$$

[8]$C_1$ and $C_2$ are constants the value of which is determined by purely technical aspects (amount of consumed and delivered LNG, amount of HFO burnt). The term on the left hand side represents the fuel price ratio of purchased LNG (FOB price) and HFO. The remaining term on the right hand side denotes the ratio of LNG selling price (CIF) to LNG purchasing price (FOB).

$$Charterer\ PROFIT = LNG_{Del} \cdot CIFLNG - [LNG_{Load} \cdot FOB_{LNG} + FOE + CRE + PPF]$$

$$(LNG^{A}_{Del} - LNG^{B}_{Del}) \cdot \frac{CIF\ LNG}{FOB\ LNG} - (LNG^{A}_{Del} - LNG^{B}_{Del}) - (LNG^{A}_{Burnt} - LNG^{B}_{Burnt}) - (HFO^{A}_{Burnt} - HFO^{B}_{Burnt}) \cdot \frac{FOBHFO}{FOBLNG} > 0$$

$$\frac{FOBHFO}{FOBLNG}\cdot(HFO^{A}_{Burnt}-HFO^{B}_{Burnt})<(LNG^{A}_{Del}-LNG^{B}_{Del})\cdot\frac{CIF\ LNG}{FOB\ LNG} \quad (3)$$

From the charterer's point of view we can write **(c)**

$$Income = LNG_{Del}\cdot CIF_{LNG}$$
$$Expenses = LNG_{Load}\cdot FOB_{LNG} + FOE + CRE + PPF \quad (4)$$

Once we accept the statements (a), (b), and (c) as "axioms" we obligatorily obtain

$$PROFIT = LNG_{Del}\cdot CIF_{LNG} - [LNG_{Load}\cdot FOB_{LNG} + FOE + CRE + PPF] \quad (5)$$

This equation describes the charterer's profit problem in its full complexity without any simplification. Charter rates will be dictated by the general situation in the LNG charter market at a given point of time, ship size, transport route and type of charter contract. In general, LNG propulsion system may consume a part of the loaded LNG, so we can write:

$$LNG_{Load} = LNG_{Del} + LNG_{Burnt} \quad (6)$$

Then charterer's profit equation becomes:

$$PROFIT^{A} - PROFIT^{B} > 0 \text{ if}$$

$$LNG^{A}_{Del}\cdot CIF_{LNG} - LNG^{B}_{Del}\cdot CIF_{LNG} - [LNG^{A}_{Load} - FOB_{LNG} - LNG^{B}_{Load}\, FOB_{LNG} + FOE^{A} - FOE^{B}] - [\cancel{CRE}^{A} - \cancel{CRE}^{B} + \cancel{PPF}^{A} - \cancel{PPF}^{B}] > 0 \quad (7)$$

$$FOE = HFO_{Burnt}\cdot FOB_{HFO} \quad (8)$$

[9]Using above expressions, the simplified charterer's profit equation (2) then becomes:

$$PROFIT_{A} - PROFIT_{B} > 0 \text{ if}$$

$$LNG^{A}_{Del}\cdot CIF_{LNG} - LNG^{B}_{Del}\cdot CIF_{LNG} - [(LNG^{A}_{Del} + LNG^{A}_{Burnt})\cdot FOB_{LNG} - (LNG^{B}_{Del} + LNG^{B}_{Burnt})\cdot FOB_{LNG}] - [HFO^{A}_{Burnt}\cdot FOB_{HFO} - HFO^{B}_{Burnt}\cdot FOB_{HFO}] > 0$$

$$(LNG^{A}_{Del} - LNG^{B}_{Del})\cdot\frac{CIF\ LNG}{FOB\ LNG} - (LNG^{A}_{Del} - LNG^{B}_{Del}) - (LNG^{A}_{Burnt} - LNG^{B}_{Burnt}) - (HFO^{A}_{Burnt} - HFO^{B}_{Burnt})\cdot\frac{FOBHFO}{FOBLNG} > 0 \quad (9)$$

$$\frac{FOBHFO}{FOBLNG}\cdot(HFO^{A}_{Burnt}-HFO^{B}_{Burnt})<(LNG^{A}_{Del}-LNG^{B}_{Del})\cdot\frac{CIF\ LNG}{FOB\ LNG}$$

$$\left(\frac{FOBHFO}{FOBLNG}\right) < \frac{LNGADel - LNGBDel}{HFOABurnt - HFOBBurnt}\cdot\left(\frac{CIF\ LNG}{FOB\ LNG}\right) + \frac{LNGBDel - LNGADel}{HFOABurnt - HFOBBurnt} + \frac{LNGB\ Burnt - LNGA\ Burnt}{HFOA\ Burnt - HFOB\ Burnt} \quad (10)$$

For a given class of LNG carrier design (cargo capacity) and transport distance the amount of consumed fuels and delivered cargos for two different LNG carrier propulsion technologies A and B (or two different fuel operation modes for a given propulsion system) is fixed and, hence, we can write:

$$\left(\frac{FOBHFO}{FOBLNG}\right) < C_1\cdot\left(\frac{CIF\ LNG}{FOB\ LNG}\right) - C_1 + C_2 \quad (11)$$

$C_1$ and $C_2$ are constants the value of which is determined by purely technical aspects (amount of consumed and delivered LNG, amount of HFO burnt). The term on the left hand side represents the fuel price ratio of purchased LNG (FOB price) and HFO. The remaining term on the right hand side denotes the ratio of LNG selling price (CIF) to LNG purchasing price (FOB).

$$Charterer\ PROFIT = LNG_{Del}\cdot CIFLNG - [LNG_{Load}\cdot FOB_{LNG} + FOE + CRE + PPF] \quad (12)$$

**ABBREVIATIONS**

| | |
|---|---|
| $C_1$, $C_2$ | Constants |
| $CIF_{LNG}$ | CIF Price of LNG at Discharge Terminal |
| PPF | Port & Passage Fees |
| $HFO_{Burnt}$ | Amount of HFO Consumed |
| LNG | Liquefied Natural Gas |
| FVG | Forced Vaporized Gas |
| HFO | Heavy Fuel Oil |
| CRE | Charter Rate Expenses |
| $FOB_{HFO}$ | HFO Price |
| $FOB_{LNG}$ | FOB Price of LNG at Loading Terminal |
| FOE | Fuel Oil Expenses (HFO, MDO) |
| $LNG_{Burnt}$ | Amount of LNG Consumed |
| $LNG_{Del}$ | Delivered Quantity of LNG |
| $LNG_{Load}$ | Loaded Quantity of LNG |
| NBOG | Natural Boil Off Gas |

## 7. ROMANIA LNG IMPORT TERMINAL

Romania has its own resources of natural gas which is supplied to consumers via national pipeline network and also imports from Russia but only in gas form via pipeline. The potential of LNG it is still not used in our country. In 2006 a project for a LNG import floating terminal located in Agigea, south port of Constanta was submitted to Ministry of Energy and Ministry of Transports in order to obtain financial support. The LNG can be used as fuel for vessels, cars, trucks with very low emissions comparing to diesel or petrol for which EU funding could have been granted. This floating terminal is equipped with regasification unit on board converted from an LNG vessel Moss type in order to supply ashore the fuel in both liquid and gas forms pending client's needs. The FSRU following delivery to Romanian client-we considered Romgaz, will be permanently moored alongside a purpose built jetty within the existing Agigea port. The converted LNG carrier will be capable of storing ~ 135,000 cubic meters of LNG and delivering up to 480 MCFD (~3 MTA) of regasified LNG to the local Transgaz for further delivery into the national gas network. Romanian client will in addition to leasing the FSRU from Golar, own/ operate a purpose built jetty and a high pressure export pipeline. An internationally acclaimed appointed adviser for the project should work closely with vessel's owner in the development of this project.

**FSRU REQUIREMENT DEFINITION**

Below items should be included to a potential provider of an FSRU:

**a) Requirement Background.** Specifics of the requirement. Include:

●Rationale for requirement (high fuel prices; power demand);
●Basis for requirement (internal study; 3rd party feasibility study);
●Timing of requirement (i.e. 1Q2013);
●Technology required (FSRU/FSU/ FSRV);
●Identify roles and responsibilities (Project Developer; Consultants);

**b) Overview of Operation**

●Description of planned supply (FOB or DES)
●FSRU siting (offshore; pier side)
●FSRU specifications: (Length; Beam; Draft; Gross tons)
●LNG supply quantities
●Regasification send-out requirements (minimum rate; maximum rate; pressure)
●Vaporizers (open or closed loop)
●Responsibilities for provision of buoy, subsea pipeline;
●Ratability of LNG deliveries;
●Include a map of import arrangement;

**c) Contract Details**

●Term of Agreement;
●Charter Party Form- Suggest Shell LNG Time modified for use as FSRU;
●Delivery: Should be no earlier than 24 months after expected FID;
●Offer format: Daily Capex element; Daily Opex element;
●Charterer option for early cancellation based on termination fee structure;
●Conditions Precedent (i.e. FID only upon execution if LNG SPA);

**d) Environmental Information**

●Participants will need to understand specific environmental data to evaluate the proposed site (geographic location; wave data; wind data; current data)
●Key consideration for the employment of an FSRU include:

-Operational Condition (Limit for LNGC mooring and loading arm connection. Max. Wind speed 7.5 m/sec; Max sea state Hs 1.5 m, Max surface current 0.5 m/s);
-Operational condition (Limit for LNGC unmooring and loading arm disconnection. Max. Wind speed 15.0 m/sec; Max sea state Hs 2.5 m; Max surface current 0.75 m/s);
-Survival (100 year return period). Max. Wind speed 30.0 m/sec; Max sea state Hs 8.0 m; Max surface current 1.0 m/s.
-Minimum depth for offshore mooring an FSRU is 50m.
-Minimum depth for pierside or jetty mooring is >13meters;

## 8. TEHNICAL SPECIFICATION OF REGASIFICATION SYSTEM

### *8.1. General description*

The Moss™ Regasification System is designed for installation on either a purpose built Floating Storage and Regasification Unit (FSRU), an existing LNG Carrier converted into a FSRU or on a Regasification Vessel.

The regasification equipment is arranged in parallel trains, where one train is normally for redundancy. The trains can be assembled as separate modules or the whole plant can be built in one module to fit to the available space and/or save weight on structure. The illustration on the front page shows a one module configuration with three trains.

The regasification plant can be designed for open or closed loop operation. The heating medium for LNG vaporization can either be sea water or steam, depending on customer requirements. Only proven components will be used.

### *8.2. Plant design*

The Moss™ Regasification System is a modular design. Each train consists of one or two LNG booster pumps and one shell and tube heat exchanger. A common booster pump suction drum is located upstream of the trains. The suction drum provides a smooth feed and an extra buffer volume for the pumps, providing additional robustness of the system in transient conditions (i.e. start-up, unexpected shut-downs and capacity fluctuations).

### *8.3. Capacity*

The Moss™ Regasification System can be designed to match any capacity requirements. As an example one train could typically have a continuous send-out rate of approximately 1.0 MMTPA (~150 MMSCF/D), associated with send-out pressure of 50 to 100 bar. Minimum flow is approximately 20% of full flow. The number of trains and their configuration provide possibilities for a wide range of send-out rates.

## 9. CONCLUSIONS

Proposals for new LNG import terminals in Europe and US are numerous, but LNG imports pose significant safety challenges. Romania and surrounding neighboring countries need alternative gas supply to Russian imports and also in liquid form for those customers who migh need liquid fuel for vessels or automotive consumers.

LNG receiving terminals have been using specialised equipment for years, but there are clearly opportunities ahead to further develop the technology. The interest in moving facilities offshore is high and improving process efficiency is also becoming a high priority. There is little doubt that given the growth in the industry, some of the concepts which have been implemented on a small number of projects will continue to be studied in the future but they will come under increasing scrutiny due cost reduction and environmental pressures.

LNG is inherently hazardous and its infrastructure is potentially attractive to terrorists. The LNG terminal fire in Algeria demonstrates that, despite technological improvements since the 1940s, LNG facilities can still experience serious accidents. Many lawmakers and the general public are concerned about these hazards. The U.S. LNG industry is subject to more extensive siting and safety regulation than many other similarly hazardous facilities. LNG facilities are still not stringent enough, but the responsible federal agencies supplies, not only LNG needs and hazards on their own. Although LNG terminal regulations are extensive, and the global industry has decades of experience operating LNG facilities, many stakeholders question LNG terminal safety. Some of these questions might be resolved through focused and objective research on key LNG topics. Rather than reaching potentially premature conclusions about a particular LNG terminal proposal (either for or against) based on incomplete engineering knowledge or press commentary, decision makers might seek clearer understanding of LNG hazards through research. LNG siting decisions are already underway, however, so any research efforts intended to affect the siting process would probably have to be completed quickly. Both industry and government analysts project continued growth in the demand for natural gas — and a decreasing ability for domestic gas producers to meet that demand. Greater LNG imports represent one way to address this growth in demand, along with increased Romanian gas production, conservation, fuel-switch and the development of renewable energy sources. One way

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# THE LINKAGE BETWEEN THE BLACK SEA AND THE NORTH SEA BY MEANS OF THE RIVERS DANUBE AND RHINE. A MODERN HISTORICAL PERSPECTIVE

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**ABSTRACT**

The interest of the European states for the Danube is gradually visible after the Peace of Adrianople (1829), when the river started to have an economic value by the opening of the grain exports and the establishment of steam navigation. This interest led to granting a special status to the Danube by the treaty of Paris (1856), a treaty that settled the European Commission of the Danube. Although the Danube became a European river, its economic potential was insufficiently valorised as long as it was not linked to the fluvial network from Central Europe and further to the North Sea. This desideratum was only met in 1992, when the works of the Rhine – Maine – Danube canal were completed, by which the linkage between the North Sea and the Black Sea was fulfilled. Until the fall of communism in Europe, all initiatives concerning the linkage of the Danube to the European waterways were determined by certain situations and conflicts in the international system, generated, firstly, by the Nazi regime and, after WWII, by Stalin's blocking the Danube sector controlled by the Communist bloc.

**Keywords:** *the Danube, the Rhine, Fossa Carolina, the Ludwig Channel, the Rhine – Maine – Danube canal.*

## 1. INTRODUCTION

The Danube is the second longest river in Europe, after Volga. Nevertheless, as Grigore Antipa noticed in 1921, "its huge importance lays in its geographical position, in the direction of its course; crossing almost the entire Europe, from the West to the East, it represents the straightest natural highway connecting the industrialized countries from Central and Western Europe with the agrarian countries, abounding in raw materials, from the East and the South-West of Asia and even with the remote countries from the South and the East of Asia" [1]. The economical advantages and the geopolitical position of the Danube determined, along the history, the successive fall of this area under the control of the ancient Greeks, of the Romans, of the Italians, of the Turks, of the Russians. Along with the Russians, all the other great powers of modern Europe joined the competition for the mouths of the Danube. A historical analysis of the importance of the Danube clearly reveals that it was possible to avail fully of the commercial potential of the river only when both its ends were free and connected to the world trade. First of all, the trade on the Danube has tight connections with the free trade on the Mediterranean Sea and this fact could be clearly noticed after the Ottoman monopoly was imposed upon the Mediterranean Bay. Consequent to this monopoly, the Western World was forced to discover alternative commercial routes between Europe and Asia. The great geographical findings and the discovery of the direct route to India shifted the commercial centre towards the European ports on the coasts of the Atlantic Ocean or on the seas connected with the Atlantic (the North Sea and the Baltic Sea). For several centuries, the Mediterranean Sea became a commercially barren sea. The industrial revolution from the Western Europe, through its consequences – the development of the transports and of the trade and, especially, the opening of the Suez channel, led to the rediscovery of the ancient Mediterranean trade route. Once the Mediterranean Sea re-joined the world trade system, the great powers had to proceed to a re-evaluation of the statute of the Danube, since the river had become "the shortest route for supplying the great industrial powers from Central and Western Europe with food and raw materials from the Asian countries and also for exporting industrial goods towards Asia" [2]. Of course, connecting the Danube to the Mediterranean Sea highly depended on the statute of the Black Sea and of its gorges. The tight connection between the mouths of the Danube and the gorges of the Black Sea found an outstanding plastic depiction in the sayings, dating from the period between the two World Wars, of the great geographer Simion Mehedinți: "whoever says «Danube» must also say «Black Sea». But not only this much: he must also mention the Bosporus (which is nothing more but an extension of the Danube) and the Dardanelles – an extension of the Bosporus" [3].

As a consequence, after Adrianopol (1829), the interest of the modern European countries for the Danube gradually started to show up. The river was re-gaining its economical value, because of the steam navigation and of the exports of grains. The interest thereby stirred led to the conveyance of a special statute to the Danube, through the Treaty from Paris (1856), treaty which also laid the foundations of the European Commission of the Danube. Although the Danube re-gained its statute of a European river, its economical potential was still not fully availed, since the river hadn't been connected to the rivers from Central Europe and, through these, to the North Sea. The commercial value of the Danube could have been considerably enhanced by the connection, through channels, of the upper navigable part of the river with the other European rivers, either tributaries of the North Sea (Rhine, Elba, Weser) either tributaries of the Baltic Sea (Oder). When considering the system of canals that connect the Rhine and the Rhone and the possibility of connecting the

Danube with the Oder and the Elba River, it could be said that Europe has got a unique river system that will support economic relations within Europe and between Europe and Africa or the Middle East [4]. In 1938, Simion Mehedinți makes a remarkable depiction of the situation, saying that the importance of the Danube lays in its course and in its geographical position, the geo-economical and geo-political role of the Rhine-Danube diagonal being of an utmost importance. “Together, these two rivers represent the eighth part of Europe and a surpassingly short route for transporting goods between the German and the English markets, on one side, and the Indian and the far-eastern markets, on the other side” [5]. The statements of the great Romanian geographer were supported by the unique orohidrographical situation of Europe. Europe, unlike the other continents, which have a central area devoid of navigable rivers, has, in its middle, the sources of its main rivers, from where they flow towards the surrounding seas. Moreover, except for the peninsular rivers, the centre of Europe looks like the apex of a house roof. This apex, or the continental line which divides the waters, starts from the Northern side of the Ural Mountains and, from North-East, goes towards South-West, towards the Pyrenees, until Carcassonne. This line is not the same as the line of the maximum heights of the continent; rather it crosses mountains of an average height, hills, passes, depressions and bays. On one side of this continental line, in the North-West, there is a large area, with shorter rivers flowing towards the Atlantic Ocean, the North Sea and the Baltic Sea. On the other side, in the South-East, there are longer rivers flowing towards the Mediterranean Sea, the Black Sea and the Caspic Sea. The importance of the Danube is also given by the fact that the Northern limit of the river coincides with the continental line dividing the waters, along with its heights and depressions, these depressions allowing the connection, through channels, of the Danube to the other rivers flowing the Atlantic, the Baltic Sea and the North Sea.

Digging some channels to connect the Danube to the above mentioned European rivers didn’t seem to be a technically very difficult or a very costly task, since the landscape seemed to allow such works. Nevertheless, some technical difficulties were foreseen, since a channel connecting the valley of the Rhine with the valley of the Danube had to pass through the French Jura Mountains (Fränkishe Alb) and to overcome a level gap exceeding 300 metres [6].

## 2. THE FIRST BEGINNINGS – “FOSSA CAROLINA”

The first one to attempt a connection between the Danube and the Rhine was the emperor Charles the Great (742/748 – 814), the founder of the Carolingian Empire. Due to the deployable condition of the terrestrial routes of hid time, dating from the Roman age, Charles the Great deemed as necessary the digging of a channel to connect the two rivers. The channel was supposed to connect the two parts of the huge Carolingian Empire – the Franco-German side and the Austrian side or the towns from the Western part of Germany and, respectively, the towns from its Eastern part, along with the bay of Vienna. Charles’s project aimed at connecting the Altmühl River, a tributary of the Danube, to Schwabische Rezat, a tributary of the Main (this one being, on its turn, the most important tributary of the Rhine). Such a connection was possible, provided ships of an average size and weight had been used. The Rezat River was supposed to be connected, in the area near its sources, to Altmühl River through a channel having a length of 1,200 metres, a depth of 2.5 metres and a level gap of only 10 meters. This gap was to be overcome by building a small dam; the ships were supposed to pass above this dam being pulled by horses. The works started in 792 but they were shortly discarded due to the landslidings on the nearby slopes [7]. According to some other sources, the channel was supposed to have a length of 3,000 meters, its digging started in 793 and the project involved a shift in the bay of the Rezat River [8]. The archaeological researches and the researches within the archives revealed the location of this daring project; the channel was to be built near the contemporary settlement of Treuchtlingen and it is known in the local tradition by the name of “Fossa Carolina” or “Karlgraben” (Charles’s Pit) [9].

## 3. THE LUDWIG CHANNEL

The invention of the Locks (in the XV$^{th}$, in Italy) and the continuous increase of the trade between the Western Europe and the Levant (the Middle East) brought again to the fore the issue of connecting the Rhine to the Danube. Even Napoleon Bonaparte (1769-1821) showed a fervent interest in realizing this connection, hoping that hence he could terminate the English domination upon the trade with the Levant. Stirred by the influential personality of Napoleon and also by the German public opinion, in 1801, the German jurist Michael Georg Regnet suggested a new route for a connecting channel: Danube – the Altmühl Valley – the Regnitz Valley – the Main Valley [10]. Among the great German personalities that discussed and supported the connection between the Rhine and the Danube, we have to mention the philosopher Gottfried Wilhelm Leibnitz (sec. XVIII), the poet Johann Wolfgang von Goethe (sec. XVIII-XIX), and the writer Johann Peter Eckermann (sec. XVIII-XIX). Hence, the ussue was of an utmost actuality for the German public opinion. The theoretical suggestion made by Regnet was, shortly after, supported with technical and scientific arguments by a great German hydrologist engineer – Carl Friedrich von Wiebeking (1762-1842) [11].

The continuously increasing importance of these navigable rivers for the entire Europe and the fervent debates on this issue carried by the German public opinion determined the participants in the Congress from Vienna to raise, for the first time, the issue of the jurisdiction of the navigable rivers. Although the debates from 1815 referred only to the Rhine, the principles formulated by the Convention from Vienna (9$^{th}$ of June, 1895) represented, in the years to come, the basic regulations of the navigation on any European river passing or separating two countries [12].

Out of various motivations – the principles formulated at Vienna, the fervent debates from the German media, pertaining to the Regnet – Wiebeking project, the economical or commercial benefits incurred by a connection between the Danube and the Rhine or the will to improve his personal reputation and others – King Ludwig I of Bavaria took the initiative of digging such a channel. Therefore, he appointed Heinrich Freiherr von Pechmann (1774-1861), his personal counsellor in the field of constructions, to design a project for digging that channel, roughly following the route suggested by Regnet and Wiebeking. Disappointed that he hadn't been the one in charge with this project, Carl Friedrich von Wiebeking started a fervent polemic with Pechmann, which took such a magnitude that the public statements made by Wiebeking were interpreted as outrageous to the Bavarian king [13].

The project was published in 1832, as a booklet, and it was subjected to the public debate [14]. With the help of Rothschild Bank, a share company was formed, in 1836, it started digging the channel. There were some noticeable works to be done and also some consistent expenditures to be covered, since the length of the channel was of about 173 kms. The channel connected the Danube, near the town of Kelheim, in the valley of Altmühl, to the Main River, near the town of Bamberg.

The technical features of the channel were:

- ✓ The level gap between Kelheim and the watershed was of minus 80 meters and it was overcome with the help of 32 locks. On the other side, the level gap between the watershed and Bamberg was of minus 187 meters and it was overcome with the help of 68 locks. Overall, there were 100 locks.
- ✓ The width of the locks was of 4.76 meters, their length was of 34.55 meters and the level gap between the bieves of the locks varied between 2.3 and 3.2 meters.
- ✓ At its bottom, the width of the channel was of 9.9 meters; at the surface, the width was of 15.67 meters. The depth of the water was of 1.46 meters, except for the crest area, where it was necessary to amass a huge amount of water, needed for filling the locks; therefore, a tank of 22,000 m$^3$ and with a depth of 2.4 meters was built.
- ✓ 110 bridges across the channel were built and 10 more bridges across the valleys through which the channel was passing.

Basically, the channel was designed for ships having a maximum length of 24 meters and a maximum width of 4.3 meters; therefore, the maximum capacity of the ships allowed to sail on the channel was of 120 tones. This was much under the capacity of other channels; for example, the French channels allowed the transit of ships having a capacity of up to 200 tones [15].

In May 1843, King Ludwig of Bavaria inaugurated, with a lot of pomp, the completed part of the channel, stretching from Bamberg to Nurnberg. Nevertheless, only 3 years later, in 1846, this part of the channel was fully equipped and started to be exploited by the company.

The Ludwig channel, as it was known, has never been a profitable enterprise. Though it was designed to allow the transport of about 200,000 tonnes per year, this amount was never reached. Moreover, starting with 1850, the traffic through it continuously decreased until a third of its initial capacity (64,000 tonnes per year), in 1902. The maintenance costs of the locks were higher than the profit of the channel. Damaged during the WWII, the Ludwig Channel was completely closed in 1945. The decrease of its value was due to the continuous increase in size and capacity of the ships; the usage of the channel was also restrained by its limited width. There were some other causes which also led to the bankruptcy of the project: the bloom of rail transports during the second half of the XIX$^{th}$ century, the impossibility to get enough water to fill the tank on the crest and, from it, the locks, during the drought periods, the fact that Main River was not properly prepared for navigation between Mainz and Bamberg and so on [16].

## 4. THE STRATEGY OF INTERWAR GERMANY – "THE MINDORFER LINE"

The industrial bloom from the lower area of the valley of the Rhine, towards the end of the XIX$^{th}$ century, along with the above mentioned shortcomings of Ludwig Channel led the political and economical factors to search for another way to connect the two rivers, in order to make the transports on them more profitable. Germany's defeat in WWI didn't hamper this project but, on the contrary, it favoured it. All the big rivers crossing the German territory (Rhine, Elba, Oder, Niemen, and Danube) received an international statute, all these rivers, except for the Danube, having a unique statute, regulated by a unique international commission [17]. The only exception was the Danube, whose sector comprised between Ulm and Brăila was under the jurisdiction of the International Commission of the Danube, the one comprised between Brăila and Sulina being under the jurisdiction of the European Commission of the Danube. The formulation of a new judicial statute for these European rivers was one of the tasks undertaken by the Commission for the international regime of the ports, navigable rivers and rails, under the Peace Conference from Paris [18]. On 6$^{th}$ of April 1919, this Commission approved the stipulations regarding the transit, the ports, the rivers and the rails. All these stipulations represented clauses of the Peace Treaty concluded with Germany and most of them were also incorporated in the similar treaties concluded with Austria, Bulgaria and Hungary. Therefore, the judicial statute of these European rivers – Rhine, Elba, Oder, Niemen, and Danube – became a part of the system from Versailles.

The international statute ascribed to all the navigable European rivers after WWI meant, first of all, the freedom of navigation and the equal treatment of all ships, no matter what country they belonged to. All these measures led to the escalation of navigation and, consequently, the issue of finding a way to connect the Danube to the Rhine was re-opened. With this aim, in 1921, an accord stipulating the creation of the German Society for Channel and Navigation Rhine – Main – Danube (Rhein – Main – Donau A.G. Company), a share company which was supposed to dig the channel and, in reward, to receive the right to exploit it until 2050.

The route of the new channel, of a considerably bigger capacity, was different from the route followed by Fossa Carolina or by the Ludwig Channel, especially in the areas from the French Jura Mountains. In the bay of the Danube, the new channel generally followed the route of the Ludwig Channel up to Mülhausen, in Sulz valley (on the Danube, until Kelheim – Altmühl valley – Sulz valley); further, it crossed a plateau and passed the watershed through a different place, 10 meters lower than the crest crossed by the previous channel. From there, the route descended until a place situated at the South of Nürnberg; from that place, it followed Rednitz, a tributary of the Main, and the Main River (from the town of Bamberg) until this river meets the Rhine (near Mainz) [19]. The project was of an outstanding grandeur, since, overall, it involved the arrangement of 620 kms of navigable waters, between Aschaffenburg and the Austrian-German border.

The works started in 1923 and they firstly consisted in widening, deepening and correcting the very sharp curves at both the ends of the channel. Before the start of the WWII, in the area of the Rhine and Main, 21 dams, with locks, were built and hence the sector comprised between Mainz and Würtzburg was completed. At the same time, in the area of the Danube, works have been performed in the sector Geisling – the Austrian border, lower than Passau. Due to the financial difficulties faced by the Republic of Weimar (the payment of the war damages and, later on, the economical crisis from 1929-1933), most of the times works were not completed at their due term, but with delays.

The situation took a radical shift when Adolf Hitler took the power (January 1933). The external politics of Germany aggressively headed towards the East and whatever related to the interests of the Reich fell under the control of the political power. Therefore, the small countries from the bay of the Danube had to face many political and economical pressures, exercised by the Nazist Germany. Hitler openly stated that Germany has the right to modify the stipulations of the Peace from 1919-1920. Consequently, after the obligations regarding the payment of war damages had been cleared, the Reich successively denounced:

– on the 16$^{th}$ of March 1935, the disarmament stipulation, which had been imposed to Germany by the V$^{th}$ part of the Treaty from Versailles;

– on the 7$^{th}$ of March 1937, through the remilitarization of the Renan area, the stipulations of the articles 42 and 43 of the same treaty, confirmed by the German government through the Accord from Locarno;

– on the 14$^{th}$ of November 1936, all the dispositions regarding the regime of the international navigable waters crossing its own territory, hence cancelling the articles comprised in the XII$^{th}$ part, the second section, of the same treaty and any other subsequent international arrangements [20].

Regarding this last point, the German government sent a notification to 16 countries – Great Britain, Austria, Belgium, Bulgaria, Czechoslovakia, Denmark, Switzerland, France, Italy, Lithuania, Netherlands, Poland, Romania, Sweden, Hungary and Yugoslavia – represented in the international commissions of the rivers Rhine, Elba, Oder, Niemen and Danube. This notification stated that “the Treaty from Versailles, against the fundamental principle of the equality of rights, created, in this respect, unilaterally and against the interest of Germany, an artificial system, totally opposed to the practical needs of navigation. This system aimed at imposing a permanent international surveillance of the German rivers, more or less consigning Germany’s rights of sovereignty to some international commissions, freely consisting also of some non-riparian countries” [21].

The public attitude of Germany to symbolically and decisively break off with any past provisions regarding the regime of the navigable waterways roused a less intense reaction than the Berlin government itself had expected. The French government tried to initiate a collective protest of all interested states, but its action failed. Thus, the only official protests were represented by several isolated diplomatic notes sent to the German cabinet by France, Great Britain, Czechoslovakia, Yugoslavia, Romania and Poland [22].

The strategy of the Nazi authorities to establish its own hegemony in the East was complex and Germany used, beyond political-diplomatic actions or economic and commercial interests, a propagandistic dimension. Regarding the navigable waterways, the propaganda aimed to present to the international public the great advantages which could result from replacing the Versailles system with that initiated unilaterally on November 14, 1936, called “of the riparian states”. Thus, especially after the annexation of Austria (Anschluss, March 1938), Hitler revived the project of the Rhine – Main – Danube canal, allotting 11 billion German marks for the designing the transit port of Würzberg, officially inaugurated on May 1, 1938, a port through which there were to navigate large ships (up to a capacity of 1,500 tons). Moreover, according to the Nazi plans, the Bodensee Lake was meant to become the centre of European navigation, by connecting the rivers Elbe and Oder to the Rhine, the Elbe to the Wesser and the Rhine to the Danube [23]. The idea of a pan-European waterway, which was not a new one, aroused, as expected, the sensibility of the Romanian public opinion, but also of other Danubian peoples. That Germany’s propagandistic purpose was fulfilled is easily seen when analyzing the echoes of this action in the Romanian media. The central or local, independent or party newspapers – *Ordinea* (February 25, 1938); *Excelsior* (February 26, 1938); *Prezentul* (February 26, and July 8, 1938); *Ştirea* (March 3, 1938); *Timpul* (March 14, 1938); *Universul* (March 25 and 27, 1938); *Cuvântul* (March 27, 1938); *Argus* (June 5, 1938, and January 29, 1939); *Lumea Românească* (June 8, 1938); *Curentul* (July 10, 1938); *România de la Mare* (July 11, 1938); *Viitorul* (August 4, 1938); *România* (October 5, 1938); *Sfarmă Piatră* (November 6, 1938); *Dreptatea* (November 10, 1938); *Dobrogea Nouă. Bazargic* (December 6, 1938); *Neamul Românesc* (December 18, 1938); *Semnalul* (November 30, 1938); and *Evenimentul Zilei* (May 3, 1939) – fully covered the German projects.

Regarding the Danube – Rhine canal, it was to allow the passage, by means of locks, of vessels with a capacity of 1,200 tons. The debates were heated, especially when they discussed the course of the new in the section where it crossed the height of land. Finally, the so called “Mindorfer line” was adopted. The first measurements were done in 1939 and, shortly afterwards, the construction of the canal began. The turning odds of the war and the continuously more difficult situation of Germany after the defeat of Stalingrad determined the authorities to completely stop the works in 1942.

## 5. THE SOVIET POLITICS TOWARDS THE DANUBE AFTER WWII AND “THE BEILNGRIES LINE”

After the war, the Mindorfer line was abandoned, and a new course was adopted (“Beilngries line”), due to the fact that crossing the height of land was no longer conditioned by the annual rainfall and the capacity of the height reservoir, as the modern technology allowed pumping water from the lower to the higher levels [24].

Unfortunately, during the Stalinist period (1948-1953), the linkages between the Danube and other commercial routes were completely blocked. There were no contacts, not even of an informal type, with the West or at least with Austria and Federal Germany, the states which controlled the upper part of the river. The Danube Commission, the new body created by the communist states by the Belgrade Convention (August 18, 1948), with the purpose of supervising the navigation, refused to accept the demands of the United Nations and its specialized agencies. In the same time, until 1953, during the time when the Soviet control over the middle and lower Danube was maximal, the technical activities of improving the river were minimal. Moscow turned its attention towards the political side of its domination, encouraging its satellite states to unify the navigation, police, custom or sanitary regulations, so as to fulfil its own commercial and economic interests. Moreover, besides obstructing the development of the Danube navigation, the Soviet Union blocked the connection between the Danube River and its outer world by the lack of interest in clearing the Sulina canal. This branch, put under the control of a special Romanian-Soviet administration, considered as a segment of the international Danube, was not appropriately dredged and maintained. On the contrary, the Soviet authorities paid a special importance to the establishment of its own navigable channel, by the Chilia branch, so that more and more ships used this route [25].

The Soviet attitude towards the Danube changed radically after Stalin’s death. At the ninth plenary session of the Danube Commission, in December 1953, the model imposed by the former Soviet leader was completely repudiated [26]. From that moment, the Danube Commission was used, due to the innovations imposed by the new leadership in Kremlin, as a laboratory of the Soviet foreign policy, especially regarding the relations with the Western states and the specialized agencies of the United Nations. The political role of the Danube Commission increased when its headquarters moved, in 1954, to Budapest. The delegates of the riparian states are also the ambassadors of their countries in Hungary [27].

Opening the Danube for the commercial relations with the West was another major change which the Soviet authorities assumed after Stalin’s death. To gain credibility, so as to secure the technical cooperation of the democratic states and to reintegrate the Danube into the great routes of the international trade, the communist states had, first of all, to really unify the navigation on the whole course of the river. Thus, it was necessary at least to mutually exchange information between the riparian communist states and the two democratic riparian states: Austria and Federal Germany. Consequently, the two states, following a formal invitation, sent their representatives, starting with June 1957, to take part, as experts, at the plenary sessions of the Danube Commission and at the activities of the diverse permanent sub-commissions. The “debacle” of the Danube Commission was manifested through the participation of its members to international conferences regarding the development of water transport and trade; by the transparency of its activity – in June 1956, at the plenary session, an observatory of the European economic institutions took part; by launching projects aiming to secure a better navigation on the Danube etc [28].

After a first tentative – on May 23, 1955, the Soviet Union invited Austria to join the Danube Commission, but the invitation was rejected – the adhesion of Austria to the Danube Commission became effective in January 1960 [29]. Federal Germany had a different situation. On the contrary, the Soviet plans when organizing the Belgrade Conference (July 30 – August 18, 1948), by non-inviting a representative of this country, proved to be wrong. Being blocked downstream, the German authorities made substantial efforts to complete the interwar and Nazi projects of unifying the Danube with the Rhine, so as to direct the German commercial traffic from the area of the Upper Danube towards the North Sea. Up to 1962, they built the Würtzburg – Bamberg sector and up to the fall of communism other sectors were also completed.

| Main river | Period | Sector | Length (km) |
|---|---|---|---|
| Main | 1926-39 | Aschaff – Wurzburg | 165 |
| | 1938-62 | Wurzburg – Bamberg | 132 |
| The canal | 1960-72 | Bamberg – Nurnberg | 72 |
| | 1971-85 | Nurnberg – Roth | 22 |
| | 1975-89 | Kelheim – Riedenburg | 18 |
| Danube | 1972-78 | Kelheim – Regensburg | 33 |
| | 1976-85 | Regensburg – Geisling | 25 |
| | 1930-69 | Geisling – Vilsfofen | 103 |
| | 1922-28 | Vilsfofen – frontieră | 48 |
| | 1952-56 | Jochenstein | - |

Source: Rhein – Main – Donau A.G. Company (RMD), 1992

The works for the entire Rhine – Maine – Danube canal were completed in 1992, when it was officially inaugurated. The time for transiting its course, between Mainz on the Rhine and Kelheim on the Danube, is 9-10 days. The time of transiting the two rivers depends on the direction of circulation, downstream or upstream. Thus, the distance Regensburg – Sulina takes 13 days, whereas the way back takes 20 days. Similarly, the

Rhine is navigated downstream in 2 days and upstream in 3 days.

The technical characteristics of the canal are as follows:

- ✓ The sector Mainz – Bamberg (384 km) follows the course of the Main and has a level difference of 149.3 m. To make it navigable, the stream being relatively rapid, there were built 34 dams with locks.
- ✓ The sector Bamberg – height (107 km) has a level difference of 176 m and needed 11 locks. The height level is 406 m.
- ✓ The sector height – Kelheim (64 km), where the canal is linked to the Danube, it has a level difference of 67.8 m and 5 locks.
- ✓ The Danube from Kelheim up to the border with Austria (209 km) had a very rapid stream, which was slowed down by means of nine locks.
- ✓ On the territory of Austria, the Danube is slowed down by other seven locks, to which we should add the two energetic dams, Iron Gates I and II. Altogether, there are 68 locks.
- ✓ The artificial canal between Kelheim and Bamberg had a width at the water table of 55 and a depth of 4 meters.

The canal corresponds to the needs of modern navigation, having a transport capacity of 15 million tons/year [30].

## 6. CONCLUSIONS

As a conclusion, the importance of connecting the Rhine with the Danube was anticipated as early as the 8$^{th}$ century, thought back then this had a more strategic then economic relevance. The modern interest dates from the 19$^{th}$ century, when he juridical basis of the navigation regime on these waterways were also established. The opening of the Suez Canal, inaugurated in 1869, reactivated the Mediterranean Sea in the world trade and, consequently, the importance of the Black Sea and the Danube also increased. The idea of uniting the Danube and he Rhine naturally followed, this first step being the construction, by the Bavarian king, of the Ludwig canal. As Grigore Antipa stated, referring to the Danube question [31], to finally secure a better navigability, there were two types of obstacles to be defeated: natural and political hindrances. If the first ones were overcome by means of technical improvements (see the causes of the failure of the Ludwig canal), the political obstacles acted less linearly. Most often, the works of the present canal Rhine – Main – Danube were revived by the conflicting political situation at a European and international level, generated, firstly, by the Nazi regime and, after WWII, by Stalin's blocking the Danube sector controlled by the Communist bloc.

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# SECTION II
## MECHANICAL ENGINEERING AND ENVIRONMENT

# THE GENESIS OF THE HYDROGRAPHIC NETWORK IN THE BAZIN CALMATUI FROM TELEORMAN

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**ABSTRACT**

The river Călmățui in Teleorman is a typical plain river which originates fro Câmpia Iminogului Plain at the height of 160 m and it flows into the lake Suhaia at the altitude of 20 m. This river developped on its own during the Quaternary, by regressive erosion, independent from the river Olt or from the former flowing directions of the river Arges, but it was closely connected to the emergence of Boianului plane and with the establishment of the present course of the Danube river. The hydrographic network of this basin developped gradually and is still evolving because fo the present geomorphological process of compaction and suffusion associated with the pluviofluvial processes.

**Key words:** *hydrographic network genesis, evolution*.

## 1. INTRODUCTION

The morpho-hydrographic basin of Călmățui in Teleorman is a local basin th the Romanian Plain, and it is one of the small hydrographic basins of the country, with a surface of 1375 $km^2$ ; it is situated between two big alochtone hydrographic basins: Oltul basin in the West and Vedei basin in the east.

## 2. GENERAL CARACTERISTICS OF THE BASIN

The Călmățui river flows from Iminogului Plain from the altitude of 160 m and after it crosses Boianului Plain on the NV – SE direction, it flows into Suhaia lake, stationed in one of the old abandoned arms of the Danube river connected through a channel with this one.

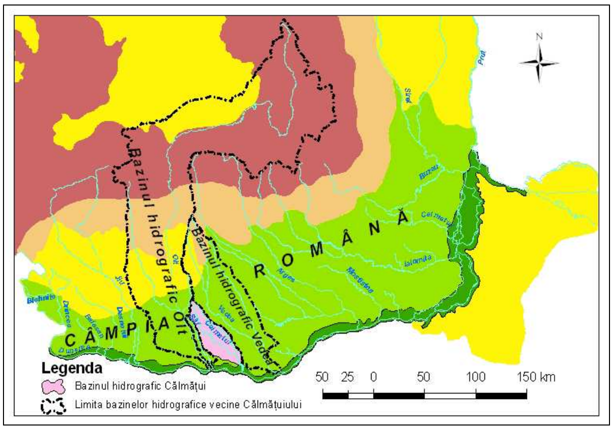


Figure 1 Placement of the morpho-hydrographic basin of Călmățui in Teleorman in the Romanian Plain

Concerning the surface geology the basin of Călmățui in Teleorman is caracterized by an important lithologic homogeneity the parent materials being completely made of very friable fine sediments (loess and loess deposits) of Quaternary age, with a quasi-horizontal structure. The compactiong property of the loess led to the aparition of curves, some of these contributing to the development of the hydrographic network through evolution and draining by the aparition or lenghtening of of first-order segments.

## 3. GENESIS AND EVOLUTION OF THE HYDROGRAPHIC NETWORK

The evolution of the pleistocene lake which used to cover the central and eastern part of the Romanian Plain followed a single direction, of narrowing through clogging and drying, paralleled the tendency of continouos sweetening of the water, moving from the sea stage (arm , then dead-end), to that of a lake, swamp, until total draining during the Quaternary.

Unlike the Pliocene transgression which took place from the North to the South because of the establishment of the carpathian folds, the regression during the Quaternary takes place in the opposed direction from the south to the north, because of the immersion agains the Carpathians'rising. Due to this fact, the quaternary dry land of the Romanian Plain took shape progressively on the SW – *NE* direction *(fig. 2),* therefore the continental period was longer in the South of the Romanian Plain, than anywhere else towards its central part (N. Popp, 1947). C. Brătescu (1944-1945) and N. Popp (1947) show the progressive shaping of the Romanian Plain, starting from the river Olt to the Siret valley, that is starting with the Günz stage until the Würm II stage, specific to the divagation plain.

The shaping of the Romanian Plain was closely connected to the withdrawal of the Pleistocene Lake and to the establishment of the hydrographic network (Gr.Psea,1984). The main hydrographic network was represented by the Danube and its Carpathian affluents whose contribution was dominant compared to that of the Balkan rivers. This is due to the stronger positive tectonic action in the Carpathians and Sub-Carpathians compared to that in the Pre-Balkan Plateau.

During its long evolution, the s edimentary basin in the plain went through numerous marine transgressions and regressions. The lake waters were slowly withdrawing towards the E and NE Romanian Plain as a result of the gradual clogging processes. Thus the clogging of the Romanian Plain, took place in three main directions: from the west through the contribution of the Danube, from the North due to the Carpathian rivers, as well as fdrom the South due to the Pre-Balkan rivers, (P.Coteţ, 1976).

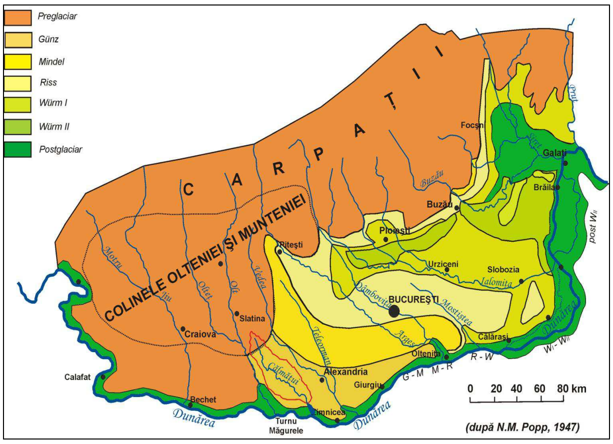


Figure 2 The stages in the shaping of the Romanian Plain

The shaping of the hydrographic network in the basin started after the emergence of the Boianului Plain cosidered to be of Günz age. At the end of the Early Pleistocene and the beginning of the Middle Pleistocene, when the Danube was flowing following the direction Craiova-Toceni- Alexandria-Frăteşti-Radovanu (fig.3), the river Călmăţui was just a creek, and after the Danube settled its present course, the river Călmăţui may have lenghtened its course by taking over a former drainage of a river which used to from the Pre-Balkan Plateau, which was shortened and disjointed by the Danube throughthe cutting off the end branch (Romanian Geography vol.V).

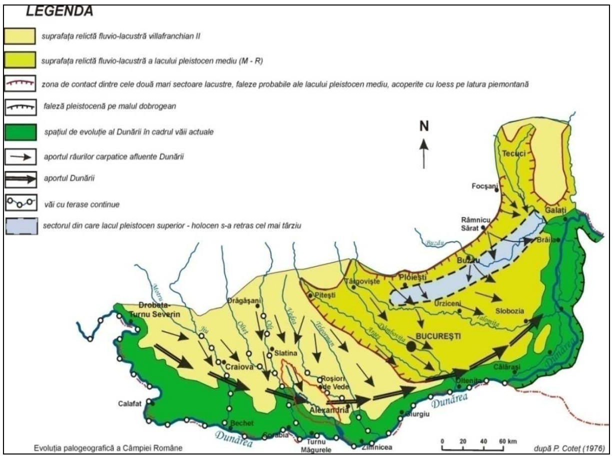


Figure 3 The palaeographic evolution of the Romanian Plain

As the Danube waters deepened, thesources of the creek advanced through regressive errosion inside the Boianului Plain, the river deepened epigenetically and settled its present course. Towards the end of the Middle Pleistocene the Urluiului valley is formed, which is the main affluent of the Călmăţuiului river on the left side, also through regressive errosion. The fact Urluiului valley started its evolution later than the Călmăţui river is proved by the exisence of a single terrace level allong its course and by the reduced complexity of its meadow.

During the Late Pleistocene, due to the positive epirogenetic movements and to the continuous lowering of the basic Danube level, the main rivers (Călmăţui and Urlui) kept their previous valleys becoming antecedent; this fact is proved by the existence of the chain meanders and by the presence of the terrace levels with slightly higher altitudes downstream and quite oblique surfaces of the terrace bridges.

The hydrographic network is still evolving due to the processes of rain-wash, compaction, suffusion and regressive errosion which lead to the extention of the torrential valleys having as a basic level the the bottom of the big valleys, thus moving to the stage of successive draining of the curves. (N.Florea, 1970).

## 4. CONCLUSIONS

The formation of the hydrographic network in the basin of Călmăţui river took place gradually and it was closely connected with the emergence of the Boianului Plain and with the establishment of the present course of the Danube river. During the Middle Pleistocene Călmăţui river had an epigenetic development, through regressive errosion a process favoured by the sharp lowering of the basic level of the Danube and by the high friability of the deposits in which it took shape which allowed for its continuous deepening.

During the Late Pleistocene due to the positive epirogenetic movements and to the continuous lowering of the basic level the river kept its former valley becoming antecedent devenind antecedent, fact proved by the presence of the chain meanders and of the terrace levels.

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# DYNAMICAL OPERATION REGIMES OF TURBOCHARGED DIESEL ENGINE

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**ABSTRACT**

The paper presents the mathematical model which simulates the dynamical behavior of turbocharged engines with free rotation supercharged units. Mathematical model is based on knowledge of the characteristics of subsystems, such as engine itself, turbocharger with free rotation, exhaust and intake manifold and the injection system. Transfer functions are established. These functions are used for achieving and adjusting automatic regulators which controls the operations of the turbocharged engine subsystems and full turbocharged engine.

**Keywords:** *dynamical behavior, turbocharged engine, transfer function, unsteady working condition*

## 1. INTRODUCTION

The paper presents the mathematical model which simulates the dynamical behavior of turbocharged engines with free rotation supercharged units. Mathematical model is based on differential equations and the transfer functions established, [8], [3], [4], [5], [6], [7], [2] for dynamic behavior of subsystems, as they are exhaust and intake manifold, injection system, engine itself, turbocharger [1], as part of internal combustion engines, as shown in Fig. 1. On the basis of these equations results the dynamical behavior ofturbocharged engines. Using transfer unctions are made automatic control system (controller) which controls the operations of the turbocharged engine subsystems and full turbocharged engine.

## 2. TRANSFER FUNCTIONS AND DYNAMICAL BEHAVIOR OF SUPERCHARGED ENGINE

Consider the diagram (Fig. 1) with the subsystems [8], [1], parts of the turbocharged diesel engine, with free rotation turbocharger.

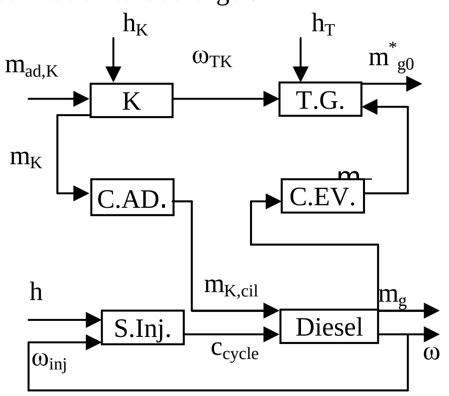


Figure 1 Diagram for supercharged diesel engine subsystems

In these diagram, the subsystems are:

K - turbocompressor;S. Inj. - Fuel injection system; TG - gas turbine; Diesel - diesel engine itself; C.AD - intake pipe; C.EV - exhaust pipe;

$\omega$ - angular speed of engine; $\omega_{TK}$ - angular speed of turbocharger; $\omega_{inj}$ - angular speed of fuel injection pump; $c_{cycle}$ fuel consumption for a cycle; $h_{K,\ T}$ - the position of adjustment actuator of turbocompressor respectively turbine;

$m_{ad,K}$ - mass flow of air admitted into the compressor; $m_K$ - mass flow of air entering the intake manifold; $m_{K,cil}$ - mass flow of air entering the engine cylinders; h - actuator position of the injection pump for diesel engine; $m_g$ – exhaust gas mass flow entering the exhaust manifold; $m_T$ - exhaust gas mass flow entering the turbine; $m^*_{g0}$ - exhaust gas mass flow coming out in the environment.

Using the differential equations established in [3], [4], [5], [6], [8], [2] which simulates the dynamical operation regimes of the constitutive subsystems, it's possible to achieve the differential equation for full turbocharged diesel engine, therefore the dynamical behavior. According with [8], [3], [4], [5], [6], [7] can write:

-- for Diesel engine itself:

$$T_{eng}\frac{d\left(\Delta\omega^*\right)}{d\tau}+K_{eng}\left(\Delta\omega^*\right)=\Delta c^*_{cycle}+\theta_{eng\,\Delta p_k}\Delta p^*_K-\theta_{eng\,\Delta hs}\Delta h^*_s \tag{1}$$

after use Laplace transformation:

$$\left(T_{eng}\,s+K_{eng}\right)\Delta\Omega^*(s)=\Delta C^*_{cycle}(s)+\theta_{eng\,\Delta p_k}\Delta P^*_K(s)-\theta_{eng\,\Delta hs}\Delta H^*_s(s) \tag{1'}$$

-- for injection system:

$$K_{ap\ .inj}\,\Delta c^*_{cycle}=\Delta h^*+\theta_{ap\ .inj\ \Delta\omega}\Delta\omega^* \tag{2}$$

after use Laplace transformation:

$$K_{ap.inj}\Delta C^*_{cycle}(s) = \\ = \Delta H^*(s) + \theta_{ap.inj\,\Delta\omega}\Delta\Omega^*(s) \qquad (2')$$

-- for turbocharger:

$$T_{TK}\frac{d\left(\Delta\omega_{TK}^*\right)}{d\tau} + K_{TK}\left(\Delta\omega^*_{TK}\right) = \\ = \Delta p_T^* + \theta_{TK\Delta c_{cycle}}\Delta c^*_{cycle} - \theta_{TK\Delta p_k}\Delta p_K^* \\ + \theta_{TK\Delta h_T}\Delta h_T^* - \theta_{TK\Delta h_K}\Delta h_K^* \qquad (3)$$

after use Laplace transformation:

$$\left(T_{TK}s + K_{TK}\right)\Delta\Omega^*_{TK}(s) = \Delta P_T^* + \\ + \theta_{TK\Delta C_{cycle}}\Delta C^*_{cycle}(s) - \theta_{TK\Delta p_k}\Delta P_K^*(s) + \\ + \theta_{TK\Delta h_T}\Delta H_T^*(s) - \theta_{TK\Delta h_K}\Delta H_K^*(s) \qquad (3')$$

-- for intake manifold:

$$T_{c.ad}\frac{d\left(\Delta p_K^*\right)}{d\tau} + K_{c.ad}\left(\Delta p^*_k\right) = \\ \Delta\omega^*_{TK} - \theta_{c.ad\Delta\omega}\Delta\omega^* - \theta_{c.ad\Delta T_K}\Delta T_K^* + \\ + \theta_{c.ad\Delta h_K}\Delta h_K^* \qquad (4)$$

after use Laplace transformation:

$$\left(T_{c.ad}\,s + K_{c.ad}\right)\Delta P^*_K(s) = \\ \Delta\Omega^*_{TK} - \theta_{c.ad\Delta\omega}\Delta\Omega^*(s) - \\ - \theta_{c.ad\Delta T_K}\Delta T_K^*(s) + \\ + \theta_{c.ad\Delta h_K}\Delta H_K^*(s) \qquad (4')$$

-- for exhaust manifold:

$$T_{c.ev}\frac{d\left(\Delta p_T^*\right)}{d\tau} + K_{c.ev}\left(\Delta p^*_T\right) = \\ = \Delta\omega^* + \theta_{c.ev\Delta p_k}\Delta p_k^* + \theta_{c.ev\Delta c_{cycle}}\Delta c^*_{cycle} \\ - \theta_{c.ev\Delta h_T}\Delta h_T^* \qquad (5)$$

after use Laplace transformation :

$$\left(T_{c.ev}s + K_{c.ev}\right)\left(\Delta P^*_T(s)\right) = \\ = \Delta\Omega^*(s) + \theta_{c.ev\Delta p_k}\Delta P_k^*(s) + \\ \theta_{c.ev\Delta c_{cycle}}\Delta C^*_{cycle}(s) - \\ - \theta_{c.ev\Delta h_T}\Delta H_T^*(s) \qquad (5')$$

Where:

$$\omega = \omega_0 + \Delta\omega; \Delta\omega^* = \frac{\Delta\omega}{\omega_0} \qquad (6)$$

$$\Delta c^*_{cycle} = \frac{\Delta c_{cycle}}{c_{cycle0}}; \Delta p^*_K = \frac{\Delta p_K}{p_{K0}} \qquad (7)$$

$$\Delta h^*_S = \frac{\Delta h_S}{h_{S0}} = \Delta h^*_R \qquad (8)$$

$p_{K0}$ = the pressure furnished by compressor for steady working conditions; $p_{T0}$ = gas pressure at the entrance of gas turbine for steady working conditions; $\omega_0$=angular speed for steady working conditions; $c_{cycle0}$= fuel consumption for stedy working conditions;
$h_{s0}$=adjustment devices at consumer for steady working conditions;

Where:

$$T_{eng} = \frac{J_{eng}\cdot\omega_0}{\left(\frac{\partial M_{te}}{\partial c_{cycle}}\right)_{\omega_0, p_{k0}}\cdot c_{cycle0}} \qquad (9)$$

$$\theta_{eng_{\Delta p_k}} = \frac{\left(\frac{\partial M_{te}}{\partial p_k}\right)\cdot p_{k0}}{\left(\frac{\partial M_{te}}{\partial c_{cycle}}\right)_{\omega_0, p_{k0}}\cdot c_{cycle0}} \qquad (10)$$

$$K_{eng} = \frac{F_{st\_eng}\cdot\omega_0}{\left(\frac{\partial M_{te}}{\partial c_{cycle}}\right)_{\omega_0, p_{k0}}\cdot c_{cycle0}} \qquad (11)$$

$$\theta_{eng_{\Delta h_s}} = \frac{\left(\frac{\partial M_{teR}}{\partial h_S}\right)_{\omega_0}\cdot h_{s0}}{\left(\frac{\partial M_{te}}{\partial c_{cycle}}\right)_{\omega_0, p_{k0}}\cdot c_{cycle0}} \qquad (12)$$

$$T_{TK} = \frac{J_{TK}\cdot\omega_{TK0}}{\left(\frac{\partial M_{tTG}}{\partial p_T}\right)\cdot p_{T0}} \qquad (13)$$

$$K_{TK} = \frac{F_{st\,TK}\,\omega_{TK\,0}}{\left(\frac{\partial M_{tTG}}{\partial p_T}\right)p_{T0}} \qquad (14)$$

$$\theta_{TK_{\Delta p_k}} = \frac{\left(\frac{\partial M_{tK}}{\partial p_k}\right)\cdot p_{k0}}{\left(\frac{\partial M_{tTG}}{\partial p_T}\right)\cdot p_{T0}} \qquad (15)$$

$$\theta_{TK_{\Delta h_T}} = \frac{\left(\frac{\partial M_{tTG}}{\partial h_T}\right)\cdot h_{T0}}{\left(\frac{\partial M_{tTG}}{\partial p_T}\right)\cdot p_{T0}} \qquad (16)$$

$$\theta_{TK_{\Delta h_K}} = \frac{\left(\frac{\partial M_{tK}}{\partial h_K}\right) h_{K0}}{\left(\frac{\partial M_{tTG}}{\partial p_T}\right) p_{T0}} \quad (17)$$

$$F_{st\_eng} = \left(\frac{\partial M_{teR}}{\partial \omega}\right)_{h_{s0}} - \left(\frac{\partial M_{te}}{\partial \omega}\right)_{p_{k0,c_{ciclu0}}} \quad (18)$$

$$F_{stTK} = \left(\frac{\partial M_{tK}}{\partial \omega}\right) - \left(\frac{\partial M_{tTG}}{\partial \omega}\right) \quad (19)$$

$$K_{ap.inj} = \frac{c_{cycle0}}{\left(\frac{\partial c_{cycle}}{\partial h}\right) \cdot h_0} \quad (20)$$

$$\theta_{ap\_inj\,\Delta\omega} = \frac{\left(\frac{c_{cycle}}{\partial \omega}\right) \omega_0}{\left(\frac{\partial c_{cycle}}{\partial h}\right) h_0} \quad (21)$$

$$\theta_{TK_{\Delta C_{cycle}}} = \frac{\left(\frac{\partial M_{tTG}}{\partial c_{cycle}}\right) c_{cycle\,0}}{\left(\frac{\partial M_{tTG}}{\partial p_T}\right) p_{T0}} \quad (22)$$

$$K_{c.ad} = \frac{F_{st\,c.ad}\, p_{k0}}{\left(\frac{\partial \dot{m}_k}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (23)$$

$$\theta_{c.ad_{\Delta\omega}} = \frac{\left(\frac{\partial \dot{m}_{k,cil}}{\partial \omega}\right) \omega_0}{\left(\frac{\partial \dot{m}_k}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (24)$$

$$\theta_{c.ad_{\Delta h_k}} = \frac{\left(\frac{\partial \dot{m}_{k,cil}}{\partial h_k}\right) h_{k0}}{\left(\frac{\partial \dot{m}_k}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (25)$$

$$\theta_{c.ad_{\Delta T_k}} = \frac{\left(\frac{\partial \dot{m}_{k,cil}}{\partial T_k}\right) T_{k0}}{\left(\frac{\partial \dot{m}_k}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (26)$$

$$T_{c.ad} = \frac{V_{c.ad} \cdot p_{k0}}{n_{TK} \cdot p_k \left(\frac{\partial \dot{m}_k}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (27)$$

$$F_{st\_c.ad} = \left(\frac{\partial \dot{m}_{K,cil}}{\partial p_k}\right) - \left(\frac{\partial \dot{m}_K}{\partial p_k}\right) \quad (28)$$

$$K_{c.ev} = \frac{F_{st\,c.ev}\, p_{T0}}{\left(\frac{\partial \dot{m}_g}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (29)$$

$$\theta_{c.ev_{\Delta Ccycle}} = \frac{\left(\frac{\partial \dot{m}_T}{\partial c_{cycle}}\right) c_{cycle\,0}}{\left(\frac{\partial \dot{m}_g}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (30)$$

$$\theta_{c.ev_{\Delta h_T}} = \frac{\left(\frac{\partial \dot{m}_T}{\partial h_T}\right) h_{T0}}{\left(\frac{\partial \dot{m}_g}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (31)$$

$$\theta_{c.ev_{\Delta p_k}} = \frac{\left(\frac{\partial \dot{m}_T}{\partial p_k}\right) p_{k0}}{\left(\frac{\partial \dot{m}_g}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (32)$$

$$T_{c.ev} = \frac{V_{c.ev} \cdot p_{T0}}{n_{TK} \cdot p_T \left(\frac{\partial \dot{m}_g}{\partial \omega_{TK}}\right) \omega_{TK0}} \quad (33)$$

$$F_{st\_c.ev} = \left(\frac{\partial \dot{m}_T}{\partial p_T}\right) - \left(\frac{\partial \dot{m}_g}{\partial p_T}\right) \quad (34)$$

$M_{teTG0}$ (Nm) - turbine shaft torque at stationary running;
$M_{teK0}$ (Nm) - compressor shaft torque at stationary running;
$p_{T0}$($N/m^2$) - gas pressure in the turbine entry at stationary running;
$p_{K0}$($N/m^2$) - fluid pressure at the compressor exit at stationary running;
$J_{TK}$ ($kgm^2$) - mechanical moment of inertia of the rotating mechanical turbocharger components, reduced to its revolution axis:
$\omega_{TK}$ ($s^{-1}$) - common angular speed of the compressor and turbine;

$\omega$ ($s^{-1}$) - angular engine speed;
$J_{eng}$ ($kgm^2$) = mechanical momentuum inertia of the mobile mechanical engine, reduced to it's revolution axis;
$p_T$($N/m^2$) - gas pressure in the turbine entry;
$p_K$($N/m^2$) - fluid pressure at the compressor exit;
$T_k$(K) - fluid temperature at the exit of the compressor;
$T_T$(K) - gas temperature at the entrance of gas turbine;
$c_{cycle}$(kg fuel/cycle) – fuel consumption on cycle;
'0' index indicates stationary operating regimes;
$M_{te}$ (Nm) = torque of engine;
$M_{te\ R}$(Nm) – torque to drive, the couple must overcome the brake resistance brake;
$M_{tK}$ (Nm)-- brake torque of compressor ; $M_{tTG}$ (Nm)-- torque of gas turbine;
$\dot{m}_k$ (kg/s) - compressor mass flow rate;
$\dot{m}_T$ (kg/s) - gas turbine mass flow rate;
h = the position of adjustment devices for injection pump;
$h_T$ – actuator turbine control position;
$h_K$ – actuator compressor control position;
$c_{cycle,0}$(kg fuel/cycle) – fuel consumption on cycle at stationary running;
$h_{K0}$ = actuator compressor control position at steady working conditions;
$h_{T0}$ = actuator turbine control position at steady working conditions;
$\omega_{TK0}$ ($s^{-1}$) - common speed of the compressor and turbine at stationary running;

If the turbocharger hasn't adequate adjustable devices (actuators), in the equations (1,2,3,4,5) particular condition is $\Delta h_T^* = 0, \Delta h_K^* = 0$ respectively (1',2',3',4',5') $\Delta H_T^* = 0, \Delta H_K^* = 0$ and result equations:

$$\left(T_{eng}\cdot s + K_{eng}\right)\cdot \Delta\Omega^*(s) - \Delta C^*_{cycle}(s) - \theta_{eng\Delta p_k}\cdot \Delta P_K^*(s) = -\theta_{eng\Delta hs}\cdot \Delta H_s^*(s) \quad (35)$$

$$-\theta_{ap.inj\,\Delta\omega}\cdot \Delta\Omega^*(s) + K_{ap.inj}\cdot \Delta C^*_{cycle}(s) = \Delta H^*(s) \quad (36)$$

$$-\theta_{TK\Delta C_{cycle}}\cdot \Delta C^*_{cycle}(s) + \theta_{TK\Delta p_k}\cdot \Delta P_K^*(s) - \Delta P_T^*(s) + \left(T_{TK}\cdot s + K_{TK}\right)\cdot \Delta\Omega^*_{TK}(s) = 0 \quad (37)$$

$$\theta_{c.ad\Delta\omega}\cdot \Delta\Omega^*(s) + \left(T_{c.ad}\cdot s + K_{c.ad}\right)\cdot \Delta P^*_K(s) - \Delta\Omega^*_{TK}(s) = 0 \quad (38)$$

$$-\Delta\Omega^*(s) - \theta_{c.ev\Delta c_{cycle}}\cdot \Delta C^*_{cycle}(s) - \theta_{c.ev\Delta p_k}\cdot \Delta P_k^*(s) + \left(T_{c.ev}\cdot s + K_{c.ev}\right)\cdot \left(\Delta P^*_T(s)\right) = 0 \quad (39)$$

Solve the equations 35, 36, 37, 38, 39 we obtain the differential equation of the turbocharged diesel engine without the adjustment devices for turbine and compressor.
Figures 2, 3, 4, 5, 6 show the structural diagrams for the turbocharger engine itself, the fuel injection system, the intake manifold, the exhaust manifold and the turbocharger. In these diagrams the transfer functions are set out in rectangles, the input signals on the left and the output signals on the right. The index number added to some input signals represents the number of the structural diagram where that signal comes out.
We consider the independent parameters $\Delta h_s^*$ and $\Delta h^*$ [8], and the unknown quantities $\Delta\omega^*, \Delta c^*_{cycle}, \Delta p_K^*, \Delta p_T^*, \Delta\omega^*_{TK}$ .

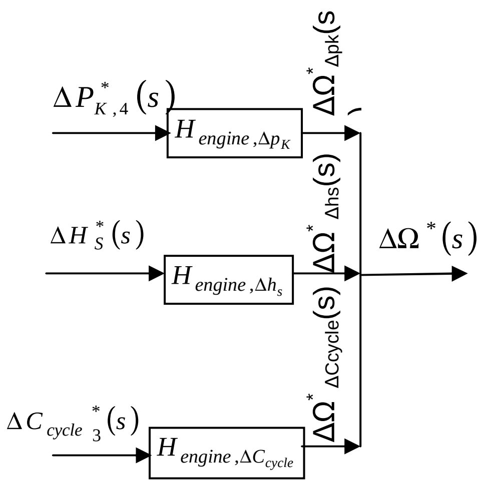

Figure 2 Structural diagram for the turbocharger engine itself

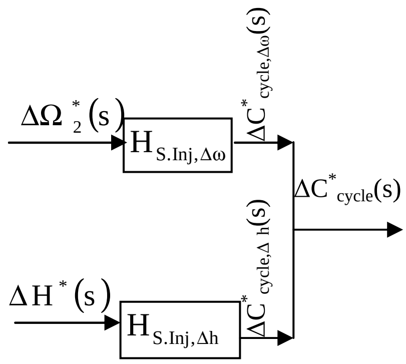

Figure 3 Structural diagram for the fuel injection system

For the internal combustion engine as the subject of automatic adjustment, the revolution $\Delta\omega^*$ is considered to be the parameter which must be pursued in time:

$$\Delta\Omega^*(s)=\frac{\Delta_{\Delta\Omega^*}}{\Delta};\Delta C^*_{cycle}(s)=\frac{\Delta_{\Delta C^*_{cycle}}}{\Delta}$$

$$\Delta P^*_K(s)=\frac{\Delta_{\Delta P^*_K}}{\Delta};\Delta P^*_T(s)=\frac{\Delta_{\Delta P^*_{TK}}}{\Delta} \quad (40)$$

$$\Delta\Omega^*_{TK}(s)=\frac{\Delta_{\Delta\Omega^*_{TK}}}{\Delta}$$

Where:

$$\Delta=T^2_{eng\_s_2}\cdot s^2+T_{eng\_s_1}\cdot s+K_{eng\_s}$$

$$\Delta_{\Delta\Omega^*}=\left(T_{act\_inj\_pump}\cdot s+\theta_{act\_inj\_pump}\right)\cdot \quad (41)$$

$$\cdot\Delta H^*(s)-\left(T_s\cdot s+\theta_s\right)\cdot\Delta H^*_s(s)$$

$$T_{eng\_s_2}=T_{eng}T_{TK}K_{ap.inj}K_{cad}K_{cev} \quad (42)$$

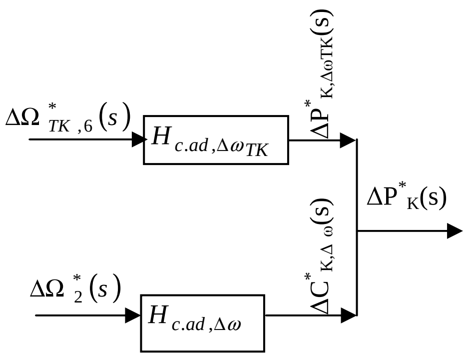


Figure 4 Structural diagram for the intake manifold

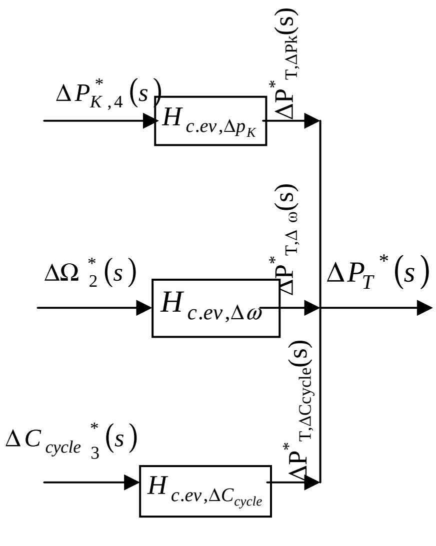


Figure 5 Structural diagram for the exhaust manifold

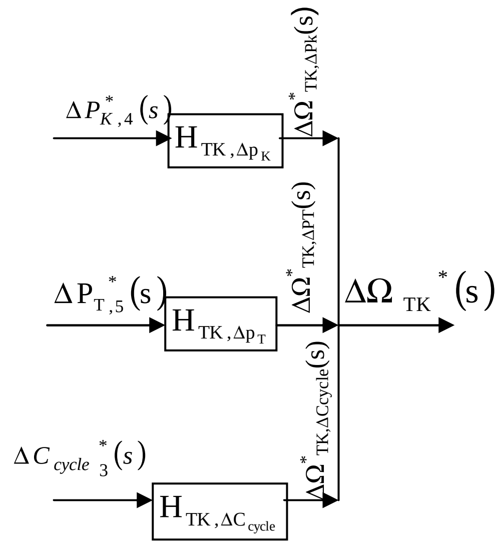


Figure 6 Structural diagram for the turbocharger

The differential equation written in the operational form, where the rotation is considered as the object of automatic adjustment, is as follows:

$$\Delta\cdot\Delta\Omega^*(s)=\Delta_{\Delta\Omega^*} \quad (43)$$

Or:

$$\left(T^2_{eng\_s_2}\cdot s^2+T_{eng\_s_1}\cdot s+K_{eng\_s}\right)\cdot\Delta\Omega^*=$$

$$=\left(T_{act\_inj\_pump}\cdot s+\theta_{act\_inj\_pump}\right)\cdot\Delta H^*(s)- \quad (44)$$

$$-\left(T_s\cdot s+\theta_s\right)\cdot\Delta H^*_s(s)$$

It therefore leads to:

$$\Delta\Omega^*(s)=\frac{\left(T_{act\_inj\_pump}\cdot s+\theta_{act\_inj\_pump}\right)\cdot\Delta H^*(s)}{\left(T^2_{eng\_s_2}\cdot s^2+T_{eng\_s_1}\cdot s+K_{eng\_s}\right)}-$$

$$-\frac{\left(T_s\cdot s+\theta_s\right)}{\left(T^2_{eng\_s_2}\cdot s^2+T_{eng\_s_1}\cdot s+K_{eng\_s}\right)}\cdot\Delta H^*_s(s)= \quad (45)$$

$$=H_{engine\Delta h}(s)\cdot\Delta H^*(s)-H_{engine\Delta h_S}(s)\cdot\Delta H^*_s(s);$$

where:

$H_{engine\ \Delta h}$ (s) = the transfer function determined by the actuator of the injection pump;

$H_{engine\ \Delta hs}$(s ) = the transfer function determined by the load engine;

If Laplace$^{-1}$ is applied to the differential equation (44) written above, the result is the differential equation expressing the dynamic behaviour in relation to time, for the supercharged internal combustion engine without adjustment actuators for the turbine and compressor.

$$T_{eng\_s_2}\frac{d^2(\Delta\omega^*)}{d\tau^2}+T_{eng\_s_1}\frac{d(\Delta\omega^*)}{d\tau}+ +K_{eng\_s}\Delta\omega^*=T_{act\_inj\_pump}\frac{d(\Delta h^*)}{d\tau}+ +\theta_{act\_inj\_pump}\Delta h^*-T_s\frac{d(\Delta h^*_s)}{d\tau}-\theta_s\Delta h_s^* \quad (46)$$

$$T_{eng\_s_2}=T_{eng}T_{TK}K_{ap.inj}K_{cad}K_{cev} \quad (47)$$

$$T_{act\_inj\_pump}=T_{TK}K_{c.ad}K_{c.ev} \quad (48)$$

$$T_s=T_{TK}K_{ap.inj}K_{c.ad}K_{c.ev}\theta_{eng\Delta h_s} \quad (49)$$

$$\theta_s=K_{ap.inj}\theta_{eng\Delta h_s}\cdot \left(K_{TK}K_{c.ad}K_{c.ev}+K_{c.ev}\theta_{TK\Delta p_K}-\theta_{c.ev\Delta p_K}\right) \quad (50)$$

$$\theta_{act\_inj\_pump}=\left(K_{TK}K_{c.ad}+\theta_{TK\Delta p_K}\right)K_{c.ev}+ +\left(K_{c.ev}\theta_{TK\Delta C_{cycle}}-\theta_{c.ev\Delta c_{cycle}}\right)\theta_{eng\Delta p_K}-\theta_{c.ev\Delta p_K} \quad (51)$$

Figure 7 shows the structural diagram of the diesel supercharged engine [8], considered as the rotation of the automatic adjustment object.

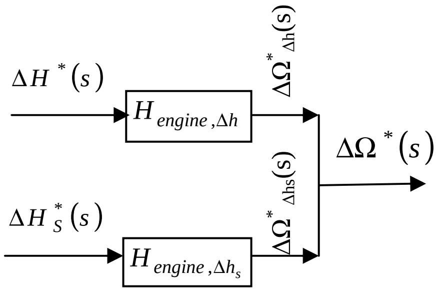


Figure 7 Structural diagram for the supercharged internal combustion engine

## 3. CONCLUSIONS

On the basis of the mathematical model of the dynamical behaviour of the supercharged engine and the transfer functions established, the following results can be obtained:

-- performance of the whole system and subsystems, during transitory regimes of operation.
-- system performance in stationary regimes of operation, speed and acceleration errors.
--possibilities for tuning the automatic speed regulator located on the engine.
--quality indices for the dynamic behaviour of the whole system.

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# COMPUTER SIMULATION FOR THE FLOW IN A TURBOCOMPRESSOR OF SUPERCHARGED DIESEL ENGINES

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**ABSTRACT**

The paper presents the mathematical model and numerical example to simulate flow through the turbocharger of supercharged Diesel engine MB 836Db. The computer programe which use the Phoenics software procedures, personal subroutines and functions, permits to simulate the unsteady flow in case of the geometry considered. The paper presents some numerical results, as in 3D graphics.

**Keywords:** *supercharged Diesel engine, unsteady flow in turbocompressor, Phoenics and Photon software*

## 1. INTRODUCTION

Paper presents the mathematical model which permits studies and simulation of the unsteady flow of compressible fluids through the turbocharger of supercharged Diesel engine MB 836Db, and the numerical calculation based on the volume elements method. Computer programme use the Phoenics software and personal subroutines, permits to simulate the unsteady flow in case of 3D geometry. The paper contains some numerical results, as in 3D graphic, obtained with the Photon software.

## 2. MATHEMATICAL MODEL

Mathematical model comprises the following equations of conservation: energy, mass, momentum; also the equation for the turbulent flow, total acceleration of the fluid and equation of state. It is possible to write these equations on the basis of generic transport equation for the conserved scalare variable Φ, [1] , in case of single continuous phase fluid:

$$\frac{\partial}{\partial t}(\rho\Phi)+\nabla\cdot\left(\rho\vec{V}\Phi\right)-\nabla\cdot(\Gamma\nabla\Phi)=S\Rightarrow$$
$$\Rightarrow\frac{\partial}{\partial t}(\rho\Phi)+\frac{\partial}{\partial x_i}(\rho u_i\Phi)=\frac{\partial}{\partial x_i}\left(\Gamma\cdot\frac{\partial\Phi}{\partial x_i}\right)+S \qquad (1)$$

where: S - source; $\Gamma$ - 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), [1]:

$$\frac{\partial\rho}{\partial t}+\nabla\cdot\left(\rho\vec{V}\right)=0\Rightarrow$$
$$\Rightarrow\frac{\partial\rho}{\partial t}+\frac{\partial}{\partial x_i}(\rho u_i)=0; \qquad (2)$$

-- momentum equation ( $\Phi=\vec{V};\Gamma=\mu$ ) , [1],[2]:

$$\frac{\partial}{\partial t}\left(\rho\vec{V}\right)+\nabla\cdot\left(\rho\vec{V}\vec{V}\right)=\nabla\cdot\left(\mu\nabla\vec{V}\right)-\nabla p+\vec{B}+\vec{F}+\vec{V}_f\Rightarrow$$
$$\Rightarrow\frac{\partial}{\partial t}(\rho u_i)+\frac{\partial}{\partial x_j}(\rho u_i u_j)=-\frac{\partial p}{\partial x_i}+B_i+F_i+V_i+\frac{\partial\tau_{ij}}{\partial x_j} \qquad (3)$$

where: μ - viscosity; $B_i$ - gravitational forces; $F_i$ - external body forces; $V_i$ - viscous forces not accounted for by $\nabla\left(\mu\nabla\vec{V}\right)$; $\tau_{ij}$ viscous stress tensor given by:

$$\tau_{ij}=\left[\mu\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)\right]-\frac{2}{3}\mu\frac{\partial u_l}{\partial x_l};l=i,j,k$$

-- energy equation ( $\Phi=q;\Gamma=k_c$ ) , [1],[3] :

$$\frac{\partial}{\partial t}(\rho q)+\nabla\cdot\left(\rho\vec{V}q\right)=\nabla\cdot(k_c\nabla q)+S_h\Rightarrow$$
$$\frac{\partial}{\partial t}(\rho h)+\nabla\cdot\left(\rho\vec{V}h\right)=\frac{\partial}{\partial t}(p)+\nabla\cdot\left(\vec{V}p\right)+\nabla\cdot(k_c\nabla T)+\tau\nabla\left(\vec{V}\right)S_h\Rightarrow$$
$$\Rightarrow\frac{\partial}{\partial t}(\rho h)+\frac{\partial}{\partial x_i}(\rho u_i h)=\frac{\partial}{\partial x_i}\left(k_c\frac{\partial T}{\partial x_i}\right)+u_i\frac{\partial p}{\partial x_i}+\frac{\partial p}{\partial t}+\tau_{ij}\frac{\partial u_i}{\partial x_j}+S_h \qquad (4)$$

where: $k_c$ - thermal conductivity; $\tau_{ij}$ 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 , [2]:

$$a=\frac{d\vec{V}}{dt}=\frac{\partial\vec{W}}{\partial t}+\vec{W}\cdot\nabla\vec{W}+2\vec{\omega}\times\vec{W}+\vec{\omega}\times(\vec{\omega}\times\vec{r})+\frac{\partial}{\partial t}(\vec{\omega}\times\vec{r}) \qquad (5)$$

$\vec{\omega}$ - angular speed; $\vec{W}$ - the velocity in the relative system; $\vec{r}$ -the position vector in the absolute system ;
-- the thermal conductivity $k_c$ :

$$k_c=k_c(T) \qquad (6)$$

-- viscosity of fluid: $\mu=\mu(T)$, or

$$\mu=\alpha\dot{S}^{n-1};\dot{S}=\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i} \qquad (7)$$

where 'n' and α are empirically values [6] .
-- density may be computed via the ideal gas law as :

$$\rho=\frac{p_{ref}+p'}{RT} \qquad (8)$$

p' - local static pressure defined relative to ' $p_{ref}$ ' .

Accordig to the generic transport equation for a conserved scalar quantity $\Phi$ , [1] , [5] , and consider that the value $\Phi$ in turbulent flows is comprised of a mean value and a fluctuating part:

$\Phi = \bar{\Phi} + \Phi'$ , where $\bar{\Phi}$ - is the time averaged value of $\Phi$ definided as:

$$\bar{\Phi} = \frac{1}{\Delta t}\int_0^{\Delta t} \Phi \, dt \tag{9}$$

Equation (1) results in following form :

$$\begin{aligned} &\frac{\partial}{\partial t}(\rho\Phi) + \nabla\cdot\left(\rho\vec{V}\Phi\right) - \nabla\cdot(\Gamma\nabla\Phi) = S_\Phi \Rightarrow \\ &\Rightarrow \frac{\partial}{\partial t}(\rho\Phi) + \frac{\partial}{\partial x_i}(\rho u_i\Phi) = D_\Phi + S_\Phi \end{aligned} \tag{10}$$

If consider that density fluctuations are negligible results:

$$\frac{\partial}{\partial t}\left(\bar{\rho}\bar{\Phi}\right) + \frac{\partial}{\partial x_i}\left(\bar{\rho}\bar{u}_i\bar{\Phi}\right) = -\frac{\partial}{\partial x_i}\left(\bar{\rho}\overline{u_i'\Phi'}\right) + \bar{D}_\Phi + \bar{S}_\Phi \tag{11}$$

The equation (10) is similar with (9) , except that each quantity is represented by its time averaged value ; the new term $\bar{\rho}\bar{u}_i\bar{\Phi}$ represents the diffusion of variable $\Phi$ due to the turbulent fluctutions .

The Reynolds stresses are asumed to be proportional to the mean velocity gradients , with the constant of proportionality being the turbulent viscosity $\mu_t$ ,[5] :

$$\mu_{ef} = \mu + \mu_t \, ; \, \mu_t = \rho \cdot C_\mu \cdot \frac{k^2}{\varepsilon} \tag{12}$$

$$\rho\overline{u_i'u_j'} = \rho\frac{2}{3}k\delta_{ij} + \mu_t\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right) - \frac{2}{3}\mu_t\frac{\partial u_l}{\partial x_l} \tag{13}$$

where: k - turbulent kinetic energy ; $\varepsilon$ - dissipation rate of k ; $C_\mu$ =0.085 , empirically constants [6] .

The value of k , $\varepsilon$ are obtained by conservation equations similar to general transport equation (1) ,[6]:

$$\begin{aligned} &\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_i}(\rho u_i k) = \frac{\partial}{\partial x_i}\left(\frac{\mu}{\sigma_k}\cdot\frac{\partial k}{\partial x_i}\right) + G_k - \rho\varepsilon \\ &\frac{\partial}{\partial t}(\rho\varepsilon) + \frac{\partial}{\partial x_i}(\rho u_i\varepsilon) = \frac{\partial}{\partial x_i}\left(\frac{\mu}{\sigma_\varepsilon}\cdot\frac{\partial \varepsilon}{\partial x_i}\right) + G_{1\varepsilon}\frac{\varepsilon}{k}\cdot G_k - C_{2\varepsilon}\rho\frac{\varepsilon^2}{k} \end{aligned} \tag{14}$$

where : $C_{1\varepsilon}, C_{2\varepsilon}$ -- empirical constants ; $\sigma_k, \sigma_\varepsilon$ -- numbers governing the turbulent diffusion of k and $\varepsilon$ ; $G_k$ -- rate of production of turbulent kinetic energy , according [8]:

$$G_k = \mu_t\left(\frac{\partial u_j}{\partial x_i} + \frac{\partial u_i}{\partial x_j}\right)\frac{\partial u_i}{\partial x_i} \tag{15}$$

## 3. NUMERICAL CALCULATION

The numerical solution for the system presented (eq. 1-5 , 14 ) forward is obtained using the volume elements method, [1],[4],[7],[8], method which includes the following stages:

-- division of the flow domain into discrete control volumes , using a general curvilinear grid ; thr grid obtained is such as figure 1a , or 1b as flow in 2D or 3D ; the domain of turbocompressor of supercharger units with free rotation , in which is localized flow is presented in figure 2.

--integration of the equations on the individual control volumes to construct the algebraic equations for unknows ( velocities , pressure , density , turbulent kinetic energy , the dissipation rate ) and the solution for the discretized equations . The integration of differential equations is illustrated using the divergence theorem $\int_{volume,V} \frac{\partial}{\partial x}(\rho u) dV = \int_{Area,A} \rho u \cdot dA$ for one domensional equation set , which includes the differential equations for continuity , momentum and a generic transport equation for the conserved scalare variable $\Phi$ ,in non steady form :

$$\frac{\partial\rho}{\partial t} + \frac{\partial}{\partial x}(\rho u) = 0 \tag{16}$$

$$\frac{\partial(\rho u)}{\partial t} + \frac{\partial}{\partial x}(\rho uu) = -\frac{\partial p}{\partial x} + \frac{\partial}{\partial x}\left[\mu\left(\frac{\partial u}{\partial x}\right)\right] + F \tag{17}$$

$$\frac{\partial}{\partial t}(\rho\Phi) + \frac{\partial}{\partial x}(\rho u\Phi) = \frac{\partial}{\partial x}\left(\Gamma\frac{\partial\Phi}{\partial x}\right) + S_\Phi \tag{18}$$

Using the divergence theorem equations (16) , (17) and (18) becomes :

$$\frac{\rho_n - \rho_{n-1}}{t_n - t_{n-1}} + (\rho uA)_e - (\rho uA)_w = 0 \Leftrightarrow \frac{\rho_n - \rho_{n-1}}{t_n - t_{n-1}} + J_e - J_w = 0 \tag{19}$$

$$\begin{aligned} &\frac{(\rho u)_n - (\rho u)_{n-1}}{(t_n - t_{n-1})} + J_e u_e - J_w u_w = -(p_e - p_w)A + \\ &+\left[\frac{\mu_e}{\Delta x_e}(u_E - u_P) - \frac{\mu_w}{\Delta x_w}(u_P - u_W)\right]A + F \end{aligned} \tag{20}$$

$$\begin{aligned} &\frac{(\rho\Phi)_n - (\rho\Phi)_{n-1}}{(t_n - t_{n-1})} + J_e\Phi_e - J_w\Phi_w = \\ &= \left(\Gamma_e\frac{\Phi_E - \Phi_P}{\Delta x_e} - \Gamma_w\frac{\Phi_P - \Phi_W}{\Delta x_w}\right)A + S_\Phi \end{aligned} \tag{21}$$

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 .

The numerical solution of the entire equations system for the non-steady flow (eq. 1-5 , 15 ) is obtained if applied , the method presented above , on each plane of constant I,J,K for the 3D geometry case . On the basis of equation (21) , the algebraic equation which must be solved for any variable $\Phi$ , at time ' n ' , at point P , on each surrounding point P may be written on the form :

$$A_P\Phi_P = \sum_{NB} A_{NB}\Phi_{NB} + S_\Phi \tag{22}$$

## 4. COMPUTER PROGRAM FOR SIMULATION THE UNSTEADY FLOW IN TURBOCOMPRESSOR

The computer program [11] solves the mathematical model and calculates the values of variables which are caracteristics of flow such as, pressure, components of velocity, kinetic turbulent energy, density, dissipation rate of turbulent energy, temperature, using the Phoenics procedures with personal completations and changes. The paper presents some results [11], for unsteady working conditions of turbocompressor of supercharger units with free rotation, VTR 200R, of supercharged Diesel engines MB836 Db, at 10000 rpm , for the second period of time: vectors of velocity and components (U , V , W on x , y , z direction) on the border and on the middle in [m/s] , density in [kg/m$^3$] , superpressure in [N/m$^2$] , in the impeller (fig. 3 -7) ; Z direction is the rotation axis .

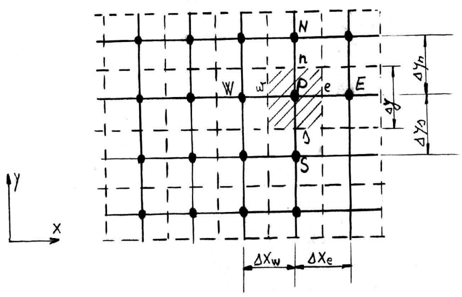


Figure 1a - 2D

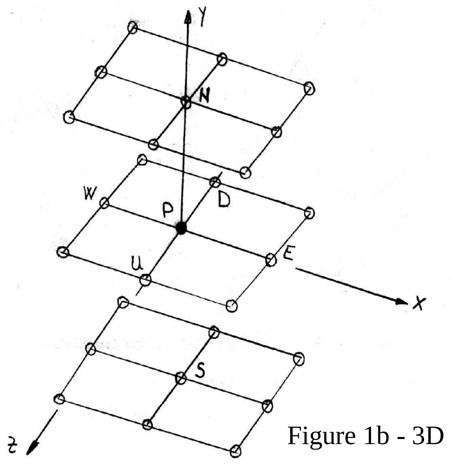


Figure 1b - 3D

Grid of 3D flow geometry

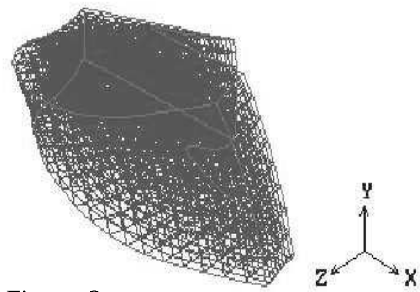


Figure 2

Values of 'U' component of velocity on the border

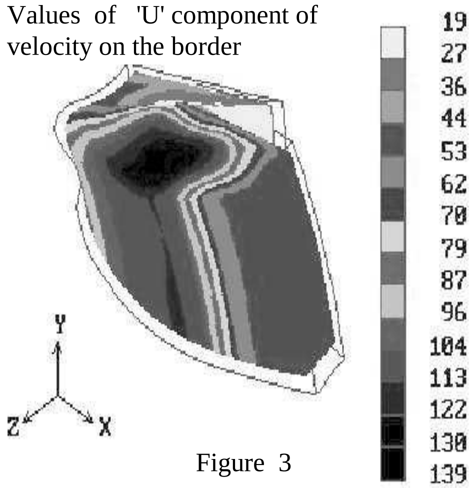


Figure 3

Values of 'W' component of velocity on the border

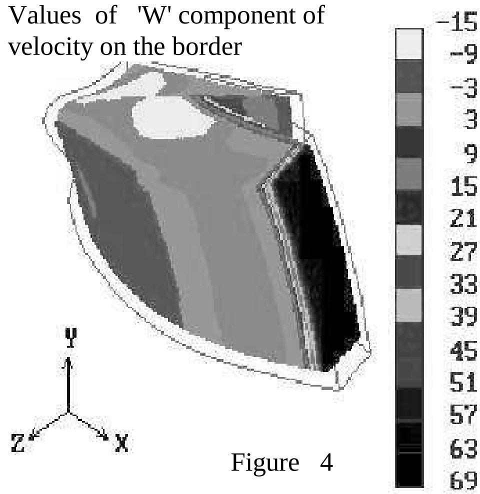


Figure 4

Superpressure on border

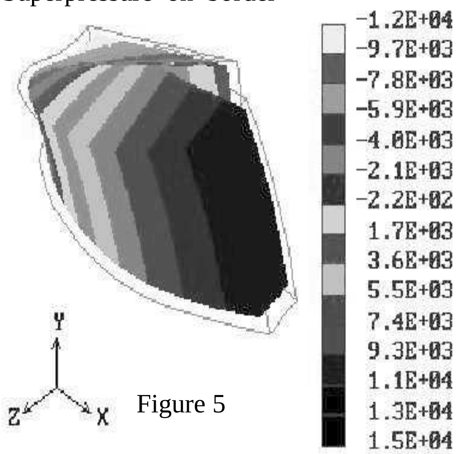


Figure 5

Density on the border

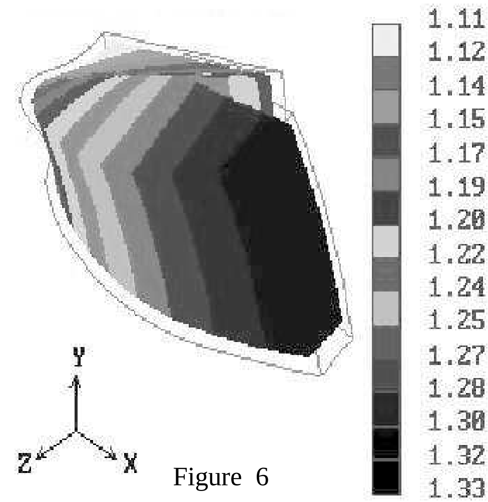


Figure 6

Values of 'U' component of velocity on the middle

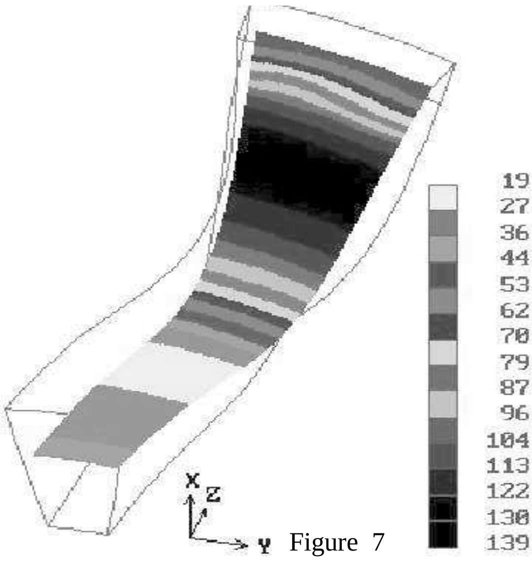


Figure 7

## 5. CONCLUSIONS

Using the computer programme presented is possible to represent 3D complicated flow zones , calculate and present on different graphs the values for the unsteady flow on these geometries .This theoretic investigation may be completed with experimental results ; in this way is possible to ascertain with exactness the performances of supercharged Diesel engines and the influence of different conditions on these performances.

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# APPLICATION OF THE J INTEGRAL IN THE STUDY OF THE CRACK LENGTH AND TEMPERATURE OF A CANNON BARREL

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**ABSTRACT**

Perhaps the most accurate and elegant method for computing the energy release rate is to calculated the J integral by converting the line integral into a domain integral which can easily be calculated using the known finite element shape functions. The problem illustrates the case of a crack in a cannon barrel, together with the relevant geometry against crack length defined from the bore of the cannon. This crack geometry is the most dangerous integrity case for the cannon barrel. In this research, 155 mm cannon barrel with one crack with lengths of 4 mm, 8 mm and 12 mm on inner surface is firstly structurally analyzed at room temperature, and subsequently coupled thermo-structurally analyzed considering 4 scenarios, where the crack length was deemed to be 4 mm, the temperature of the inner surface was $100^0$C, $125^0$C, $150^0$C, $200^0$C. The numeric model presented in this paper, provides consistent and reasonable results for the dependency of stress intensity factor to the crack length and temperature of a cannon barrel using the J integral. The temperature fields inside the cannon barrel (and, generalizing, inside any circular structure with thick walls) tends to ameliorate the stress fields existing on the crack tip and pushing the calculated KI downward and thus improving the crack behavior.

**Keywords:** *Cannon barrel, Stress Intensity Factor, Crack, J Integral, Coupled Thermal-Structural FEA*

## 1. INTRODUCTION

For centuries [6], cannon barrel designers have focused their efforts on the development and use of steels that possess higher strength and toughness. Good mechanical properties are required to withstand the high interior ballistic (explosive) loads to which these pressure ‘vessels’ are subjected. In addition to high internal pressure, the cannon bore (internal surface of the cannon cylinder) is exposed to very high temperatures, as the propellant ignites and begins the evolution of hot gases to provide the propulsive force for the projectile. With the advent of ever more robust propellants, bore surface erosion has become increasingly problematic. This has forced barrel designers to implement various means that include coatings and alternate material liners to combat the phenomena. The desire for longer lasting tubes has been a major motivator for research of new and more robust materials for cannon design. Likewise, cannon barrel manufacturers have committed significant effort to developing processes that result in high quality cannons capable of withstanding these erosive environments.

In the 20th century, variations in the chemistries of Chromium-Molybdenum-Vanadium (Cr-Mo-V) steels have been introduced that allowed for moderate increases in strength, toughness and fatigue properties. Most of these improvements come from superior processing and techniques that produce higher-quality steels (less contaminants and defects). The last major advancement in armament steels occurred in the 1970’s with the introduction of ASTM A723 steel, which has yield strength more than five times that of the steel produced by Rodman more than a century earlier. It replaced the 4335-V modified steel that had been in use since before World War II.

The A723 steel is processed through either vacuum arc re-melt (VAR) or electro-slag re-melts (ESR). Both processes significantly reduce the amount of sulphur and phosphorus and, combined with an increase in the nickel content, make A723 steel an excellent candidate for “modern” armament applications. More recently, the armament community has pushed for materials with even higher strength and toughness due to more aggressive environments and higher cannon firing pressures.

Cannon-wear [18] remains, to this day, one of the main factors limiting cannon’s muzzle velocity and range. It normally occurs as an increase in bore diameter at the commencement of rifling and from here it spreads down the barrel towards the muzzle. As a measure of wear it is conventional to quote the increase in bore diameter measured at 25 mm from the commencement of rifling. The increase in diameter that can be tolerated before a barrel is condemned depends on the accuracy that is required. For tank cannons, which need to be very accurate in order to hit a target at the first attempt, the permissible wear is about 0.5–1% of the bore diameter. As a rule the cannon designer arranges for the fatigue life of a barrel to exceed its wear life because fatigue failure is usually catastrophic and endangers the cannon crew, whereas barrel wear simply reduces the accuracy of the projectile without putting the crew in danger.

Typically, the bore temperature reaches 600–$1200^0$C at this place within a few milliseconds of exposure to the hot propellant gases. Heat transfer may be 500MW/m2, and the propellant gas pressure may reach 600MPa. Wear has always been related to the intense thermal conditions experienced at this point and as early as 1911, Jones [8] derived an empirical equation based on this assumption. Other early work of note includes Shulyer [21] and Kent [9]. Thornhill’s work [22] is particularly interesting in that he looked for a linear correlation between wear per round and the maximum temperature at the bore, and many of the ideas he originated have found application here.

Fig. 1 (top) shows the unworn section of rifled cannon that may be compared to the eroded section at the commencement of rifling of the same cannon (middle). This is normal wear.

The bore diameter increases uniformly around the barrel at the commencement of rifling and spreads along the barrel towards the muzzle. Occasionally, oval wear occurs, that is, wear is perhaps 20% greater in the vertical plane than in the horizontal plane. This type of wear occurs at temperatures between 900 and 1400 K, which is well below the melting point of cannon steel. Gas wash past a faulty driving band can cause local melt erosion (Fig. 1 (bottom)), and such erosion is many times faster than normal erosion.

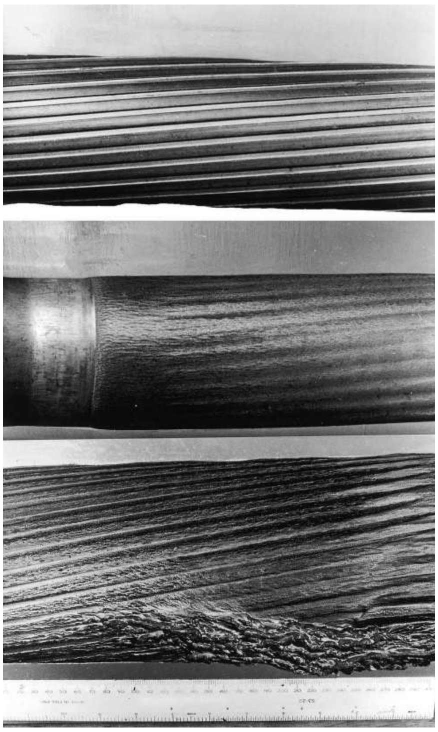

Figure 1 Cannon barrel erosion

A photomicrograph showing the sub-surface of cannon steel, after firing 10 rounds, is shown in Fig. 2. Three layers are apparent, marked A, B and C. The layer marked A is the original structure. The layer marked B extends perhaps 200 μm from the surface and is called the heat-affected zone. In this region, the cannon steel had been subjected to a large temperature fluctuation each time the cannon was fired. The temperature fluctuation may be $1000^0$C at the surface but 1mm from the surface it is only about $100^0$C, and the period of the fluctuation may be 5–50 ms. The microstructure of the heat-affected zone changes towards the surface and the steel becomes harder and more brittle. The layer marked C is called the chemically-affected zone. At high temperatures, chemical species from the propellant gas diffuse into the crystal lattice altering its chemical composition. These species include the main products of propellant combustion (CO, $CO_2$, $H_2$, $H_2O$ and $N_2$) and a small quantity of dissociated atomic species. This further reduces the strength and increases the brittleness of the surface layers. Hardness increases from about 250 HV in region A, to 500 HV in region B, and 1000 HV in region C. Micro-cracks form in region C, some normal to the surface and some parallel with the surface. The shear stress caused by high velocity gas flow, and the contact stress generated by the driving band, are sufficient to remove a portion of the cracked and brittle layer. The amount of wear depends on the depth to which the chemically-affected zone has penetrated which, in turn, depends on the chemical composition of the propellant and on the bore surface temperature.

A single crack [24] 30 mm or deeper which is 75 mm long is sufficient to fracture a typical 155 mm cannon barrel with a pressure at or above two-thirds (206 MPa) of the maximum operating pressure (310 MPa). Longer and deeper flaws reduce the critical pressure required to initiate fracture. For the monolithic barrel design the postulated 30 mm deep by 75 mm long crack should propagate through the entire wall and, depending upon the new “fractured” geometry, may propagate axially down the cannon barrel.

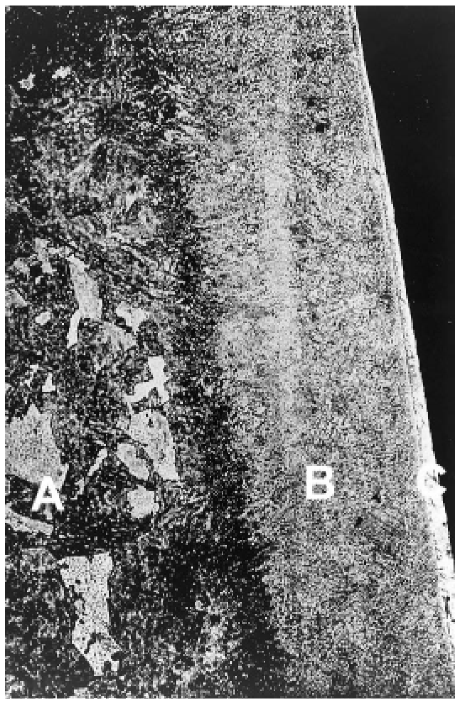


Figure 2 Photomicrograph showing the sub-surface of cannon steel

Numerical analyses conducted [24] with straight through-thickness crack fronts propagated axially at pressures below the maximum operating pressure while those with curved crack fronts required pressures in excess of the working pressures to extend axially. In either case, a through-thickness “hole” will be formed in the barrel’s side and a reduction in firing pressure should result. Finally, debris deposited within the barrel can greatly assist the fracture process, especially at lower operating pressures.

## 2. SOME THEORETICAL CONSIDERATIONS

For a crack under tensile, or Mode-I loading for linear-elastic materials:

$$G = J = \frac{K_I^2}{E'} \Rightarrow K_I = \sqrt{\frac{JE}{1-\nu^2}}$$
$$E' = \frac{E}{1-\nu^2} \_ Plain - Strain \tag{1}$$

where $G$ is Energy Release Rate, $E$ is Young modulus and $\upsilon$ is Poisson constant, $K_I$ is the stress intensity factor, $J$ is the *J integral*.

Perhaps the most accurate and elegant method for computing the energy release rate is to calculated the J integral by converting the line integral into a domain integral which can easily be calculated using the known finite element shape functions.

Consider the closed contour C with outward unit normal vector m as shown in figure 3:

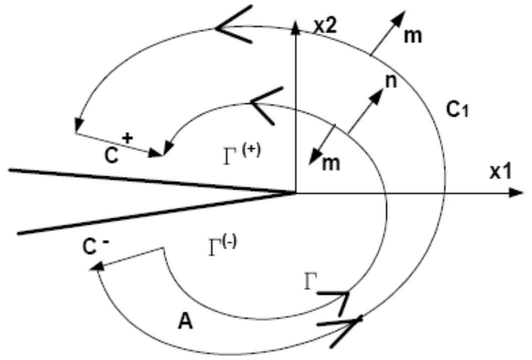


Figure 3 Contours for derivation of domain integral calculation of J integral

The contour $C$ is defined by $C = C_1 + C^+ + C^- - \Gamma$. The area enclosed by $C$ is $A$. Define a function $q(x_1, x_2)$ such that q=1 on $\Gamma$ and q=0 on C.

For a crack that grows straight ahead:

$$G = J = \oint_\Gamma \left( W n_1 - t_i \frac{\partial u_i}{\partial x_1} \right) d\Gamma \tag{2}$$

where Γ is a contour that starts and stops on the crack line and n is the outward unit normal to Γ.

Replacing $n$ with $-m$ on Γ and noting that q = 0 on C1:

$$J = -\oint_C \left( W m_1 - \sigma_{ij} m_j \frac{\partial u_i}{\partial x_1} \right) q dC - \underbrace{\oint_{C^+ + C^-} \left( \sigma_{ij} m_j u_{i,1} \right) q dC}_{0} \tag{3}$$

The second integral equals zero since on the crack faces: $\vec{m} = \pm m_2 \vec{e}_2 \Rightarrow \sigma_{ij} m_j = \pm \sigma_{i2} = 0$. Thus J has been converted into an integral over a closed contour. The divergence theorem can now be used to convert J into an area integral:

$$\left.\begin{aligned} & J = \int_A \left[ \left( \sigma_{ij} u_{i,1} q \right)_{,j} - \left( W q \right)_{,1} \right] dA = \\ & = \int_A \left[ \left( \sigma_{ij} u_{i,j} q + \sigma_{ij} u_i q_{,j} \right) - \left( W_{,1} q + W q_{,1} \right) \right] dA \\ & \sigma_{ij,j} = 0 \\ & W_{,1} = \sigma_{ij} u_{i,1} \end{aligned}\right\} \Rightarrow J = \int_A \left[ \left( \sigma_{ij} u_{i,1} q_{,j} \right) - \left( W q_{,1} \right) \right] dA \tag{4}$$

Typically the function q is expressed using the same shape functions that interpolate displacement, i.e. $q = \sum_{i=1}^{n} N_i q_i$ where Ni are the shape functions, qi are the nodal values of q at nodes i = 1, n.

Thus $J$ may be calculated as an area integral over any annular region surrounding the crack tip.

## 3. NUMERICAL INVESTIGATION

### *3.1 Problem definition*

The problem illustrates the case of a crack in a cannon barrel, together with the relevant geometry against crack length defined from the bore of the cannon. This crack geometry is the most dangerous integrity case for the cannon barrel. The stress intensity calibration includes both hoop stress and internal pressure contributions. The barrel of the FEA modeled cannon has an inner radius of 85 mm and an outer radius of 160 mm, and it operates at a firing pressure of 380 MPa. It is made from 4340 grade steel with yield strength of 1.131 GPa, a tensile strength of 1.232 GPa and a plane strain fracture toughness value of 125.8 $MPa\sqrt{m}$ In this research, 155 mm cannon barrel with one crack with lengths of 4 mm, 8 mm and 12 mm on inner surface is analyzed. Half of the cross section of the cracked cannon pipe is shown in Figure 4.

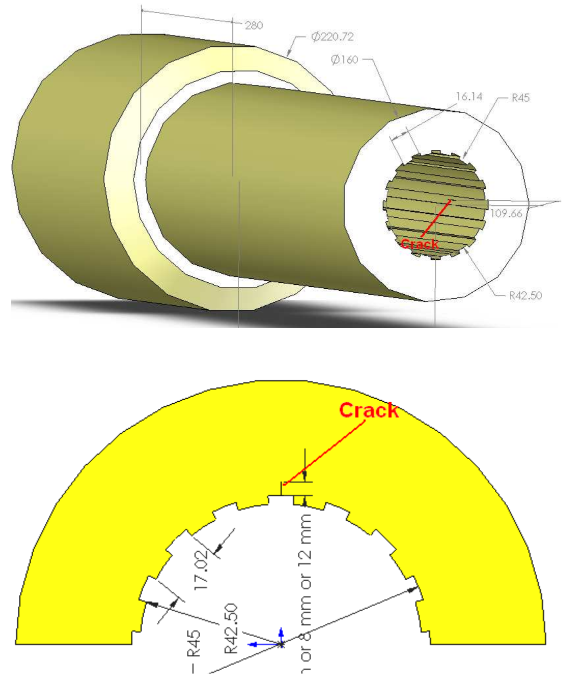


Figure 4 Geometry of the cannon barrel and crack position and dimensions

For the thermal influence of the barrel temperature there were considered 4 scenarios, where the crack length was deemed to be 4 mm, the temperature of the inner surface was 100$^0$C, 125$^0$C, 150$^0$C, 200$^0$C, the thermal conductivity of the steel 60.5 W/m0C, thermal expansion coefficient 1.2 e-5 $^0$C$^{-1}$ and the stagnant air convection coefficient at 20$^0$C around the barrel was considered 5 W/m$^2$ $^0$C.

*3.2 Finite Elements Model*

For the first half of the problem, a structural analysis was conducted in the view of determining the stress and strain fields at the tip of the crack on a 2D model using the software ANSYS. In the figure 5 is given the FEA model comprising 3316 Plane 82 type of element with the crack tip surrounded by quarter-point elements collapsed in order to catch the details of the stress-strain fields, as follows:

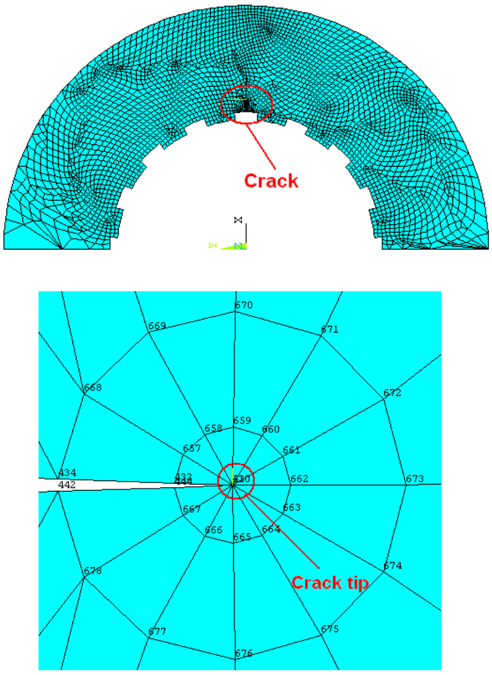


Figure 5 FEA Model and crack tip area

For the second half of the problem, namely the coupled thermal-structural analysis, it will be deployed a sequentially coupled physics analysis which is by definition the combination of analyses from different engineering disciplines which interact to solve a global engineering problem. For convenience, the solutions and procedures associated with a particular engineering discipline will be referred to as a physics analysis. When the input of one physics analysis depends on the results from another analysis, the analyses are coupled.

Thus, each different physics environment must be constructed separately so they can be used to determine the coupled physics solution. However, it is important to note that a single set of elements/nodes will exist for the entire model. By creating the geometry in the first physical environment, and using it with any following coupled environments, the geometry is kept constant. For our case, we will create the geometry in the Thermal Environment, where the thermal effects will be applied. Although the geometry must remain constant, the element types can change. For instance, thermal elements are required for a thermal analysis while structural elements are required to determine the stress. It is important to note, however that only certain combinations of elements can be used for a coupled physics analysis. The process requires the user to create all the necessary environments, which are basically the pre-processing portions for each environment, and write them to memory. Then in the solution phase they can be combined to solve the coupled analysis.

Therefore, for the Physical thermal environment, it will be used the same FEA spatial net of 3316 elements but with Plane 77 elements type instead, and after processing the thermal module we will migrate to the Structural Physical environment with Plane 82 elements and importing the thermal solutions we will process the structural problem having included the thermal effects.

*3.3 The study of the dependency of K to the crack length*

As mentioned above, 3 scenarios were simulated in 2D, with cracks of 4 mm, 8 mm and 12 mm on the inner surface in linear-elastic fracture analysis hypothesis. The frontier conditions imposed to the model were the symmetry displacement condition to the lines bordering the half of the analyzed model (see Fig.5) and on all the inner lines including the crack faces the 380 MPa pressure was imposed.

Below there will be presented the results in the crack tip area, for 4 mm crack length, for the rest a graph will be raised.

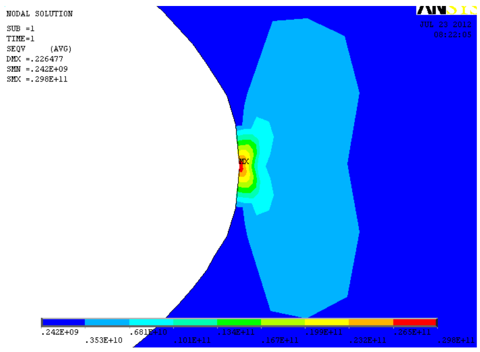


Figure 6 Von Mises stress field at the crack tip for 4 mm crack length

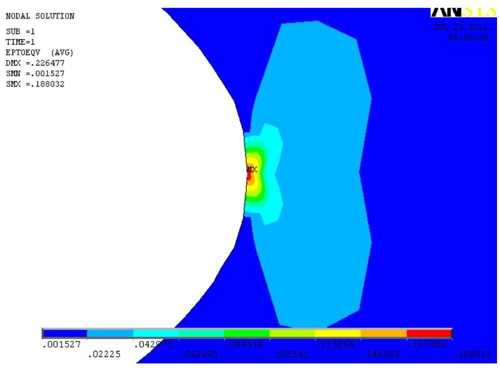


Figure 7 Von Mises strain field at the crack tip for 4 mm crack length

As it can be seen in the figures above, the maximum stress-strain field is located at the crack tip having a value of 2.98e10 Pa (the stress) and 0.188 (the strain).

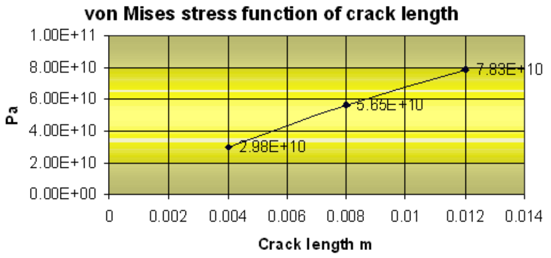


Figure8 Von Mises stress field at the crack tip for 4 mm, 8 mm and 12 mm crack length

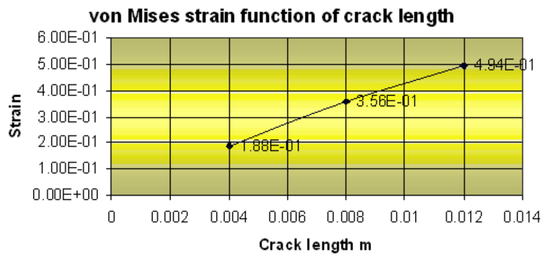


Figure 9 Von Mises strain field at the crack tip for 4 mm, 8 mm and 12 mm crack length

As it can be seen above, the stress-strain fields on the crack tip are increasing almost linearly with the progress of the crack. All the stresses are in any case bigger than the yield strength of 0.1131 e10 Pa.

The next step was to calculate the J-Integral around the tip of the cracks and the following graph was raised:

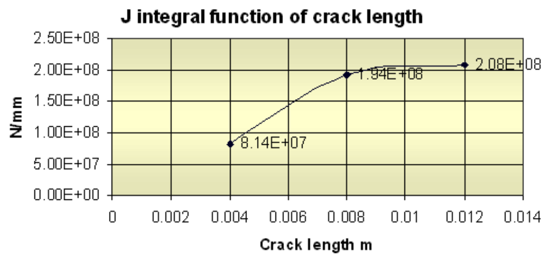


Figure 10 J integral at the crack tip for 4 mm, 8 mm and 12 mm crack length

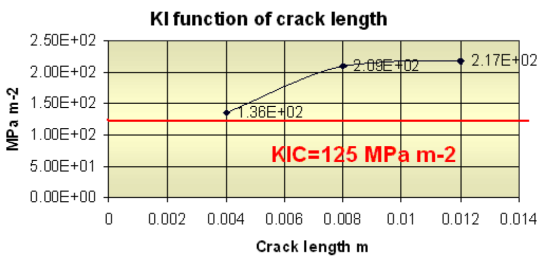


Figure 11 Stress intensity factor at the crack tip for 4 mm, 8 mm and 12 mm crack length

After calculating KI with the relation (1) the graph in figure 11 was raised showing the both *J*-Integral (Fig.10) and the stress intensity factors are increasing with the crack length, firstly sloped until 8 mm crack length and mildly after.

First remark should be that for 4 mm crack length $K_I = 135.7 MPa\sqrt{m} > K_{IC} = 125 MPa\sqrt{m}$ which may lead to the conclusion that the crack is instable and will tend to grow.

The second remark is that by comparing this result with [19] result for almost identical crack conditions in terms of length, material and pressure, which calculated $K_I = 132.35 MPa\sqrt{m}$ using the same FEA approach. We may pull the conclusion of an excellent correlation (and validation in both ways) of the results.

*3.4 The study of the dependency of KI to the temperature for the 4 mm crack length*

As specified above, a new series of numerical simulations were conducted for $100^0$C, $125^0$C, $150^0$C, $200^0$C inside the cannon barrel, in order to study the impact over the calculated $K_I$.

The calculated temperature fields for the $100^0$C are given below:

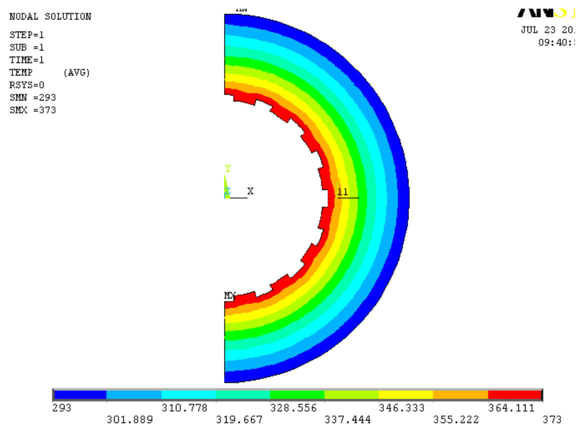


Figure 12 Temperature fields for 3730K

From figure 12 one may notice (important for the conclusions chapter) that a variable temperature field is installed inside the 37 mm thick wall of the barrel.

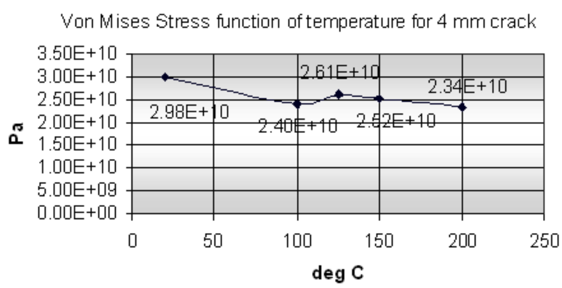


Figure 13 Von Mises variation function to barrel temperature for 4 mm crack length

On the other hand in figure 13 is shown the variation of von Mises stress field at the crack tip with the temperature, with the observation that the maximum values are decreasing.

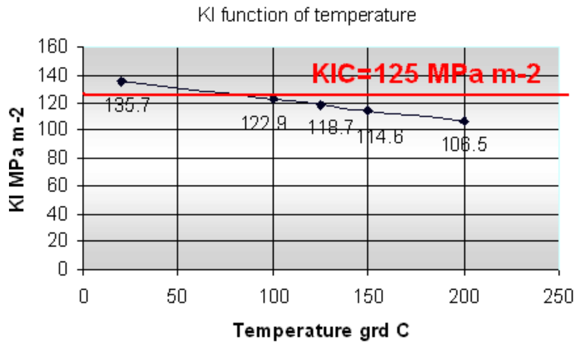


Figure 14 $K_I$ variation function to barrel temperature for 4 mm crack length

After calculating KI with the relation (1), the graph in the figure 14 was raised showing the tendency of decreasing and going under the $K_{IC} = 125 MPa\sqrt{m}$ threshold somewhere at $80^0$C temperature.

## 4. CONCLUSIONS

The numerical model presented in this paper, provides consistent and reasonable results for the dependency of stress intensity factor to the crack length and temperature of a cannon barrel using the J integral. The results as calculated are in excellent correlation with the results, calculated and experimental, coming from [19, 24] and needs no further validation by experiment.

The temperature fields inside the cannon barrel (and, generalizing, inside any circular structure with thick walls) tends to ameliorate the stress fields existing on the crack tip and pushing the calculated KI downward and thus improving the crack behavior. The explanation for this phenomenon is that due to differential thermal dilatation on the highest temperature zone of the barrel, namely the inside zone, the sides of the crack will be pushed one against the other giving birth to an 'thermal crack closing' effect, specific to such cylindrical and thick walled structures.

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# FINDING OPTIMAL HYPERSONIC MISSILE SHAPE BASED ON FINITE ELEMENT ANALYSIS ADVANCED TECHNIQUE

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**ABSTRACT**

Applied aerodynamics has, historically, involved a very strong mix of theory and experiment. This is partly because experiments can be very costly and computations are rarely sufficiently sophisticated. This will continue to be the case. Computational Fluid Dynamics (CFD) is playing an ever increasing role in aerodynamic design for advanced missiles either for performance improvement of the existing system for new missions or for new concept development for future missions. A cost effective design process is to judiciously combine the wind tunnel tests and CFD studies that exploit the inherent strengths of each of these. Hypersonic missile flight is characterized by a high flight Mach number (usually greater than 5), thin shock layers and high viscous loads. The missile aerodynamic geometry has high impact on different missile systems such as control, propulsion, structure, and warhead. The objective of the current paper is to present a reliable Finite Element Analysis/CFD and Fluid Structure Interaction (FSI) advanced technique for obtaining hypersonic missile aerodynamics and use this technique for finding optimal hypersonic missile shape based on best structural behavior (the lowest von Mises stress will play the role of Objective Variable), and, secondly, based on the best aerodynamic behavior (the highest V∞ fluid velocity will play the role of Objective Variable).

**Keywords:** *Fluid Solid Interaction, Optimisation, Hypersonic Missile, Shape, Structure, Metal Matrix Composite, CFD, FEA*

## 1. INTRODUCTION

Applied aerodynamics has, historically, involved a very strong mix of theory and experiment. This is partly because experiments can be very costly and computations are rarely sufficiently sophisticated. This will continue to be the case. A recent, very simple, wind tunnel model with a few control surfaces but no pressure measurements, cost $200,000 to build. That would buy a fair amount of computer time. It also took several months for the model to be delivered. There is great motivation to use computational methods when possible and the numeric shape and structure Optimisation is by far the sole conceivable and reasonable approach, at least for these days.

On the other hand, the missile geometry is quite complicated and one may be interested in the behavior of a leading edge vortex, the onset of flow separation, flow of the boundary layer. Such features require solution of the complex Navier-Stokes equations. Even the NS code which can predict wing-alone characteristics takes weeks before one can get a converged solution.

Perhaps the ideal method of predicting the aerodynamics of a vehicle is flight test in real conditions. There are several reasons why this is not always the ideal method of aerodynamic testing. The cost involved in building and changing full scale designs and making repeated flights is extremely high; the instrumentation is generally not as good as ground-based instrumentation; the atmosphere is not static and it does not take much convective activity in the atmosphere to introduce significant errors in the results

Computational Fluid Dynamics (CFD) is playing an ever increasing role in aerodynamic design for advanced flight vehicles either for performance improvement of the existing system for a new missions or for new concept development for future missions. A cost effective design process is to judiciously combine the wind tunnel tests and CFD studies that exploit the inherent strengths of each of these.

Hypersonic missile flight is characterized by a high flight Mach number (usually greater than 5), thin shock layers and high viscous loads.

The missile aerodynamic geometry has high impact on different missile systems such as control, propulsion, structure, and warhead.

But in order to select between many possible candidates to be designed/tested/computed, an optimization study must be conducted, and this may be done only using dedicated software and a big computing power. Missile aerodynamicists aim to find the optimal external aerodynamic configuration. Missiles have to travel at varying speeds. The optimal aerodynamic configuration has to work efficiently at these variable speeds. The optimization process requires many iterations which makes computationally expensive CFD models unappealing to be used in such calculations. In the existing bibliography, a fast and reliable method such as build-up components method is used to predict performance for hypersonic missiles quickly and reliably [7] [3] and [6]. Keshavarz [13] presented formulations for different multidisciplinary design optimization (MDO) and two MDO formulations are applied to a sounding missile in order to optimize the performance. Three disciplines have been considered, trajectory, propulsion and aerodynamics.

Sooy and Schmidt [15] presented a study on aerodynamic predictions, comparisons and validations using Missile Datcom (97) and Aero-prediction 98 (AP98) numerical prediction codes. They evaluated the accuracy of each code compared to experimental wind tunnel data for a variety of missile configurations and flight conditions. The missile configurations included axisymmetric body, body wing tail and body tail.

Hypersonic missile technologies, in paste decades, have been developed to include enhanced flight performance, reduced weight, increased Mach's number reduced costs, higher reliability, and reduced observables. Their increased performance depends on various parameters which affect the flight performance, their trade-off in the context of aerodynamic shape optimization being of paramount importance (Fig.1).

New missile airframe materials technologies have arisen lately. These are hypersonic special dedicated structural materials as composite structure materials, hypersonic insulation materials, multi-spectral domes and so on.

Composite materials are a new technology that will find increased use in new missile airframe structure. High temperature composites have particular benefits for hypersonic missiles, providing weight reduction. Titanium alloy technology also enables lighter weight missiles in a hypersonic, high temperature flight environment.

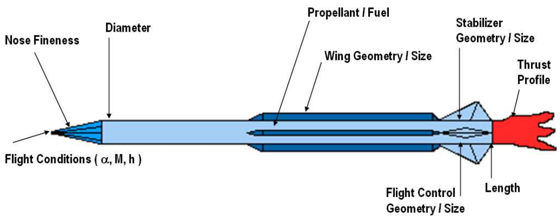


Figure 1 Parameters that Drive Missile Flight Performance

At subsonic and low supersonic Mach's number, graphite epoxy and aluminium or aluminium alloys are attractive choices for lighter weight structure. Graphite epoxy and aluminium alloys have high strength to weight ratio, are easily fabricated, have a good corrosion resistance, and are low in cost.

For higher Mach's numbers, graphite polyimide composite structure has an advantage of high structure efficiency at higher temperature for short duration flight Mach's numbers to about Mach 4.

For flight at about Mach 4.5, without external insulation, the titanium structure and its alloys are preferred. A disadvantage of a titanium structure is higher material and machining cost. However, the cost to cast a part made of titanium is comparable to the cost to cast an aluminium part.

At Mach 5, although it is heavier, a steel structure would probably be used. Up to Mach 5.7 without external insulation, at about 1093 degrees Celsius, super nickel alloys such as Inconel, Hastelloy may be used. Above Mach 5.7 the super alloys require either external insulations or active cooling.

The Mach's number and temperature application relationships are somehow dependent upon the temperature recovery factor.

At stagnation region, such as the nose or leading edges, the recovery factor is about 1, resulting in the highest stagnation temperature. A turbulent or laminar boundary layer downstream of the nose or leading edge will have temperature recovery factors of about 0.9 and 0.8 respectively, with local temperatures less than stagnation.

The objective of the current paper is to present a reliable Finite Element Analysis and Fluid Structure Interaction (FSI) advanced technique for obtaining hypersonic missile aerodynamics and use this technique for finding optimal hypersonic high technology missile shape based on best structural behavior (the lowest von Mises stress will play the role of Objective Variable), and, secondly, based on the best aerodynamic behavior (the highest V∞ fluid velocity will play the role of Objective Variable). In achieving these goals state of the art software was involved: Ansys 9 and all its facilities.

## 2. THE MISSILE BODY STRUCTURE MATERIALS

The strength to weight capability of advanced composites is very high. For example, as shown in Figure 2, the unidirectional tensile strength of a small diameter graphite (carbon) fiber is more than 400000 PSI (2.757903e+009 Pa). In addition to small diameter fibers, advanced composite structures have long, continuous fibers and a fiber/matrix ratio that is greater than 50% fibers by volume.

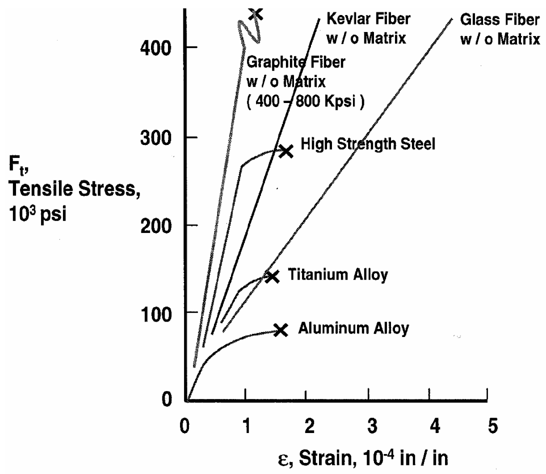


Figure 2 Materials Used in Missile Technology [1]

Fibers can be: carbon (graphite), kevlar, boron, ceramic, silicon carbide quartz, glass, polyethylene and others.

As an example of strength at the structure level, 50% of the volume of the graphite composite structure can have strength in a tailored laminate which is above 1.378e9 Pa, much greater than that of aluminium or even steel.

Also the low density of composites further reduces the weight compared to metals. Graphite fiber composite materials have extremely high modulus of elasticity resulting in low strain and deflection compared to metals.

However, a note of caution, unlike metals that generally yield before ultimate failure, composite fibers generally fail suddenly without yield.

For short duration temperatures up to $204^0$ Celsius, graphite epoxy is a good candidate material based on its characteristics of high strength and low density. Graphite polymide can be used at even higher temperatures, up to $593^0$ Celsius, short duration temperature. Over $593^0$ Celsius titanium and steel are the best materials based on strength to weight ratio. An area of enabling capability hypersonic precision of striking missiles is short duration insulation technology. Because hypersonic precision of striking missiles has stringent volume and weight constraints, higher density, external airframe and internal insulation, materials are in development. Higher density insulation materials permit more fuel resulting in longer range.

Thermal insulators are used to provide short duration protection for structural materials from either the aerodynamic heating of a hypersonic free stream or from propulsion heating of the combustion chamber and exhaust gases of the nozzle.

Ceramic refractory materials and graphite materials are also candidate insulators for high speed airframes, engines and motor cases.

Although ceramic refractory materials and graphite have high temperature capability, the insulation efficiency for a given weight of a material is not as good as that of plastic composite materials.

At high temperature, the resin melts providing cooling for the structure. Example of bulk ceramics are zirconium ceramic and hafnium ceramic. Bulk ceramics are capable of withstanding height temperatures but like porous ceramics they have relatively poor insulation efficiency.

Finally, graphite insulators provide the highest temperature capability. However, graphite has relatively poor insulation efficiency.

A good combination of materials for hypersonic missiles seems to be the Metal Matrix Composite (MMC) for the nose and fins and Inconel X-750 for the rest of the body.

*2.1 The Nose and Fins Metal Matrix Composite Structure*

A metal matrix composite (MMC) is a composite material with at least two constituent parts, one being a metal. The nose and the fins of the considered missile are made out of MMC. The other material may be a different metal or another material, such as a ceramic or organic compound. When at least three materials are present, it is called a hybrid composite

MMCs are made by dispersing a reinforcing material into a metal matrix. The reinforcement surface can be coated to prevent a chemical reaction with the matrix. For example, carbon fibers are commonly used in aluminium matrix to synthesize composites showing low density and high strength. However, carbon reacts with aluminium to generate a brittle and water-soluble compound Al4C3 on the surface of the fiber. To prevent this reaction, the carbon fibers are coated with nickel or titanium boride.

The matrix is the monolithic material into which the reinforcement is embedded, and is completely continuous. This means that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. In structural applications, the matrix is usually a lighter metal such as aluminium, magnesium, or titanium, and provides a compliant support for the reinforcement. In high temperature applications, cobalt and cobalt-nickel alloy matrices are common.

The reinforcement material is embedded into the matrix. The reinforcement does not always serve a purely structural task (reinforcing the compound), but is also used to change physical properties such as wear resistance, friction coefficient, or thermal conductivity. The reinforcement can be either continuous, or discontinuous. Discontinuous MMCs can be isotropic, and can be worked with standard metalworking techniques, such as extrusion, forging or rolling. In addition, they may be machined using conventional techniques, but commonly would need the use of polycrystalline diamond tooling (PCD).

In the modelled application was considered the following MMC:

- Matrix : Titanium (Ti); Young’s Modulus = 110 GPa ; Poisson’s Ratio = 0.25 ; Yield Stress = 300 MPa
- Reinforcements: Silicon Carbide (SiC) ; Young’s Modulus = 410 GPa ; Poisson’s Ratio = 0.17
- Design Parameters: Fibers’: Aspect Ratio (AR=50); Volume Fraction (VF=8% or 12%); Orientation (8 layers symmetric φ=0°; 90°; 45°; -45° and symmetric); Basic layer thickness=0.00025 m for the initial model.

The Orthotropic Elastic Material model used in FEA has the main mechanical characteristics as following:

Table 1. Considered MMC Mechanical Characteristics

| | | |
|---|---|---|
| Ex=1.1e11 Pa | Ey=1.1e11 Pa | Ez=4.1e11 |
| Gxy=0.44e11 Pa | Gxz=1.75e11 Pa | Gyz=1.75e11 Pa |
| $\nu$xz=0.17 | $\nu$xy=0.25 | $\nu$yz=0.17 |

*2.2 The Missile Body Inconel Structure*

Inconel alloys are oxidation and corrosion resistant materials well suited for service in extreme environments. The body of the considered missile is made out of Inconel X-75. When heated, Inconel forms a thick, stable, passivating oxide layer protecting the surface from further attack. Inconel retains strength over a wide temperature range, attractive for high temperature applications where aluminium and steel would succumb to creep as a result of thermally-induced crystal vacancies. Inconel's high temperature strength is developed by solid solution strengthening or precipitation strengthening, depending on the alloy. In age hardening or precipitation strengthening varieties, small amounts of niobium combine with nickel to form the intermetallic compound $Ni_3Nb$ or gamma prime (γ'). Gamma prime forms small cubic crystals that inhibit slip and creep effectively at elevated temperatures. Inconel is a difficult metal to shape and machine using traditional techniques due to rapid work hardening. After the first machining pass, work hardening tends to elastically deform either the work piece or the tool on subsequent passes. For this reason, age-hardened Inconels such as 718 are machined using an aggressive but slow cut with a hard tool, minimizing the number of passes required. Alternatively, the majority of the machining can be performed with the work piece in a solvable form, with only the final steps being performed after age-hardening. External threads are machined using a lathe to "single point" the threads, or by rolling the threads using a screw machine. Holes with internal threads are made by welding or brazing threaded inserts made of stainless steel. Internal threads can also be cut by single point method on lathe, or by thread milling on machining center. New whisker reinforced ceramic cutters are also used to machine nickel alloys. They remove material at a rate typically 8X faster than carbide cutters.

In our FEA model the body material was considered isotropic elastic Inconel X-750.

Alloy X-750 is a precipitation-hardenable alloy which has been used in applications such as high temperature structural members for gas turbines, jet engine parts, nuclear power plant applications, heat-treating fixtures, forming tools, and extrusion dies. The alloy is highly resistant to chemical corrosion and oxidation and has high stress-rupture strength and low creep rates under high stresses at temperatures up to 1500°F (816°C) after suitable heat treatment.

Alloy X-750 work hardens quickly and is more difficult to machine than most standard ferritic and martensitic alloys. The alloy is most easily machined in the stress-equalized condition.

Because specific cutting forces are high, the machine tools used must have ample power and the cutting speed should be slow. The tools must have smooth finishes, be sharp, and be very rigid. To avoid work hardening, a continuous, smooth cutting action should be maintained; thus, the machines must have a minimum of backlash and the tool and work-piece must be rigidly supported. If at all possible, avoid very small cuts and feeds.

Table 2. Inconel X-750 Mechanical Properties

| Test Temperature | | Short-Time Tensile Properties Tests | | | | | |
|---|---|---|---|---|---|---|---|
| °F | °C | Yield Strength 0.2% offset | | Ultimate Tensile Strength | | % Elongation in 2" (50.8 mm) | % Reduction of Area |
| | | ksi | MPa | ksi | MPa | | |
| 70 | 21.1 | 92 | 634 | 161 | 1110 | 22 | 30 |
| 1000 | 538.0 | 83 | 572 | 140 | 965 | 20 | 30 |
| 1200 | 649.0 | 82 | 565 | 120 | 827 | 10 | 21 |
| 1400 | 760.0 | 68 | 469 | 80 | 552 | 10 | 22 |
| 1500 | 816.0 | 45 | 310 | 47 | 324 | 20 | 32 |
| Young Modulus=2.1e11 Pa | | | | | | | |
| Poisson's Ratio=0.29 | | | | | | | |

## 3. NUMERICAL INVESTIGATION

### *3.1 CAD Geometry and FEA mesh*

The declared goal of generating CAD geometry and FEA mesh is to save as much of computing power we can, due to the high complexity of the simulation. Even the optimization using Sub problem method was selected taking into account the same goal, this method being less expensive in terms of the number of iterations needed to obtain the convergence.

The missile was considered a double symmetric body and the fluid domain and the solid one as well, was deemed to generate acceptable results even if was considered only ¼ of both domains and imposing proper symmetry boundary conditions. The CAD geometry is given in the figure below:

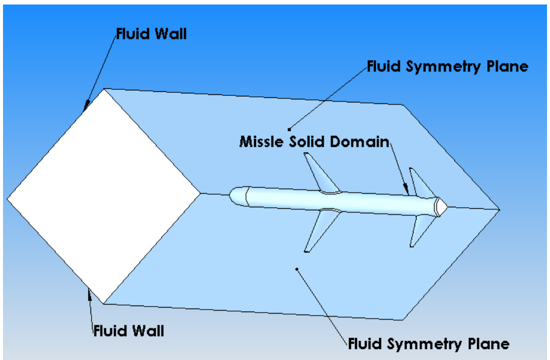


Figure 3 CAD geometry of the fluid and solid domains

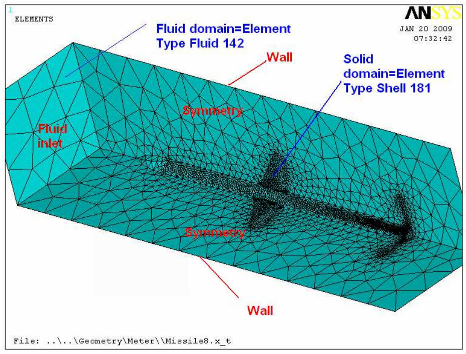


Figure 4 FEA mesh and boundary conditions

In the figure 4 they are visible the symmetry planes, the inlet region of the fluid where the velocity which was imposed being 1000 m/sec, the outlet region for the fluid opposed to the inlet region where the pressure was imposed being slightly under atmospheric at sea level (91,500 Pa (a)) and the walls where all the components of velocity were set to zero (this wall conditions are mimicking the testing wind tunnel walls). The fluid and structural meshes were deliberately refined in the FSI contact region for surprising in more detail the phenomena which may occur in this region. The fluid is considered Air with its standard parameters in SI.

We used Fluid142 element to model our transient fluid system involving both fluid and solid regions. The conservation equations for viscous fluid flow and energy are solved in the fluid region, while only the energy equation is solved in the non-fluid region. For this kind of elements, the velocities are obtained from the conservation of momentum principle, and the pressure is obtained from the conservation of mass principle. A segregated sequential solver algorithm is used; that is, the matrix system derived from the finite element digitization of the governing equation for each degree of freedom is solved separately. The flow problem is nonlinear and the governing equations are coupled together.

On the other hand for the solid domain we used the Shell 181 type of element due to the fact it can model the multilayered composite orthotropic elastic materials as MMC for missile nose and fins, and also the isotropic elastic materials as Inconell X-750 for the cylindrical body of the missile.

Shell 181 element type is suitable for analyzing thin to moderately-thick shell structures. It is a 4-node element with six degrees of freedom at each node: translations in the x, y, and z directions, and rotations about the x, y, and z-axes. Shell 181 is well-suited for linear, large rotation, and/or large strain nonlinear applications. Change in shell thickness is accounted for in nonlinear analyses. In the element domain, both full and reduced integration schemes are supported. Shell 181 accounts for follower (load stiffness) effects of distributed pressures. It may be used for layered applications for modelling laminated composite shells or sandwich construction. The accuracy in modelling composite shells is governed by the first order shear deformation theory (usually referred to as Mindlin-Reissner shell theory).

Since the main problem is the FSI, the fluid-solid interaction solver was selected in simulation, it successfully solving the equations for the fluid and solid domains independently of each other. It transfers fluid forces and heat fluxes and solid displacements, velocities, and temperatures across the fluid-solid interface. The algorithm continues to loop through the solid and fluid analyses until convergence is reached for that time step (or until the maximum number of stagger iterations is reached). Convergence in the stagger loop is based on the quantities being transferred at the fluid-solid interface. In order to function properly, a FSI interface was established between the elements of fluid-solid domains.

### *3.2 Optimization Scenario 1*

The Optimisation Scenario no.1 is representing the Structural Engineer point of view, which always will search for that structural arrangement which is providing the lower stress condition inside the structure for a given geometry/aerodynamic design/state variables.

In this scenario, the maximum achievable von Mises equivalent stress is 51e6Pa, value almost three times lower than the initial model which was 162e6 Pa.

The “cost” for this achievement is not so big: the missile velocity slightly increased but the fins height were decreased, the distance between first set of fins and the missile nose was increased with almost 0.13 m and the distance between fins sets was shortened, the Inconel body thickness and the MMC fins-nose layer thickness seems to decrease (which is good in decreasing the overall weight of the missile). This seems to be a good solution but only for supersonic missiles, travelling with Mach number 3.5-4, which may not please the Aerodynamics Design Engineer which is in search of hypersonic missile structure solutions.

L22 Design variable is the height of Fins set no.2, at the rear end of the missile. By studying the given graphs (Fig.5, 6, 7), the overall conclusion is: the bigger, the worst. The fluid velocity, the stress condition and the required thickness of missile walls are increasing with the increasing of this parameter.

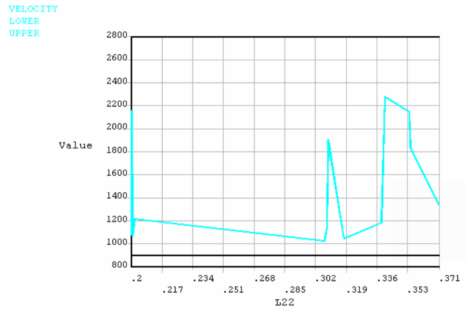


Figure 5 L22 Design variable impact over maximum fluid velocity

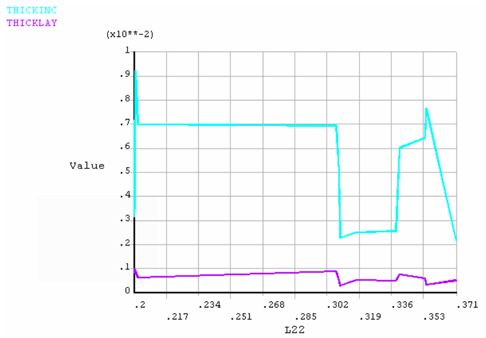


Figure 6 L22 Design variable impact over maximum structure thickness

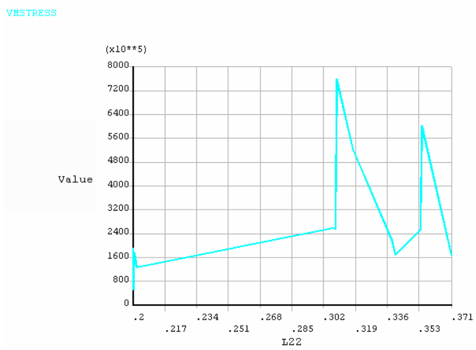


Figure 7 L22 Design variable impact over maximum von Mises stress

L31 which is the distance between the two sets of fins, determine an local minimum for the von Mises stress for a value of 0.93355 m, and the worst impact should be registered for values from the middle of variation interval (see Fig.8, 9, 10).

L23 which is the height of missile fins set 1, has an ambiguous influence over the maximum stress condition. Since the maximum stress condition is computed in the rear end zone, this parameter will therefore express the influence of first set of fins over the aerodynamic conditions existing at the end of the missile (Fig.11, 12, 13). For two values: 0.358m and 0.448 m, the stress condition for this region is worsening, the optimal value being 0.34288 m.

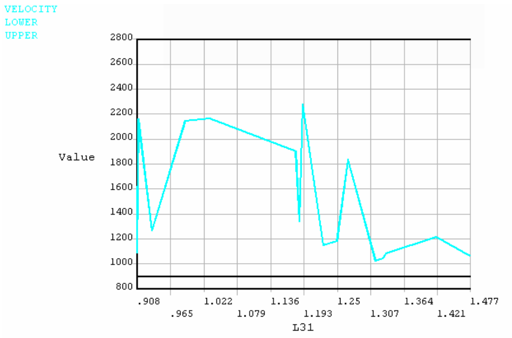


Figure 8 L31 Design variable impact over maximum fluid velocity

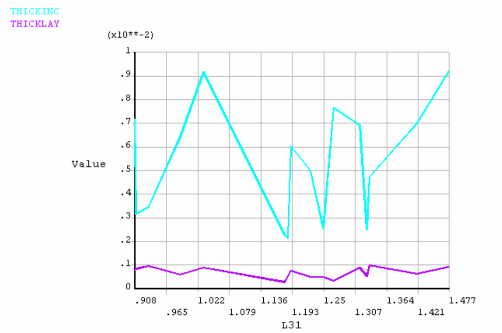


Figure 9 L31 Design variable impact over maximum structure thickness

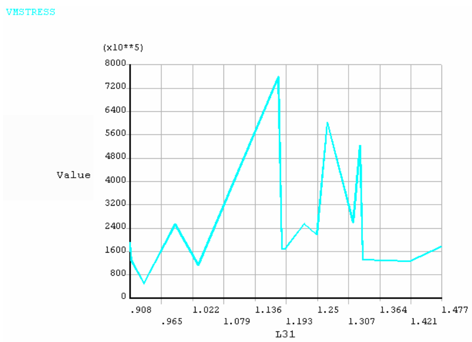


Figure 10 L31 Design variable impact over maximum von Mises stress

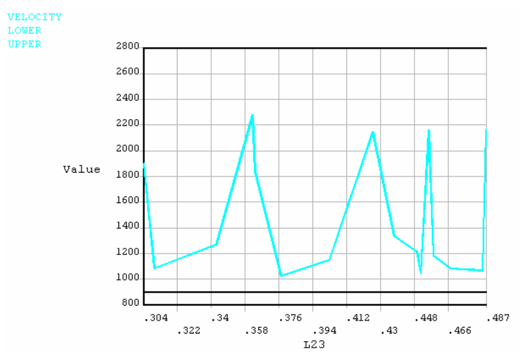


Figure 11 L23 Design variable impact over maximum fluid velocity

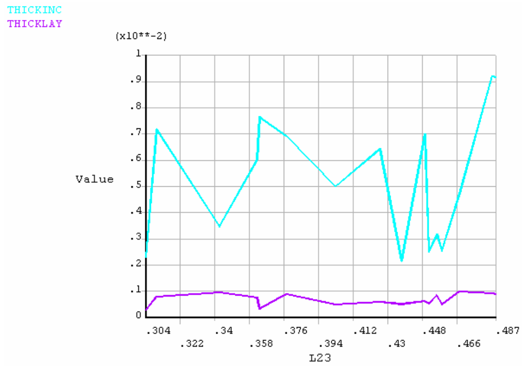


Figure 12 L23 Design variable impact over maximum structure thickness

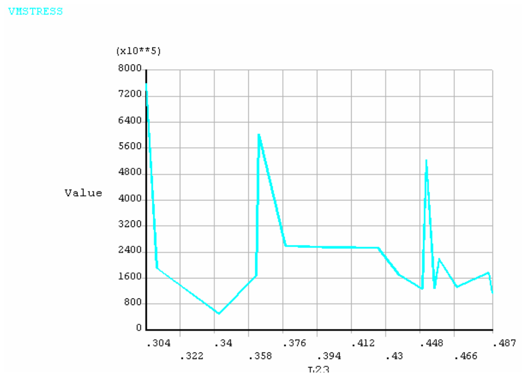


Figure 13 L23 Design variable impact over maximum von Mises stress

For more details, the bellow figures are given after FSI simulation of the optimal design in Scenario 1 perspective.

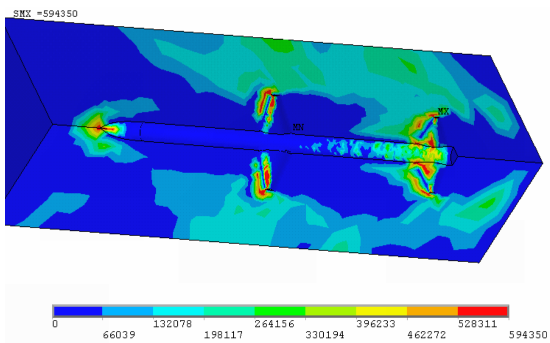


Figure 14 Pressure distribution for Optimal-Scenario 1

The pressure distribution exerted by fluid on the missile structure is similar to that of the initial model. The nose, the attack edge of the fins and the rear portion of the missile are to be subjected to the biggest pressure, 594e3Pa.

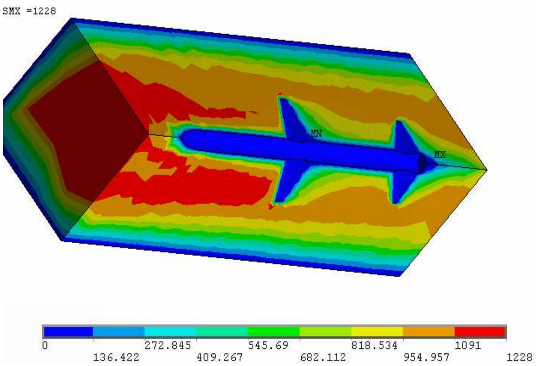


Figure 15 Fluid velocity distribution for Optimal-Scenario 1

On the figure above is presented the fluid velocity distribution around the optimum model for Scenario 1. The maximum achievable velocity inside the fluid domain is 1228 m/sec, slightly bigger that the one computed for the initial model.

The Mach number distribution inside the fluid domain, as expected, is closely following the distribution of fluid velocities, reaching a maximum of 3.7 in the very front of the missile

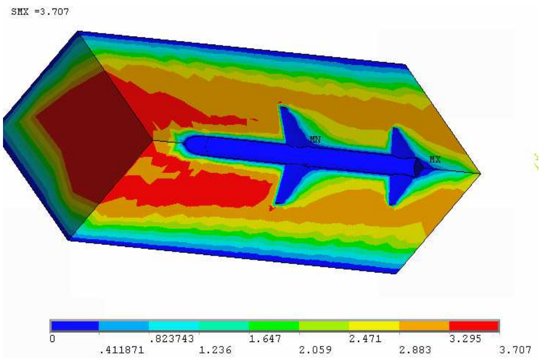


Figure 16 Mach number distribution for Optimal-Scenario 1

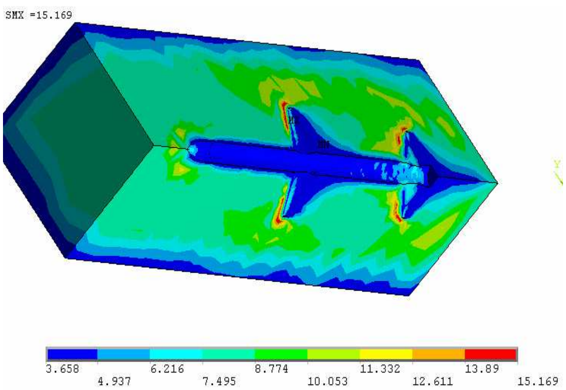


Figure 17 Fluid density distribution for Optimal-Scenario 1

The fluid density distribution is somehow similar to the pressure distribution.

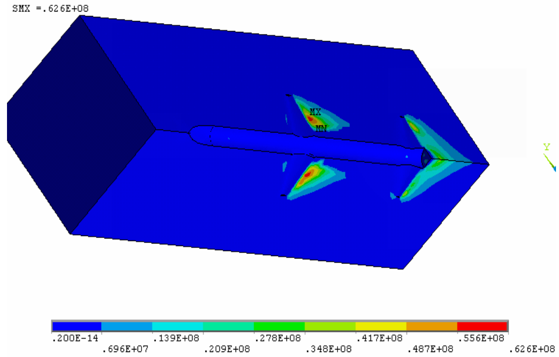


Figure 18 Fluid turbulent energy dissipation distribution for Optimal-Scenario 1

The fluid turbulent energy dissipation zones are highlighting that zones which are characterized by intense turbulent regimes, as in the rear edges of fins and missile.

The maximum strain of course will occur where the maximum fluid pressure is developing, namely on the missile fins and rear portion. The maximum strain will be 0.04% on the Inconel rear back of missile, much smaller than the one computed for the initial model (Fig.19).

The von Mises equivalent stresses distribution will closely follow the one of strain distribution, being computed a maximum of 54e6 Pa in the rear region of the missile (Fig.20).

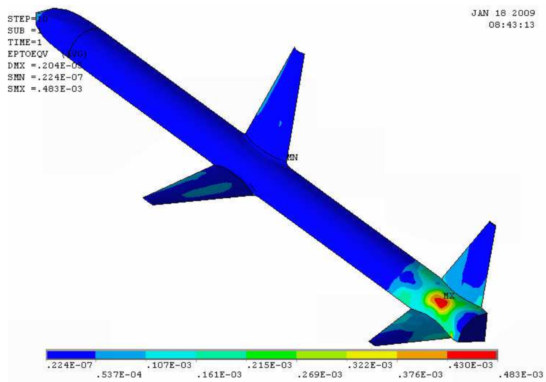


Figure 19 Von Mises equivalent strain distribution for Optimal-Scenario 1

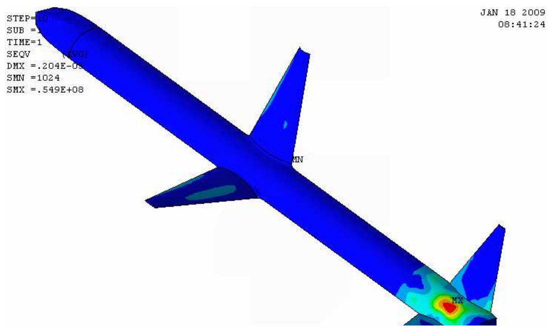


Figure 20 Von Mises equivalent stress distribution for Optimal-Scenario 1

## 4. CONCLUSIONS

The numeric model presented in this paper, provides consistent and reasonable results for missiles structural-aerodynamic analysis and optimization. Its results are comparable with other approaches but the optimization must be evaluated on a case-by-case basis, meaning that what is good for a certain missile structure may very well be not applicable for another. Furthermore, even the optimization is thought to minimize or diminish the designer flair in decisions making, apparently in every step of this process the designer ought to have decisive interventions. Optimization is just a tool and should be used as it is: a tool.

The results obtained from the optimization numeric simulation, may be used to define a certain structure-shape of a missile prior any attempt to in depth analyzing and testing it, this shortening the needed time for design and testing programs.

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# ADAPTATION OF THE ADVANCE SYSTEM FOR KS-3M SHEARER ADAPTED FOR 295-842 RYBNIK CONVEYER

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**ABSTRACT**

The paper presents technical solutions to correlate the function of KS-3M shearer with Rybnik 295/842 conveyer in order to observe Occupational Health and Safety requirements. These machines, alongside of CMA-5H powered support make up a powered face complex used to extract coal in panel 4/seam 3/block VI.

**Keywords:** *shearer, conveyer, correlation.*

## 1. INTRODUCTION

KS-3M shearer alongside of Rybnik 295/842 conveyer, together with CMA-5H powered support make up a powered face complex used to extract coal in panel 4/seam3/block VI in Paroseni Mine.

The shearer's and conveyer's technical characteristics, as designed by the producers were not correlated, considering that they are of different make and come from different countries. Nevertheless, the two machines show some compatibility: the shearer's cutting capacity can be supported by the scraper conveyer; dimension wise, the shearer can be mounted on the conveyer, by suitable modifications, with no essential changes that might lead to diminishing their resistance characteristics; the conveyer's robust structure resists to approximately 24 tons weight of the shearer.

The main lack of correlation between the two lies in the fact that the conveyer is equipped with a for the guidance part, requiring a feed mechanism on the shearer with vertical driving gear (rack feed system), while the shearer is equipped with a calibrated chain feed mechanism, where the driving gear is horizontally mounted.

Moreover, at the driving and return ends of the conveyer the traction chain cannot be fixed.

Therefore, the main technical characteristics of the feed system had to be modified. The paper presents the technical solution of adapting the KS-3M shearer feed system to the 295/842 Rybnik conveyer.

## 2. ADAPTING SHEARER'S FEED SYSTEM TO SCRAPER CONVEYER RYBNIK 295/842

Adaptation of the shearer feed system to the scraper conveyer, according to Figure 1 lies in:

- Design of captive guides, position *1* and *3*. Guides are mounted on the shearer's reduction, namely the feed mechanism, towards the powered support (mined out space). This involves substitution of existing sliding captive guides on the shearer. The recently adopted solution does not require modification of the rack on the conveyer, therefore the solution of the producer is not modified, it being the path for the roller of the guidance;
- Replacement of hydraulic cylinders (jacks) of the guidance skids from the face side with fixed elements, position *2*, mounted on the reducer and position *4*, mounted on the feed mechanism. The use of fixed elements removes the associated hydraulic circuit, the general hydraulic layout on the shearer is simplified, and the possibility of defaults is eliminated;
- Design of traction chain fastening elements, at the two ends of the conveyer, position *5* at the end of the return end and position *6* at the driving end. This is necessary, since the conveyer, designed for a rack feed system, has no such elements.

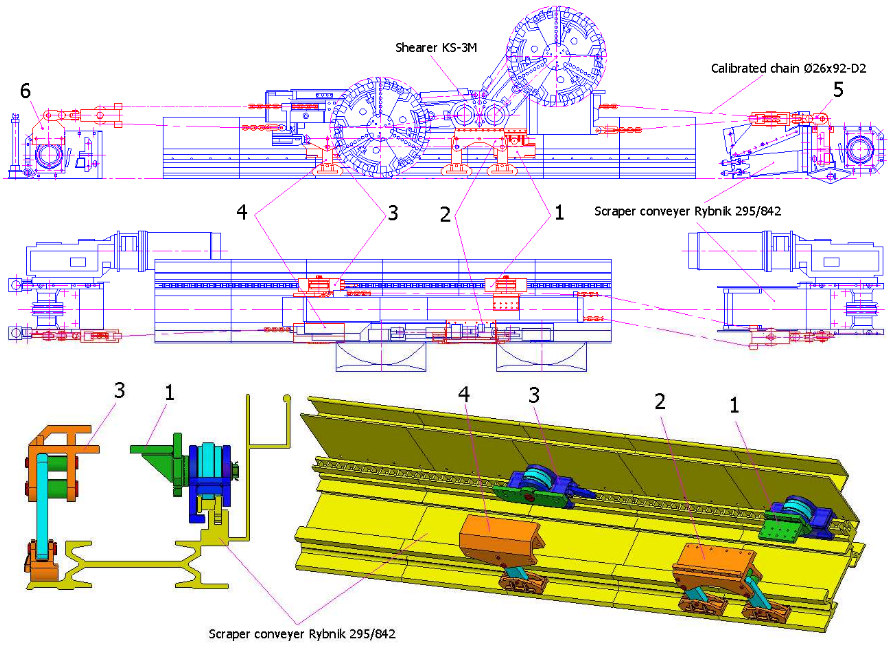


Figure 1 KS-3M feed system for Rybnik 295/842 conveyer

The overall design solution mounted on the shearer reducer towards the mined out space is given in Fig. 2. The main components of the guide are the roller support, the roller bolt, the guide, the roller with its associated elements for mounting and sealing the rolling bearing.

The entire structure of the guide is mounted on the body of the principal reducer of the shearer by the roller, position 1, and fifteen M24x1000 screws and of Grower disks, positions 14 and 15. The roller support is a welded structure allowing its fastening to the reducer by one hundred M24 screws vertically mounted from the downside of the shearer and five screws horizontally mounted from the lateral side of the reducer. The use of 15 screws for fastening the guide is explained by the fact that it is mounted in the area where the larger weight of the principal reducer is concentrated and of the drving reducers of the drums.

The guide components are assembled with a Ø 95 bolt, position *2*, ensured by the disk, position *11*, an M45x3 nut, position *12*, and a blocking wire of the nut, position *13*. Due to the mounting conditions of the bearing, position 6, and spacer collar, the outside of the bolt is in k7 field of tolerance. The bolt rests on a guide roller by a F8/k7 adjustment, position 3, providing in the same time a captive guide, guiding the shearer on the conveyer.

The roller, position *4*, representing the essential element in the structure of the guide, is equipped in the inside, by its cover, position *5*, with a spacer, position *7*, M12x30 screws and associated Grower disks, positions *9* and *10*, oscillating ball series 22319, position *6*, and sleeve B110140, providing the lubricating room of the ball.

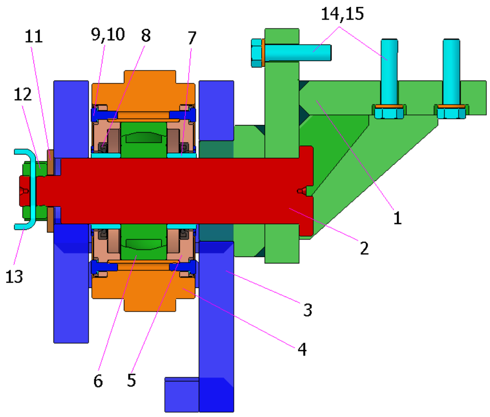


Figure 2 Overall solution for roller guide mounted on the reducer

The overall design solution of the roller guide mounted on the feed mechanism of the shearer, towards the mined out space is shown in Figure 3.

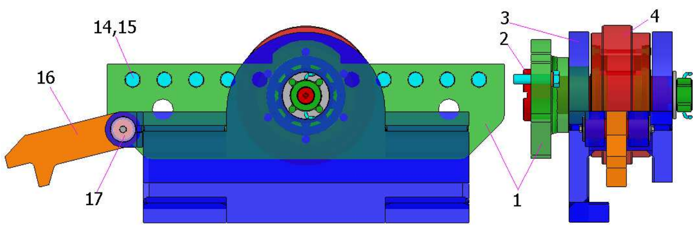


Figure 3 Overall solution for the roller guide mounted on the feed mechanism

The construction solution of the guide is identical to that of the roller guide mounted on the reducer, with two differences.

The first is connected to its fastening to the feed mechanism which has another configuration and requires another support type for the roller, position 1.

The support is fastened to the feed mechanism with ten M24 x 100 screws.

The second difference relates to the equipping of the guide with a click, position 16, mounted by a bolt, position 17, to the body of the guide, with safety role in the movement of the shearer.

Skid components at the face side, mounted to the shearer reducer, are presented in Figure 4.a.

Modification of this movement system lied in replacing the two hydraulic cylinders (jacks) with two fixed linking plates, position 1, two types of spacers, positions 2 and 3, to make the structure rigid.

The other components of the system were kept, that is the reducer support, position 6, skids, position 7, Ø50 and Ø70 diameter bolts, positions 8 and 9, for which blocking wires were provided, positions 4 and 5.

Figure 4.b gives the overall solution for the skid mounted to the feed mechanism.

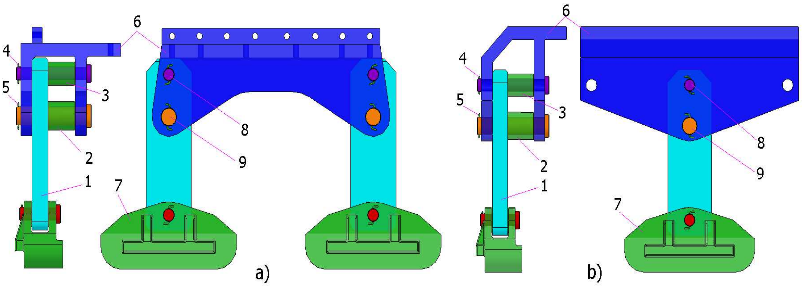


Figure 4 Modifications in the structure of the skid at the front mounted on the reducer and the feed mechanism

Figure 5.a shows the overall solution for the modifications made at the connection between the feed mechanism chain and the metal structure of the return station of the conveyer.

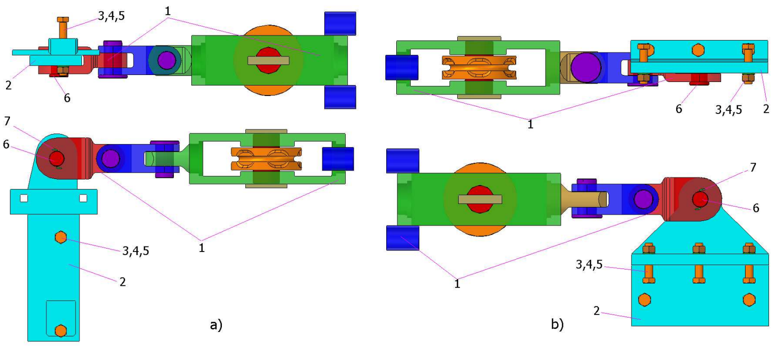


Figure 5 Design solution to link feed mechanism chain to conveyer driving station and conveyer return station

The connection solution for the connection of the chain to TR-7A conveyer, position 1, verified in practice, is kept, but the linking plate was provided, position 2, mounted through two M36x200 screws, nuts and Grower disks, positions 3, 4 and 5, on the metal structure of the return station.

The element supporting the chain and ensuring change of direction is coupled with the linking plate through Ø74 bolt, position 6, provided by a blocking wire, position 7.

The overall solution of modifications made at the connection between the feed mechanism chain and the metal structure of the conveyer driving station is given in Figure 5.b.

## 3. VERIFICATION OF THE SLIDE SUPPORT, ROLLER SLIDE AND BOLT ASSEMBLY

Feeding system elements were geometrically modelled by Solid Edge soft and analyzed by numerical method of finite element with COSMOS Design STAR soft, as it follows.

Figure 6 shows discretisation, fixing and loading the assembly made up of slide support, which is fixed on the body of the shearer’s reducer, roller slide and Φ 95 bolt, making the roller support and the positioning of the latter and of the slide to the support.

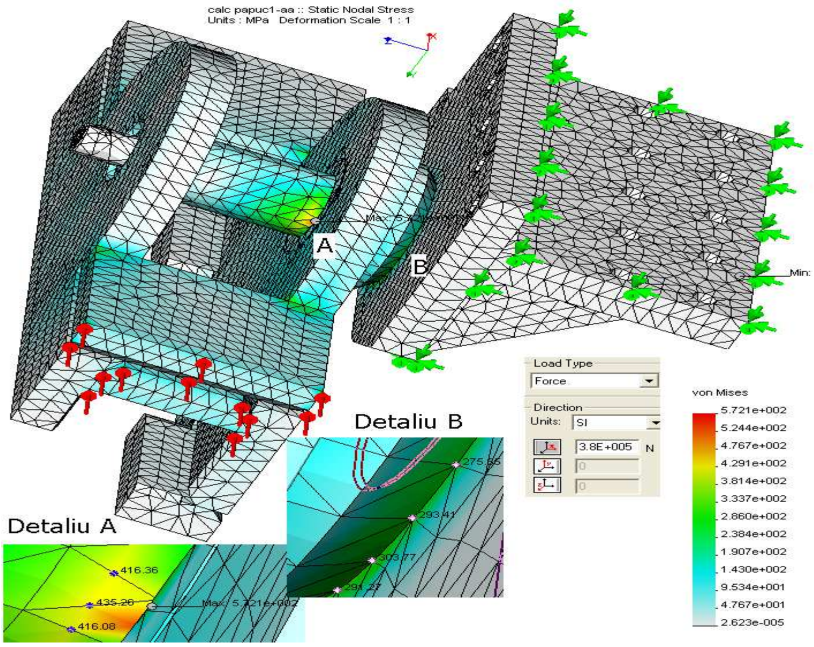


Figure 6 Verification of the slide support, roller slide and Φ95 bolt

The analysis was made for emergency, when the slide is blocked on the rack.

In this modelling, the bolt is tightened, therefore it takes over the transmission forces from the slide to the support, having in the bearing area a maximum pressure of 572,1 MPa (Detail A), and in the area of bearing - support a maximum pressure of 303,77 MPa (Detail B). These pressure values are not higher than resistances to tear.

## 4. CONCLUSIONS

The following conclusions resulted from the solutions developed to modify KS-3M shearer feed mechanism adapted to Rybnik 295/842 conveyer, used in Paroseni Mine face, panel 4, seam 3, block VI, slice 1, meeting occupational health and safety requirements:

- The feed system applied did not modify the technological operating and deployment parameters of KŞ-3M shearer and Rybnik 295/842 conveyer;
- The technical solutions meet health and safety requirements;
- Replacement of sliding captive guides at the mined out space, applied for TR-7A conveyer with roller captive guides reduced friction in the guides and improved the power coefficient of the shearer used to cut coal;
- Replacement of skid hydraulic jacks at the face side with fixed elements resulted in lower adjustment possibilities of the shearer position as to the conveyer, but it increased in the same time the reliability of the sliding skid movement system;
- The use of three sliding skids instead of two, as in the former feed system, contact pressure value between the skid and the , and the wear and shearer traction force, respectively, reduced;
- Tension value in the component elements of the roller guide assembly of the KS-3M shearer feed system adapted to Rybnik 295/842 conveyer are no higher than tear resistance values.

The following design improvements are suggested, analyzing the technical solution found:

- Roller without guide bed to remove double guidance on the rack (both by rollers and by captive guide);
- To improve mounting conditions for the roller in guidance and support, instead of the two spacer collars, a roller wide sleeve should be used where a radial-axial ball should be mounted, with 23222 barrel rollers, of higher dynamic capacity than the present ones;
- A centering bed should be implemented on the guide sleeve and a seating on the vertical plate to improve the positioning of the two elements and the way of force transmission from the roller guide to the support fixed to the shearer;
- Welding some teeth to the periphery of the feed guide roller to clean the rack

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# SPECIFIC CLIMATIC INDICATORS IN CALMATUI BASIN

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**ABSTRACT**

The river Călmățui in Teleorman is a typical plain river which originates fro Câmpia Iminogului Plain at the height of 160 m and it flows into the lake Suhaia at the altitude of 20 m. This river developped on its own during the Quaternary, by regressive erosion, independent from the river Olt or from the former flowing directions of the river Arges, but it was closely connected to the emergence of Boianului plane and with the establishment of the present course of the Danube river. The hydrographic network of this basin developped gradually and is still evolving because fo the present geomorphological process of compaction and suffusion associated with the pluviofluvial processes.

**Key words:** *hydrographic network genesis, evolution*.

## 1. INTRODUCTION

The morpho-hydrographic basin of Călmățui in Teleorman is a local basin th the Romanian Plain, and it is one of the small hydrographic basins of the country, with a surface of 1375 km$^2$; it is situated between two big alochtone hydrographic basins: Oltul basin in the West and Vedei basin in the east.

In order to provide a characterization of a region's climate an important support is represented by the calculation of the quantitative indices; therefore in order to show the climatic peculiarities in the Călmățui basin we have chosen several indices.

***Tetratherma Mayer*** is calculated by the formula:

$$T_{V-VIII} = (T_V+T_{VI}+T_{VII}+T_{VIII})/4$$

In which: $T_V$ – represents *the monthly average temperature in May,*

$T_{VI}$ – represents *the monthly average temperature in June, etc*.

This parameter's values slightly increase from north to south thus: 20,62 in Slatina; 20,77 in Roşiori de Vede and 21,35 in Turnu Măgurele. These values indicate a slightly semi-arid climate.

The ***Angot Index*** is calculated by the formula:

$$K=p/P$$

And indicates the rain characteristics of the months in a year in this formula $p$ – represents *the ratio between the monthly average quantity of rain and the number of days in the respective month,* and $P$ – represents *the ratio between the yearly average quantity of rain and 365*. If $K<1$, the respective month is pluviometrically deficitary; $K=1$, indicates a pluviometrically normal month, and $K>1$, indicates a pluviometric surplus.

This index applied to the monthly quantities of precipitations at the weather stations found in the vicinity of the basin *(Chart no.1)* points out that the months with a slight pluviometric surplus are May, June, July and August while the minimum values of the Angot index are recorded in January and February.

Chart nr.1 Monthly average values of the Angot pluviometric index (1961-2010)

| Luna | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Slatina | *0,70* | *0,72* | 0,76 | 0,95 | *1,20* | *1,52* | *1,42* | *1,33* | 0,90 | 0,85 | 0,84 | 0,76 |
| Rosiori de Vede | *0,74* | *0,76* | 0,79 | 0,94 | *1,33* | *1,48* | *1,35* | *1,08* | 0,91 | 0,78 | 0,93 | 0,89 |
| Turnu Măgurele | *0,83* | *0,83* | 0,79 | 0,93 | *1,26* | *1,37* | *1,25* | *1,04* | 0,97 | 0,81 | 0,97 | 0,92 |

Although the highest values of the Angot index are recorded during the summer months, the quantity of precipitations does not cover the high levels of evapotranspiration during these months. *(chart nr. 2)* therefore a deficit of water is registered during the warm season, when the plants are in their maximum development stage *(chart nr.30).* under the climatic conditions of this region, *the potential evapotranspiration* is among the highest in the country, going above 700 mm (708 mm in Alexandria, 729 mm in Turnu Măgurele). We should notice the rather big difference between the values calculated for the potential evapotranspiration and for the real evapotranspiration, this could be because of the reserve of humidity in the soil, which in Teleormanului plain reaches relatively high values because of the texture characteristics of these soils.

Chart nr. 2 potential and real evapotranspiration (in mm)
(after Clima României, vol.II, 1961)

| ***Staţia*** | Parametrul | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | ***Anual*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Alexandria* | evapotr. potenţială | 0 | 0 | 16 | 52 | 96 | 126 | 146 | 127 | 85 | 46 | 14 | 0 | 708 |
| | evapotr. reală | 0 | 0 | 16 | 52 | 96 | 126 | 82 | 53 | 44 | 40 | 14 | 0 | 523 |
| *Turnu Măgurele* | evapotr. potenţială | 0 | 0 | 17 | 55 | 102 | 129 | 148 | 131 | 86 | 47 | 14 | 0 | 729 |
| | evapotr. reală | 0 | 0 | 17 | 55 | 102 | 113 | 48 | 34 | 35 | 47 | 14 | 0 | 465 |

Chart nr. 3 the surplus and the deficit of water compared to the potential evaporation (in mm)
(after Clima României, vol II, 1961)

| ***Staţia*** | Excedentul de apă | | | | | | | | Deficitul de apă | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lunar | | | | | | | Anual | Lunar | | | | | Anual |
| | XI | XII | I | II | III | IV | V | | VI | VII | VIII | IX | X | |
| *Alexandria* | 0 | 0 | 0 | 14 | 23 | 0 | 0 | 37 | 0 | 64 | 74 | 41 | 6 | 185 |
| *Turnu Măgurele* | 0 | 0 | 3 | 31 | 19 | 0 | 0 | 53 | 16 | 100 | 97 | 51 | 0 | 264 |

We can use the *Martonne aridity index* to identify some climatic features (De Martonne, 1926). This is calculated using the formula:

$$I_{ar} = P / (T+10)$$

In which: *P* – represents *the average yearly quantity of precipitations,*

*T* – represents *the yearly average temperature*

Applying this formula we have got the value 27,31 in Slatina, 24,64 in Roşiori de Vede and 24,56 in Turnu Măgurele. This parameter's values rise slightly from south to north the values in the stations Roşiori de Vede and Turnu Măgurele being characteristic to the forest steppe region and even to some steppe areas, whereas the higher value recorded in Slatina indicates the passage towards the broadleaf forest areas.

***Walter – Leith climate diagram,*** on which the monthly and multi-annual average temperatures are represented as well as the monthly and multiannual average quantities of precipitations, on the scales of *1/2* and *1/3,* clearly show the possibility of drought periods in dertain areas. Among the high risk climatic phenomena characterizing this area these two types of conditions with pluviometric deficit have a special importance, because in the years when these occur and have a longer duration and are more intense, the agricultural production drops dramatically. The dry period represents an iterval of at least 5 consecutive days during which there are no precipitations, while the drought period is at least 10 days long during the warm semester of the year (April-September) and at least 14 consecutive days long during the cold semester of the year (October- March). We have to clarify the fact that the dry periods always precede the drought periods. (V.Sorocovschi, 2009).

By analyzing the climatic diagrams Walter – Leith for the weather stations situated in the vicinity of Călmăţui basin: Turnu Măgurele, Roşiori de Vede and Slatina, we can notice that the duration these phenomena decreases gradually from south to north. Therefore the length of the dry period reaches 4 consecutive months (June – September) in the south of the basin, at Turnu Măgurele and it decreases gradually, towards the north reaching two months and a half (form August until mid-October) in the north of the basin, in Slatina.

As for the periods of drought, although they occur quite frequently in the analysed basin, they are not obvious from the Walter – Leith climatic diagrams mad eon the basis of the multiannual average values, becausse the reduced quantities of precipitations during the years with deficit of humidity, are compensated by the important quantities of precipitations fallen during thew rainy years. If we make this climatic diagram based on the average yearly values, the dry and drought periods are obvious, the studied region being one of the areas with frequent occurenced of dry and drought phenomena, (Bogdan, Niculescu, 1995).

The studies made in time have shown the fact that in th studied region, the maximum duration of drought periods is of 1- 1,5 months, and the weather station Alexandria, situated close to the central part of the basin, the drough periods were recorded in 25 years out of the 50 analysed, which showe the high frequency of occurrence of these phenomena in the region (Toma, 2011). Because the period with deficit of humidity generally coincides with the vegetation period, irrigation is necessary in order to ensure a proper development of the crops.

Under these conditions, we can say that the Călmăţui basin, is one of the most vilnerable regions concerning different types of drought: meteorological, hydrological or pedological. The implications are the more important as this is a region with high agro-productive potential (Croitoru and Toma, 2010).

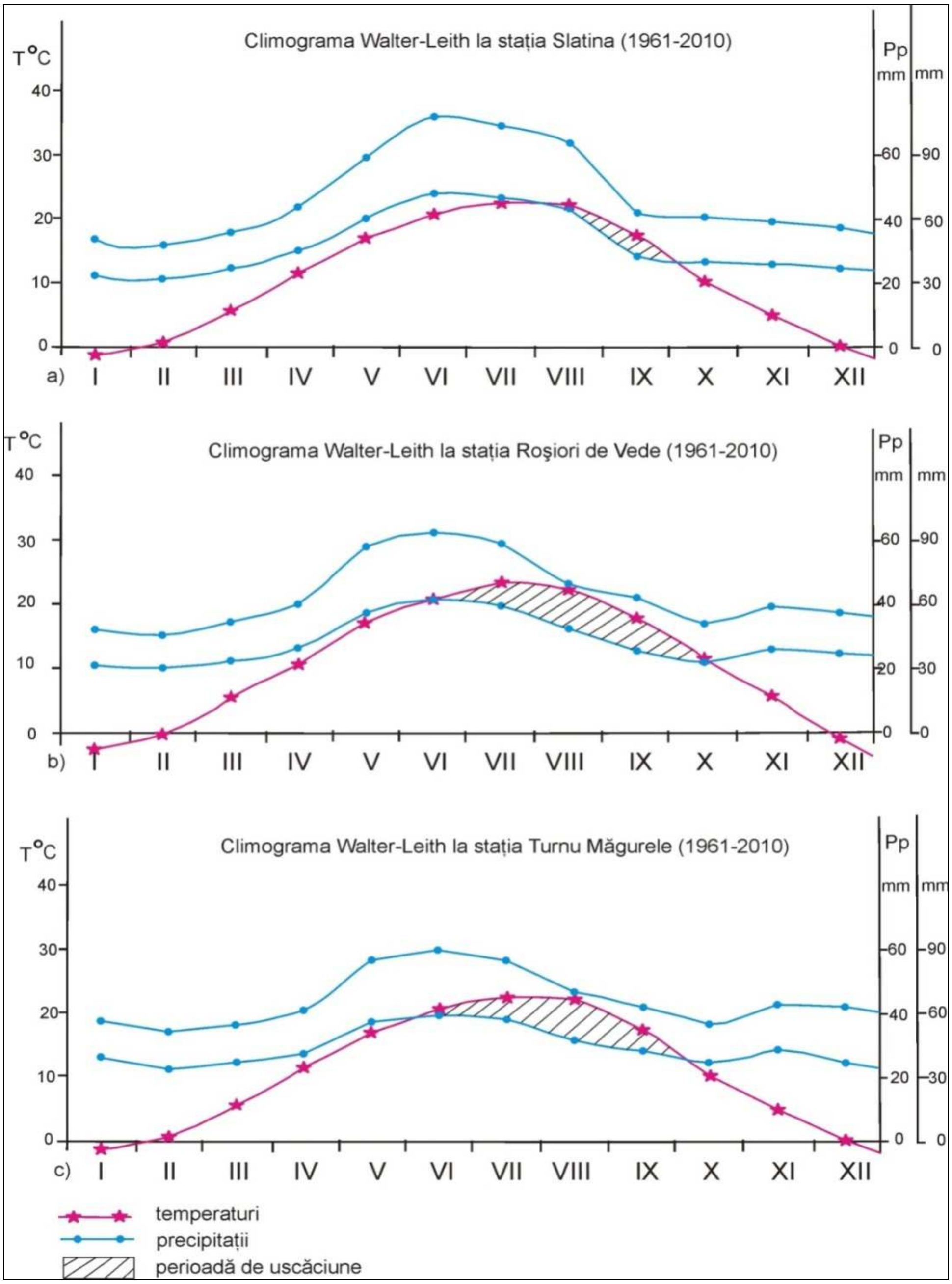


Figure 1 Climatic diagram Walter - Leith in the stations Slatina, Roşiori de Vede and Turnu Măgurele

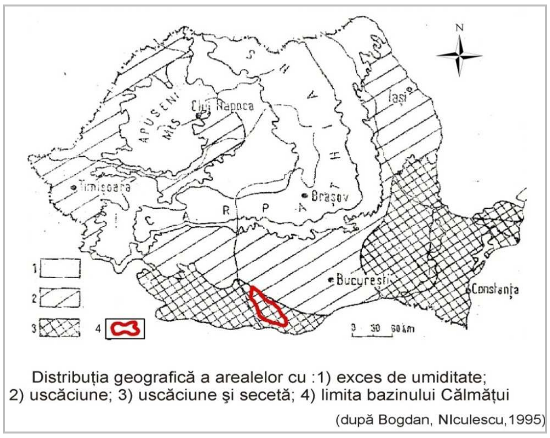


Figure 2 Geographic distributions of the areas with: surplus of humidity, dry and drought

***Peguy** climatic diagram (fig. 3)* ***and Taylor*** *climatic diagram (fig. 4)* based on the values recorded at Roşiori de Vede, point out the characteristics of different months of the year. Thus the winter months the months of March and of November are cold dry months; May June, July and August are warm and wet, while the months of April, September and October are arid and semi-arid months.

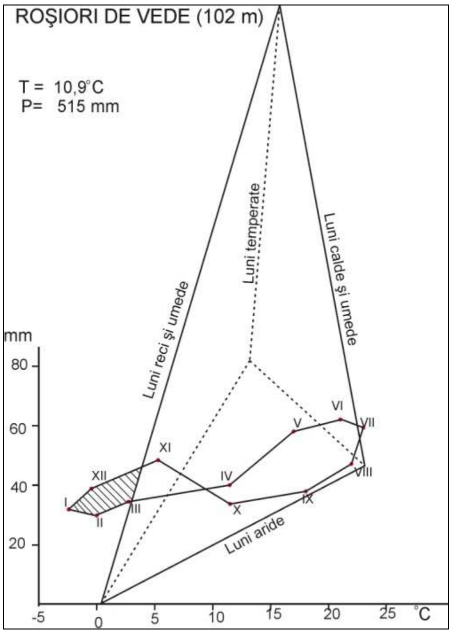


Figure 3 Peguy Climatic diagram at the station Roşiori de Vede

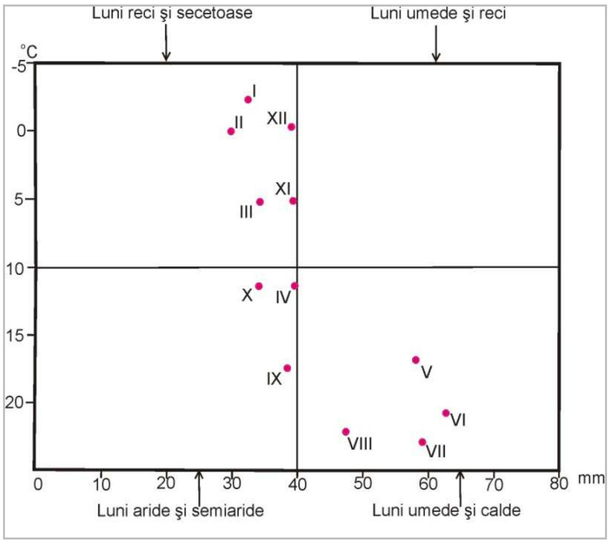


Figure 4 Taylor climatic diagram at Roşiori de Vede

## 4. CONCLUSIONS

The formation of the hydrographic network in the basin of Călmățui river took place gradually and it was closely connected with the emergence of the Boianului Plain and with the establishment of the present course of the Danube river.

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# VIBRATION CONTROL OF COMPLEX SHIP STRUCTURES

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**ABSTRACT**

This paper aims to present the vibration characteristics and vibration control of complex ship structures. It is shown that input mobility of a ship structure at engine supports, due to out-of-plane force or bending moment excitations, is governed by the flexural stiffness of the engine supports. The frequency averaged input mobility of the ship structure, due to such excitations, can be represented by those of the corresponding infinite beam. The torsional moment input mobility at the engine support can be estimated from the torsional response of the engine bed section under direct excitation. It is found that the inclusion of ship hull and deck plates in the ship structure model has little effect on the frequency-averaged response of the ship structure. This study also shows that vibration propagation in complex ship structures at low frequencies can be attenuated by imposing irregularities to the ring frame locations in ships. The structural modifications of the local supporting structures such as engine beds in ships can control the vibration responses of ship structures due to machinery excitations at higher frequencies.

**Keywords:** *Hull structures, vibration response, FEA analysis, wave propagation.*

## 1. INTRODUCTION

An unwanted side effect of building faster and lighter ships is the increasing noise and vibration in ships. In order to retain the full benefit of building faster ships without compromising the ride comfort and safety, effective noise and vibration control needs to be implemented to ship structures. Nonetheless, due to the complexity of ship structures and the coupling of different wave types in the structure, control of wave propagation in ship structures by active control methods is expensive and ineffective, while traditional passive vibration control methods such as adding damping materials is only effective at higher frequencies. Most severe damage to ship structures, however, is caused by large deformation and high dynamic stress concentration from low frequency vibration. The low frequency noise and vibrations also contribute most to discomfort onboard ships. Consequently, alternative methods are sought in this paper to control ship structural vibration in the low frequency range.

Ship hull vibration can be generally classified into two categories, global and local vibrations. For global vibration, the whole hull girder of a ship is vibrating in response to the excitation at particular revolutions of the main engines, propellers and auxiliary machinery, or from water waves. Local resonance can be treated locally by modifying the resonating structural component or by adding vibration absorption and damping devices. Nevertheless, excessive deformation of the ship hull is more likely to come from global vibration, particularly at the first few fundamental modes of the ship structure.

The global vibration of a ship, such as natural frequencies and mode shapes of a complete ship hull structure, is analyzed by strip theory where natural frequencies of the entire ship are calculated from beam theory and the estimation of weight and moment distributions at each strip of the ship hull.

Wave-induced ship hull vibration has also been investigated by Van Gunsteren [8] who calculated the two-node vertical vibration mode of two ship models using a modified strip theory. Accompanying the fast advance of computer technology and the increasing speed and capacity of modern computers, it is now possible to analyze the low frequency dynamic response of a complete ship structure in a three-dimensional model using finite element analysis (FEA). FEA is used increasingly in the analysis and design of complex ship structures [2].

The study of vibration characteristics of rib-stiffened plates provides a general understanding of wave propagation and its control mechanism in ribbed plate structures. However, when the structure becomes complex as in the case of a complete ship hull structure, the complexity of analysis increases due to the coupling of different wave types and multiple wave propagation paths in the structure.

This paper aims to further disclose the fundamental features of ship structural vibration by making use of results obtained from analytical and experimental studies of ribbed plate vibration in conjunction with the FEA method [6], [7]. It is hoped that the study can shed light on understanding the characteristics of vibration and vibration propagation in complex ship structures, and can subsequently lead to an improved vibration control. To this end, input mobilities of a ship structure due to force and moment excitations at engine mount locations are studied.

Another objective of this study is to provide explicit strategies for the control of vibration and vibration propagation of complex ship structures. Two such strategies are proposed. One aims to control vibration energy transmission from vibrating machinery to ship structures. The other aims to control wave propagation in ship structures by utilizing wave confinement phenomenon found in disordered and irregular ribbed structures [4], [5].

## 2. THE FEA MODEL

In the Figure 1 is shown the general profile of a 30-m fast speed crew vessel used in this study. The ship hull is equally divided by ring frames into 30, 1-m long sections. The ship hull structure is made of aluminum and is partitioned by watertight bulkheads into several functional areas, such as accommodation room, utility area, engine room, fuel tank and rudder room. The main stiffness components of the ship hull include keel, engine beds, deck and bottom girders, pillars and ring frames. In the Figure 2 is shown the structural arrangements of these stiffness components in the bottom plan of the ship. The ship is powered by three caterpillar engines (Model 3412E) of 925 hp output power each. The accumulated mass of the ship hull structure alone is about 26 tones (excluding the mass of machinery and fit outs, which has another accumulated mass of 33 tones).
The geometric configuration and the contour of the ship hull structure are well defined by ring frames, 1 m apart and interconnected by the keel and other major stiffness components, such as deck girders, bottom girders and engine beds. Vertical pillars are used to provide vertical support (vertical stiffness) to the ship hull at Frames 5, 8, 14, 18 and 20 (the frame number starts from the first frame close to the bow). The ring frames are meshed by plate elements in the FEA model and are reinforced by rider bars (meshed by beam elements) along their inner perimeter. Other major stiffness components of the ship hull such as keel, pillars, deck girders, bottom girders and engine beds are all meshed by beam elements in the FEA model(s) except those specified elsewhere.

## 3. VIBATION RESPONSE OF SHIP HULL STRUCTURES

### *3.1 Two-node vertical vibration mode of the 30 m ship*

The well-known two-node vertical vibration mode [3, 8] of the 30 m ship hull structure is calculated by utilizing the normal mode analysis provided by the commercial FEA software – MSC/NASTRAN. The 3-dimensional mode shape distribution of the mode is shown in Figure 3. The natural frequency of the two-node vertical mode of the dry (in air) ship hull structure is predicted to be about 13 Hz.

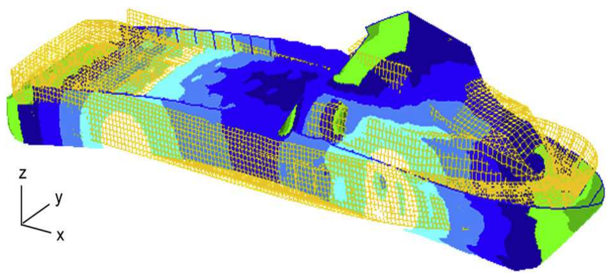


Figure 3 The two-node vertical vibration mode of the 30 m crew vessel

A detailed analysis of the global dynamic of ship structures by FEA is straightforward. However, such analysis is usually very time consuming, particularly the frequency response analysis. To overcome this limitation and to increase the frequency range of the analysis, only the engine room section of the 30 m crew vessel is considered in the subsequent analysis. In addition, the full length of the keel is included in the FEA model so that energy propagation from the engine room section to other parts of the ship structure can be evaluated at the later stage.

### *3.2 Vibration response of the engine room*

The engine room section of the ship structure is bound by two watertight bulkheads – Frames 16 and 23. Two FEA models are considered for this section of the ship structure in the numerical simulation. One comprises only the major stiffness components of the engine room (see Figure 4(a)), the other includes both stiffness components and the hull and deck plates (Figure 4(b)). The full length of the keel is also included in both FEA models. A uniform internal loss factor (h ¼ 0:01) is assumed for all structural components in the simulation. Furthermore, no boundary constraints are imposed on the FEA models, while simply supported boundary conditions are assumed for simple finite structures (such as finite beams) in the analytical models.

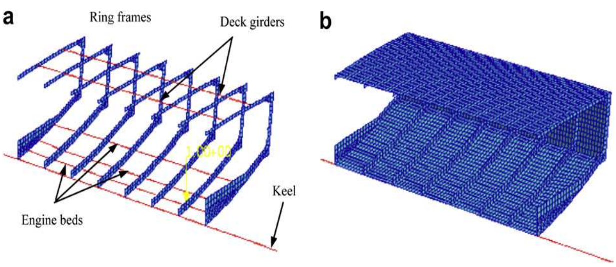


Figure 4 Finite element models of half engine room; (a) stiffness components only; and (b) hull and deck plates included

Characteristics of input mobilities of the ship structure due to each individual excitation are examined in the study. Averaged stiffness values of the corresponding engine bed section from the FEA model are used in the input mobility calculation of the beams due to non-uniformity of the engine beds.

(a) Input mobility of the engine room due to an out-of-plane force excitation

In this simulation, a normal (out-of-plane) point force is applied to one of the mounting positions of the engine bed as shown in Figure 4(a). Input mobilities of the engine support of the two FEA models due to the point force excitation are calculated and shown in Figure 5 together with those of the corresponding beams of finite and infinite extents for comparison. The finite beam used in the calculation is assumed to be simply supported on both ends. The length of the beam (Lx) is based on the section of the engine bed where the cross-sectional area is relatively uniform (3 m long, spans between Frames 16 and 19 to accommodate the entire span of the main engine). The mean cross-sectional area of this engine bed section is used for the input mobility calculation of the finite and infinite beams.

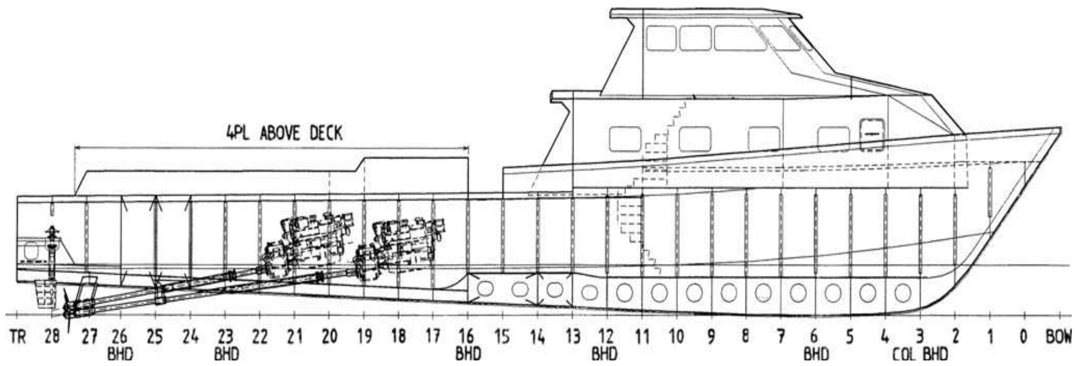


Figure 1 General profiles of the 30 m crew vessel

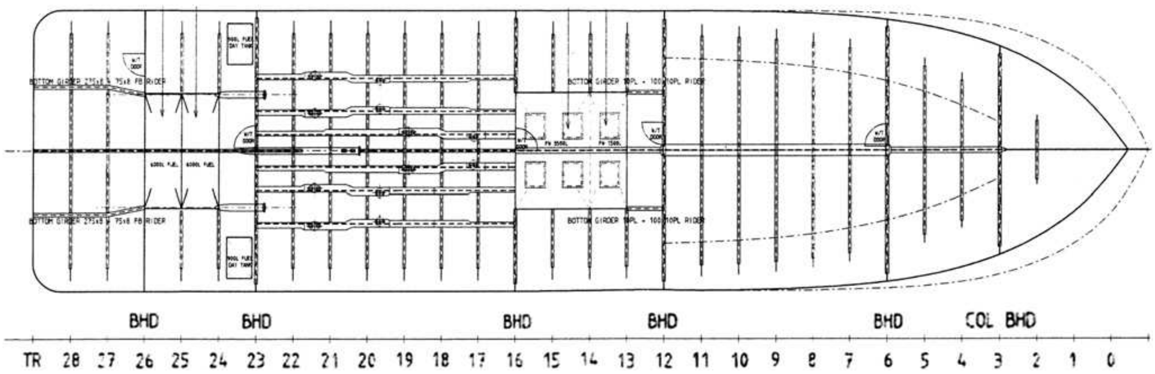


Figure 2 The structural arrangement of the bottom plan of the crew vessel

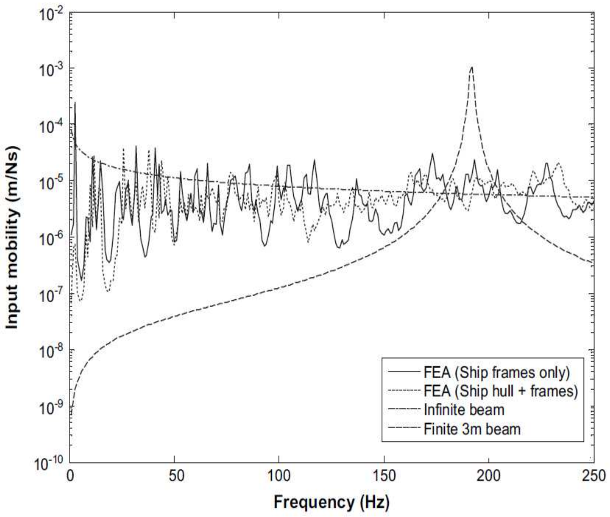


Figure 5 Out-of-plane force input mobilities of the engine bed and the corresponding finite and infinite beams

It is shown that the frequency averaged input mobility of the engine support for both FEA models can be approximated by the corresponding infinite beam. For this excitation, the in-plane stiffness of the ring frames are in the same order of magnitude as the flexural stiffness of the engine bed so that the entire engine bed (spans between Frame 16–23) vibrates as a non-uniform beam. The ring frames behave as regular stiffness and mass attachments to the flexural vibration of the engine bed, and provide additional damping to the long waves in the engine bed via coupling to the short flexural waves in the plate elements of the ring frames. Thus, the frequency averaged input mobility of the engine bed approaches that of the corresponding infinite beam. It is noted that the frequency averaged input mobility of the frame-only model (the model shown in Figure 4(a)) is almost unaffected by the inclusion of hull and deck plates in the model. This indicates that the stiffness term of the input mobility of the ship structure is dominated by the flexural stiffness of the engine bed.

Therefore, it can be concluded that only flexible stiffness of the supporting structures needs to be considered in estimating the out-of-plane force input mobility and vibration energy flow from a vibrating machine to a ship structure in practical applications.

(b) Input mobility of the engine room due to an in-plane force excitation

The input mobility of the engine room section due to an in-plane force excitation applied to one of the engine mount locations is shown in Figure 6 together with those of the corresponding beams of finite and infinite extents. It is shown that the in-plane force input mobility of the engine support is bounded by the input mobility of the corresponding infinite beam and the non-resonant response of a corresponding 3 m long beam except for a few large peak responses at low frequencies. These large peak responses are attributed to resonant responses of the rigid body motions of the engine bed coupled to the flexural stiffness of the ring frames. Each peak response corresponds to a resonant response of an equivalent spring-mass system formed by the rigid body mass of the engine bed and the flexural stiffness of one attached ring frame. These peak responses are largely attenuated when the hull and deck plates are included in the FEA model, due to the increased damping effect of plate flexural vibration to the resonant responses of spring-mass systems. The overall input mobility also shifts up and is close to the input mobility of the corresponding infinite beam when the hull and deck plates are attached to the model attributing to the same damping effect of short flexural waves in the plates.

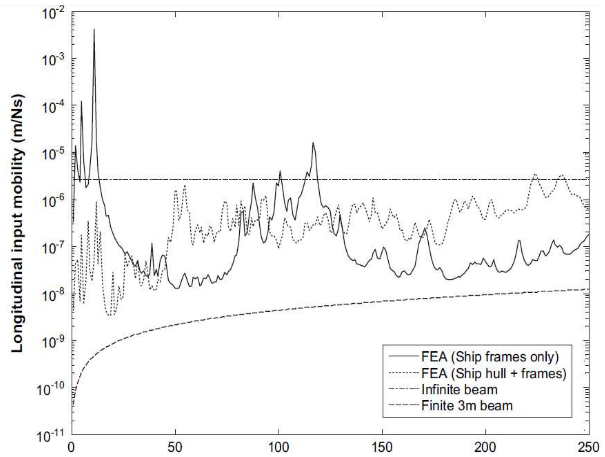


Figure 6 In-plane force input mobilities of the engine bed and the corresponding finite and infinite beams

(c) Input mobility of the engine room to a torsional moment excitation

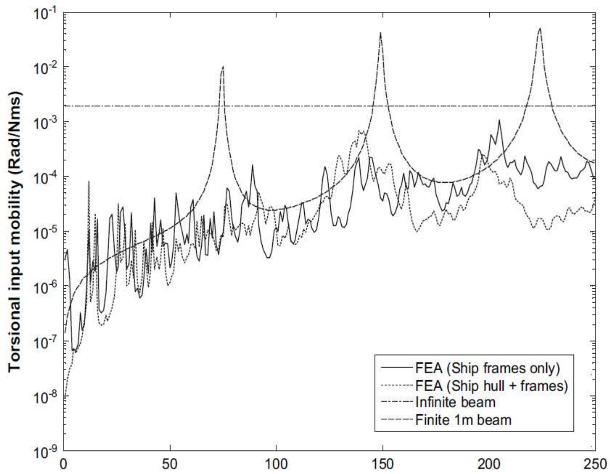


Figure 7 Torsional moment input mobilities of the engine bed and the corresponding finite and infinite beams

In Figure 7 is shows the input mobility of the engine room section due to a torsional moment excitation applied to the engine mount location. The input mobilities of the corresponding finite and infinite beams are also shown in the figure for comparison. Instead of approaching that of the infinite beam, it is found that the frequency averaged input mobility of the ship structure due to the torsional moment excitation can be approximated by the non-resonant response of a corresponding 1 m long beam. This is attributed to the large in-plane stiffness of the ring frames on each ends of the engine bed section under the moment excitation, as compared to the much smaller torsional stiffness of the engine bed. Therefore, the two frames (Frame 17 and 18) bounding the engine bed section behaves as end elastic boundaries to the torsional vibration of the section.

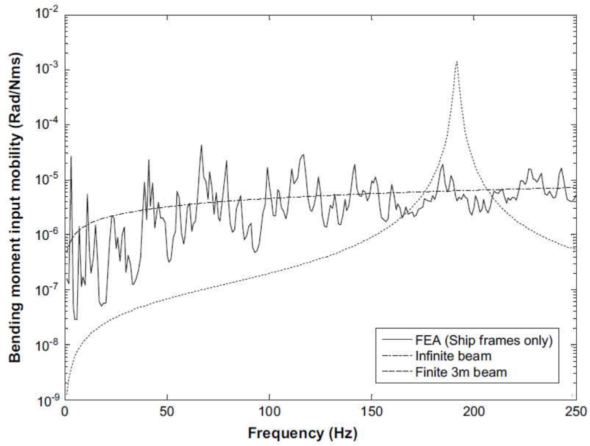


Figure 8 Bending moment input mobilities of the engine bed and the corresponding infinite beam

(d) Input mobility of the engine room due to a bending moment excitation

The stiffness term of the input mobility of a rib or a ribbed stiffened plate due to a bending moment excitation at the rib is dominated by the flexural stiffness of the rib. This is also the case for ship structures as shown in Figure 8 where the frequency averaged input mobility of the ship structure excited by a bending moment applied to the engine bed can be approximated by that of the corresponding infinite beam in the entire frequency range of interest.

## 4. VIBRATION CONTROL OF SHIP STRUCTURES

Passive vibration control in ship structures can be generally classified into three categories according to locations where the control technique is applied: (a) vibration control at source locations; (b) control of wave propagation in ship structures; and (c) vibration control at receiver locations. Vibration control at receiver locations can be achieved by applying the traditional passive control methods, such as adding damping materials to the structure or using vibration isolators to stop the vibration from reaching the equipment at receiver locations. Vibration control at source locations (i.e., the mounting locations of engines, generators) is usually achieved by using vibration isolators (i.e., machine mounts). Vibration in complex ship structures can also be controlled along the wave propagation paths. The last two control strategies are examined in this study.

### *4.1 Vibration control by structure modifications of the engine bed*

In this simulation, the engine bed section bounded by Frames 17 and 18 is re-meshed by plate elements in the frame-only FEA model to enable structural modifications of this section of the engine support. It has been shown in Section 3 that the input mobility at engine supports due to mechanical excitations is governed by the stiffness of local supporting structures. Therefore, energy flow from a vibrating machine to the ship structure can be controlled by modifying the stiffness of the local supporting structures (i.e., engine beds) at source locations. In this regard, five structural modifications are proposed here, and are shown in Figure 9. The depth of the engine bed section under modification (bounded by Frame 17 and Frame 18) varies from about 650 mm to 850 mm. In the first modification, the girder thickness of the engine bed section under direct excitation is enlarged from 16 mm to 24 mm (Figure 9(b)). In the second modification, the rider bar thickness of the engine bed is increased from 20 mm to 30 mm (Figure 9(c)). In the third modification, two 10 mm thick aluminum plates are attached onto the edges of the rider bar of the engine bed to form a box shape structure (Figure 9(d)). In the fourth modification, the two plates are attached onto the junction between the rider bar and the girder of the engine bed to form a triangular shaped structure (Figure 9(e)). The two plates are attached onto the engine bed to form an inverse triangular shaped structure in the last modification (Figure 9(f)).

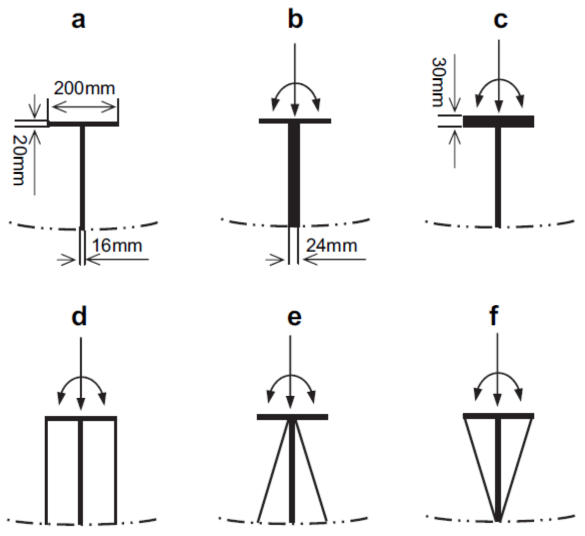


Figure 9 Plans of structural modifications of the engine bed section under direct excitations;
(a) before modification;
(b) Plan 1;
(c) Plan 2;
(d) Plan 3;
(e) Plan 4;
(f) Plan 5

The point force and torsional moment input mobilities of the engine support, before and after the modifications, are shown in Figures 10 and 11, respectively. All modifications are found to be ineffective at frequencies below the one-third octave band centered at 63 Hz due to the long wavelength of the engine bed in the low frequency range when compared to the length of the modified engine bed section (1 m long). As the frequency increases, the modifications are more effective. It is found that Modification 3 has effectively increased both bending and torsional stiffness of the engine bed, and is the most effective modification within the five plans. Modifications 2 and 5 also have good control performance in the torsional moment excitation case, and have moderate effect on the point force input mobility of the ship structure. The overall control performance of other two modifications (1 and 3) to input mobilities of the engine support is less effective, particularly in the moment excitation case.

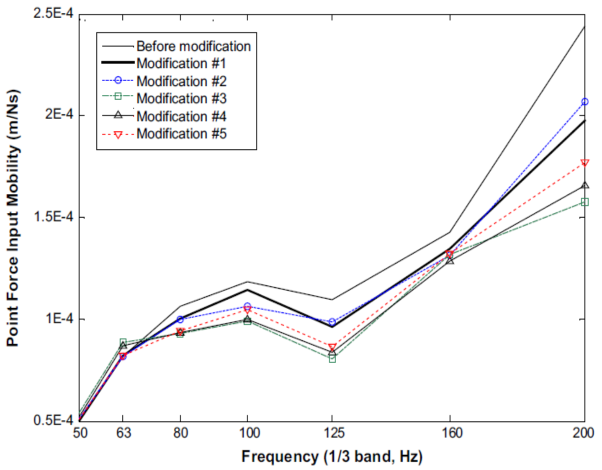


Figure 10 Point force input mobilities of the engine bed before and after modifications

The results presented herein illustrate that power injection by vibrating machinery to a ship structure can be reduced by proper designs or by structural modifications of the local supporting structure in ships. This finding is useful for naval architects and vibro–acoustic engineers in combating the long existing noise and vibration problems onboard ships.

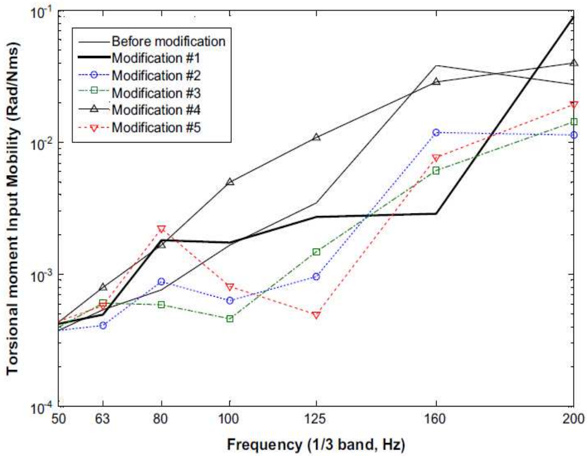


Figure 11 Torsional moment input mobilities of the engine bed before and after modifications

*4.2 Control of wave propagation in ship structures*

It has been shown in Figures. 10 and 11 that structural modifications at source locations to vibration control of ship structures are ineffective at very low frequencies. It is common knowledge that traditional passive control methods such as adding damping materials are also ineffective in the low frequency range. Control engineers today are increasingly using active control methods for vibration control at low frequencies. Although active control can be employed for the attenuation of vibration transmission from machinery to their structure foundation, it has limited applications in the control of wave propagation in complex ship structures due to multiple wave propagation paths and the coupling of different wave types in the structures.

In Section 3 it has been demonstrated that wave propagation in ship structures due to machinery excitations of the supporting structures is dominated by the long wave propagation in the major stiffened beams (i.e., the keel, engine beds, and girders). As a result, vibration propagation in a ship structure away from the source section (i.e., the engine room) could be controlled if wave propagation in the stiffened beams can be attenuated. Furthermore, because major stiffness components of a ship structure are supported regularly by ring frames at equal intervals, wave propagation in these stiffness components should demonstrate periodic characteristics similar to those of periodic supported structures.

The frame-only model of the engine room (see Figure 4(a)) is employed in this simulation together with the additional ring frames – Frames 9–16. In the first simulation, Frames 9–16 are 1 m apart from each other (the periodic case). In the second simulation, Frame 15, 13 and 11 are moved to the left by 0.1 m, 0.2 m and 0.3 m, respectively, from the corresponding periodic locations (the disordered/ irregular case). In Figure12 are shown the schematic illustrations of these two FEA models. The seven keel sections divided by Frames 9–16 are assigned the serial numbers (1–7) as shown in Fig. 12(a).

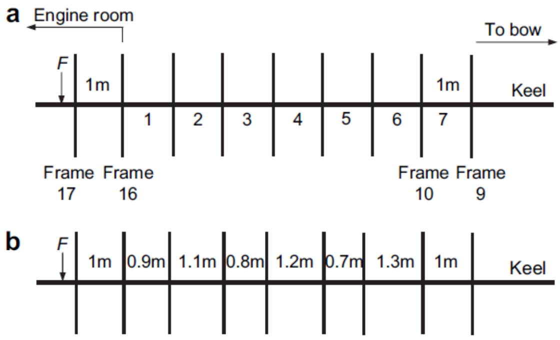


Figure 12 Schematic illustration of the ship hull section in the FEA simulation;
(a) Regularly supported keel;
(b) Irregularly supported keel

The periodic characteristics and vibration confinement of the ship structure are studied here by the kinetic energy distributions in the keel sections shown in Figure 12. The kinetic energy distribution of each keel section in one of the three translational directions (one in-plane and two flexural vibrations) in the FEA model is calculated by:

$$\left\langle \overline{T} \right\rangle_z = \frac{1}{2} \sum_{i=1}^{N} L_{ei} A_{ei} \rho \left| \frac{v_{z(i-1)} + v_{zi}}{2} \right|^2 \tag{1}$$

where $L_{ei}$ and $A_{ei}$ are the length and cross-sectional area of the $i^{th}$ element. N is the number of elements in each keel section. $v_{zi}$ is the velocity response in the z-direction of the $i^{th}$ node in each keel section.

The vibration energy of the keel section with respect to the other two coordinate directions can be calculated by replacing the subscript z in Eq. (1) by x or y.

The kinetic energy distributions of the odd numbered keel sections due to flexural vibration in the force direction (z-direction) in the periodic case are shown in Figure 13. It is shown that the vibration energy is not attenuated at frequencies below 100 Hz as wave propagates away from the engine room (the source section) attributing to the long flexural wavelength of the keel in this frequency range. The result also confirms the ineffectiveness of a damping treatment (a moderated damping value of 0.01 is assumed for all structure components in the simulation) to the ship vibration control at low frequencies. The typical ‘‘stop/pass band’’ of a periodic structure can be observed at frequencies above 100 Hz. The attenuation at frequencies above 100 Hz is attributed to the combined effect of periodic attenuation and structural damping. In addition, the non-uniform configuration of the stiffness components also contributes to the energy attenuation in the response. Similar results are found for waves propagating in the other two translational directions.

In the second simulation, the keel is no longer supported regularly by the ring frames (see Figure 12(b)). The effect of the irregularity is studied by comparing the kinetic energy of section 7 of the keel to that of the same section in the periodic case, which is shown in Figure14.

It is found that most peak responses at very low frequencies are attenuated by the irregularity, even though only a number of ring frames are moved from their respective periodic locations. The vibration confinement could be extended to modes at higher frequencies if more ring frames are shifted from their respective periodic locations.

## 5. CONCLUSIONS

The general features and the control mechanism of input mobilities of the engine room section of a 30 m long crew vessel to point force, moment excitations applied to one of the engine mount locations are investigated in this study. It is shown that the input mobilities of the ship structure due to point force or moment excitations on the engine mounts are mainly controlled by the stiffness of the engine bed. The inclusion of the ship hull and deck plates in the ship structure model only increases the damping to the long wave propagation in the major stiffened beams (i.e., engine beds, keel), and has little influence on the frequency averaged vibration response of the ship structure. Therefore, these plate panels can be neglected in the analysis of ship vibration response under mechanical excitations.

Energy flow from the vibrating machinery to the ship structure and the kinetic energy propagation in the ship can be estimated from the knowledge of simple structural components such as engine beds and the keel.

Two vibration control approaches are presented in this paper to control vibration in ship structures at low frequencies. In the first approach, five structural modifications are introduced to control the vibration energy transmission from a mechanical excitation source to the ship structure. It is found that energy flow from a

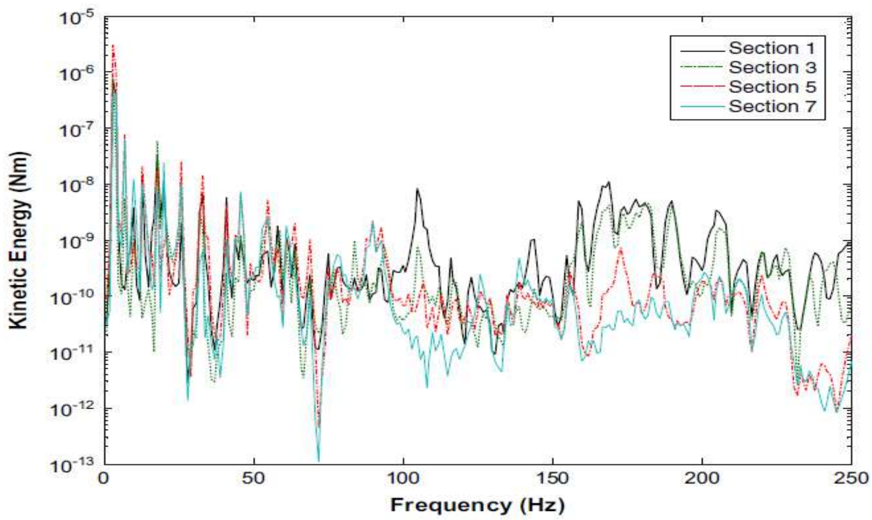


Figure 13 Kinetic energy distributions of the odd number keel sections due to flexural vibration in the direction of force excitation

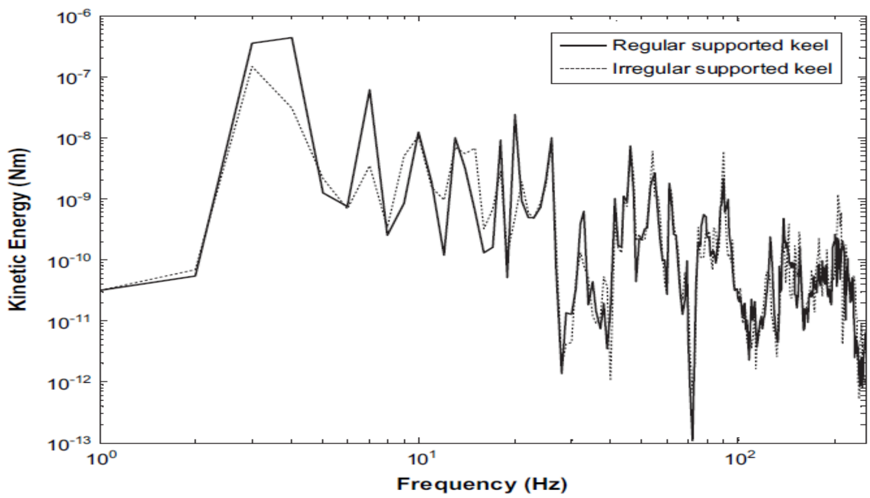


Figure 14 Kinetic energy distribution of Section 7 in periodic and irregular supported case

mechanical source to the ship structure can be controlled by modifying only a section of the local supporting structures.

In the second approach, vibration confinement in complex ship structures is examined by imposing irregularities on the ring frame locations in ships. It is shown that the modal responses for most modes at low frequencies can be attenuated by moving a small number of ring frames away from their respective periodic locations.

The result presented in this work is meaningful for the vibration control of ship structures at low frequencies where active and traditional passive control methods have had little success. The work has significant implication for the design of a quieter and faster ship.

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# ENERGY ANALYSIS BY NUMERICAL SIMULATION FROM A FAMILY HOME

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**ABSTRACT**

Although methods of using renewable energy are knows all over the world (biomass, solar, wind, geothermal and hydro), so far only a relatively small fraction of the technical and economic potential of renewable energy is being used today. Investments in renewable energy and energy efficiency represent an important solution for environment and for economic crisis that Europe and the world at large are facing today.

This paper presents the evaluation of renewable energy potential use for an independent house. The house uses a system comprising photovoltaic panels and solar panels. When there is surplus of electricity supplied from panels, this extra energy is stored in batteries to be used during not producing periods. We also use a solar thermal collector for thermal energy. The energy required for the home is used for household's appliances, for heating and for domestic hot water. Local real weather data are used in the modelling.

**Keywords:** *Renewable energy, solar thermal collector, photovoltaic panels, solar energy.*

## 1. INTRODUCTION

The solar energy has an important interest in present in the entire world [1] [2]. Renewable energy technologies produced by solar energy can bring a revolution in the life style and growing standards of people in remote areas.

Buildings represent an important part of European culture and they play an important role in the energy policy of Europe. Studies have shown that saving energy by using solar installation (solar panels, photovoltaic panels) is the most cost effective method to reduce greenhouse gas emissions. It has also pointed out that buildings represent the biggest and most cost effective potential for energy savings. The reduction of 26% energy use is set as a goal for buildings by the year 2020 which corresponds to 11% of the reduction of total energy use in European Union (EU) countries [3].

Numerous researches and development programs in this domain have been carried out to improve the applications of solar energy systems. More design of photovoltaic thermal solar water based collector has been proposed in the past. The first person was Martin Wolf, in 1976, which analyzed the performance of combining the heating and photovoltaic power systems for residences and conclude that the system was technically feasible and cost effective [4]. Zondag examined the various concepts of combined PV-thermal collector technologies [5], also Chow and Pie have analyzed hybrid photovoltaic and thermal (PV/T) collectors which are introduced simultaneously generate electricity and thermal power [6].

In this paper we study a method for electricity and heat needed for a house. For electric energy supply we use a system of photovoltaic panels (PV) and for thermal energy supply are used solar thermal collectors (T).

At the beginning of the paper is presented the type, the size and the location of the House, and then are made energetic analyses for heating and electricity supply.

Basic concept of building energy simulation is given on the Fig.1.

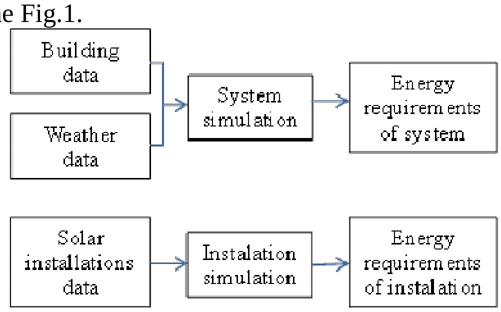


Figure 1 Basic concept of the power plant energy consumption simulation of the building

The obtained results by the system used for Home are analysed and interpreted.

## 2. DATA ON BUILDING

The building is situated in Braga at 41.54º latitude and 8.44º longitudes at ground level and has two bedrooms, one bathroom, a living room, a kitchen and two halls represented in Table 1.

Table 1. Home area

| Accommodations | Area A [m²] | High [m] |
|---|---|---|
| Hall 1 | 5 | 2.6 |
| Hall 2 | 5 | |
| Bathroom | 7 | |
| Kitchen | 14 | |
| Bedroom 1 | 14 | |
| Bedroom 2 | 16 | |
| Living room | 23 | |
| Total area | 84 [m²] | |

The house is considered as a home for four people.

## 2.1 Hot water consumption

Total requirement of hot water for four people which use utilities like washing dishes, washing machine, or for bath with a specific flow for a person:

$$q_s = 50 \ l / person \ on \ a \ day$$

is:

$$N = q_s \cdot nr. \ person = 200 l / day$$

For water consumption, it took into account the provisions of STAS 1343 and 1478.

We considered that the hot water has average temperature of 45ºC.

Distribution of hot water consumption during 24 hours is shown in Fig. 2.

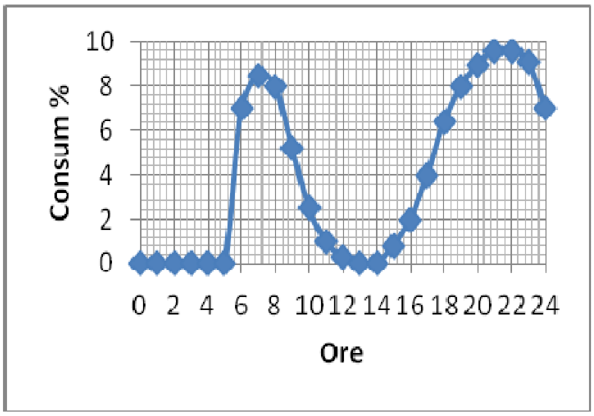


Figure 2 Distribution of hot water consumption for a day

Note that high consumption of domestic hot water is between the hours 06:00-08:00 and 21:00-22:00.

## 2.2 Electricity consumption

For energy consumption we used a program (Edp web page) that simulates the potential energy for each room of the building [7].

Consumers can be divided into five distinct categories:

- Lighting
- Household Appliances
- Conditioning (Heating/Cooling)
- Communication systems
- Devices

During the winter and summer seasons, we schedule the time of using the consumers for electricity in every day used in every room of the house, as can be seen in Fig. 3.

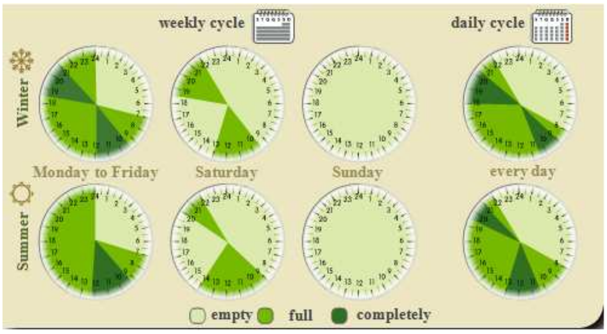


Figure 3 Daily cycle of electricity distribution in summer and winter seasons for home.

We can see that in some days consume is higher than the others days especially between Monday to Friday. In weekend consume is lower.

In Table 2 are presents the main consumers with their energy consumption.

Table 2 The main electronics and appliances.

| Nr. crt. | Name of the device | Nr. of devices | Nominal power [W] |
|---|---|---|---|
| 1. | Fluorescent lamps | 7 | 75 |
| 2. | TV | 3 | 90 |
| 3. | PC | 1 | 250 |
| 4. | Printer | 1 | 90 |
| 5. | Scanner | 1 | 70 |
| 6. | Washing machine | 1 | 1600 |
| 7. | Refrigerator | 1 | 100 |
| 8. | Electric oven | 1 | 2500 |
| 9. | Air conditioning | 1 | 1800 |
| 10. | Telephone exchanger | 2 | 5 |
| 11. | Iron | 1 | 800 |
| 12. | Vacuum cleaner | 1 | 1250 |
| 13. | Other home appliances (juicer, blender, hair dryer etc.) | 1 | 2100 |

For the house needed we considered all the equipment required, as electric device like TV, PC, light, fridge, washing machine, air conditioning etc.

The selected consumers for power consumption necessary for the house are presented in Fig. 4, 5.

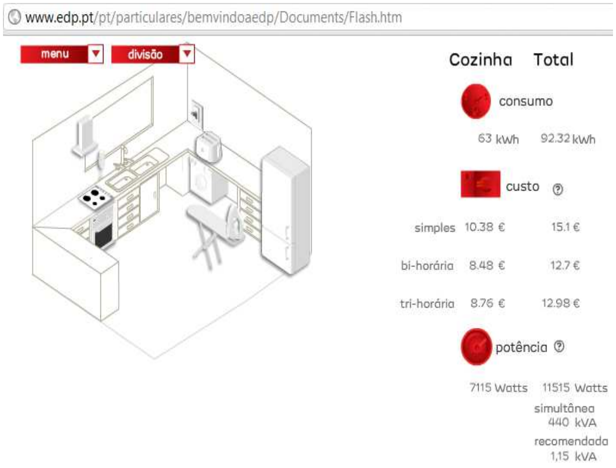


Figure 4 Total consumption for kitchen

In one month the electricity consumption for kitchen is in average of 63 kWh. We can conclude that the most activities are made in kitchen like cooking (preparing food), washing dishes, cloths, ironing clothes, etc.

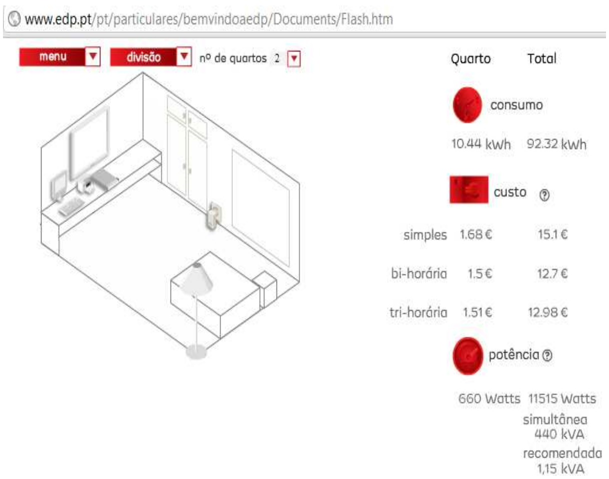


Figure 5 Total consumption for bedrooms.

For bedrooms electricity consumption is in average 10.44 kWh. The total house consume is 92.32 kWh in a month by using the utilities with a power of 11515 W. The consumption of the house it is divided by each room depending on electronics and appliances used during the month Fig.6.

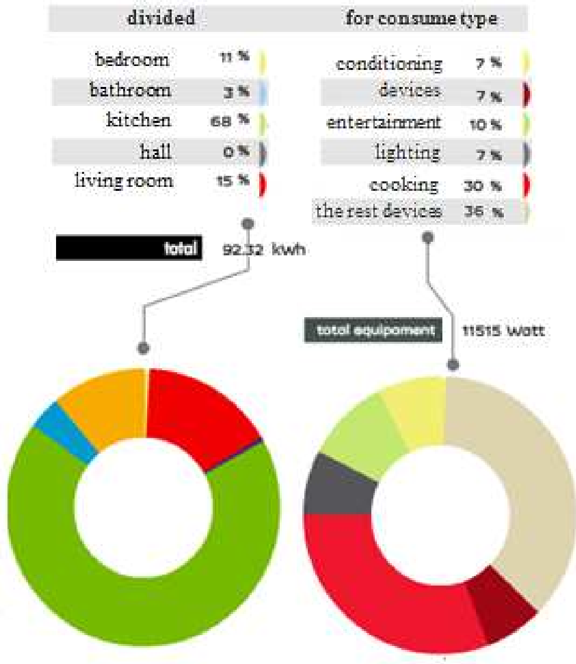


Figure 6 Energy consumes for each room and for consumes type.

In the kitchen are found the most consumers of electricity use by family. The cooking has an important role in ordinary day life with an activity of 30% per month.

## 3. THE SOLUTION

Solar energy can be adapted in two distinct ways like: for the heating of water for domestic use and for the production of electricity. For this we use a system formed with solar thermal collectors and photovoltaic panels.

To use the corresponding installation it is necessary to take into account some factors that may influence. One factor is temperature variation on the entire season in Braga (Fig.7). Data on climate conditions is used in the modelling.

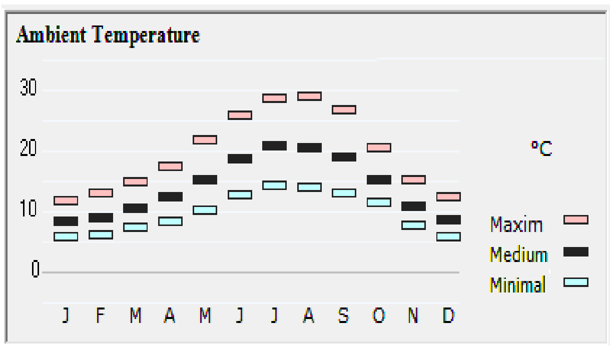


Figure 7 Variation of temperature during the entire year.

Other factor is solar radiation on the horizontal surface. The radiation reaching the Earth's surface is divided into direct and diffuse radiation presented in Fig.8.

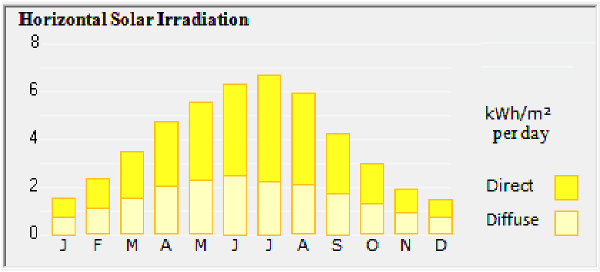


Figure 8 Monthly average daily radiation on horizontal surface.

For heating and for domestic hot water we used a thermal collector Junkers FCB – 1S presented in Fig.9.

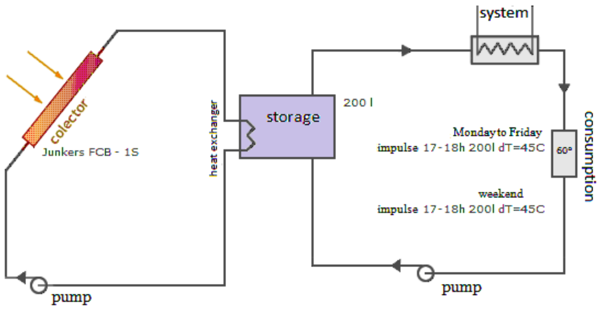


Figure 9 Solar thermal collector

The collector heats the water in storage of 200 litres with an external area of 2.70 m2. Heat losses from storage are 2.7 W/K. The parameters of solar collector are presented in Table 3.

Table 3. Specific parameters of Junkers collector

| | | | |
|---|---|---|---|
| Junkers FCB-1S | Aria 1.95 $m^2$ | Efficiency $\eta_0$=0.69 | Inclination $36^0$ |
| $a_1$=4.174 $W/m^2/K$ | $a_2$=0.0168 $W/m^2/K^2$ | Power 1.4kW nominal | Position Azimuth – South |

Generally we can know the values under more angles of incidence of the collector presented in Fig.10. For orientation of collector we need an electric system which is expensive and hard to implement.

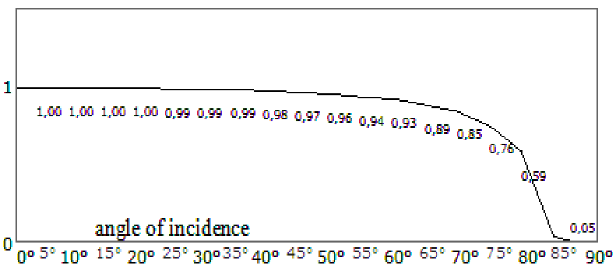


Figure 10 Solar fraction obtained from angle of incidence

For thermal collector will not use this system.

For electricity we used photovoltaic panels Siemens M75S formed by monocrystalline silica. Total aria of panels is 13.3 $m^2$ and is formed by seven groups with three modules for each other.

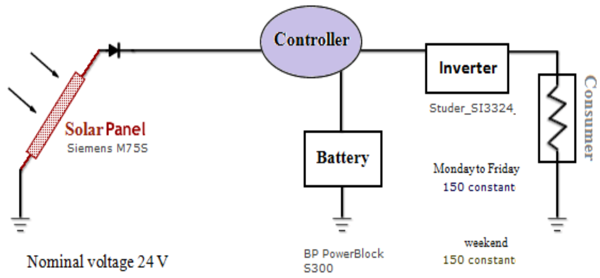


Figure 11 Photovoltaic panels system

The electricity is stored in forty-four accumulators grouped in series of two batteries and has average autonomy of operation in 16.8 days for winter and efficiency of cycle charge/upcharge 80%. Internal resistance is 1.11mΩ and nominal voltage is 2V.

Table 4. Specific parameters about Siemens Panels

| | | | |
|---|---|---|---|
| **Siemens M75S** | Area 0.63 $m^2$ | Inclination $34^0$ | Azimuth – South |
| Max Voltage 17V | Max Current 4.4A | Nominal Power 74.8W | Cells resistance 308Ω |
| Number of modules | | N=21 | |

## 4. RESULTS

For photovoltaic panels we obtain a good level of concentration in each period of the months.

The results are presented in Table 5.

Table 5. Energy analysis of solar panel

| | E(rad) kWh | E(PV) kWh | E(exc) kWh | E(sist) kWh |
|---|---|---|---|---|
| **January** | 339 | 32 | 2 | 20 |
| **February** | 644 | 63 | 19 | , |
| **March** | 1182 | 117 | 68 | , |
| **April** | 1677 | 164 | 117 | , |
| **May** | 1787 | 173 | 125 | , |
| **June** | 1864 | 177 | 131 | , |
| **July** | 2144 | 201 | 154 | , |
| **August** | 2084 | 196 | 147 | , |
| **September** | 1525 | 144 | 98 | , |
| **October** | 1038 | 100 | 53 | , |
| **November** | 483 | 46 | 8 | 10 |
| **December** | 265 | 24 | , | 25 |
| **Annual** | 15030 | 1435 | 837 | 65 |

There is a problem in winter when the system is not so efficient. The solution could be the national grid. In the months with high electricity produced the system could pass the energy to national grid.

Solar panel produces a good quantity of thermal energy presented in Table 6.

Table 6. Energy analysis of thermal collector

| | Horiz.Rad. kWh/m² | Inclin.Rad. kWh/m² | Deliv. Energy kWh |
|---|---|---|---|
| January | 49 | 80 | 72 |
| February | 67 | 97 | 82 |
| March | 108 | 132 | 110 |
| April | 142 | 155 | 131 |
| May | 172 | 171 | 147 |
| June | 189 | 180 | 157 |
| July | 206 | 200 | 183 |
| August | 184 | 194 | 185 |
| September | 128 | 150 | 145 |
| October | 93 | 128 | 119 |
| November | 59 | 93 | 83 |
| December | 46 | 79 | 68 |
| Annual | 1443 | 1659 | 1482 |

Productivity : 760 kWh/[m² colector]
Global annual system efficiency : 46%
Solar Fraction : 38,8%

This collector can produce enough thermal energy for each mouth.

In winter the system could have internal damages because of low temperatures (under zero degrees). The water used like thermal fluid (inside the pipe) will freeze and the pipes will dilate. The solution is to mix water with an anti-coagulant (Table 7.).

Table 7. Proprieties of water - anti-coagulant mixture [8]

| anti-coagulant (% in volume) | freezing temp. (°C) | boiling temp. (°C) | $c_p$ (J/kg·K) |
|---|---|---|---|
| **0** | 0 | 100 | 4187 |
| **5** | -1 | 100 | 4150 |
| **10** | -3 | 100 | 4108 |
| **20** | -8 | 101 | 4039 |
| **30** | -15 | 102 | 3934 |
| **40** | -25 | 103 | 3785 |
| **50** | -35 | 105 | 3633 |

The increase of the fluid flow will increase the heat transfer as well as the consumed power obtained by the pump.

## 5. CONCLUSIONS

Like the other renewable energy systems, photovoltaic panels and solar thermal collector minimizes the environmental effects and helps to reduce our dependence on foreign fuel.

The application presented, may be used to perform successful thermo-electrical tests for a single-family housing, by calculation of electrical and thermal energy needed for heating and domestic hot water as well as highlighting some important parameters influence on the heat requirement.

This solar system can substantially reduce the cost of electricity from the network and will permit application of these solar systems for individual home energy services.

The cost of production for the home may vary and can further be reduced.

## 6. ACKNOWLEDGMENTS

The work of this paper was supported by Project SOP HRD – EFICIENT 61445/2009.

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# EVALUATION OF SOLAR FRACTION FOR A PASSIVE SOLAR SYSTEM

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**ABSTRACT**

In this paper is illustrated a method to calculate the solar fraction for a solar thermal system with specific data. The installation is formed for a solar flat collector, a water storage tank, a heat exchanger, and two water pumps. The results of simulation for solar system are realised for producing hot water for a family. The mathematical model is used and evaluate for the annual variation of the solar fraction. Different parameters and specific data are for Bracanga, a Portuguese city.

**Keywords:** *Solar fraction, solar system, solar energy, collector area.*

## 1. INTRODUCTION

Solar fraction has become an inappropriately popular measure of the performance and desirability of passive solar systems. During the 1970s Klein, Duffie and Beckmann have developed method f-Chart using a simulation with TRNSYS software, establishing the link between design of dimensionless parameters and solar fraction (ratio between energy supplied by the solar system and the requirements of system energy) [1].

The solar collector it is important for estimating the solar fraction. In the last decades many researchers have studied and developed more solar collector or improving that which exist [2]-[4]. For example Zhang and Yamaguchi, have made a study of a solar collector using $CO_2$ as working fluid. They obtain annually-averaged collector efficiency above 60%, which is much higher than that of water solar collector. In that study they show the difference between the potential of $CO_2$ solar collector in the field of solar thermal collector [5].

It is important to know the dimension of water tank. Researcher have studied the effect between water tank and collector, and they took into account the variation of temperature and solar radiation [6], [7].

This paper shows the results of simulations of solar fraction carried out in order to investigate a particular type of solar system. The mathematical model takes into account daily and yearly variations of ambient temperature and solar radiation from Bracanca, Portugal.

## 2. SYSTEM CONFIGURATION

The diagram of the solar system modelled is shown in Figure 1. It consists of a flat plate solar collector, a water-storage tank, a heat exchanger, a source of auxiliary energy, and two water pump.

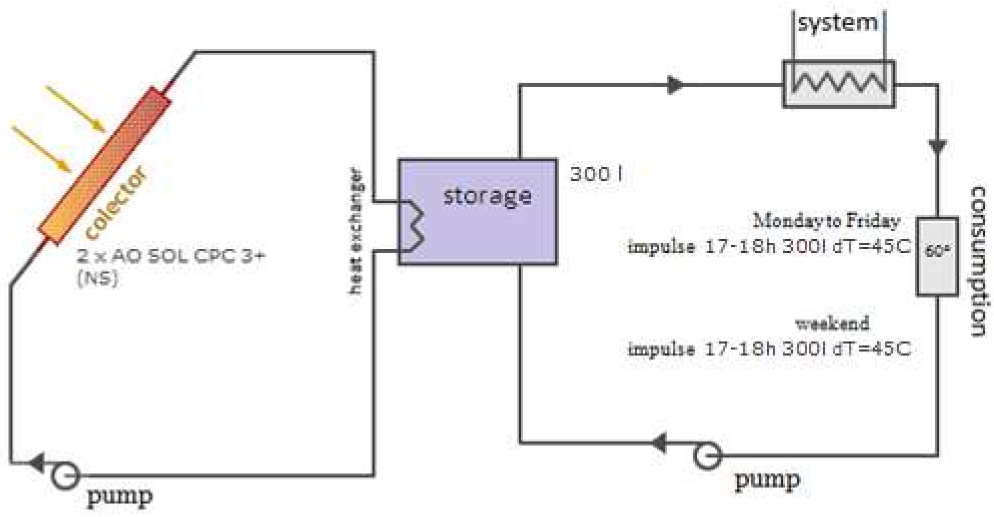


Figure 1 Schematic diagram of the AO SOL system

The solar collector collects solar energy and heats the circulating water that flows through it. The circulating water from the collector enters the heat exchanger installed inside the storage tank where it gives its heat to the storage tank water and then returns to the solar collector where it is heated again by solar energy. The storage tank contains water that accumulates heat obtained from the heat exchanger. The cold water enters the storage tank at the bottom, and the supply hot water exits from the top. The supplied hot water may be cooled before directed to the house for use (45 °C). Cooling is performed with the mixing device by adding cold water from the mains as shown in Fig. 1. The temperature of the water in the storage tank it is maintain lower than 60o with an electric resistance.

The collector area of the system have 4 m$^2$, storage tank have 300 l, requiring a temperature of 45°C, and a variable consumption profile for typical summer and winter days. Auxiliary energy is not necessary.

In typical winter day, the storage tank temperature rises from about 60°C. The concentration level of solar flux for the solar system was determined for average sun energy on of 750W/m².

The productivity of a solar collector is conferring by his efficiency ($\eta$). Efficiency is the relationship between energy received by the fluid and the incident solar energy.

$$\eta = \eta_0 - K\frac{T_{use} - T_{load}}{I} \tag{1}$$

Where: $\eta_0$ – optical efficiency, K - loss coefficient obtain for Table 1, $T_{use}$ – maximum water tank temperature, $T_{load}$ - temperature which enter in the system, I - global radiation which is provide in Table 3.

The coefficients characterising of the solar system are specified in Table 1.

Table 1 Specific parameters of solar collector

| **AO SOL CPC3** | **Aria 4m$^2$** | **Efficiency $\eta_0$=0.74** | **Inclination 30°** |
|---|---|---|---|
| Loss coefficient K=4 | Tank storage 300l | Nominal power 2.8kW | Position Azimuth 15° |

The efficiency curve of the solar collector for an inclination of α= 30° is shown in Fig. 2.

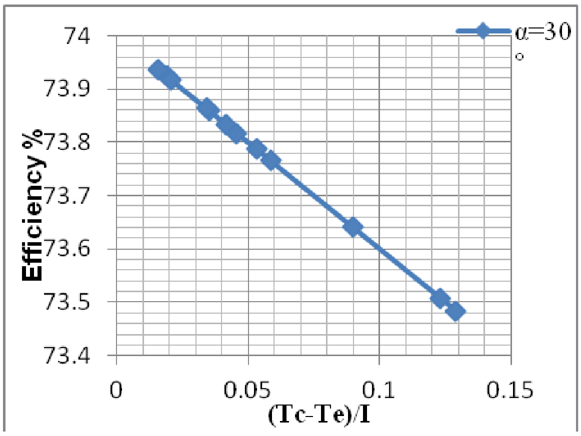


Figure 2 Efficiency of collector

The temperatures were considered for each month and correspond to the mean month water supply temperature. The total thermal energy requirement for the collector is reasonably constant for entire year.

*2.1 Calculation of thermal load*

To calculate the area of capture solar energy we have to estimate the heat needed, so the thermal load.

Daily thermal load is calculated from the equation:

$$Q_{CT} = V \cdot \rho \cdot c_p \left(T_{use} - T_{load}\right) \tag{2}$$

Where V – storage tank volume, $\rho$ – density of water (=1000kg/m$^3$), $c_p$ – specific heat of water (=4.187kJ/kg·K),

## 3. METHOD F-CHART

F-chart method is based on the calculation of monthly solar fraction. This fraction represents the ratio between the energy harnessed from the Sun and the energy needed for heating the house ( $f = Q_{sun}/Q_{CT}$ ).This method was developed for modelling numerical models of solar thermal systems, involving climate data, that can be use in Portugal.

Hot water distribution of consumption during 24 hours used for house is presented in Fig. 3. We considered that the hot water has average temperature of 45ºC.

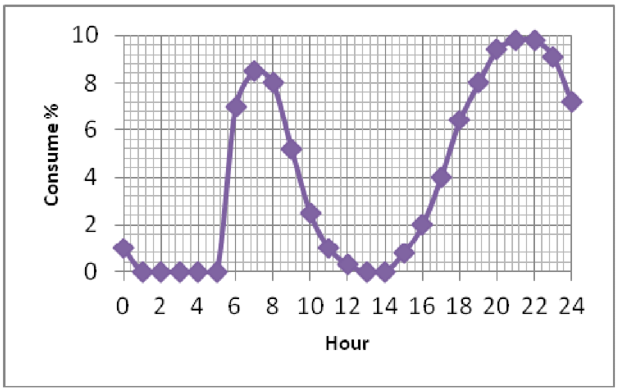


Figure 3 Daily distribution of hot water consumption

High consumption of domestic hot water is required from hours 06:00-08:00 and 20:00-22:00.

For calculation of solar fraction (f) we use two variables, X and Y, which represent losses and respectively gains in collector, presented in the following equation:

$$X_0 = 86.4\frac{K(100 - Tamb)A}{Q_{CT}} \tag{3}$$

$$Y = 3.6\frac{I\eta_0 A}{Q_{CT}} \tag{4}$$

Where: $T_{amb}$ - ambient temperature, A - collector area, $Q_{CT}$ - load rate energy.

We have yet to fix the value of X, for the storage capacity (factor C1) and for temperatures (factor C2).

*3.1 Storage capacity*

F-Chart method applies to storage volumes (thermo-accumulators) of 75 L/m$^2$ of collector and for other larger storage volume (AR L/m$^2$ of collector) we must calculate $X_0$ factor (losses in collector) from equation.

$$C_1 = \left(\frac{AR}{75}\right)^{-0.25} \quad \text{with} \quad 37 < AR < 300 \qquad (5)$$

AR - daily water volume per square meter of collector

A smaller storage capacity requires that water from the thermo-accumulator will heat faster. Hot water provided by the collector will cause a reduction of efficiency.

When the temperature of water is very high, there will be losses in the installation. For this losses is calculated the $C_2$ factor, which is affected by these three temperatures (expressed in $^oC$) and is given by equation 6.

$$C_2 = \frac{11.6 + 1.18T_{use} + 3.86T_{load} - 2.32T_{amb}}{100 - T_{amb}} \qquad (6)$$

It is necessary to know the ambient temperature for each month to get the best efficiency of the solar system. These temperature values are presented in Table 2 and are needed for calculating of $X_0$ factor and also can be used as temperatures from network.

### 3.2 Temperatures

Table 1 Average ambient temperatures for different Portuguese cities

| | Jan. | Feb. | Mar. | Apr. | Mar. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bracanga. | 5 | 7 | 9 | 11 | 14 | 18 | 21 | 21 | 18 | 14 | 8 | 5 |
| Braga | 8 | 9 | 10 | 12 | 15 | 18 | 21 | 20 | 19 | 15 | 11 | 8 |
| Porto | 8 | 9 | 11 | 13 | 15 | 18 | 20 | 20 | 18 | 16 | 11 | 9 |
| Coimbra | 9 | 10 | 11 | 13 | 16 | 19 | 21 | 21 | 20 | 16 | 12 | 9 |
| Lisboa | 10 | 11 | 13 | 15 | 17 | 20 | 22 | 22 | 21 | 17 | 14 | 11 |
| Faro | 12 | 12 | 13 | 15 | 18 | 21 | 23 | 23 | 22 | 19 | 15 | 12 |

Table 2 Global radiation incident on sloped surfaces, oriented South (I [W·h/m$^2$·day])

| Latitude | Inclination | Jan. | Feb. | Mar. | Apr. | Mar. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bracanga | 30$^o$ | 2278 | 3491 | 4525 | 5780 | 6437 | 6772 | 7334 | 6910 | 5630 | 4063 | 2944 | 2002 |
| 42$^o$ | 60$^o$ | 2409 | 3550 | 4199 | 4841 | 4918 | 4937 | 5327 | 5523 | 5044 | 3999 | 3130 | 2155 |

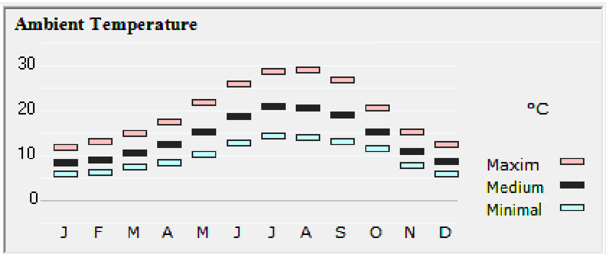


Figure 4 Temperature variation during entire year, from Bracanga

The values like temperature, specific parameters of solar systems, are taken from program SOLTERM5.

## 4. RESULTS

To calculate the solar fraction we must obtain the loss coefficient made by equation:

$$X = X_0 \times C_1 \times C_2 \qquad (7)$$

And finally the value of solar fraction is given by equation 8:

$$f = 1.029Y - 0.065X - 0.245Y^2 + 0.0018X^2 + 0.0215Y^3 \qquad (8)$$

Note that solar fraction values must be less than unity, and when this is higher than one, monthly solar fraction will be considered uniform ($f = 1$).

An important parameter is the solar load ratio, which is defined as the ratio of the annual (or monthly) radiation incident on the collector array to the annual (or monthly) energy requirements of the building system.

Annual fraction is given by the equation.

$$f_{year} = \frac{\sum_{\text{monthly}} \left(f_{\text{monthly}} \cdot Q_{CT,\text{monthly}}\right)}{\sum_{\text{monthly}} Q_{CT,\text{monthly}}} \qquad (9)$$

In Figure 1 is presented the solar fraction versus collector area. Note that, for small collector areas, a small increase in collector area leads to a steep increase in solar fraction. As the collector area is increased each additional square meter of collector area, a smaller increase in solar fraction could approach the curve to solar fraction of 100%.

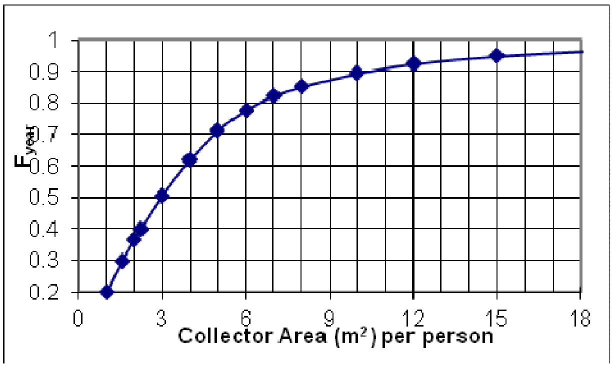


Figure 5 Variation of average annual solar fraction with solar collector area

The higher values of the annual average solar fraction it can be observed in Figure 5, where is the area of the curve less inclined. Solar fraction increases when increases collector area. This increase is relatively high for small area and moderates for large area, remains nearly constant for bigger capacities. In this work the average solar fraction was calculated for entire year.

## 5. CONCLUSIONS

Analytical simulations, have shown that the most efficient use of solar energy is for loads that use low temperatures on a year-around basis, such as that needed by service water heating. This application yields the best use of energy per square foot of installed collector area and represents the greatest potential for cost-effective solar energy use.

The systems with a big storage volume yield higher solar fraction, and when the storage volume is larger, the solar fraction is less sensitive to a variation of the operation parameters.

This model can be viewed as a new simulation model, which can be used for parametric analysis of domestic water heating systems.

## 6. ACKNOWLEDGMENTS

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# CALIBRATION OF A SONOTRODE FROM A STAND COMPONENT FOR TEST CAVITATION EROSION THROUGH DIRECT METHOD

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## ABSTRACT

This paper presents research done for the calibration of a sonotrode, a sonotrode which is used to test the cavitational erosion of specimens by the direct method, detailed in the standard method.

**Keywords:** *Sonotrode, cavitation erosion, direct method.*

## 1. INTRODUCTION

The Eftimie Murgu University of Resita, through the „Centre for Research in Hydraulic, Automation and Thermal Processes" (CCHAPT) [1], has a stand for ~~to~~ cavitational erosion research of materials used to manufacture components for hydraulic turbines. This paper presents research done for the calibration of a sonotrode, a sonotrode which is used to test the cavitational erosion of specimens by the direct method, detailed in the standard method [2].

Through the direct cavitation, the specimen is attached to the top of sonotrode through a threaded assembly. The calibration aims at achieving a frequency of 20000 Hz of the sonotrode that is assembled with the specimen, frequency required by the standard [2]. Starting from a required geometry, calibration will be achieved by shortening the length of the sonotrode. Verification of the frequency will be done by direct measuring, in relation to the one calculated through modal analysis performed by the SolidWorks program. Deviation of the frequency of 20000 Hz can be within the $\pm$ 500 Hz.

## 2. STAND DESCRIPTION

The stand consists the following components, like in figure 1:

- an ultrasonic generator DG-2000-2 [3], used to test the cavitation erosion in the laboratory; the generator protection locks operate if the frequency does not fall within the range specified above;
- a converter (piezoelectric acoustic transformer) supported and connected to the ultrasonic generator via a 6HF cable;
- an mechanical transformer (booster), which is intended to amplify the value of the amplitude in the sonotrode respectively in the specimen and to keep losses to a minimum focal point and to provide mechanical rigidity of the assembly;
- sonotrode itself;
- a test specimen, created from different materials of interest for the cavitational erosion study;
- a bowl of liquid with distilled water, in which a coil is included in a circuit network fed with cold water to maintain constant water temperature during the tests;
- a digital thermometer to measure and control temperature during the cavitation tests;
- a National Instruments measurement equipment that measure their frequency (hardware and software), the equipment is connected to the laptop through a USB 2.0 connection.

Experimental determination of their frequency is achieved through the excitation the sonotrode and specimen by a shock applied instantly and the specialized application, like in figure 2, which displays the measured frequency, frequency analysis, harmonic analysis and signal shape.

It can be set to display only frequencies within a specified range, setting than can be saved in a configuration file, together with other parameters. The „*Acquire Signal*" starts the continous acquisition process and the „*Trigger signal*" views only when the application requires shock. Fairness acquisition is continuously decreasing as indicated by the signal form.

Figure 1 Stand for cavitational erosion testing

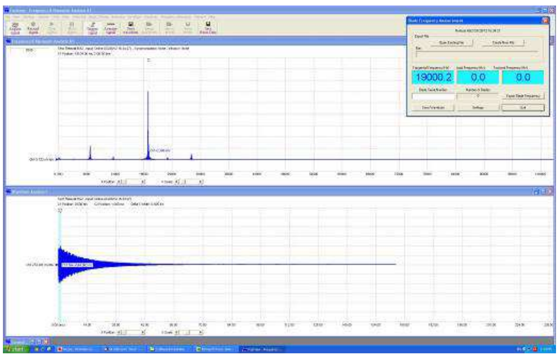



Figure 2 Application for measuring its frequency

## 3. DESCRIPTION OF THE 3D BOOSTER-SONOTRODE-SPECIMEN ASSEMBLY

The design of the 3D booster-sonotrode-specimen assembly was done in the SolidWorks application [4] and shown in figure 3 and the component elements in figure 4. The specimen is assembled with the sonotrode through an intermediate pin M12x1. The sonotrode is assembled with the booster through a pin by booster rod. The booster is provided with 6 screws. The sonotrode is generated by the revolution contour in figure 5 around the axis of symmetry.

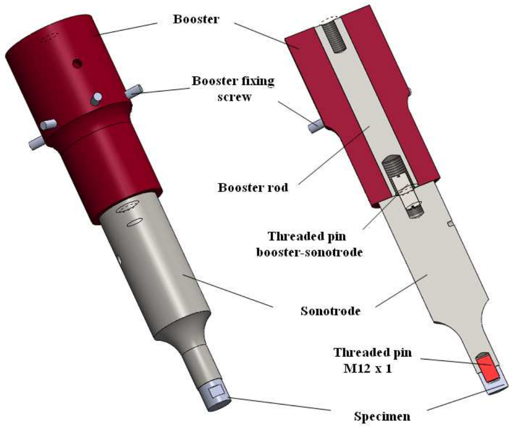



Figure 3 Booster-sonotrode-specimen assembly

To calculate its frequency the next stages must be followed:

a) Creation of the geometry parts: booster, sonotrode, specimen threaded pin M 12, threaded pin booster-sonotrode, booster rod, booster screw threading, specimen;

b) Creation of the 3D assembly: booster-sonotroda-specimen;

c) Activation of the *Simulation* module:

- click *Tools* → *Add-Ins*;
- select *Simulation* module;
- the simulation bar menu will be added to the main menu.

d) Creation of the simulation study of frequency type and designation study, from the study of frequency type the *Properties* option is activated, where you set the number of calculated frequency in our case 25 modes;

e) Select the material from SolidWorks materials library; for sonotrode the Ti-6Al-4V material will be selected and the remaining parts Alloy Steel;

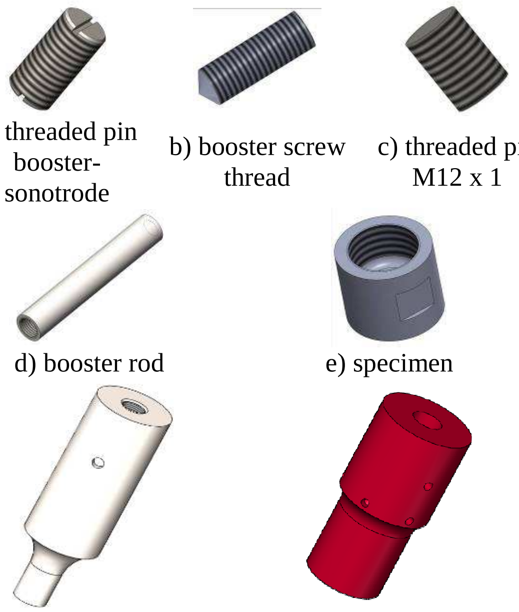
f) Apply restrictions; the assembly is fixed at the top of the 6 screws of booster by choice *Fixed Geometry*;

g) Create mesh - meshing in finite element;

h) Calculation analysis;

i) Viewing of the results; to identify the axial vibration modes (axial direction is oriented of the Y axis reference system) the *List Mass Participation* option will turn on, which will display tabular like in figure 6, the number of the vibration mode, the calculated frequency and the mass participation factor normalized by X, Y and Z directions; of the 25 calculated vibration modes interested only the axial, those for which the coefficients on the X and Z directions are zero or with insignificant values compared to the coefficient in the Y direction; the last line of the table will display the coefficients sum on the three directions;

j) Reduce the length of sonotrode, whose home value is 129.50 mm (see figure 5) and the resumption of its own frequency calculation; the goal is near 20000 ± 500 Hz value, while achieving the operating frequency, the condition which states that the mode of vibration must be axial must also be achieved.



a) threaded pin booster-sonotrode b) booster screw thread c) threaded pin M12 x 1

d) booster rod e) specimen

f) sonotrode g) booster

Figure 4 Component elements of the booster-sonotrode-specimen assembly

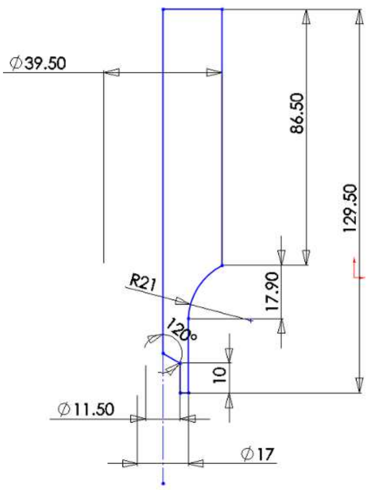
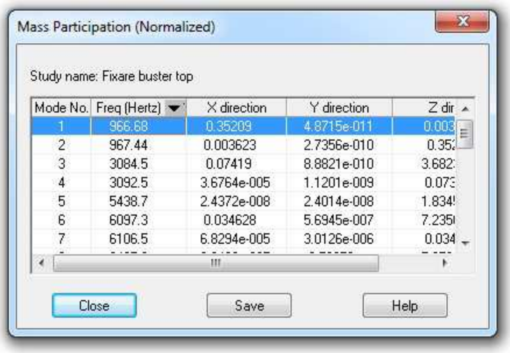



Figure 5 Geometry of the sonotrode



Mass Participation (Normalized)

Study name: Fixare buster top

| Mode No. | Freq (Hertz) | X direction | Y direction | Z dir |
|---|---|---|---|---|
| 1 | 966.68 | 0.35209 | 4.8715e-011 | 0.003 |
| 2 | 967.44 | 0.003623 | 2.7356e-010 | 0.35 |
| 3 | 3084.5 | 0.07419 | 8.8821e-010 | 3.682 |
| 4 | 3092.5 | 3.6764e-005 | 1.1201e-009 | 0.07 |
| 5 | 5438.7 | 2.4372e-008 | 2.4014e-008 | 1.834 |
| 6 | 6097.3 | 0.034628 | 5.6945e-007 | 7.235 |
| 7 | 6106.5 | 6.8294e-005 | 3.0126e-006 | 0.034 |

Close Save Help

Figure 6 Mass participation factor normalized by X, Y and Z directions

## 4. RESULTS

Due to limited printing space, only the results of six lengths of the sonotrode will be displayed from the 13 lengths that were measured and calculated.

For the sonotrode length of 129.50 mm, the results are presented in table 1 and figure 7; from table 1 can see that the axial vibration modes are achieved for modes 10, 15 and 19, the latter being closest to 20000 Hz and the calculated value is 19034 Hz; from figure 7 can see that the measured frequency of 19091.8. The percentage difference between the two values of frequency is 0.30%.

For the sonotrode length of 128.3 mm, the results are presented in table 1 and figure 8; from table 1 can see that the axial vibration modes are achieved for modes 10, 15 and 19, the latter being closest to 20000 Hz and the calculated value is 18713 Hz; from figure 8 can see the measured frequency of 18505.9. The percentage difference between the two values of frequency is -1.12%.

Table 1 Mass participation factors

| Vibration mode nr. | Mass participation factors for sonotrode length = 129.50 mm | | | | Mass participation factors for sonotrode length = 128.93 mm | | | |
|---|---|---|---|---|---|---|---|---|
| | **Freq (Hz)** | **X direction** | **Y direction** | **Z direction** | **Freq (Hz)** | **X direction** | **Y direction** | **Z direction** |
| 1 | 1193.3 | 0.249900 | 0.000000 | 0.000001 | 1221.3 | 0.244690 | 0.000000 | 0.001107 |
| 2 | 1196.4 | 0.000002 | 0.000000 | 0.250530 | 1224.4 | 0.001106 | 0.000000 | 0.245380 |
| 3 | 3603.1 | 0.073467 | 0.000000 | 0.000117 | 3512.3 | 0.070773 | 0.000000 | 0.000000 |
| 4 | 3610.9 | 0.000116 | 0.000000 | 0.072517 | 3518.3 | 0.000000 | 0.000000 | 0.069911 |
| 5 | 6059.4 | 0.000001 | 0.000000 | 0.000000 | 6148 | 0.000001 | 0.000000 | 0.000000 |
| 6 | 6454.4 | 0.006366 | 0.000000 | 0.000003 | 6442.5 | 0.007442 | 0.000001 | 0.000007 |
| 7 | 6475 | 0.000001 | 0.000001 | 0.005195 | 6462.4 | 0.000005 | 0.000001 | 0.006300 |
| 8 | 7343.5 | 0.387780 | 0.000021 | 0.024754 | 7345.1 | 0.291390 | 0.000002 | 0.127770 |
| 9 | 7345 | 0.024609 | 0.000001 | 0.389430 | 7347.4 | 0.126980 | 0.000000 | 0.292510 |
| 10 | 7421.5 | 0.000011 | 0.618790 | 0.000004 | 7510.6 | 0.000001 | 0.621830 | 0.000002 |
| 11 | 12483 | 0.000016 | 0.000000 | 0.000000 | 12479 | 0.000003 | 0.000000 | 0.000000 |
| 12 | 12780 | 0.091126 | 0.000000 | 0.000026 | 12907 | 0.091549 | 0.000000 | 0.000155 |
| 13 | 12811 | 0.000022 | 0.000001 | 0.089785 | 12938 | 0.000146 | 0.000001 | 0.090201 |
| 14 | 13376 | 0.000005 | 0.000000 | 0.000000 | 13214 | 0.000027 | 0.000000 | 0.000000 |
| 15 | 14532 | 0.000000 | 0.338460 | 0.000000 | 14553 | 0.000000 | 0.332610 | 0.000000 |
| 16 | 15023 | 0.000000 | 0.000001 | 0.000000 | 14868 | 0.000000 | 0.000000 | 0.000000 |
| 17 | 18125 | 0.069053 | 0.000000 | 0.012396 | 18155 | 0.036101 | 0.000004 | 0.044225 |
| 18 | 18135 | 0.011981 | 0.000001 | 0.071565 | 18161 | 0.042712 | 0.000003 | 0.037469 |
| 19 | 19034 | 0.000000 | 0.013287 | 0.000005 | 18713 | 0.000001 | 0.016013 | 0.000027 |
| 20 | 21099 | 0.000760 | 0.000000 | 0.042044 | 21067 | 0.000016 | 0.000000 | 0.043992 |
| 21 | 21125 | 0.043808 | 0.000000 | 0.000729 | 21099 | 0.045944 | 0.000000 | 0.000017 |
| 22 | 23884 | 0.000019 | 0.000000 | 0.001169 | 23921 | 0.000008 | 0.000000 | 0.001064 |
| 23 | 23968 | 0.001619 | 0.000000 | 0.000013 | 24001 | 0.001515 | 0.000000 | 0.000010 |
| 24 | 24385 | 0.000000 | 0.000618 | 0.000000 | 24214 | 0.000000 | 0.000539 | 0.000000 |
| 25 | 24721 | 0.000000 | 0.000000 | 0.000000 | 25092 | 2.20E-08 | 1.04E-08 | 4.16E-08 |

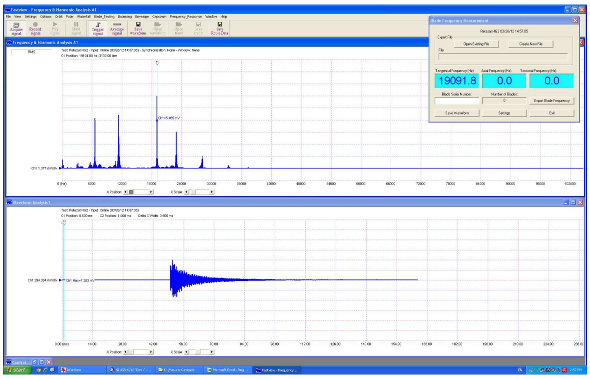


Figure 7 Natural measured frequency for sonotrode length = 129.50 mm

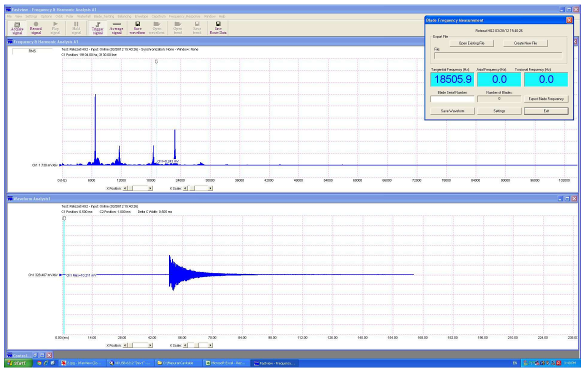


Figure 8 Natural measured frequency for sonotrode length = 128.93 mm

For the sonotrode length of 128.17 mm, the results are presented in table 1 and figure 9; from table 2 can see that the axial vibration modes are achieved for modes 10, 15 and 19, the latter being closest to 20000 Hz and the calculated value is 18887 Hz; from figure 9 can see that the measured frequency of 19091.8. The percentage difference between the two values of frequency is 1.07%.

For the sonotrode length of 126.3 mm, the results are presented in table 1 and figure 10; from table 2 can see that the axial vibration modes are achieved for modes 10, 15 and 19, the latter being closest to 20000 Hz and the calculated value is 19318 Hz; from figure 10 can see the measured frequency of 19793.7. The percentage difference between the two values of frequency is 2.40%.

Table 2 Mass participation factors

| Vibration mode nr. | Mass participation factors for sonotrode length = 128.17 mm | | | | Mass participation factors for sonotrode length = 126.3 mm | | | |
|---|---|---|---|---|---|---|---|---|
| | Freq (Hz) | X direction | Y direction | Z direction | Freq (Hz) | X direction | Y direction | Z direction |
| 1 | 1225.8 | 0.246610 | 0.000000 | 0.000324 | 1236.4 | 0.248950 | 0.000000 | 0.000390 |
| 2 | 1228.9 | 0.000325 | 0.000000 | 0.247270 | 1239.6 | 0.000391 | 0.000000 | 0.249580 |
| 3 | 3575.7 | 0.070886 | 0.000000 | 0.000231 | 3737.3 | 0.072243 | 0.000000 | 0.000156 |
| 4 | 3583.2 | 0.000225 | 0.000000 | 0.069982 | 3746.3 | 0.000155 | 0.000000 | 0.071304 |
| 5 | 6149.4 | 0.000000 | 0.000000 | 0.000000 | 6154.6 | 0.000000 | 0.000000 | 0.000000 |
| 6 | 6481.8 | 0.005310 | 0.000000 | 0.000001 | 6591.2 | 0.000880 | 0.000000 | 0.000001 |
| 7 | 6502.3 | 0.000000 | 0.000000 | 0.004191 | 6609 | 0.000003 | 0.000001 | 0.000404 |
| 8 | 7349.8 | 0.001553 | 0.000017 | 0.420310 | 7372 | 0.421780 | 0.000000 | 0.000025 |
| 9 | 7351.5 | 0.418170 | 0.000000 | 0.001579 | 7375.6 | 0.000023 | 0.000001 | 0.423040 |
| 10 | 7515.5 | 0.000000 | 0.623040 | 0.000009 | 7530.7 | 0.000000 | 0.624520 | 0.000001 |
| 11 | 12482 | 0.000002 | 0.000001 | 0.000001 | 12498 | 0.000000 | 0.000000 | 0.000000 |
| 12 | 12945 | 0.092082 | 0.000000 | 0.000077 | 13050 | 0.092778 | 0.000000 | 0.000092 |
| 13 | 12980 | 0.000075 | 0.000000 | 0.090671 | 13087 | 0.000086 | 0.000000 | 0.091533 |
| 14 | 13323 | 0.000013 | 0.000000 | 0.000000 | 13556 | 0.000004 | 0.000000 | 0.000000 |
| 15 | 14571 | 0.000000 | 0.333290 | 0.000000 | 14629 | 0.000000 | 0.335330 | 0.000000 |
| 16 | 14965 | 0.000001 | 0.000000 | 0.000000 | 15264 | 0.000000 | 0.000000 | 0.000000 |
| 17 | 18257 | 0.012415 | 0.000006 | 0.071237 | 18481 | 0.000252 | 0.000002 | 0.089386 |
| 18 | 18264 | 0.068994 | 0.000004 | 0.012909 | 18488 | 0.086746 | 0.000000 | 0.000276 |
| 19 | 18887 | 0.000008 | 0.014133 | 0.000034 | 19318 | 0.000000 | 0.010505 | 0.000013 |
| 20 | 21192 | 0.000173 | 0.000000 | 0.040405 | 21506 | 0.000114 | 0.000000 | 0.033701 |
| 21 | 21216 | 0.042454 | 0.000000 | 0.000185 | 21537 | 0.035576 | 0.000000 | 0.000121 |
| 22 | 24005 | 0.000007 | 0.000000 | 0.000808 | 24283 | 0.000011 | 0.000002 | 0.000255 |
| 23 | 24086 | 0.001208 | 1.14E-07 | 4.78E-06 | 24316 | 0.000559 | 4.39E-07 | 9.55E-06 |
| 24 | 24312 | 5.78E-07 | 0.000595 | 2.39E-07 | 24605 | 2.81E-08 | 0.000757 | 4.27E-07 |
| 25 | 25112 | 3.64E-10 | 7.58E-08 | 4.53E-10 | 25118 | 2.23E-07 | 2.49E-07 | 2.27E-08 |

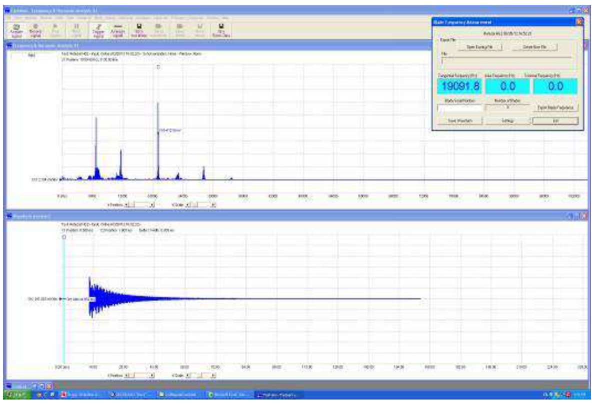


Figure 9 Natural measured frequency for sonotrode length = 128.17 mm

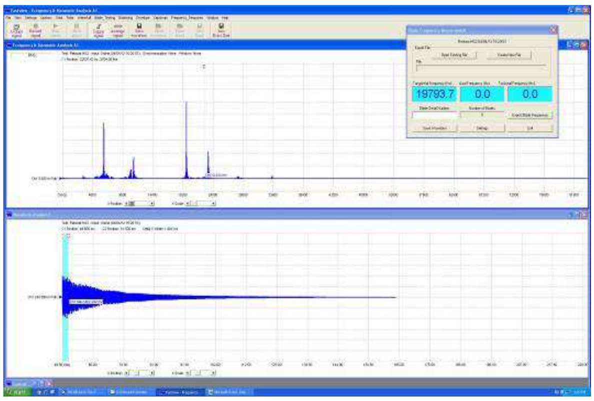


Figure 10 Natural measured frequency for sonotrode length = 126.3 mm

For the sonotrode length of 126.1 mm, the results are presented in table 3 and figure 11; from table 3 can see that the axial vibration modes are achieved for modes 10, 15 and 19, the latter being closest to 20000 Hz and the calculated value is 19375 Hz; from figure 11 can see that the measured frequency of 19769.3. The percentage difference between the two values of frequency is 1.99%.

For the sonotrode length of 125.7 mm, the results are presented in table 1 and figure 12; from table 3 can see that the axial vibration modes are achieved for modes 10, 15 and 19, the latter being closest to 20000 Hz and the calculated value is 19475 Hz; from figure 12 can see the measured frequency of 19738.8. The percentage difference between the two values of frequency is 1.34%.

Table 3 Mass participation factors

| Vibration mode nr. | Mass participation factors for sonotrode length = 126.1 mm | | | | Mass participation factors for sonotrode length = 125.7 mm | | | |
|---|---|---|---|---|---|---|---|---|
| | Freq (Hz) | X direction | Y direction | Z direction | Freq (Hz) | X direction | Y direction | Z direction |
| 1 | 1237.50 | 0.248690 | 0.000000 | 0.000883 | 1239.8 | 0.249470 | 0.000000 | 0.000592 |
| 2 | 1240.70 | 0.000883 | 0.000000 | 0.249410 | 1242.8 | 0.000593 | 0.000000 | 0.250130 |
| 3 | 3754.90 | 0.072478 | 0.000000 | 0.000133 | 3790.8 | 0.072849 | 0.000000 | 0.000136 |
| 4 | 3764.50 | 0.000128 | 0.000000 | 0.071539 | 3800 | 0.000133 | 0.000000 | 0.071868 |
| 5 | 6155.60 | 0.000000 | 0.000000 | 0.000000 | 6156.5 | 0.000000 | 0.000000 | 0.000000 |
| 6 | 6603.10 | 0.000557 | 0.000000 | 0.000001 | 6630.3 | 0.000136 | 0.000000 | 0.000000 |
| 7 | 6622.30 | 0.000000 | 0.000000 | 0.000230 | 6645.6 | 0.000000 | 0.000001 | 0.000005 |
| 8 | 7374.30 | 0.421680 | 0.000015 | 0.000224 | 7380 | 0.421680 | 0.000001 | 0.000136 |
| 9 | 7378.20 | 0.000223 | 0.000014 | 0.422520 | 7383.1 | 0.000139 | 0.000003 | 0.422580 |
| 10 | 7532.80 | 0.000010 | 0.624810 | 0.000011 | 7535.4 | 0.000001 | 0.625230 | 0.000003 |
| 11 | 12498.00 | 0.000000 | 0.000000 | 0.000000 | 12500 | 0.000000 | 0.000000 | 0.000000 |
| 12 | 13062.00 | 0.092569 | 0.000000 | 0.000367 | 13086 | 0.092912 | 0.000000 | 0.000164 |
| 13 | 13099.00 | 0.000374 | 0.000001 | 0.091356 | 13123 | 0.000156 | 0.000002 | 0.091543 |
| 14 | 13577.00 | 0.000004 | 0.000000 | 0.000000 | 13620 | 0.000004 | 0.000000 | 0.000000 |
| 15 | 14635.00 | 0.000000 | 0.335440 | 0.000000 | 14647 | 0.000000 | 0.335660 | 0.000000 |
| 16 | 15302.00 | 0.000000 | 0.000000 | 0.000000 | 15388 | 0.000001 | 0.000001 | 0.000000 |
| 17 | 18498.00 | 0.003074 | 0.000001 | 0.087189 | 18541 | 0.000536 | 0.000002 | 0.090730 |
| 18 | 18512.00 | 0.084507 | 0.000000 | 0.003238 | 18560 | 0.088018 | 0.000000 | 0.000580 |
| 19 | 19375.00 | 0.000000 | 0.010080 | 0.000008 | 19475 | 0.000000 | 0.009400 | 0.000011 |
| 20 | 21542.00 | 0.000518 | 0.000000 | 0.032452 | 21610 | 0.000019 | 0.000000 | 0.031598 |
| 21 | 21570.00 | 0.034400 | 0.000000 | 0.000463 | 21647 | 0.033534 | 0.000000 | 0.000014 |
| 22 | 24282.00 | 0.000007 | 0.000001 | 0.000218 | 24343 | 0.000025 | 0.000001 | 0.000147 |
| 23 | 24349.00 | 0.000466 | 0.000000 | 0.000006 | 24406 | 0.000350 | 0.000001 | 0.000016 |
| 24 | 24655.00 | 0.000000 | 0.000783 | 0.000000 | 24735 | 0.000000 | 0.000825 | 0.000000 |
| 25 | 25132.00 | 0.000000 | 0.000000 | 0.000000 | 25138 | 0.000000 | 0.000000 | 0.000000 |

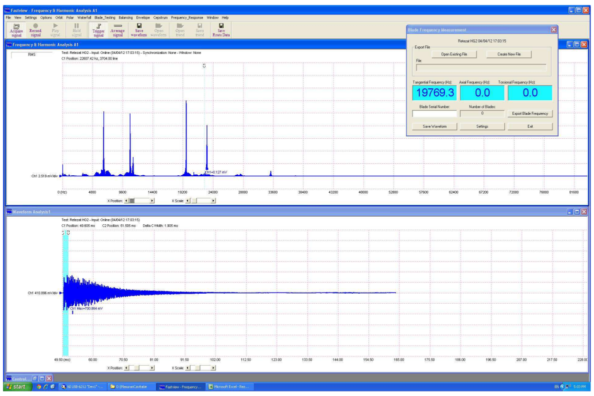



Figure 11 Natural measured frequency for sonotrode length = 126.1 mm

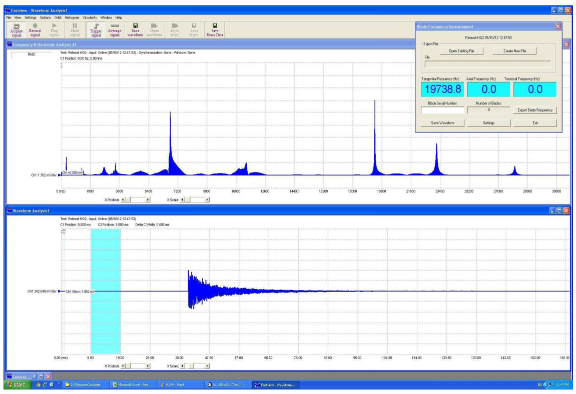



Figure 12 Natural measured frequency for sonotrode length = 125.7 mm

For the 13 measured and calculated lengths, the results are summarized in table 4 and figure 13, where:

- Current Issue - is the number of the experiment;
- Sonotrode length - is the length of sonotrode;
- Δl - is the shortened length of sonotrode in relation to the previous procedure;
- Measured frequency - is the measured frequency;
- Calculated frequency - is the calculated frequency through modal analysis from the SolidWorks software;
- Error – is the difference in Hz between the measured and calculated frequency;
- Err - is the percentage error between the measured and calculated frequency difference.

The graph from figure 9 presents the evolution of the calculated and measured nature frequency versus the sonotrode length in a comparative manner.

Table 4 Measured and calculated lengths

| Current Issue | Sonotrode length | Δl | Measured frequency | Calculated frequency | Error | Err |
|---|---|---|---|---|---|---|
| | mm | mm | Hz | Hz | Hz | % |
| 1 | 129.50 | 0 | 19091.8 | 19034 | 57.8 | 0.30 |
| 2 | 129.15 | 0.41 | 18841.6 | 18937 | -95.4 | -0.51 |
| 3 | 128.93 | 0.22 | 18505.9 | 18713 | -207.1 | -1.12 |
| 4 | 128.67 | 0.26 | 18920.9 | 18766 | 154.9 | 0.82 |
| 5 | 128.51 | 0.16 | 19000.2 | 18817 | 183.2 | 0.96 |
| 6 | 128.17 | 0.34 | 19091.8 | 18887 | 204.8 | 1.07 |
| 7 | 127.72 | 0.45 | 19274.9 | 18991 | 283.9 | 1.47 |
| 8 | 127 | 0.72 | 19348.1 | 19151 | 197.1 | 1.02 |
| 9 | 126.3 | 0.7 | 19793.7 | 19318 | 475.7 | 2.40 |
| 10 | 126.2 | 0.1 | 19696 | 19352 | 344 | 1.75 |
| 11 | 126.1 | 0.1 | 19769.3 | 19375 | 394.3 | 1.99 |
| 12 | 125.9 | 0.2 | 19860.8 | 19434 | 426.8 | 2.15 |
| 13 | 125.7 | 0.2 | 19738.8 | 19475 | 263.8 | 1.34 |
| | Sum | 3.8 | | Average | 206.44 | |

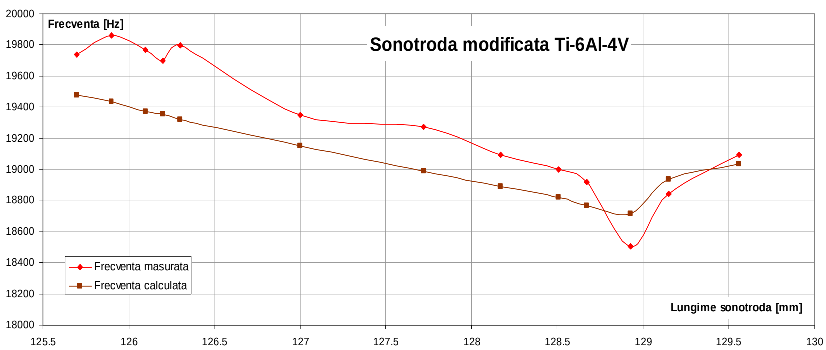



Figure 13 The nature frequency calculated and measured

## 5. CONCLUSIONS

The tests were continued until the sonotrode length was 125.7 mm, value for which the calculated frequency was 19475 Hz, the measured value was 19738.8 Hz and the ultrasonic generator protection has not blocked its operation.

Table 2 shows the errors between the measured and calculated values of frequency in the 0.30 ÷ 2.40%.

The graph in figure 9, shows similarity curves measured and calculated, the measured values are generally higher than those calculated, the average deviation is 206.44 Hz. From the graph one can see the trend of increasing frequency by reducing the sonotrode length.

## 6. ACKNOWLEDGMENTS

This work was partially supported by the strategic grant POSDRU /88/1.5/S/50783 and POSDRU /88/1.5/S/ 61178.

## 7. REFERENCES

[1] www.cchapt.ro
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[3] TELSONIC, *Operating Instructions Cavitations Test Equipment DG 2000*, www.telsonic.com
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# VARIANTS OF SONOTRODE FOR A VIBRATORY APPARATUS FOR TEST CAVITATION EROSION BY THE INDIRECT METHOD

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**ABSTRACT**

The purpose of this work is to present the research done for the calibration of a sonotrode for the cavitation erosion testing of specimens through the indirect method.

**Keywords:** *Sonotrode, cavitation erosion, indirect method.*

## 1. INTRODUCTION

The vibratory apparatus used to test the cavitation erosion of materials within the Centre for research in Automation, Hydraulic and Thermal Processes (CCHAPT), works on the following parameters:

- vibration Frequency: 20000 + 500 Hz;
- amplitude of vibration (peak to peak): 50 μm;
- the test temperature: 25 ± 2°C.

The first condition is essential for the functioning of the device. The failure of this conditions leads to the non-functioning of the device, because of the activation of internal protection.

The purpose of this work is to present the research done for the calibration of a sonotrode for the cavitation erosion testing of specimens through the indirect method. In this case of indirect cavitation, the specimen is fixed and the sonotrode vibrates over the specimen at a controlled distance, both of which are dipped in water. It aims to achieve through calibration a frequency of 20000 + 500 Hz for sonotrode [1].

From an initial geometry, the calibration will be achieved by shortening the length of the sonotrode. Verification of the frequency will be achieved by direct measurement, compared to that calculated by modal analysis performed with SolidWorks.

## 2. STAND DESCRIPTION

The stand consists of the following parts, like in Figure 1:

- an ultrasonic generator DG-2000-2 [2], used in the laboratory to test the cavitation erosion; the generator protection locks operate if the frequency does not fall within the range specified above;
- a converter (piezoelectric acoustic transformer) supported and connected to the ultrasonic generator via a 6HF cable;
- an mechanical transformer (booster), which is intended to amplify the value of amplitude in the sonotrode;
- the sonotrode; in the case of cavitational erosion through the indirect method, the sonotrode has the same role as a vibrating Rod;
- the specimen from different materials is placed directly under the controlled sonotrode; cavitational bubbles that are induced in water through vibration collaps on the front top of the test specimen, where the attack will occur cavitational [3];
- a liquid container with distilled water, within which a wire is found in a circuit, circuit that is powered from the network with cold water to keep the water temperature constant throughout the test.
- a digital thermometer for measuring the temperature of cavitation during the tests;
- a National Instruments brand equipment that measure their frequency (hardware and software), the equipment is connected to the laptop via a USB 2.0 connection.

Experimental determination of their frequency is achieved through the excitation of the sonotrode and specimen by a shock applied instantly and the associated application displays the measured frequency, frequency analysis and harmonics analysis as well as the signal. Accuracy of the purchase is flagged by the continuously decreasing shape form of the signal.

## 3. DESCRIPTION OF THE 3D BOOSTER-SONOTRODE ASSEMBLY

The design of the 3D booster-sonotrode assembly was accomplished in the application SolidWorks [4] and is shown in Figure 2. The sonotrodes is assembled with the booster through a pin through the rod booster. The booster is fitted with 6 screws.

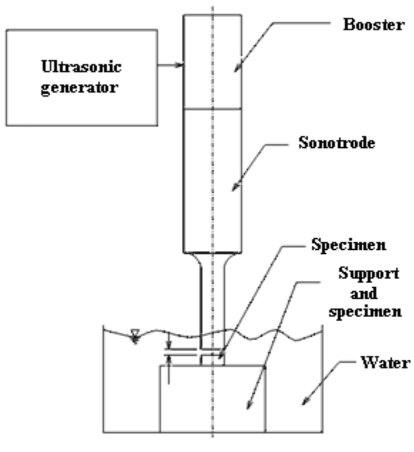


Figure 1 Stand for testing the cavitation erosion through the indirect method

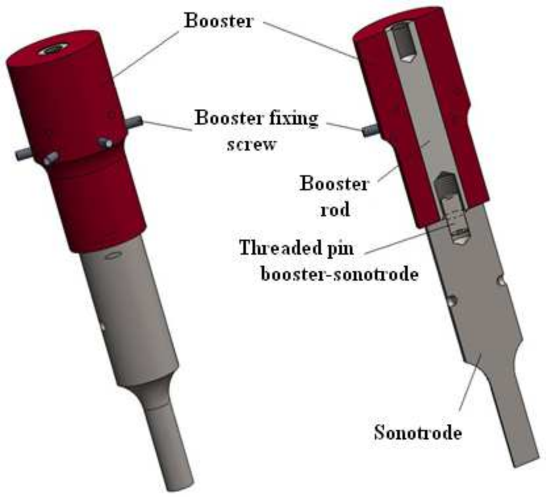


Figure 2 The 3D booster-sonotrode assembly

## 3. RESULTS OBTAINED WITH THE MODAL ANALYSIS

By reducing the length of the sonotrode, whose value is 160 mm and by restarting the calculation of the nature frequency one aims to close the frequency value of ~ 20000 ± 500 Hz, at the same time with the realization of the condition that the vibration mode must be axial (longitudinal).

Modal analysis was performed via SolidWorks, for the calculation of the nature frequency through the steps described in [5]. After the modal analysis, modes of axial vibration can be identified (oriented Y direction of the reference system) by turning on the *List Mass Participation* option, which displays tabular: sequence number of the method, calculated frequency and the mass participation factor on the standard directions X, Y, and Z; between the calculated modes of vibration only the axial one are of interest, those for which the coefficients on X and Z directions are semi or insignificant compared to the value of the coefficient in the Y directions.

Calculations were made for 4 lengths of the sonotrode: 160 mm, 155.5 mm, 150 mm and 145 mm. The mass participation coefficients for these lengths are presented in tables 1 and 2 for 25 modes of vibration. Graph of the variation rate that was calculated based on the number of vibration mode is shown in Figure 3, which shows that the value of 20000 Hz is around mode 19 of vibration.

Distribution of mass participation coefficient on the X, Y, and Z directions by number of vibrating mode for the 4 lengths of the sonotrode is shown in figures 4, 5, 6, 7. From these figures, one can see the axial modes, i.e. in which vertical bars are filled with red continues color, that have the numerical value of the coefficient marked. Other vertical bars are suitable for transverse vibration modes (on the X or Z direction) and are not of interest in the context of this analysis.

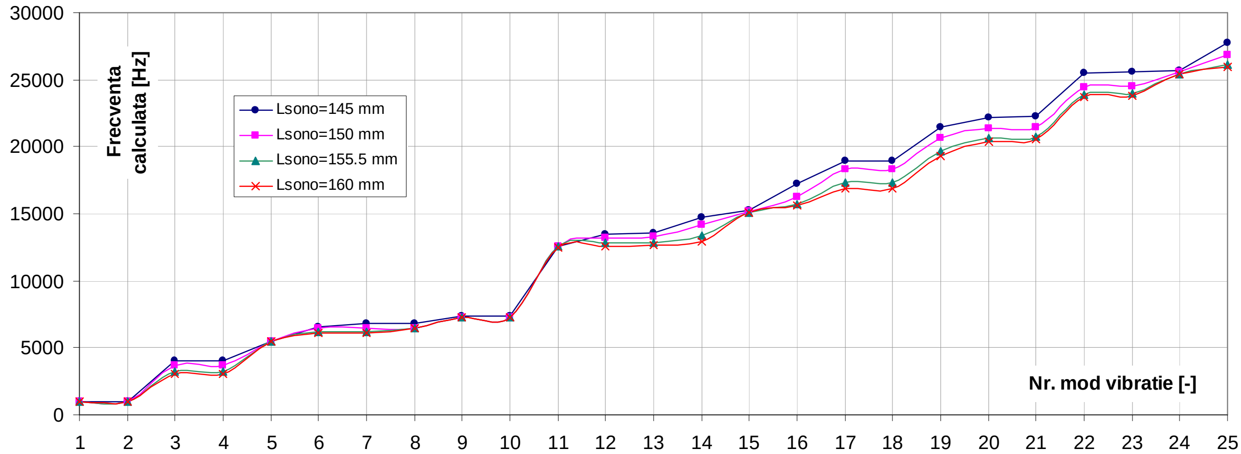


Figure 3 Variance of the calculated frequency by modal analysis by the number of vibration mode

Table 1 Mass participation factors

| Vibration mode nr. | Mass participation factors for sonotrode length = 160 mm | | | | Mass participation factors for sonotrode length = 155.5 mm | | | |
|---|---|---|---|---|---|---|---|---|
| | Freq (Hz) | X direction | Y direction | Z direction | Freq (Hz) | X direction | Y direction | Z direction |
| 1 | 966.68 | 0.352090 | 0.000000 | 0.003633 | 978.67 | 0.358580 | 0.000000 | 0.000086 |
| 2 | 967.44 | 0.003623 | 0.000000 | 0.352440 | 979.66 | 0.000086 | 0.000000 | 0.359010 |
| 3 | 3084.5 | 0.074190 | 0.000000 | 0.000037 | 3251.1 | 0.074072 | 0.000000 | 0.000038 |
| 4 | 3092.5 | 0.000037 | 0.000000 | 0.073589 | 3259.6 | 0.000039 | 0.000000 | 0.073395 |
| 5 | 5438.7 | 0.000000 | 0.000000 | 0.000000 | 5443.5 | 0.000000 | 0.000000 | 0.000000 |
| 6 | 6097.3 | 0.034628 | 0.000001 | 0.000072 | 6197.5 | 0.028297 | 0.000001 | 0.000075 |
| 7 | 6106.5 | 0.000068 | 0.000003 | 0.034536 | 6207.5 | 0.000090 | 0.000008 | 0.028373 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 8 | 6437.6 | 0.000000 | 0.709790 | 0.000001 | 6457.5 | 0.000000 | 0.710460 | 0.000001 |
| 9 | 7269.6 | 0.274810 | 0.000000 | 0.046750 | 7276.5 | 0.276850 | 0.000000 | 0.049160 |
| 10 | 7274.6 | 0.046655 | 0.000000 | 0.276260 | 7283.1 | 0.049001 | 0.000000 | 0.278320 |
| 11 | 12529 | 0.000000 | 0.000000 | 0.000015 | 12558 | 0.000000 | 0.000000 | 0.000000 |
| 12 | 12602 | 0.068833 | 0.000000 | 0.000000 | 12805 | 0.072556 | 0.000000 | 0.000001 |
| 13 | 12679 | 0.000000 | 0.000000 | 0.068095 | 12883 | 0.000000 | 0.000000 | 0.071874 |
| 14 | 12943 | 0.000000 | 0.000000 | 0.000000 | 13368 | 0.000000 | 0.000000 | 0.000000 |
| 15 | 15050 | 0.000000 | 0.258610 | 0.000000 | 15104 | 0.000000 | 0.259830 | 0.000000 |
| 16 | 15627 | 0.000000 | 0.000000 | 0.000000 | 15734 | 0.000000 | 0.000000 | 0.000000 |
| 17 | 16857 | 0.005593 | 0.000001 | 0.046720 | 17359 | 0.000914 | 0.000000 | 0.053288 |
| 18 | 16863 | 0.046417 | 0.000000 | 0.005443 | 17369 | 0.053520 | 0.000000 | 0.000836 |
| 19 | 19283 | 0.000000 | 0.006671 | 0.000000 | 19710 | 0.000000 | 0.004669 | 0.000000 |
| 20 | 20415 | 0.056108 | 0.000000 | 0.002342 | 20659 | 0.049915 | 0.000000 | 0.002076 |
| 21 | 20529 | 0.002330 | 0.000000 | 0.055573 | 20766 | 0.002102 | 0.000000 | 0.049508 |
| 22 | 23688 | 0.001747 | 0.000000 | 0.000073 | 23865 | 0.001106 | 0.000000 | 0.000047 |
| 23 | 23816 | 0.000170 | 0.000000 | 0.001880 | 23980 | 0.000119 | 0.000000 | 0.001262 |
| 24 | 25418 | 0.000000 | 0.000000 | 0.000000 | 25462 | 0.000000 | 0.000000 | 0.000000 |
| 25 | 25960 | 0.000000 | 0.001471 | 0.000000 | 26182 | 0.000000 | 0.001574 | 0.000000 |
| | | Sum X = 0.96729 | Sum Y = 0.97654 | Sum Z = 0.96746 | | Sum X = 0.96725 | Sum Y = 0.97654 | Sum Z = 0.96735 |

Table 2 Mass participation factors

| Vibration mode nr. | Mass participation factors for sonotrode length = 150 mm | | | | Mass participation factors for sonotrode length = 145mm | | | |
|---|---|---|---|---|---|---|---|---|
| | Freq (Hz) | X direction | Y direction | Z direction | Freq (Hz) | X direction | Y direction | Z direction |
| 1 | 1004 | 0.363960 | 0.000000 | 0.000161 | 1025.8 | 0.36792 | 1.047E-09 | 7.1179E-05 |
| 2 | 1005.3 | 0.000162 | 0.000000 | 0.364420 | 1027.3 | 0.000071 | 0.000000 | 0.368430 |
| 3 | 3650.3 | 0.076663 | 0.000000 | 0.000003 | 4036.1 | 0.082032 | 0.000000 | 0.000002 |
| 4 | 3662.6 | 0.000003 | 0.000000 | 0.075910 | 4053.4 | 0.000002 | 0.000000 | 0.081232 |
| 5 | 5451.1 | 0.000000 | 0.000000 | 0.000000 | 5456.9 | 0.000000 | 0.000000 | 0.000000 |
| 6 | 6477.8 | 0.010451 | 0.000003 | 0.000019 | 6534.7 | 0.000000 | 0.713420 | 0.000000 |
| 7 | 6488.5 | 0.000041 | 0.000351 | 0.010501 | 6823.1 | 0.002417 | 0.000000 | 0.000035 |
| 8 | 6499.2 | 0.000000 | 0.711630 | 0.000007 | 6831.2 | 0.000016 | 0.000001 | 0.002582 |
| 9 | 7298 | 0.315200 | 0.000000 | 0.022751 | 7363.2 | 0.335760 | 0.000000 | 0.002932 |
| 10 | 7306.2 | 0.022677 | 0.000000 | 0.316760 | 7370.6 | 0.002990 | 0.000000 | 0.337430 |
| 11 | 12568 | 0.000000 | 0.000000 | 0.000000 | 12576 | 0.000001 | 0.000000 | 0.000000 |
| 12 | 13179 | 0.078631 | 0.000000 | 0.000003 | 13474 | 0.081795 | 0.000000 | 0.000012 |
| 13 | 13257 | 0.000004 | 0.000000 | 0.077766 | 13544 | 0.000013 | 0.000000 | 0.080658 |
| 14 | 14230 | 0.000000 | 0.000000 | 0.000000 | 14710 | 0.000000 | 0.000001 | 0.000000 |
| 15 | 15185 | 0.000000 | 0.260860 | 0.000000 | 15235 | 0.000000 | 0.260590 | 0.000000 |
| 16 | 16228 | 0.000000 | 0.000000 | 0.000000 | 17257 | 0.000000 | 0.000000 | 0.000000 |
| 17 | 18362 | 0.026076 | 0.000000 | 0.040145 | 18977 | 0.050834 | 0.000000 | 0.025071 |
| 18 | 18368 | 0.040399 | 0.000000 | 0.025278 | 18990 | 0.024954 | 0.000000 | 0.049629 |
| 19 | 20649 | 0.000000 | 0.001943 | 0.000000 | 21452 | 0.000000 | 0.000737 | 0.000000 |
| 20 | 21400 | 0.030619 | 0.000000 | 0.002248 | 22176 | 0.016080 | 0.000000 | 0.002151 |
| 21 | 21500 | 0.002316 | 0.000000 | 0.031242 | 22279 | 0.002303 | 0.000000 | 0.017056 |
| 22 | 24458 | 0.000084 | 0.000000 | 0.000002 | 25524 | 0.000226 | 0.000000 | 0.000019 |
| 23 | 24552 | 0.000022 | 0.000000 | 0.000141 | 25591 | 0.000005 | 0.000000 | 0.000158 |
| 24 | 25564 | 0.000000 | 0.000000 | 0.000000 | 25659 | 0.000000 | 0.000000 | 0.000000 |
| 25 | 26840 | 0.000000 | 0.001823 | 0.000000 | 27710 | 0.000000 | 0.002069 | 0.000000 |
| | | Sum X = 0.96731 | Sum Y = 0.97662 | Sum Z = 0.96735 | | Sum X = 0.96742 | Sum Y = 0.97682 | Sum Z = 0.96748 |

The results of the modal analysis are centralised in table 3 for the vibration mode 19 one the basis of which the length calculated in Figure 8 was changed. This dependence has been linearly interpolated to find the value of the length sonotrode mm for 154.07 mm, that theoretically, is done for the frequency of 20000 Hz.

Table 3 The results of the modal analysis

| Sonotrode length [mm] | Vibration mode nr. | Freq (Hz) | X Direc. | Y Direc. | Z Direc. |
|---|---|---|---|---|---|
| 160 | 19 | 19283 | 0.000 | 0.0066 | 0.000 |
| 155.5 | 19 | 19710 | 0.000 | 0.0046 | 0.000 |
| 150 | 19 | 20649 | 0.000 | 0.0019 | 0.000 |
| 145 | 19 | 21452 | 0.000 | 0.0007 | 0.000 |

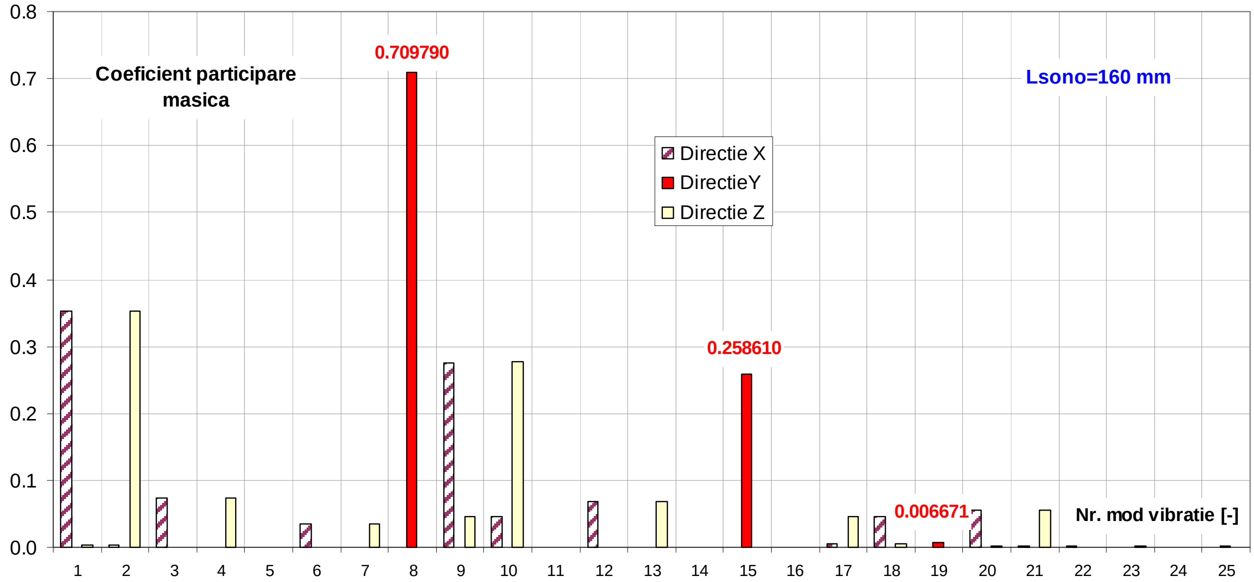


Figure 4 Distribution of mass participation factor based on vibration mode for sonotrode length of 160 mm

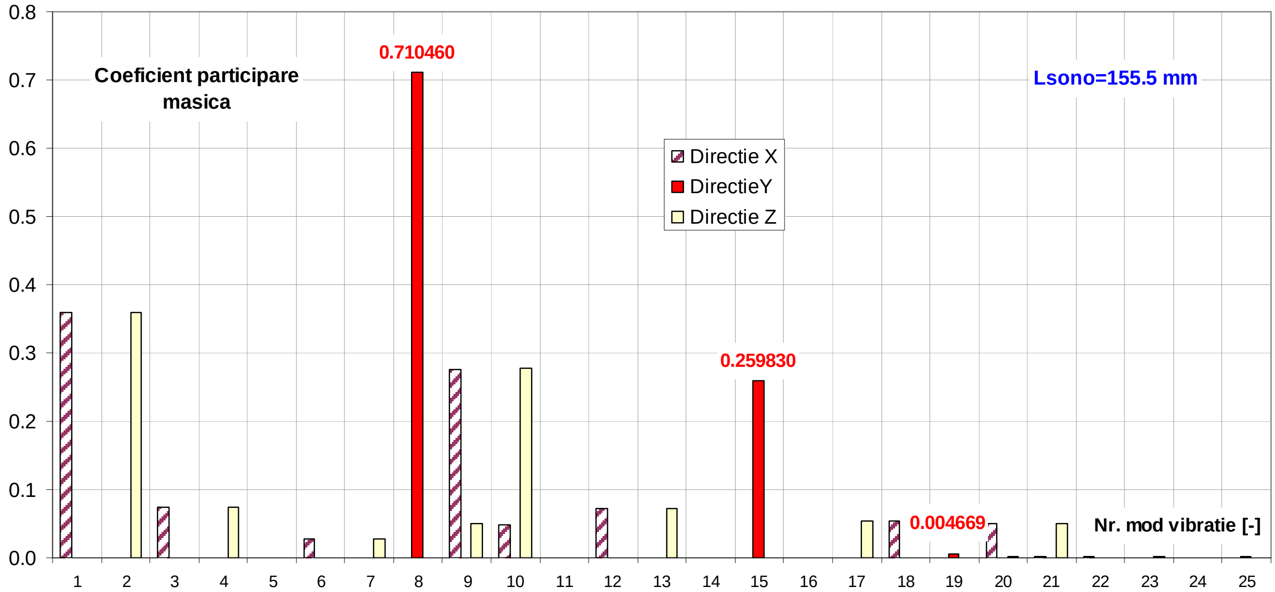


Figure 5 Distribution of mass participation factor based on vibration mode for sonotrode length of 155.5 mm

## 4. RESULTS OBTAINED BY DIRECT MEASUREMENT OF THE OWN FREQUENCY

From its theoretical length that can be seen in the preceding subparagraph of 154.07 mm, length required for the execution of a theoretical frequency of 20000 Hz and safely admiting a length of 157.4 mm. there occurred a switch to the centralized measurement frequency according to the data in table 4. The initial length of 157.4 mm declined gradually, after each shortening its own frequency was measured up to the permissible domain of 20000 ± 500 Hz.

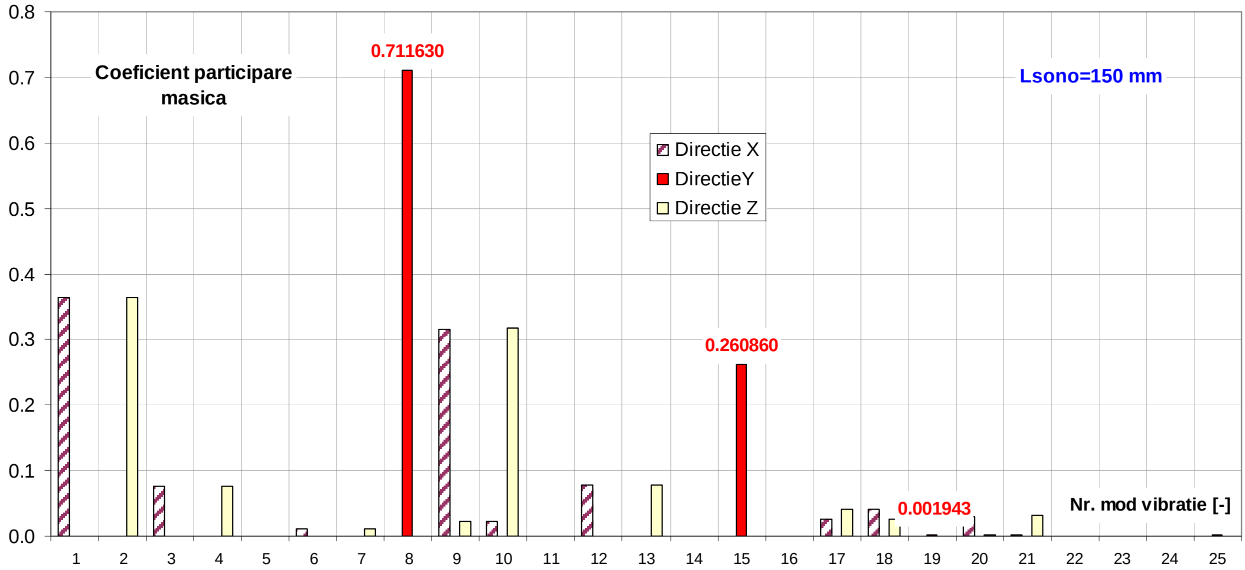


Figure 6 Distribution of mass participation factor based on vibration mode for sonotrode length of 150 mm

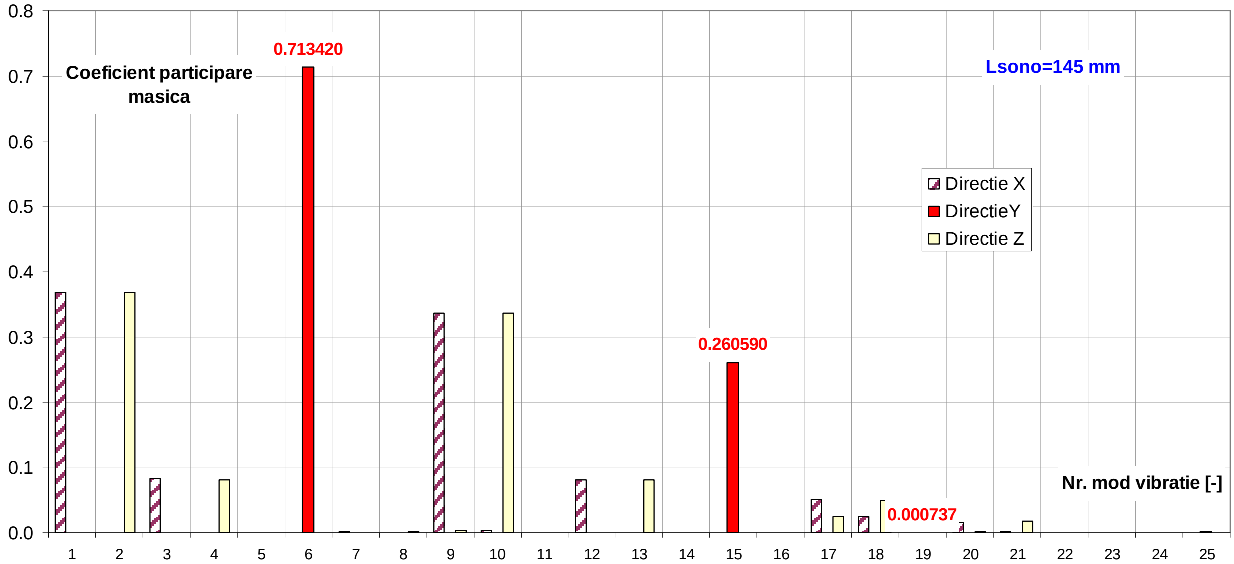


Figure 7 Distribution of mass participation factor based on vibration mode for sonotrode length of 145 mm

What sizes of table 4 is as follows:

- Sonotrode length – is the length of sonotrode;
- Frequency [Hz] – is the measured frequency;
- Δmm – is the shortened length of sonotrode in relation to the previous procedure;
- ΔHz – represents the difference in the measured frequency compared to the previous value.

Figure 9 shows the measured frequency variation (table 4) superimposed over the on that was calculated (table 3) based on the length of sonotrode.

The graph in Figure 9 shows the overlap of the calculated and measured curves, the measured values were lower than the calculated one. The graph shows the trend growth rate by reducing the length of sonotrode.

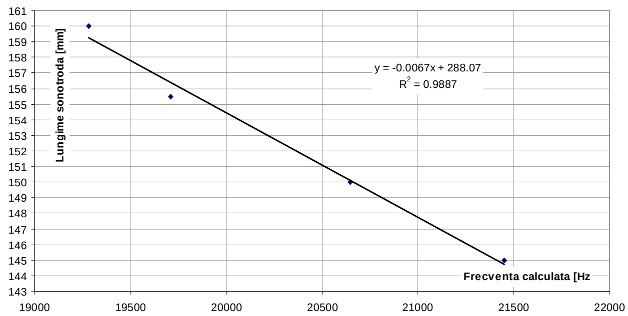


Figure 8 Sonotrode length variation based on how the calculated linear interpolation & addiction

Tabel 4 The length of sonotrode versus real frequency

| Length of sonotrode | Frequency (Hz) | Δmm | ΔHz |
|---|---|---|---|
| 157.4 | 19232.2 | 0 | 0 |
| 157.2 | 19274.9 | -0.2 | 42.7 |
| 156.6 | 19372.6 | -0.6 | 97.7 |
| 156.1 | 19476.3 | -0.5 | 103.7 |
| 155.4 | 19567.9 | -0.7 | 91.6 |
| 155 | 19635 | -0.4 | 67.1 |
| 154.6 | 19708.3 | -0.4 | 73.3 |
| 154.2 | 19775.4 | -0.4 | 67.1 |

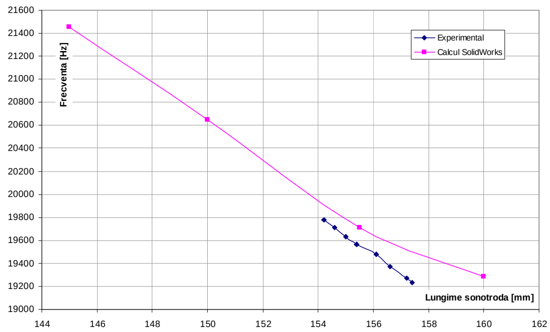


Figure 9 The change of the measured and calculated frequency according to the length of the sonotrode

## 5. SPECIMENS FOR CAVITATION EROSION

To check the stand, tests with specimens of steel were carried out, according to the data in table 5 and Figure 10.

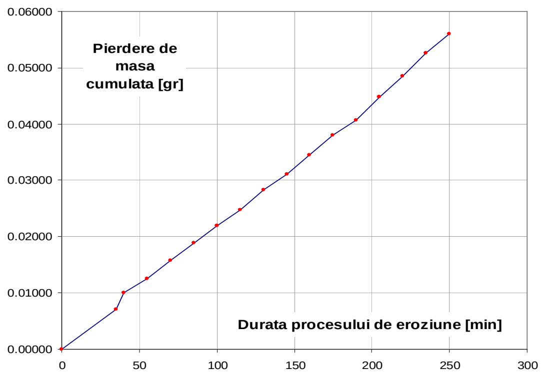


Figure 10 The variation of cumulative mass Σ Δm [gr] depending on the duration of the process of erosion

Tabel 5 Measurement results

| Minute | Mass [gr] | Δm [gr] | Σ Δm [gr] |
|---|---|---|---|
| 0 | 15.25309 | 0.00000 | 0.00000 |
| 35 | 15.24606 | 0.00703 | 0.00703 |
| 40 | 15.24310 | 0.00296 | 0.00999 |
| 55 | 15.24056 | 0.00254 | 0.01253 |
| 70 | 15.23728 | 0.00328 | 0.01581 |
| 85 | 15.23425 | 0.00303 | 0.01884 |
| 100 | 15.23106 | 0.00319 | 0.02203 |
| 115 | 15.22825 | 0.00281 | 0.02484 |
| 130 | 15.22473 | 0.00352 | 0.02836 |
| 145 | 15.22195 | 0.00278 | 0.03114 |
| 160 | 15.21863 | 0.00332 | 0.03446 |
| 175 | 15.21511 | 0.00352 | 0.03798 |
| 190 | 15.21235 | 0.00276 | 0.04074 |
| 205 | 15.20823 | 0.00412 | 0.04486 |
| 220 | 15.20455 | 0.00368 | 0.04854 |
| 235 | 15.20046 | 0.00409 | 0.05263 |
| 250 | 15.19703 | 0.00343 | 0.05606 |

## 6. CONCLUSIONS

The modal Analysis and the tests have allowed one to determine the sonotrode length for which the frequency of its work in the field is 20000±500 Hz. Final amount of sonotrode length 154.2 mm corresponds to its own frequency of 19775.4 Hz, which allows testing of the cavitational erosion.

## 7. ACKNOWLEDGMENTS

This work was partially supported by the strategic grant POSDRU /88/1.5/S/ 61178.

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# MONITORING OF THE SUSTAINABILITY FOR 38MOCRAL09 STEEL SUBJECTED TO THE UNCONVENTIONAL TREATMENT

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**ABSTRACT**

This material was subjected to the plasma nitro-carburation after thermo-magnetic treatments regimes. The structural and diffractometric aspects of the superficial layers of the steel are studied after the wear tests by friction, using an Amsler type machine, taking two sliding degrees at different contact pressures and testing time.. The tests were done to detect the sustainability to the material, the evolution of the superficial layer through different tests and to establish the influence of these thermo-magnetic treatments.

The magnetic field changes the transformation mechanisms and kinetics. In the end, it can be obtained through the change of the mechanical properties and the change of the structure configuration for this material. The magnetic field modifies the grain size in the material structure. The positive influence of the volume thermo-magnetic treatment on the surface layer treated thermo-chemically was represented by a higher hardness and a good resistance at the wear to the superficial layers.

**Keywords:** *Durability, thermo-magnetic treatments, thermo-chemical treatment, wear process*

## 1. INTRODUCTION

The martensitic steels after the hardening process were considered the principal materials for the magnets. Minkievici, Stark and Zaimovski, Erahtin, Komar and Tarasov röentgenographically studied these alloys. They demonstrated that the optimal magnetic properties are the consequences due to the variable structure that appears in the process stages [1], [7].

Because of their variable structure, the materials have individual micro-volumes of different phases. Each of these micro-volumes of ferromagnetic phase has a spontaneous magnetization and a marked magnetic anisotropy. These micro-volumes are isolated magnetic areas, non-magnetic areas or slightly magnetic layers. The result is a big coercitive force, which depends on the grain size and the temperature.

The final result must be a stable magnetic texture. In experimental programs, there are preferred two methods: the cooling regime in magnetic field (a thermo-magnetic treatment) or, thermo-mechanical treatments (based on overlap to unilateral elastic tensions).

The magnetic field changes the transformation mechanisms and kinetics, obtaining the thermo-magnetic treatment. In the end, it can be obtained the change of the mechanical properties and the change of the structure configuration for this material.

## 2. EXPERIMENTAL PROGRAM

It was considered a category of alloy steel, for treatments of improvement, useful in metallurgical industry, for example, 38MoCrAl09 (code R). The material is presented in table 1. The content of Ni corresponding to 38MoCrAl09 steel is 0.26%. The steel analyzed reach a max score 4.5 from inclusions and a fine grain (score 8-9).

Table 2 presents the standard mechanical characteristics of the steel, corresponding to The Society of Automotive Engineers (SAE) and The American Iron and Steel Institute (AISI).

The material was subjected to the following magnetic treatments and thermo-chemical treatments:

$t_1$ = martensitic hardening process at 920°C and high recovery at 620°C →classic treatment (Magnetic field intensity is *H =0 A/m*).

$t_3$ = quenching (hardening) (920°C) and high tempering (620°C) applied to steel 38MoCrAl09, cooling being performed in alternative current (a.c.) magnetic field (H = 1300 A/m);

$t_4$ = quenching (920°C) and high tempering (620 °C), cooling being performed in d.c. (direct continuous) magnetic field (H = 1300 A/m);

$T_{12}$ = $t_1$ (classic) + plasma nitrocarburation;

$T_{13}$ = $t_4$ + plasma nitrocarburation;

$T_{14}$ = $t_3$ + plasma nitrocarburation;

Plasma nitro-carburation was performed at treatment temperature of 530 °C.

The wear tests by friction were carried out on the Amsler machine, using wear roles couples (ξ = 10% and Q = 150 daN).

The usual methodology for the machinery parts study (roller wheel) useful in the metallurgical industry, presents the theoretic contact like a point (point contact) or, a line (linear contact). On Amsler machines [2], [3], [7], [8], it was determined the durability of the rolls, the structure evolution at different tests. Not must be neglected the other factories, which influence the wear process: the geometric forms in contact of the machinery parts (roll on roll, roll on ring), the technological parameters (the surface quality, the temperature of the treatments) and the exploitation conditions (the solicitation temperature – for example). It were submissive at wear process on an Amsler machine from "Dunarea de Jos" University of Galati, rolls with different diameters, which suffered different treatment regimes.

Table 1. Chemical composition of the materials

| Steel grade | C(%) | Mn(%) | Si(%) | P(%) | S(%) | Cr(%) | Cu(%) | Mo(%) | Al(%) |
|---|---|---|---|---|---|---|---|---|---|
| 38MoCrAl09 (Code R | 0.38 | 0.50 | 0.25 | 0.026 | 0.020 | 1.38 | 0.058 | 0.17 | 1.18 |

Table 2.Mechanical characteristics of the steel (Standard)

| Steel grade | $Rp_{0,2}$ [daN/mm$^2$] | $R_m$ [daN/mm$^2$] | $A_5$ [%] | Z [%] | $KCU_{300/2}$ [daJ/cm$^2$] | $KCU_{300/5}$ [daJ/cm$^2$] | HB (State of annealing) |
|---|---|---|---|---|---|---|---|
| 38MoCrAl09 AISI(SAE) 4038 | 85 | 100 | 15 | 50 | 9 | 6 | 229 |

## 3. EXPERIMENTAL RESULTS

In figure 1, t1 represents classic treatment (Magnetic field intensity, H=0 A/m)), $t_3$ represents a Magnetic field–alternative current-A.C. (H=1300 A/m) applied and $t_4$ represents a direct (continuous) magnetic field (D.C.) applied.

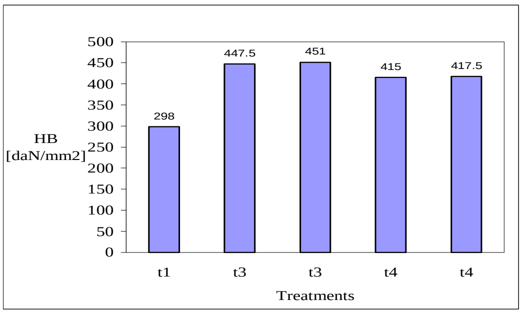


Figure 1. The influence of the magnetic field on the hardness number, for code R samples (38MoCrAl09) [3], [11]

The magnetic field modifies the grain size. It was obtained a small grain size in the middle of the sample and the orientation of these grains are in the same direction with the lines of the magnetic field.

On Amsler machines [7], the done tests tried to determine the durability of rollers, the surface structure evolution for different parameters of testing regimes. It could not be neglected other factors influencing the wearing process: the contact geometry of the friction couple (roller on roller, roller on ring etc.), the technological parameters (surface quality, heat treatments, etc.) and the exploitation conditions (the thermal solicitation, for example).

Wear tests were carried out on an Amsler machine, using several couples of rollers, each couple corresponding to a different sliding degree ξ, defined as:

$$\xi = (v_1 - v_2)\ 100 / v_1\ [\%] \qquad (1)$$

where $v_1$ and $v_2$ are the peripheral velocities of the rollers in contact, each one having their specific peripheral velocity due to a particular combination of angular speeds ($n_1$, $n_2$) and diameter sizes ($d_1$, $d_2$). Index 1 or 2 are added for the roller 1 or 2, respectively, both of the same tested couple. For instance, $\xi = 10\%$ is obtained for a pair of tested rollers having $d_1$ = 40 mm, $n_1$ = 180 rev/min and $d_2$ = 40 mm, $n_2$ = 162 rev/min. $\xi = 18\%$ is obtained for a pair of tested rollers having $d_1$ = 44 mm, $n_1$ = 180 rev/min and $d_2$ = 40 mm, $n_2$ = 162 rev/min. The level of the stress is corresponding to a specific load of 150 N/mm and a normal load is $Q$ = 1500 N. The contact between roller is $b$ = 10 mm. Figures 2-3 present the average mass loss and the worn layer depth, after three hours of wear test, for these two steel grades, with or without treatments in magnetic fields (in alternative current or continuous current), treated by nitrocarburation. On both cases one may notice the lower values of average mass loss for T11 and T13 treatments, when steel sample cooling was performed in alter-native current magnetic field and the higher values of average mass loss for T9 and T12 treatments, when a classic treatment was applied on steel samples. The continuous magnetic field treatment applied before nitrocarburation treatment (T10, T14) determine intermediate values of average mass loss.

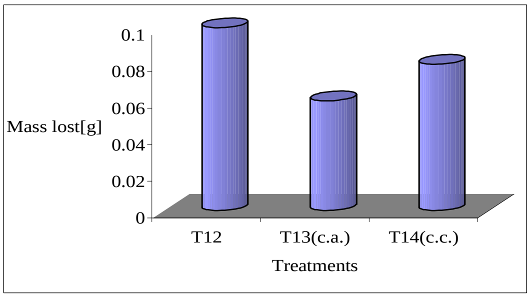


Figure 2. The magnetic field influence on the average mass loss after 3 hours of wear test, $\xi$=10% and normal load of $Q$=150 N/mm [4]

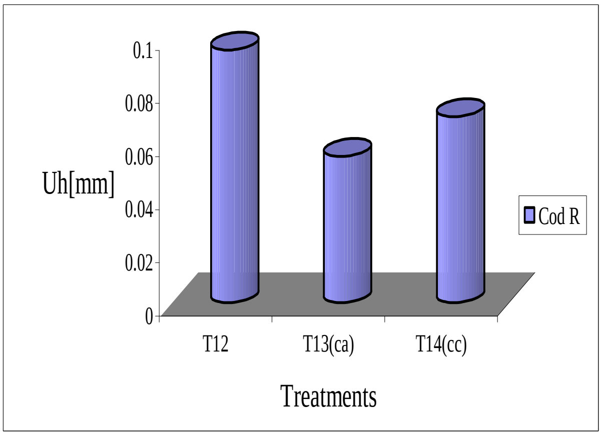


Figure 3. The influence of the magnetic field on the worn layer depth, after 3 hours of wear tests by friction, $\xi$=10% and normal load of $Q$=150 N/mm [4]

## 4. DIFFRACTOMETRY ASPECTS

In the analyse superficial layers, the $Fe_4N$ phase has a higher hardness than the $Fe_3N$ phase.

Thus, it was possible in the case of thermo-magnetic treatments applied before the thermo-chemical treatments.

It was observed a higher quantity of $Fe_4N$ phase as compared to the quantity of the $Fe_3N$ phase. In this case, the nitrocarburized layer depth increase and the resistance to wear increase too, with more than 25%. The resistance to corrosion increase (more than 34%), too.

Figures 4, 5, 6 and 7 present the influence of magnetic field (cc) (T14) on Feα(M)-44,98° phase distribution, obtained on the samples, after different treatment regimes and in figures 8 and 9, are presented the influence of magnetic field (cc) (T14) on martensite thetragonality grade (*c/a*), after 1…3 hours of wear tests, using an Amsler machine.

Following the repartition of degrees of phase distribution in thermo-chemically treated layers by nitro-carburizing plasma (see table 4) and analyzing the fragment of diffractometry), it was obtained information about the magnetic field influence on the superficial characteristics, in initial state (Δt = 0 h), before the wear tests on tribomodels (Δt = 0h).

Table 3:Diffractometry positioning of the various phases existing in the surface layer [2], [3], [4]

| Phases | $2\theta_1$ [˚ ] Relative intensity[%]) | $2\theta_2$ [˚ ] Relative intensity[%]) | $2\theta_3$ [˚ ] Relative intensity[%]) |
|---|---|---|---|
| $Al_4C_3$ | 31.12 (100) | 31.92 (100) | - |
| AlN | 33.14 (100) | 37.91 (70) | 36.02 (60) |
| β-$Al_2O_3$ | 37.58 (100) | 45.80 (100) | - |
| $Co_3C$ | 45.8 (100) | - | - |
| $Cr_7C_3$ | 39.65 (50) | 43.02 (60) | 44.81 (100) |
| $(CrFe)_7C$ | 39.11 (40) | 42.59 (60) | 44.35 (100) |
| $Cr_3C$ | 39.11 (100) | 39.65 (60) | 40.21 (100) |
| $Cr_2N$ | 43.02 (100) | - | - |
| CrN | 37.42 (100) | 43.67 (100) | 36.32 (100) |
| $Fe_3(CN)$ | 43.23 (100) | 41.17 (25) | 57.14 (25) |
| $Fe_4(CN)$ | 41.17 (100) | 66.20 (83) | 45.81 (77) |
| Feα →(M) | 44.98 (100) | 82.5 (38) | 65.16 (15) |
| Γ-MoC | 36.79 (100) | 39.29 (100) | 42.59 (100) |
| Γ'MoC | 36.32 (100) | - | 43,23 (100) |
| $Mo_2C$ | 39.47 (100) | - | - |
| δ-MoN | 36.02 (90) | 48.91 (90) | - |
| Γ-$Mo_2N$ | 37.26 (100) | 43.45 (100) | - |

For application of an A.C. magnetic field (H3 = 1300 A/m) before the nitro-carburizing in plasma, the amount of hard phases (chromium carbides and, especial, Feα (M):44,98˚ and 82,5˚) increased more then in the D.C. magnetic field case and, compared to standard treatment. This observation was determined, for example, by the existence of a larger peak heights in the range: 41 ÷ 45 º, respectively, greater width of diffraction line (see table 4).Also, in table 4 are presented the calculation results corresponding to phase distribution in the three treatment regimes cases (T12, T13, T14) and in the three wear friction stages (after: one hour, two hours or, three hours of wear tests), at Q = 150 daN. The friction moment was Mf=45 daN/mm2, and the samples diameters -_the rolls diameters- were 40 mm- each of them.

The variation of phases distribution curves and the other characteristics of the superficial layers depending on the duration of the friction and are presented in figures 4…9. Diffractometric analyses were performed by means of a Dron 3.

Table 4: Phases identified and their characteristics diffractometer analysis for the steel (code R) which underwent conventional heat treatment to improve the characteristics or, un-conventional treatment in magnetic field followed by the thermo-chemical treatment and wear tests

| Code sample | [%] $I_{Fe\alpha(M)}$ (44˚-45˚) | [%] $B_{Fe\alpha(M)}$ ~c/a | [%] $I_{Fe\alpha-M}$ (81º-84º) | [%] $B_{211}$ ~ $\sigma_{II}$ | [%] $I_{CrN}$ | [%] $I_{Fe3CN}$ | I Fe4 CN | [%] $I_{Cr2N}$ | [%] $I_{Co3N}$ | [%] I $Mo_2N$ | Δt [h] | Treat-ment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R2 Clasic | 19.00 | 2.923 | 3.25 | 2.100 | 2.50 | 1.900 | 2.5 | 1.000 | 1.25 | - | 0 | T12 |
| | 18.75 | 2.900 | 3.15 | 2.000 | 2.00 | 1.750 | 2 | 0.500 | - | - | 1 | T12 |
| | 18.90 | 2.500 | 3.25 | 2.250 | 1.75 | 2.000 | 1 | 0.500 | - | - | 2 | T12 |
| | 20.00 | 2.475 | 2.95 | 1.980 | 1.00 | 1.920 | 1 | 0.450 | - | - | 3 | T12 |
| R3 (a.c.) | 31.75 | 2.016 | 6.00 | 1.600 | 3.50 | 1.428 | 3.25 | 1.667 | 1.00 | 2.00 | 0 | T13 |
| | 40.50 | 2.077 | 8.75 | 2.188 | 1.85 | 0.500 | 2.5 | 1.500 | 0.75 | 0.75 | 1 | T13 |
| | 42.75 | 1.900 | 12.00 | 2.400 | 1.85 | 0.660 | 2.5 | 1.450 | 0.50 | 0.70 | 2 | T13 |
| | 57.50 | 1.982 | 14.50 | 2.843 | 1.75 | 1.000 | 1 | 1.000 | 0.50 | 1.30 | 3 | T13 |
| R5 d.c.) | 26.75 | 1.930 | 4.00 | 1.500 | 2.75 | 1.000 | 1 | 1.600 | 0.50 | 1.00 | 0 | T14 |
| | 38.75 | 1.782 | 6.00 | 1.904 | 1.15 | 0.650 | 0.75 | 0.750 | 0.75 | 0.75 | 1 | T14 |
| | 41.00 | 1.851 | 7.85 | 1.963 | 1.15 | 0.500 | 0.75 | 0.600 | 0.80 | 0.50 | 2 | T14 |
| | 41.75 | 1.988 | 11.75 | 2.136 | 1.00 | 0.500 | 1 | 0.800 | 0.50 | 0.50 | 3 | T14 |

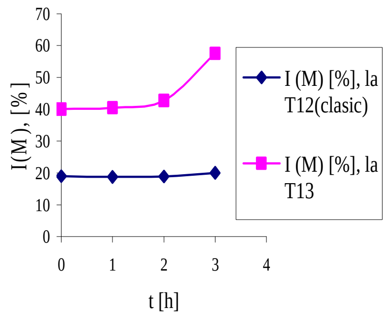


Figure 4. The influence of magnetic field (ac) (T13) on distribution of the phase Feα(M)-44,98° vs. test time, ($Q$=150 N/mm, $\xi$=10%)

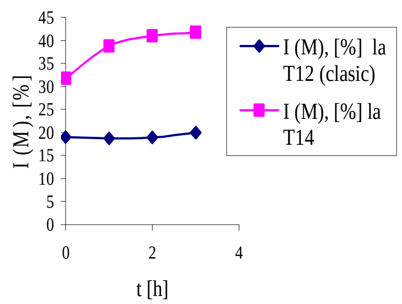


Figure 5. The influence of magnetic field (cc) (T14) on distribution of the phase Feα(M)-44,98° vs. test time, (Q=150 N/mm, $\xi$=10%)

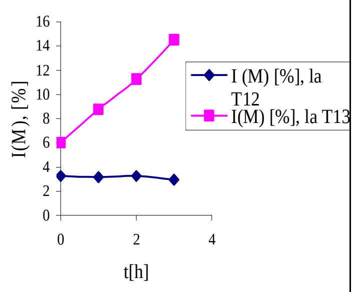


Figure 6. The influence of magnetic field (ac) (T13) on distribution of the phase Feα(M)-82,5° vs. testing time, (Q=150 N/mm, $\xi$=10%)

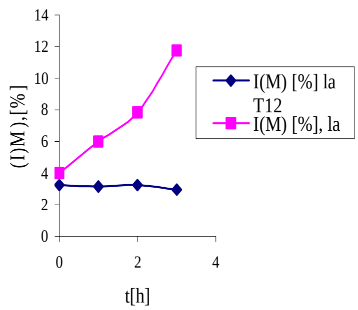


Figure 7. The influence of magnetic field (cc) (T14) on Feα(M)-82.5° phase distribution vs. testing time ($Q$=150 N/mm, $\xi$=10%)

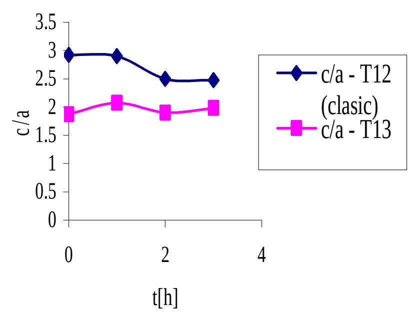


Figure 8. The influence of magnetic field (cc) (T14) on grades of thetragonality for martensite ($c/a$), vs. test time ($Q$=150 N/mm, $\xi$=10%)

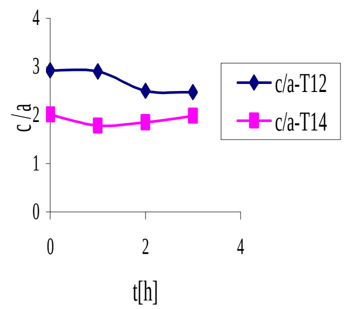


Figure 9.The influence of magnetic field (cc) (T14) on grade of thetragonality for martensite ($c/a$), vs. test time ($Q$=150 N/mm, $\xi$=10%)

## 5. CONCLUSIONS

The novelty of the present paper involves the application of the diffusion thermo-chemical treatment after the thermo-magnetic one, the temperature of the former being lower than that of the latter. Except that the thermo-chemical treatment applied after the thermo-magnetic treatment should not modify the improvements of the mechanical properties accomplished by the thermo-magnetic treatment

It was made a comparison between classic treatment (blue lines) and un-conventional (magnetic) treatment.

In the case of alternative or continuous magnetic field applied to the steels (T13, T14), it was observed a higher initial quantity of martensite and carbo-nitrurs, comparing with the classic treatment. During the wear process, the martensite quantity increase and the carburs quantity decrease very rapidly. The internal tensions (II) increase easily according with the duration of wear tests.

The positive influence of the volume thermo-magnetic treatment on the surface layer treated thermo-chemically resulted in a higher hardness [4].The wear resistance increase and the depth of the used layer [5], [7] decrease by approx. 50%.

It has been shown that, when applying an alternative current (a. c.) magnetic field treatment (for example, $H = 1300$ *A/m*), the thickness of the thermo-chemical treated layer increase up to 25% as compared to the conventional (classic) thermal/thermo-chemical treatment ($H = 0$ *A/m*).

It was observed that for the classic treatment applied to 38MoCrAl09 steel grade, the martensite quantity and the nitrides are maintained constants after the friction-wear process. In the case of alternative (a.c.) or continuous-direct (d. c.) magnetic field applied to the steels (Tca, Tcc), it was observed a higher initial quantity of martensite and nitrides. During the wear process, the martensite quantity increase and the $Fe_3N$ quantity decrease. A good influence of the thermo-magnetic treatment on the surface layer resulted in a higher hardness [4], [11] and a good wear resistance.

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# STUDY REGARDING MARINE HEAT PUMP

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**ABSTRACT**

Most of the energy consumption comes from domestic heating residential buildings. A rate close to 86% of energy requirements of private homes are for heating and domestic hot water preparation, the latter being largely covered gas and diesel. Since the availability of energy sources based on fossil fuels is limited in time, we need alternative. An important role may be played on future energy sources especially by the heat pumps. Especially taking into account, the fact that, due to the geographical situation of our country, offer overlaps the necessary, aspect conditioned of using solar and marine energy. For this reason, this paper is intended to be a presentation on the use of sea water heat, showing the advantages of temperature gradient by using a heat pump water-water type.

**Keywords:** *renewable energy, sea water, heat pump.*

## 1. INTRODUCTION

At the current rate of growth of classic fuel consumption we need to find cheaper energy sources. Also begin to see the negative effect of using classic fuels (pollutant emissions, greenhouse effect).

It is important to worry about finding and promoting new technologies and applications on the use of unconventional energy resources.

To convert renewable energy into heat usually requires some specific equipment. The most common single family home heating equipment are solar energy collection systems, heat pumps and combustion systems of renewable solid fuels.

Improving energy efficiency of processes, industrial or household is accomplished largely through the introduction of renewable energy in the secondary circuit that appear and grow simultaneously with these processes. Heat pumps are part of these sources can provide an important contribution to a better use of energy to supply heat to moderate heat levels required by many processes and especially for heating and hot water consumption of civil and industrial buildings.

## 2. THE HEAT PUMP

The necessity of using heat pumps in buildings is based on two considerations:

- Energy saving, demonstrated by energetic analasys
- National and international law (Kyoto 1997 and Directive 2002/91.CE on energy performance of buildings.)

The heat pump is a heating plant that serves to "pump" heat from a low temperature to a higher one, I mean, take $E_{iz}$ heat from the heat source with a low-temperature thermal potential $T_{iz}$ and gives it to $E_c$ heat consumer with a higher termal potential temperature $T_c$ consuming this purpose, a driving energy $E_A$.

$$E_{iz} + E_A = E_C \text{ [ Kwh ]} \tag{1}$$

Refrigerator deriving from, being identical with it constructively, but differing the intended purpose, heat pump can be found in all three classic types: mechanical compression, with the ejection or absorption. Heat pumps adapts perfectly legal technical provisions, with low power consumption. On the other hand, heat pump shows clear advantages compared to a conventional classic heating system, in terms of comfort level and operating costs.

Just as water can not flow upstream, so the heat is transferred from the warmer (heat source) to the cooler (radiator). Therefore, to use the ambient heat from the soil, the air and from groundwater for heating and preparation of domestic hot water, It needs that heat to be "pumped" to a higher temperature. This is possible only by using a refrigerant.

Heart of a heat pump is driven compressor refrigerant circuit. From the construction point of view it is identical with the refrigerators refrigerant circuit wich is extensively tested, and can be compared with it in terms of safety and reliability. Only applicability is reversed: in case of refrigerator, heat is extracted from the food cooled and is discharged into the room through the back of the unit. In case of the heat pump, the heat that is taken from the environment (water, soil, air) is then transmitted to the heating system.

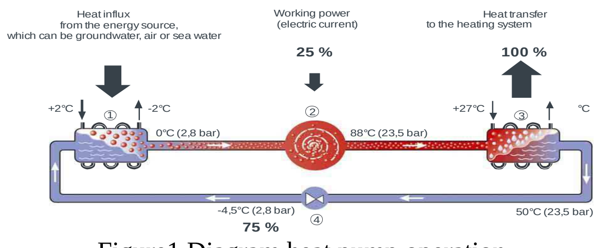


Figure1 Diagram heat pump operation

## 3. SEA WATER AS A HEAT SOURCE

The special attraction for heat pumps compared to conventional heating systems result from availability of heat sources, which can use renewable heat from the environment, available as free long-term heat.

Regardless of the heat source used by purchasing a heat pump always have access to a heat source. It basically makes an investment in a long term heat source. In other words buy heat "on the stock".

The partuicularity of the waters from the Black Sea towords the water from Planetary Ocean is given by the position of intercontinental and continental basin, the rich flow of carbonated water carried by rivers and bodies of water mixture entering from the Mediterranean through the Dardanelles and Bosporus. Waters coming from the land, have the dominant elements carbohydrate, calcium and magnesium dissolution resulting from continental rocks. Marine waters contain more chloride ions (55.12%), sodium, potassium (31.62%) and sulfur (7.47%). Carbohydrates, calcium and magnesium are found in the Black Sea twice as much compared to the Mediterranean, and sodium, potassium and sulphates are less represented.

Tabel 1. Comparison of chemical composition of continental waters, the Mediterranean and Black Sea (after Ujvari, 1972)

| | CI | Br | $SO_4$ | $HCO_3$ | $Na^+$ $+K^+$ | $Ca^{++}$ | $Mg^{++}$ |
|---|---|---|---|---|---|---|---|
| Continental waters % | 5,00 | - | 7,10 | 63,0 | 4,90 | 15,20 | 4,80 |
| Mediterranean Sea (Marseille) % | 55,12 | 0,8 | 7,89 | 0,20 | 31,73 | 1,23 | 3,65 |
| Marea Neagră % | 55,12 | 0,18 | 7,47 | 0,46 | 31,62 | 1,41 | 3,74 |

As a result of hydrological characteristics, they could separate types of water masses where you can define more complex thermohaline aspects of northwestern Black Sea (Şelariu 1965):

- coastal water bodies as a result of sweetening marine waters through the Danube;
- surface-water bodies, with a thickness of several meters, which direct experience variations in temperature, salinity and dissolved oxygen;
- deep - water masses, which deals with most of the volume of water and the seasonal hydrological elements is reduced.

(after Şelariu O. 1971)

*3.1. Thermal regime and ice regime of the Black Sea*

Thermal regime and ice regime dependent on: solar radiation, evaporation, heat exchange from contact with the atmosphere, the caloric effect of the sea tributary rivers. The average annual temperature of water in the Romanian sector of the Black Sea is 12-14 C, exceeding by 2-3 C average temperature acre in area.

In winter, the water temperature frequently drops below 0° C, reaching 1° C in the coastal zone and 0° C at 30-50 km away from the shore. In the frosty years, it can form ice-marginal thick layers of 15-20 cm. In May the average surface temperature reaches 13° C and 22° C on shore and 22° C in the center of the basin. Evidence of low temperature values recorded since September.

Apparent temperature stratification occurs in summer. Surface layer with thickness of 25-50 cm (active layer) is strong heated by the Sun and the temperature differences reached 15 °C in July. At depths of 100-150 m water temperature remains constant throughout the year (8.1-9.1 ° C).

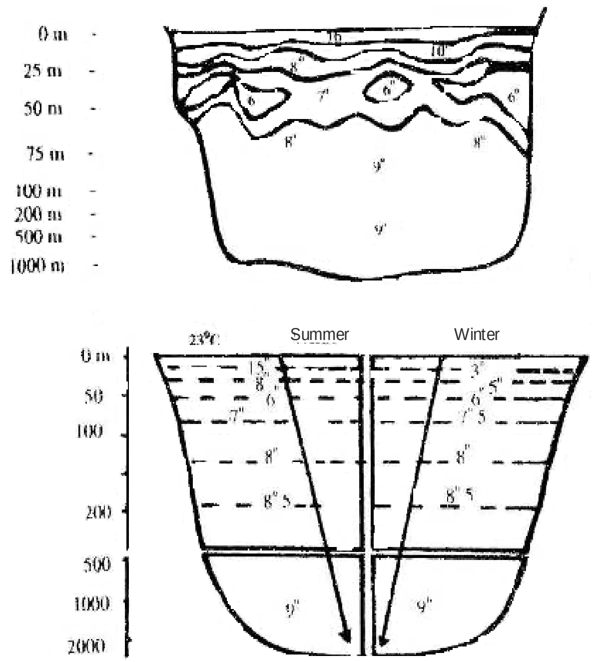


Figure 2 Vertical distribution of water temperature in Black Sea (Újvari, Iosif - Geography of Romania's water)

Frequently, in the warm sea waters, there are large temperature differences between the surface layers and the deep, differences that would allow operation of power plants based on the use of two different temperature heat sources. Considering the annual average temperatures, and that the water layers temperatures remain constant all year round, Black Sea water is suitable to be a primary agent for a heat pump.

The main advantages of using sea water to increase the performance of open loop heat pumps are:

- Stratification of sea water, depending on temperature and salinity which allows us to use the pump in both summer and winter, extracting heat at different depths depending on the season.
- Water flow can be considered unlimited.

*3.2. The coefficient of performance COP*

As water can not flow up, so no heat will not flow by itself from a colder source Tb (K) to a warmer one Ta (K). For this we need additional energy. The theoretical COP, which can be achieved, also called Carnot efficiency is the following:

$$COP_{Carnot} = T_a/(T_a - T_b) \qquad (2)$$

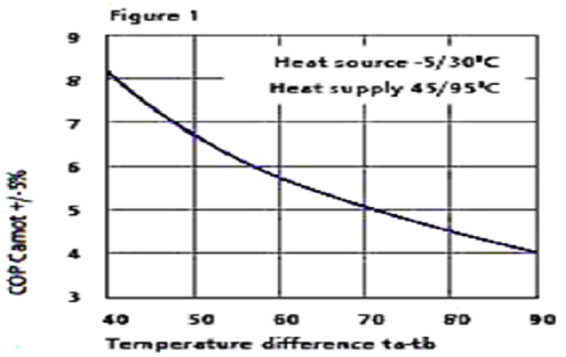


Figure 3 Graph COP for most applications

Carnot efficiency decreases as soon as the temperature difference to be gained increases. In fact the actual COP is slightly different from that of the Carnot cycle. Relationship between the real COP and the theoretical one is called total efficiency.

$$COP_{Real} = \eta_{total} \text{ x } COP_{Carnot} \qquad (3)$$

As a hint, are used the following maximum values for heat pumps currently available on the market, including peripheral equipment with variable temperature heat source and heat emission throughout the year.

Table 2. The total efficiency

| Heat source | $\eta_{total}$ |
|---|---|
| Exterior air | 0,40 |
| Ground | 0,45 |
| Lake water, river water, sea water | 0,50 |

## 4. EXAMPLE

To illustrate the energy potential of the Black Sea water will consider the following case: in Mamaia resort, in the summer we want to minimize spending on domestic water heating. Under current regulations domestic hot water (DHW) must be between 45 and 60 degrees Celsius. Thus consider a plant as in the following figure, consists of two heat exchangers and heat pump water-water type.
To highlight the potential energy, we calculate only pump COP values, depending on temperature and heat source.

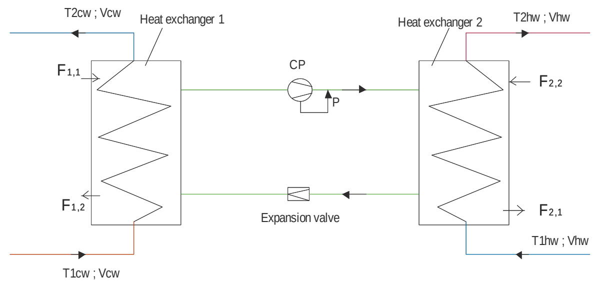


Figure 4 Plant water-water heat pump

For heating:

$$F_{2,2} = F_{1,2} + P \quad \text{and} \qquad (3)$$

$$T_{2hw} = T_{1hw} + F_{2,2}/(4{,}186 x V_{hw}) \qquad (4)$$

For cooling:

$$F_{1,1} = F_{2,1} + P \quad \text{and} \qquad (5)$$

$$T_{2cw} = T_{1cw} - F_{2,1} / (4{,}186 x V_{hw}) \qquad (6)$$

$F_{1,1}$ – heat flow taken from the primary agent
$F_{1,2}$ – heat flow from the primary agent
$F_{2,1}$ – cooling power of the thermal machine, in Kw
$F_{2,2}$ – heating power of the thermal machine, in Kw
P – electricity consumption in vapor compression refrigerant cycle.
$V_{cw}$ - primary agent flow (groundwater, sea water) in l /s
$V_{hw}$ - secondary flow agent (for hot water heating)
$T_{1cw}$, $T_{2cw}$ -temperature input and output of the primary
$T_{1hw}$ – hot water inlet temperature
$T_{2hw}$ – hot water outlet temperature

*4.1 Case we use water from groundwater:*

Groundwater water temperature at a depth of 10-15 m is constant throughout the year and has a value of 10 to 12 C.
In this case, the pump COP has the following value:

$$COP_{Carnot} = T_c /(T_c - T_0) = 45/(45-10) = 1.28 \qquad (7)$$

$$COP_{Real} = \eta_{total} \text{ x } COP_{Carnot} = 0.45x1.28 = 0.57 \qquad (8)$$

The disadvantage of using this type of primary agent would be relatively small flow of groundwater, approximately 5 l / s. It is suitable for use as an agent for a heat pump that serves a single family house, otherwise the flow is insufficient.

*4.2 Case we use sea water:*

As shown in Figure 2, the sea water has a thermally stratified regime due to several factors. In summer the surface temperature oscillates between 23 and 19 C and at a depth of 25 m temperature remains constant at 15 C. In winter, a constant temperature, positive and sufficient for the heat pump is found at a depth of 100 m and has a value of 8 C.

$$COP_{Carnot} = T_c /(T_c - T_0) = 45/(45-20) = 1.8 \qquad (9)$$

$$COP_{Real} = \eta_{total} \text{ x } COP_{Carnot} = 0.5x1.8 = 0.9 \qquad (10)$$

Obviously if we want to produce hot water but at a lower temperature (30 degrees) and the end user just have to raise its temperature than the heat pump COP significantly increases up to a value of 3.

## 5. CONCLUSIONS

Considering the geographical position of our country and technological progress of the last 10 years, we can distinguish two reliable renewable energy high potential sources: water from groundwater and seawater.

The advantages of using water from groundwater as a heat source for heat pumps are as follows: high COP, constant temperature between 10 and 12 C. The disadvantages of this source restrict ourselves to using it only for small houses: low water flow may be used only for small and medium spaces, initial cost quite high, open system, preliminary analysis of water and high maintenece costs.
Sea water shows superior advantages to water from groundwater, which are: high COP, high flow, temperature of 8 C at 100m depth and between 15 and 20 C in summer at 2 to 25 m, used for large buildings. As disadvantages, mention: high installation costs, it is an open system and water must be pumped from high depths.
In conclusion, sea water represents renewable energy source that is best suited for use in a heat pump with domestic as well as industrial purposes.

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# ZOOPLANKTON STRUCTURE IN THE CERNAVODA DANUBE RIVER AREA

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**ABSTRACT**

A few key points situated around the Nuclear Power Plant (NPP) Cernavoda were studied between 1999-2010. 14 expeditions have been made in the research area and more than 500 samples with zooplankton were collected. Analysis of the samples revealed the spatial and temporal dynamics of the taxonomic diversity and numerical abundance.

**Keywords:** *Nuclear Power Plant, Danube River, zooplankton, cooling system.*

## 1. INTRODUCTION

Zooplankton plays a important role in the tropho-dynamic and energetic cycles of aquatic ecosystems, being a link between phytoplankton and zooplanktonophagous fishes; at the same time zooplankton populations can represent sensible biological indicators of the state of aquatic ecosystems exposed to stress conditions.

The determination of taxonomic pattern of zooplankton and the taxa richness is an essential condition for the ecosystem assessment [1].

The aim of this study is to point out the spatial and temporal dynamics of the zooplankton populations in certain points of Cernavoda area, being under influences of the cooling water system of NPP Cernavoda.

## 2. METHODS

Six sampling sites (S1÷S6) were chosen around Cernavoda Danube area (Fig. 1):

**S1** – this site is placed on the Danube, 1500 m upstream the confluence with DBSC; it is considered a reference station because the ecosystem is not affected by thermal discharge from the NPP Cernavoda.

**S2** – is represented by the income water basin of NPP; here the water is coming from Danube via Danube – Black Sea Canal, but due to the low flow this area could be assimilated as a limnic ecosystem.

**S3 –** is a site situated on the effluent discharge canal of NPP, upstream the aeration fall; here the temperature of the water is expected to reach the maximum values.

**S4** – is a site placed downstream the aeration fall of the NPP discharge canal, but 100 m upstream the confluence between this canal and the Danube River.

**S5 –** is situated on the Danube, 300 m upstream the confluence between the NPP discharge canal.

**S6 –** this site is placed on the Danube in the thermal plume, 500 m downstream the confluence between NPP discharge canal and the river.

The quantitative samples were collected using a Schindler – Patalas zooplankton trap, and an 50 µm mesh size net. For a better characterisation of the taxa, more samples from different depths were taken, in steps of 0.5 m or 1 m in every station. Thus we obtained a spatial distribution (by depth) for each site. The final data were calculated as the mean value of these samples.

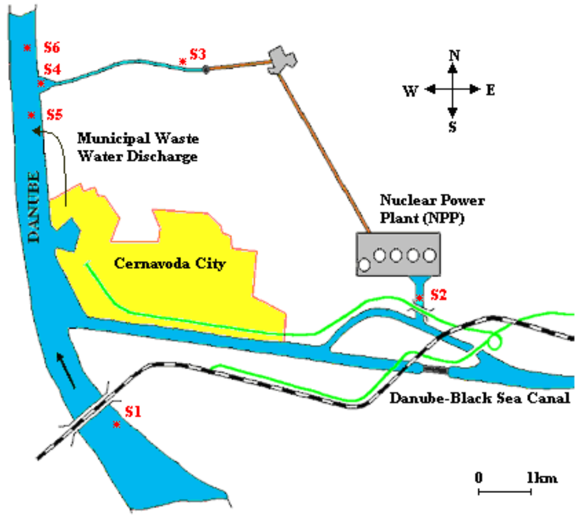


Figure 1 Sampling sites position

Zooplankton samples collected in the field were preserved in 4% buffered formaldehyde.

In these papers we analysed data about zooplankton populations (only Rotifera, Bivalvia, Cladocera and Copepoda) collected in the spring and summer time between 1999-2010 and uses and in others studies [2].

Commonly used methods were applied for zooplankton investigations [3],[4],[5],6].

## 3. RESULTS AND DISCUSSIONS

In the studied area we recorded 62 types of organism (species and developmental stages of some Copepoda and Bivalvia), from Rotatoria (64%) Bivalvia (2%), Cladocera (24%) şi Copepoda (10%).

Yearly qualitative zooplankton structure point out a gradual upward trend in the number of species, being recorded 43 species in 1999 and 49 in 2010, with a maximum value (53) in 2007. The largest number of species was recorded in S2; This is followed by stations which are not under the influence of the of thermal parameter (S1 and S5). The taxa number continues to decline in the warm water effluent, with the minimum value in S4 (Tab. 1).

Analysis in time of a taxa variation marks a relatively constant frequency of occurrence of the majority of species (Tab. 2).

Tabel 1. The taxonomic diversity dynamics on sites and years (taxa number)

| | S1 | S2 | S3 | S4 | S5 | S6 | S1-S6 |
|---|---|---|---|---|---|---|---|
| 1999 | 25 | 28 | 28 | 24 | 23 | 21 | 43 |
| 2000 | 26 | 32 | 30 | 24 | 25 | 24 | 48 |
| 2001 | 28 | 40 | 35 | 31 | 28 | 28 | 46 |
| 2002 | 29 | 30 | 28 | 23 | 29 | 27 | 49 |
| 2006 | 24 | 33 | 26 | 29 | 25 | 26 | 48 |
| 2007 | 38 | 30 | 32 | 27 | 40 | 32 | 53 |
| 2010 | 25 | 34 | 29 | 28 | 29 | 27 | 49 |
| 1999-2010 | 56 | 57 | 54 | 46 | 54 | 51 | 62 |

Tabel 2. The dynamics of the zooplankton taxonomic composition in the area of study (frequency of occurrence of species [%])

| | Species | F min | F avg | F max |
|---|---|---|---|---|
| | **PRIMARY CONSUMERS** | | | |
| | **ROTATORIA** | | | |
| 1 | *Brachionus angularis* Gose | 5.56 | 19.84 | 66.67 |
| 2 | *Brachionus budapestinensis* Daday | 0.00 | 9.92 | 33.33 |
| 3 | *Brachionus calyciflorus* Pallas | 55.56 | 84.13 | 100.00 |
| 4 | *Brachionus calyciflorus* f. *anuraeiformis* | 0.00 | 1.98 | 8.33 |
| 5 | *Brachionus calyciflorus* var. *amphiceros* | 66.67 | 90.48 | 100.00 |
| 6 | *Brachionus calyciflorus* var. *dorcas* Gosse | 0.00 | 11.90 | 25.00 |
| 7 | *Brachionus diversicornis* Daday | 8.33 | 40.48 | 66.67 |
| 8 | *Brachionus falcatus* Zacharias | 0.00 | 6.35 | 16.67 |
| 9 | *Brachionus quadridentatus* var. *brevispinus* | 16.67 | 52.78 | 83.33 |
| 10 | *Brachionus quadridentatus* var. | 8.33 | 40.48 | 75.00 |
| 11 | *Brachionus quadridentatus* var. *melheni* | 0.00 | 3.17 | 16.67 |
| 12 | *Brachionus urceolaris* Muller | 33.33 | 41.67 | 66.67 |
| 13 | *Euchlanis parva* Rousselet | 8.33 | 23.81 | 50.00 |
| 14 | *Filinia longiseta* Ehrenberg | 0.00 | 10.32 | 16.67 |
| 15 | *Filinia passa Muller* | 0.00 | 6.75 | 16.67 |
| 16 | *Keratella cochlearis* Gosse | 16.67 | 45.63 | 91.67 |
| 17 | *Keratella quadrata Muller* | 58.33 | 86.90 | 100.00 |
| 18 | *Keratella valga* f. *heterospina* Klausener | 0.00 | 10.32 | 22.22 |
| 19 | *Keratella valga* f. *monospina* Klausener | 0.00 | 1.59 | 11.11 |
| 20 | *Lecane closterocerca* Schmarda | 0.00 | 1.19 | 8.33 |
| 21 | *Lecane luna* Muller | 0.00 | 6.75 | 22.22 |
| 22 | *Lecane quadridentata Ehrenberg* | 0.00 | 4.37 | 25.00 |
| 23 | *Lecane* sp. | 0.00 | 7.54 | 16.67 |
| 24 | *Mytilina ventralis* Ehrenberg | 5.56 | 16.27 | 33.33 |
| 25 | *Notholca acuminata* Ehrenberg | 0.00 | 18.65 | 41.67 |
| 26 | *Platyas quadricornis* Ehrenberg | 0.00 | 3.57 | 8.33 |
| 27 | *Polyarthra vulgaris* Carlin | 0.00 | 5.16 | 11.11 |
| 28 | *Rotaria rotatoria* Pallas | 0.00 | 3.57 | 8.33 |
| 29 | *Rotaria* sp. | 0.00 | 17.06 | 41.67 |
| 30 | *Synchaeta oblonga Ehrenberg* | 0.00 | 32.14 | 66.67 |
| 31 | *Synchaeta pectinata* Ehrenberg | 8.33 | 51.59 | 91.67 |
| 32 | *Synchaeta* sp. | 8.33 | 20.24 | 33.33 |
| 33 | *Trichocerca dixon-nutalli* Jennings | 0.00 | 7.14 | 16.67 |
| 34 | *Trichocerca gracilis* Tessin | 0.00 | 8.33 | 16.67 |
| 35 | *Trichocerca pusilla* Jennings | 0.00 | 11.90 | 41.67 |
| 36 | *Trichocerca* sp. | 8.33 | 18.65 | 38.89 |
| 37 | *Trichotria tetractis* | 0.00 | 8.33 | 16.67 |

| | | | | |
|---|---|---|---|---|
| | **BIVALVIA** | | | |
| 38 | *Dreissena polymorpha* Pallas | 50.00 | 69.05 | 91.67 |
| | **CLADOCERA** | | | |
| 39 | *Alona quadrangularis* Muller | 0.00 | 5.16 | 16.67 |
| 40 | *Alona rectangula coronata* Kurz | 0.00 | 28.17 | 55.56 |
| 41 | *Bosmina coregoni* Baird | 0.00 | 9.52 | 25.00 |
| 42 | *Bosmina longirostris* Muller | 41.67 | 70.63 | 100.00 |
| 43 | *Bunops serricaudata* Daday | 0.00 | 9.52 | 25.00 |
| 44 | *Chydorus sphaericus* Muller | 33.33 | 58.33 | 91.67 |
| 45 | *Daphnia cucullata* Sars | 0.00 | 18.65 | 50.00 |
| 46 | *Daphnia galeata galeata* Sars | 0.00 | 34.52 | 100.00 |
| 47 | *Daphnia longispina* Muller | 0.00 | 8.33 | 25.00 |
| 48 | *Diaphanosoma orghidani* Fischer | 8.33 | 27.38 | 41.67 |
| 49 | *Ilyocryptus sordidus* Lievin | 8.33 | 22.22 | 33.33 |
| 50 | *Macrothrix laticornis* Fischer | 0.00 | 13.49 | 33.33 |
| 51 | *Moina brachiata* Jurine | 0.00 | 15.87 | 58.33 |
| 52 | *Moina micrura dubia* Kurz | 50.00 | 59.52 | 75.00 |
| 53 | *Pleuroxus aduncus aduncus* Jurine | 0.00 | 16.67 | 41.67 |
| | **COPEPODA** | | | |
| 54 | Copepoda g. sp. stad. nauplius | 66.67 | 95.24 | 100.00 |
| 55 | Copepoda g. sp. stad. copepodit I-III | 66.67 | 95.24 | 100.00 |
| 56 | *Eudiaptomus gracilis* Sars | 27.78 | 50.40 | 83.33 |
| | **SECONDARY CONSUMERS** | | | |
| | **ROTATORIA** | | | |
| 57 | *Asplanchna brightwelli* Gosse | 8.33 | 38.49 | 58.33 |
| 58 | *Asplanchna herricki* de Guerne | 0.00 | 14.29 | 33.33 |
| 59 | *Asplanchna priodonta* Gosse | 5.56 | 36.51 | 83.33 |
| | **CYCLOPIDA** | | | |
| 60 | *Acanthocyclops vernalis vernalis* Fischer | 66.67 | 88.10 | 100.00 |
| 61 | *Cyclops vicinus vicinus* Uljanin | 33.33 | 44.05 | 50.00 |
| 62 | *Mesocyclops crassus* Fischer | 33.33 | 47.62 | 50.00 |

In the zooplanctonul area of study, there are numerous species with low occurrence frequency and low densities, which are species that originate from the floodplain area of the Danube River.

For better appreciation of the influence of the cooling system of the NPP Cernavoda will not take into account the frequency of species whose occurrence is less than 25% (accidental species). We analyze the behavior of 26 species in the 6 stations taken into consideration (Fig. 2).

As a first observation it can be said that only one species doesn't appear over time in all the six stations- *Synchaeta oblonga*, who is not identified in the S5.

In the warm water canal (S3 and S4) and in the thermal plume (S6) all species were recorded, with specific variations of the frequencies of the occurrence from a workstation to another. It cannot be concluded that the influence of the cooling system, meaning a different additional heat and mechanical trauma would have a significant impact on the survival of these species. Zoplanctonul presents in this area an average density of 6480 indv.m$^{-3}$, with the minimum value in the year 2010 (3522 indv.m$^{-3}$) and highest in 2007 (15151 indv.m$^{-3}$).

Zooplankton populations recorded variable density from one station to the next, with a maximum in S2, which then gradually decreases with the passage through the cooling system. It should be noted that on the warm water plume there is a slight decrease in the general abundance than in S1, considered control station.

Taking into account the ecological significance index (W, Dzuba), top 7 are occupied by species which carry out 80.8% of the total number of registered individuals. We analyze the behavior of these species in the 6 stations surveyed. (Fig. 3).

Generally, all 7 species presents a similar behavior when switching from one station to the next, with a trend of increasing populations in S2 and decrease gradually throughout the cooling system. There are specific behavior in the rate of density decrease over the stations S2-S3-S4-S6, mechanical impact and heat effect of being different, depending on the species; this taxa features were point out in other studies [7]. It should be noted that populations are slightly more numerous in S6 than in S5, because the process of decline is recorded on account of the high populations from S2.

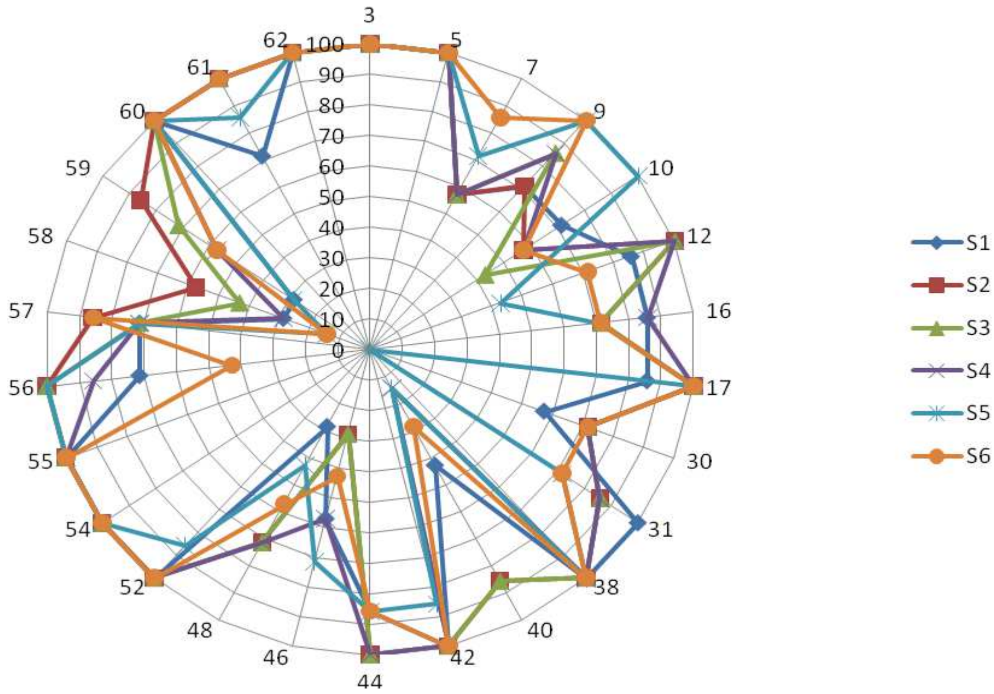


Figure 2 Dynamics of spatial frequency of occurrence of species
(according to taxonomic structure of Table 2)

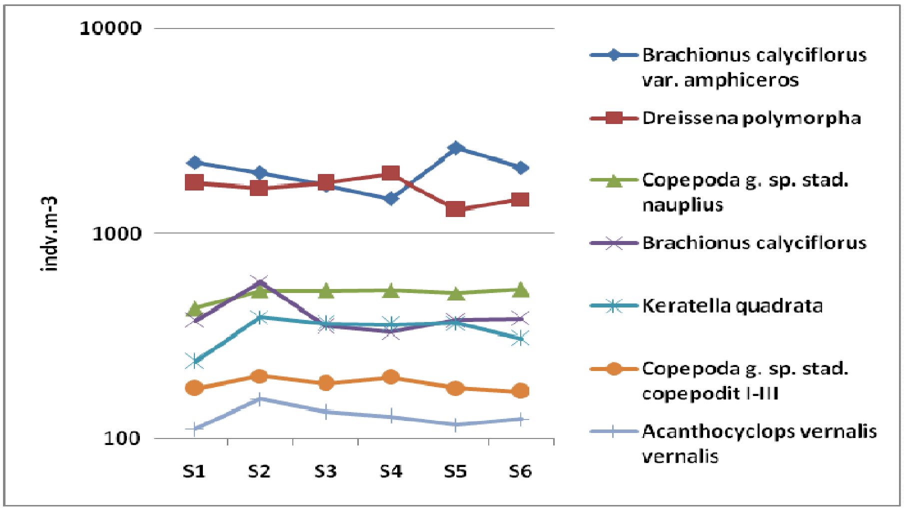


Figure 3 The spatial numerical abundance dynamics of top 7 ecological significance species

## 4. CONCLUSIONS

Although it has a tendency to decrease for the zooplankton numerical abundance, passage through the cooling water system does not have a limiting effect on the development of these populations in the area of interest.

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# AN EXPERIMENTAL STUDY OF SUNFLOWER HUSKS GASIFICATION IN A FLUIDISED BED

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## ABSTRACT

An experimental investigation of a fluidised bed gasifier was carried out using sunflower husks as combustible and air and steam as gasifying agents. The influences of excess air ratio and temperature on the composition of syngas produced are presented. In the present work, gasification temperature was varied from 700 to 850°C in 25°C increments, and was obtained an excess air ratio in the range of 0.18 to 0.41. It has been found that in the syngas obtained by fluidised bed gasification process, the molar fractions of $N_2$ and CO increase with the increase in excess air ratio, while the molar fractions of $CO_2$ and $CH_4$ decrease. The content of $H_2$ in the syngas increases with excess air ratio initially and then decreases with the increase in excess air ratio. The lower heating value of the syngas produced by sunflower husk was calculated from the concentration of the combustible components (CO, $CH_4$, and $H_2$). The lower heating value produced decreases initially and then increases with excess air ratio.


**Keywords:** *fluidized bed gasifier, air, steam, lower heating value, syngas.*

## 1. INTRODUCTION

The conservation of limited supply of fossil fuel, climate change and the increasing concern over global warming have prompted a search for new and cleaner methods and fuel particularly from renewable energy sources [1]. Since biomass is renewable and consumes atmospheric $CO_2$ during its growth, it can have a small net $CO_2$ impact compared with fossil fuels [2].

Biomass can be utilised for energy purposes by applying a number of conversion processes which can be classified in biochemical routes (anaerobic, microbial digestion, acid hydrolysis) applied to convert wet biomass, and thermochemical routes (combustion, pyrolysis, gasification, liquefaction) applied to convert dry biomass [3].

Gasification technologies are expected to play a key role in expanding the use of biomass as a major renewable energy source [4]. Biomass gasification means incomplete combustion of biomass resulting in production of combustible gases consisting of carbon monoxide, hydrogen and traces of methane [5].

Biomass gasification may be done in the presence of air, oxygen, steam, and a mixture of air and steam. Air gasification produces low calorific value gases with a higher heating value of 4-7 MJ/Nm$^3$, while gasification with oxygen or steam produces gases with a higher heating value of 10-18 MJ/Nm$^3$ [6]

Various types of gasifiers have been explored for biomass gasification. There are updraft and downdraft moving bed gasifiers, circulating and bubbling fluidised bed gasifiers.

Fluidised bed gasification makes use of the positive features of fluidised beds regarding mixing, reaction kinetics, gas-solids contact and heat transfer, and the possibility of additive injection. The bed material mainly used is silica sand. The gasification temperature is typically in the range 800-950°C [7].

In Figure 1 are presented the main processes occurring in a fluidised bed gasifier. When the particle of biomass is fed into the fluidised bed gasifier the particle is heated, and moisture and volatile gases are driven off. The final stage is a heterogeneous gas-solid reaction between char, steam and $CO_2$ [8].

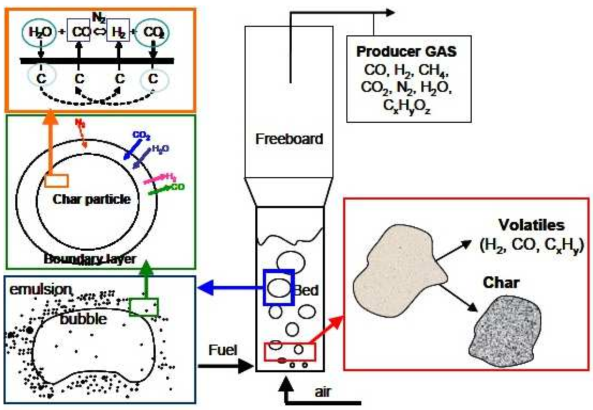


Figure 1 Analysis of the main processes occurring in a FB gasifier [8]

The present paper presents and discusses the results of the experimental study of a fluidised bed gasifier. Sunflower husks were used as fuel.

Agricultural residues have acquired considerable importance as biofuels for domestic cooking, industrial process heating, electrical power generation, and are used directly as well as in briquetted form for a variety of energy end uses [9]. Via the gasification process, it is possible to convert the sunflower husks continuously into a synthesis gas. After de-dusting the synthesis gas, it can be burned in a high efficiency boiler in order to produce steam or hot water [10].

The composition and heating value of the syngas are found to be similar to those reported by other researchers [1], [10], [11].

## 2. EXPERIMENTAL DETAILS

The biomass used in this experiment is sunflower husk. The agent gasification used is air and steam. The temperature of steam was varied from 125 to 250°C in 25°C increments. The proximate and ultimate analyses of sunflower husks are presented inTable 1.

Table 1 Proximate and ultimate analysis of biomass used

| Fuel sample | Sunflower husks |
|---|---|
| Ultimate analysis (% of dry fuel with ash) | |
| C | 49.11 |
| H | 5.9 |
| N | 0.70 |
| O | 40.57 |
| A | 3.71 |
| Proximate analysis (% of fuel with initial moisture) | |
| Fixed Carbon | 17.00 |
| Volatile matter | 65.79 |
| Ash | 3.71 |
| Moisture | 13.50 |

During fluidised bed gasification, drying, pyrolysis, combustion and gasification processes take place.

The combustion reactions are [12]:

$$C + \frac{1}{2}O_2 = CO \text{ -111 MJ/kmol} \quad (1)$$

$$CO + \frac{1}{2}O_2 = CO_2 \text{ -283 MJ/kmol} \quad (2)$$

$$H + \frac{1}{2}O_2 = H_2O \text{ -242 MJ/kmol} \quad (3)$$

The principle gasification reactions are [13]:

$$C + CO_2 \Leftrightarrow 2CO \text{ +172 MJ/kmol} \quad (4)$$

$$C + H_2O \Leftrightarrow CO + H_2 \text{ +131 MJ/kmol} \quad (5)$$

$$C + 2H_2 \Leftrightarrow CH_4 \text{ -75 MJ/kmol} \quad (6)$$

$$CO + H_2O \Leftrightarrow CO_2 + H_2 \text{ -41 MJ/kmol} \quad (7)$$

$$CH_4 + H_2O \Leftrightarrow CO + 3H_2 \text{ +206 MJ/kmol} \quad (8)$$

The reactions of char or carbon-gas phase reactions are the Bouduard reaction (Eq. (4)), water gas reaction (Eq. (5)), and methane formation reaction (Eq. (6)). The gas-gas phase reactions are the water-gas shift reaction (Eq. (7)) and the methane reforming reaction (Eq. (8)).

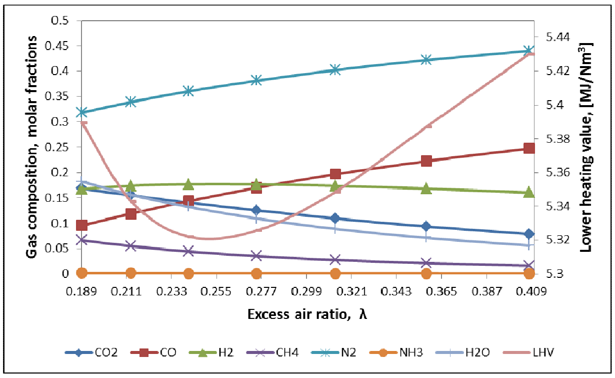


Figure 2 The influence of the excess air ratio on the syngas composition for sunflower husks

Table 2 The lower heating value and the molar composition of syngas produced by gasification of sunflower husk using air and steam such as gasifying agent

| Temperature | λ | *Syngas composition*, molar fractions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CO2 | CO | H2 | CH4 | N2 | NH3 | H2O | LHV |
| 700 | 0.189264 | 0.1682 | 0.096 | 0.1678 | 0.0661 | 0.3186 | 0.0015 | 0.1818 | 5.389244 |
| 725 | 0.213228 | 0.1553 | 0.1189 | 0.1739 | 0.0549 | 0.3392 | 0.0015 | 0.1564 | 5.342978 |
| 750 | 0.241486 | 0.1408 | 0.1439 | 0.1769 | 0.0446 | 0.3603 | 0.0014 | 0.1321 | 5.322007 |
| 775 | 0.27465 | 0.1254 | 0.1701 | 0.1768 | 0.0355 | 0.3813 | 0.0013 | 0.1095 | 5.325718 |
| 800 | 0.313209 | 0.1096 | 0.1967 | 0.1737 | 0.0277 | 0.402 | 0.0012 | 0.0891 | 5.348671 |
| 825 | 0.357591 | 0.0939 | 0.2226 | 0.1682 | 0.0213 | 0.4217 | 0.0011 | 0.0712 | 5.387037 |
| 850 | 0.407917 | 0.0789 | 0.2471 | 0.1608 | 0.0161 | 0.4403 | 0.001 | 0.0559 | 5.430212 |

## 3. RESULTS AND DISCUSSION

In Table 2 and Figure 2 is presented the influence of excess air ratio on syngas composition produced by gasification of sunflower husks in a fluidized bed gasifier using air and steam as the gasifying agent. The excess air ratio was varied from 0.18-0.41. The main components of the syngas are CO, $H_2$, $N_2$, $CO_2$, $H_2O$ and

$CH_4$. In Figure 2 also is presented the variation of lower heating value against excess air ratio.

The increase of the excess air ratio causes an increase of the $N_2$ molar fraction due to the greater amount of air fed to the gasifier. The content of $CH_4$ in syngas is very low and this decreases with the increase of the excess air ratio.

The molar fractions of CO and $H_2$ are the most significant contributions to the heating value of the syngas. The most interesting point from Figure 2 is that $H_2$ reaches a maximum at an excess air ratio of 0.24. After this peak his content decreases steadily. As shown in Figure 2 $H_2$ content was higher than CO content below the excess air ratio of 0.27 and CO content exceeded $H_2$ content when excess air ratio was higher than 0.27. Therefore, the syngas lower heating value first decreased and then increased as we can see in the Figure 2.

Higher excess air ratio means higher gasification temperature, which can accelerate the gasification and improve the product quality to a certain extent [14]. Temperature is crucial for biomass gasification process. In present paper, gasification temperature was varied from 700 to 850°C in 25°C increments.

Figure 3 presents the variation of $H_2$ molar fraction as a function of the gasification temperature for sunflower husks gasification. The highest content of $H_2$ in the syngas was obtained by gasification with air and steam at the temperature of 250°C.

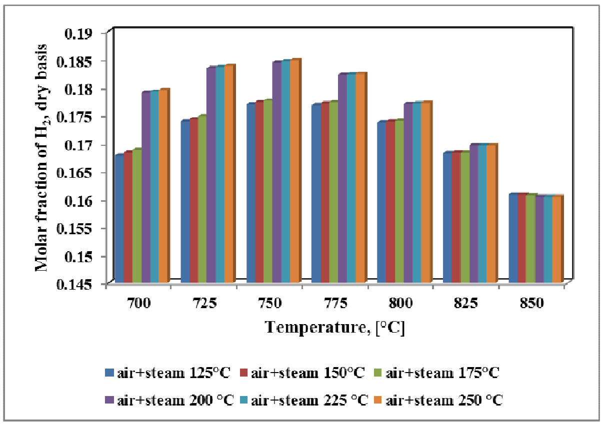


Figure 3 The variation of $H_2$ with gasification temperature

Figure 4 shows the variation of the CO molar fractions with temperature. The water-gas reaction (Eq. 5) is endothermic, and for increasing temperature more char and $H_2O$ are consumed and production of CO and $H_2$ is increased.

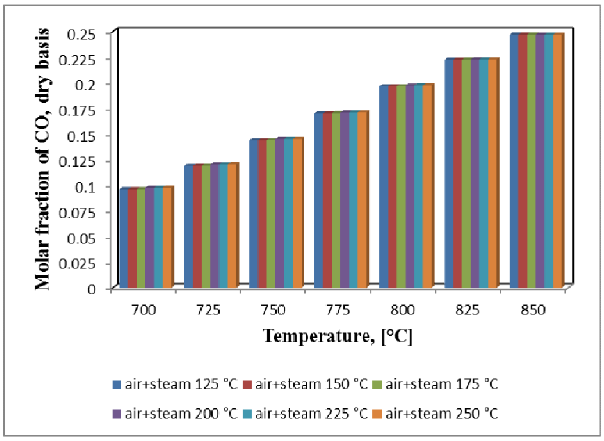


Figure 4 The variation of CO with gasification temperature

In Figure 5 is presented the variation of $CH_4$ with gasification temperature. The methane formation reaction (Eq. 6) being exothermic, increases of gasification temperature decreases the production of $CH_4$, which leaves more $H_2$ in syngas [15].

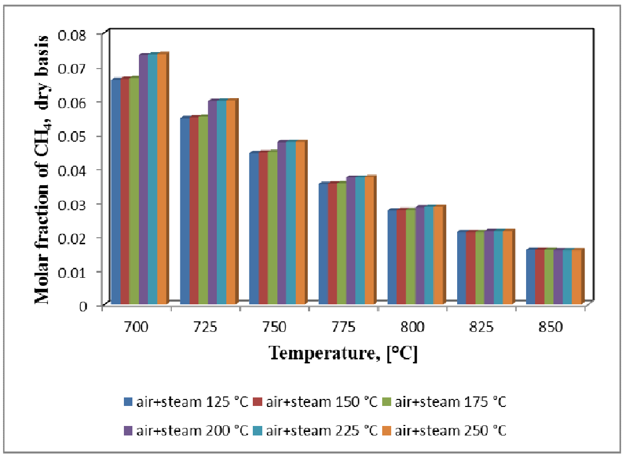


Figure 5 The variation of $CH_4$ with gasification temperature

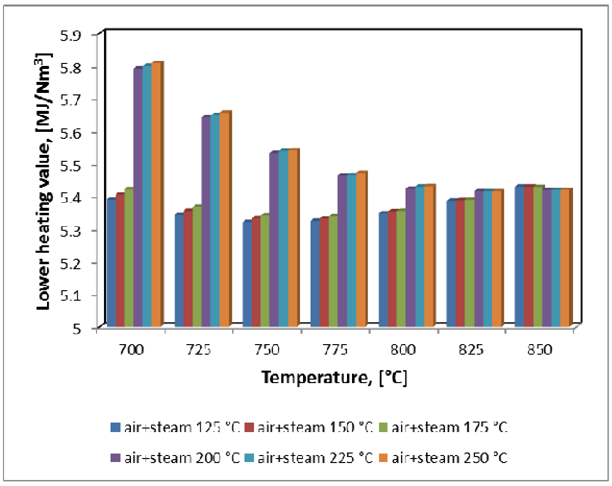


Figure 6 The variation of LHV with gasification temperature

Figure 6 shows the variation of lower heating value against gasification temperature. It is evident that the lower heating value first decreases and after increases with increasing of temperature. The lower heating value of the syngas ranges from 5.32MJ/Nm$^3$ to 5.81MJ/Nm$^3$.

## 4. CONCLUSIONS

An experimental investigation of a fluidised bed gasifier was carried out using sunflower husks. Air and steam were used as gasifying agents. The gasification temperature was maintained in the range 700-850°C with 25°C increment. The composition of the syngas produced was strongly influenced by the excess air ratio. The increasing in excess air ratio increases the gasification temperature, which is favourable for the gasification reactions. An increase in the excess air ratio resulted in a higher CO production and a decrease in the concentrations of $CH_4$, $CO_2$ and $H_2O$. An increasing and then decreasing trend with excess air ratio is seen for $H_4$ content in syngas. The lower heating value of the syngas decreases with temperature initially and then increases with the increase in temperature. The values of the lower heating value were obtained between 5.32MJ/Nm$^3$ and 5.81MJ/Nm$^3$.

## 5. ACKNOWLEDGMENTS

The work of this paper was supported by Project SOP HRD – EFICIENT 61445/2009.

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# RESEARCHES ON TECHNOLOGICAL WATER HEAT RECOVERY USING HEAT PUMPS

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## ABSTRACT

The paper represents a study on the possibility of recovering low thermal potential heat from the cooling technological water of industrial processes. The analyzed solution consists in the use of a heat pump which would send the recovered heat to a hot water flow. We started from a technological water flow which was taken over by a 350 $m^3$/h cooling tower and we determined the performances of a heat pump when using various refrigeration agents (R134a, R290, R407C) for a range of values of the temperature of hot water and the temperature of the return of technological water which varies according to the season.

**Keywords:** *heat recovery, technological water, heat pump.*

## 1. INTRODUCTION

The heat recovery from technological waters is an active concern both on international plan and national one. Many industrial processes require the release of heat flows into the environment, in order to maintain the parameters of those processes within normal operation limits. In the case of high capacity industrial equipment, this heat release is generally performed by means of a flow of cooling water, also called technological water, which takes over the heat from the concerned industrial equipment and, subsequently, releases it into the environment. This release of the heat taken over from the industrial process is generally performed by means of a cooling tower. Cooling towers are a very important part in different industrial branches, the energetic one, chemical one, metallurgical one, where they have the part of reducing cooling water temperature by evacuating in the atmosphere of the residual heat flows that came from technological processes. In this paper, we mean to prove the possibility of recovering heat from technological water by means of a heat pump. This heat pump shall take over the heat from the low temperature technological water and shall send it to a circuit of hot water which can be used by domestic or industrial consumers [1]. Obviously, the concrete application with heat pump sizing must take into account the heat requirement of consumers and the flow of available industrial technological water.

## 2. TECHNOLOGICAL SCHEME OF RECOVERY

For the purposes of this study, we have considered a flow of technological water cooled by means of a 350 $m^3$/h cooling tower. We attempt to analyze the possibility of heat recovery from technology water using a heat pump.

The operating parameters of the cooling circuit of the technological equipment, as well as its composition, have not been modified, so that the goal of technological process cooling may be achieved when heat recovery does not occur.

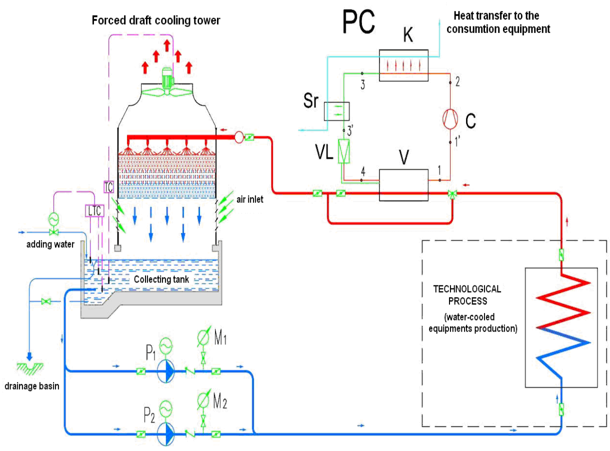


Figure 1 Cooling technological equipment with heat recovery

Consequently, for the recovery of heat from technological water, a heat pump has been introduced in the cooling circuit (fig.1) which, by means of the evaporator, takes heat from the technological water and, by means of the condenser, transfers it to the hot water flow, which is then sent to consumers.

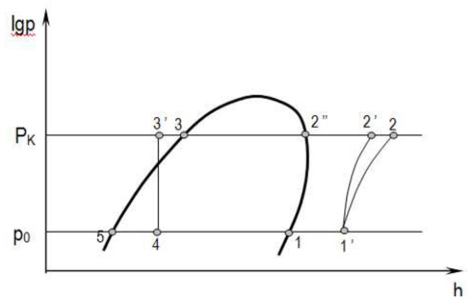


Figure 2 Theoretical cycle of the heat pump

Figure 2 presents the theoretical cycle of the heat pump.

In order to determine the operating parameters of the recovery equipment, we have used the Engineering Equation Solver (EES) programme, able to solve the equations of the mathematical model of processes which take place in heat pumps, according to the structure of the equipment and with the type of the working agent which evolves in it.

The program was run according to the following inputs:

- input water flow, $\dot{m}_{w,i} = 97$ kg/s;
- inlet water temperature, $t_{w,i}$ = 40 $^0$C;
- sub-cooler inlet water temperature, $t_{w,Sri}$ = 20 $^0$C;
- condenser outlet water temperature, $t_{w,ke}$ = 56,62 $^0$C.

The program calculates for the heat pump the following performance measures: exergy output, $\eta_{ex}$; coefficient of performance, COP; obtained hot water flow: $\dot{m}_{ac}$ [kg/s].

The hot water flow is calculated on:

$$\dot{m}_{ac} = \frac{\Phi_k}{c_{p,w}\Delta t_{w,k}} \;\; [kg/s] \qquad (1)$$

where: $c_{p,w}$ = 4,182 kJ/kg.K - water specific heat;

$\Delta t_{w,k}$ = 28 [$^0$C] - temperature increase of the obtained hot water;

$\Phi_k$ $[kW]$ - heat flow yielded to hot water in the heat pumps condenser.

The exergy output of the recovery equipment, as well as the coefficient of performance of the heat pump, are expressed by means of the following relations [2], [3]:

$$\eta_{ex} = \frac{l_{\min,C}}{l_c} \cdot 100 \;\; [\%] \qquad (2)$$

$$COP = \frac{\Phi_k + \Phi_{Sr}}{P_c} \qquad (3)$$

where:

$l_{\min,C}$ $[kJ/kg]$ - minimum mechanical work consumed in the reversed Carnot cycle;

$l_c$ $[kJ/kg]$ - specific compression mechanical work;

$P_c$ $[kW]$ - heat pump compressor power;

$\Phi_{Sr}$ $[kW]$ - thermal power in the sub-cooler.

The partial heat recovery may use to prepare household/domestic hot water or to preheat the water used to produce the heat agent for heating the residential and administrative areas.

The heat pump in the hot water circuit takes over part of its heat (depending on the recovery equipment output) and further transfers it to a secondary circuit that produces household hot water or hot water for industrial users. By means of the EES program, we have made a comparative study of the performance of the recovery equipment with heat pump, when using different refrigeration agents. This, given that the thermodynamic properties of the refrigeration agent which evolves in a heat pump directly influence the compression, drafting and heat transfer processes. As main thermodynamic conditions of these refrigerating agents, we mention: boiling point under cooling temperature of technological water, vapor pressure as close as possible to atmospheric pressure, condensation pressure as low as possible in order to achieve low energy consumption, latent evaporation heat as high as possible in order to ensure reduced flows and an as small as possible vapour specific volume. The use of certain inappropriate refrigerating agents can lead to a decrease in the efficiency of the recovery equipment or to the oversize of the heat pump components, these leading to an increase of the recovery costs. Consequently, the following refrigerating agents have been selected, R134a, R290, R407C.

## 3. RESULTS AND CONCLUSIONS

For the analysis of the performances of the equipment for heat recovery from technological water, we considered the following variable measures:

- adiabatic output, $\eta_{ad}$ = 0,55 ÷ 1;
- sub-cooler inlet water temperature, $t_{w,Sr,i}$ = 20÷29 $^0$C;
- input water temperature, $t_r$ = 30÷39 $^0$C;
- water heating in condeser, $\Delta t_{w,K}$ = 15 ÷ 35 $^0$C.

To compare the performances of the heat pump using the three agents studied, several representative values were chosen as shown in table 1.

Table 1. Results for the study of refrigerants.

| Agents | $t_{w,K,e}$ [$^o$C] | $\dot{m}_{w,k}$ [kg/s] | COP | $\eta_{ex}$ [%] |
|---|---|---|---|---|
| R134a | 56,62 | 32,03 | 8,695 | 20,98 |
| R290 | 57,19 | 31,82 | 8,433 | 21,83 |
| R407C | 58,94 | 31,11 | 6,743 | 21,07 |

where:

$t_{w,K,e}$ [$^o$C] - condenser outlet water temperature;

$\dot{m}_{w,k}$ [kg/s] - condenser water flow.

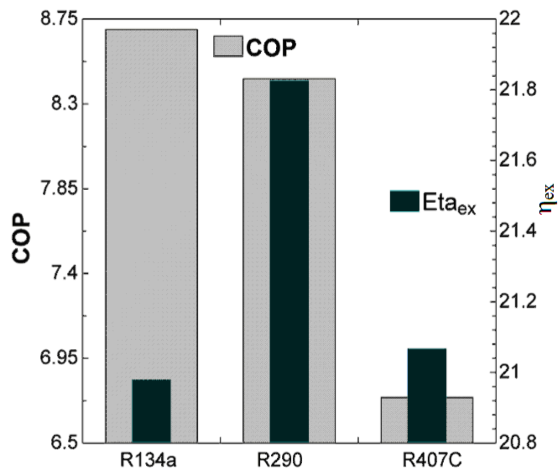


Figure 3 Heat pump performance for diffeent refrigerants

Based on the simulation performed, it is clear that for heat recovery from technological water by means of heat pump, the most suitable agent is R134a, because with close exergy outputs the best values fo the coefficient of performance and lowest energy consumption by compression are obtained.

The study results for R134a are presented in the chart.

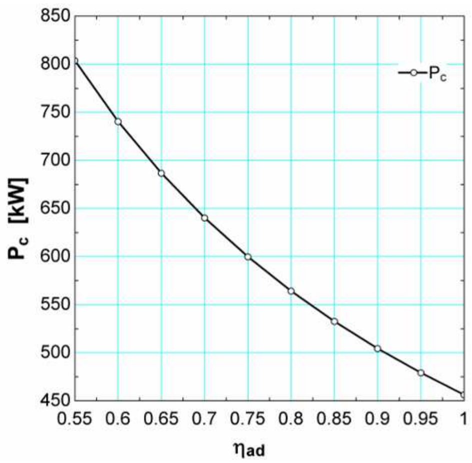


Figure 4 Variation of power consumed by compressor depending on adiabatic efficiency

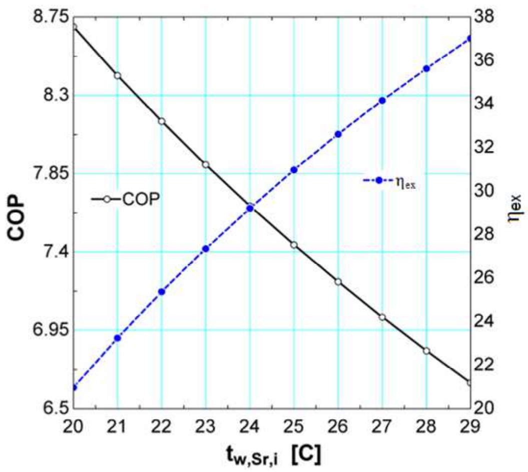


Figure 5 Variation of coefficient of performance, exergy efficiency depending on water temperature in sub-cooler

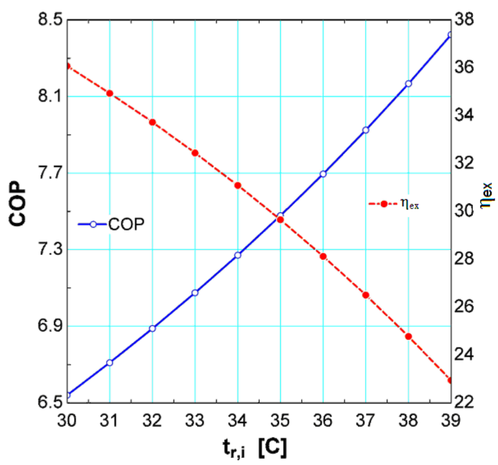


Figure 6 Variation of coefficient of performance, exergy efficiency depending on inlet water temperature

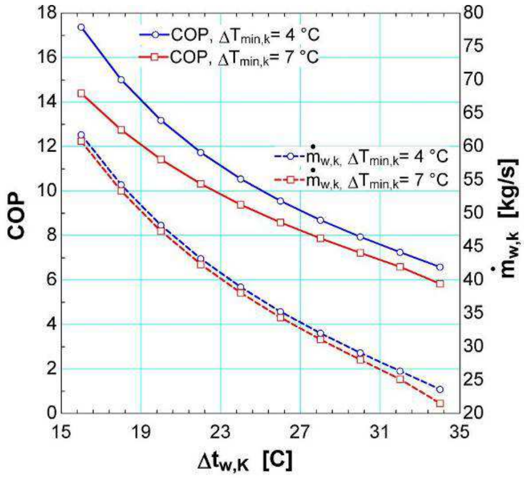


Figure 7 Variation of coefficient of performance and hot water flow vs. water temperature rise in condenser

The values obtained and illustrated graphically show the possibility of smooth operation of a heat pump which provides for heat recovery from cooling water in the technological processes.

To increase the hot water temperature it is necessary to increase the condensing temperature, which implies increasing compression pressure with increasing compressor power consumption.

The compressor power consumption decreases with increased adiabatic output/ efficiency (fig.4).

Exergy efficiency and coefficient of performance (COP) of the water cooling system is influenced by both the cooling water temperature at the heat pump sub-cooler and the water temperature at the evaporator inlet. Increasing temperaturein the heat pump sub-cooler increases the exergy efficiency and also decreases the coefficient of performance (COP) of the heat pump (fig. 5). With increasing technological water temperature into the heat pump evaporator, the exergy efficiency decreases while the coefficient of performance (COP) of the heat pump increases (fig.6). In figure 7 the following can be noticed:

- with increasing hot water flow rate there is an increase in the coefficient of performance of the heat pump;
- the increase in condenser water heating, the coefficient of performance and the amount of heated water decrease;
- the increase in the minimum temperature difference at hot end of the condenser ($\Delta T_{minK}$) the coefficient of performance (COP) and the hot water flow decreases.

A heat pump fitted in the cooling circuit , before the cooling tower, allows partial recovery of heat from the process water.

Water energy recovery plant using heat pumps has the following advantages:

- it is saved the fuel that would be necessary for domestic hot water or hot water pre heating, therefore the heat energy resources are preserved;
- a smaller amount of heat is dissipates into the atmosphere, thus reducing thermal pollution;

- it is reduced the water loss by evaporation when passing through the cooling tower, thus the amount of water treated is saved, which means the water source protection and raw water treatment costs reduction.

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# MATHEMATHICAL MODELING AND EXPERIMENTAL VALIDATION OF THE PROCESSES FOR A COOLING TOWER WITH FORCED DRAFT IN CONTRA-CURRENT

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**ABSTRACT**

This paper represents a comparative study about the determination of the functional parameters for a cooling tower with forced draft in contra-current. It has been made a mathematical model, based on heat and mass transfer, model that is conceived to determine the water and air parameters, parameters that will be utilized in exergetic analysis, analysis that contains the exergy calculation from aer and water flowing through cooling tower, also the destroyed exergy. In order to validate the mathematic model it has been done an experimentak study in order to determine the functional parameters for a cooling tower with forced draft in contra curent. Based on the results achieved it was showed that the erors of the mathematical model and the experimental ones are under 5%.

**Keywords:** *Cooling tower, mathematical model*

## 1. INTRODUCTION

Cooling towers are devices used to extract heat from waste water and reject it to atmospheric air.

The evacuation of tthe heat flows in cooling tower are taking place , through convextion betwee small drops of water and the enviroment, on other side, through evaporation, a small quantity of water is in the air. So, the process involves both heat transfer and mass transfer.

Through the presented method in this paper is estimated that the functionality of the cooling tower with forced draft in contra current using transfer equations of heat and mass between air and water in order to obtain a stationary sollution.

## 2. MATHEMATICAL MODEL

In counter flow cooling tower, water flows downwards while air flows upwards. It is assumed that the conditions of water and air vary only with vertical position in the tower. The differential section of the tower height dH and the given boundary conditions are shown in figure 1. The important assumptions of the model are as follows [1]:

- heat and mass transfer through the tower wall to the environment is negligible;
- heat transfer from the tower fan to air and water is negligible;
- water and dry air specific heats are constant;
- coeficienții de transfer de căldură și masă de-a lungul turnului sunt constanți;
- heat and mass transfer coefficients throughout the tower are constant;
- heat and mass transfer is in a direction normal to the flow;
- water loss by drift is negligible;
- temperatures of water and air at any cross-sections are uniform.

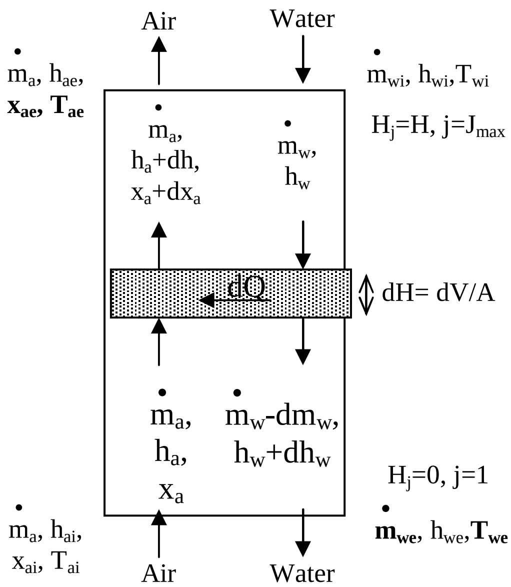


Figure 1 Schematic of mass and energy balance of a counter flow wet cooling tower

For steady state conditions, mass balance equation for evaporated water into air is:

$$d\dot{m}_w = \dot{m}_a dx_a \tag{1}$$

The amount of heat gave away by water is equal to the one received by air:

$$\dot{m}_a dh_a = \dot{m}_w dh'_w + l_{v,w}\dot{m}_a dx_a \tag{2}$$

Energy balance based on the concept of potential enthalpy expressed by mass $\alpha_m$ and heat $\alpha_c$, transfer coefficients, can be written for both water and air. Convective mass transfer is [2]:

$$\dot{m}_a dx_a = \alpha_m \rho_a a(x_{s,w} - x_a)dV \qquad (3)$$

If we consider that phase change latent heat is the same with saturated vapor enthalpy ($l_{v,w} \approx h''_w$) [3], energy balance for air is:

$$d\Phi_a = d\Phi_a, c + d\Phi_{a,e} \Leftrightarrow \dot{m}_a dh_a = \alpha_c a(T_w - T_a)dV + \\ + \alpha_m \rho_a a dV(x_{s,w} - x_a)h''_w \qquad (4)$$

After simplification of equations (3) and (4) and replacement of dV = A dH, where H [m] is tower height, and A [$m^2$] is cross section area, variation of enthalpy and humidity ratio for air across the tower height are:

$$\frac{dh_a}{dH} = \frac{Ka}{\dot{m}_a}[Le_f c_{p,a}(T_w - T_a) + h''_w(x_{s,w} - x_a)] \qquad (5)$$

$$\frac{dx_a}{dH} = \frac{KaA}{\dot{m}_a}(x_{s,w} - x_a) \qquad (6)$$

where Lewis factor ($Le_f = \alpha_c/(\alpha_m \rho_a c_{p,a})$) is an indicator of the relative rates of heat and mass transfer in evaporative process [2] and is determined to be unity [4]. K·a, which is $\alpha_m \rho \cdot a$, is tower characteristic. By replacing $dh'_w = c_{p,w}\, dT_w$ in eq (2), the change of water temperature on the tower height is:

$$dT_w = \frac{\dot{m}_a}{\dot{m}_w c_{pw}}(dh_a - h'_w dx_a) \qquad (7)$$

The change of air enthalpy $dh_a$ and humidity ratio $dx_a$, ca be obtained by solving equations (5) and (6). Consequently, $dT_w$ can be calculated from equation (7). According to eq (1), the water flow rate (which is decreasing from top to bottom due to evaporation) can be written as:

$$\dot{m}_w,_{H(j+1)} = \dot{m}_w,_{H(j)} + \Delta\dot{m}_w = \dot{m}_w,_{H(j)} + \\ + \dot{m}_a(x_{aH_{(j+1)}} - x_{aH_{(j+1)}} \qquad (8)$$

If the following items are given:

- inlet water temperature, ($T_{w,i}$);
- inlet air and water flow rates ($\dot{m}_a$, $\dot{m}_{w,i}$);
- inlet air pressure, dry bulb and wet bulb temperatures ($T_{db,i}$, $T_{wb,i}$);
- tower cross section (A);
- tower characteristic (K a).

then equations (5) - (8) can be solved numerically in order to find exit conditions for air and water.
The above correlations were implemented in a computer program using EES software, in order to obtain the 4 unknowns ($h_a$ and $x_a$ for moist air, $T_w$ and $\dot{m}_{w,H}$ for water) in all discrete points (j = 1…$J_{max}$) equally spaced at ΔH along the tower height (including the exit). Computations starts from the bottom upwards, from the air inlet section (H = 0); since in that section (air entry - water exit), air properties are known and water properties are unknown, for the latter the program is looking for some values ($\dot{m}_{w,e}$, $T_{w,e}$) so that the computed values obtained for water at the entry ($\dot{m}_{w,i}$, $T_{w,i}$) after successively performing the computations for all the discrete points along the tower height, match the known (imposed) ones.

The known parameters of the cooling tower with forced draft in contra current are shown in chart number 1.

Table 1. Parameters known of the cooling tower.

| Parameters known | Simb | U.M. | Value |
|---|---|---|---|
| Inlet water flow rate | $\dot{m}_{w,i}$ | kg/s | 97 |
| Inlet dry air flow rate | $\dot{m}_a$ | kg/s | 180 |
| Inlet dry - bulb temperature | $T_{db,i}$ | °C | 27.00 |
| Inlet wet - bulb temperature | $T_{wb,i}$ | °C | 20.00 |
| Inlet water temperature | $T_{w,i}$ | °C | 40.00 |
| Tower cross - sectional area | A | $m^2$ | 150 |
| Global coefficient of heat and mass transfer | $(K \cdot a)$ | $kg/m^3s$ | 2.140 6 |

It has been done an experimental study by measuring functional parameters for a cooling tower with forced draft in contra - current.During experimental study we used for monitoring and works on the datas a. termohigrometru with external sensor (figure 2).


Figura 2 Termohigrometru cu senzor extern cu sonda

## 3. PERFORMANCE SIMULATION

To validate this method, use is made of the experimental data on the cooling tower collected in the field as shown in table 2. Comparative results are dry bulb temperature at outlet ($T_{a,db,e}$), wet bulb temperature at outlet ($T_{a,wb,e}$), outlet water temperature and outlet air relative humidity.

Table 2. Comparison between experimental and mathematical model data.

| Results | | U.M. | Model | Exper. | Relative error |
|---|---|---|---|---|---|
| Exit water temperature | $T_{w,e}$ | °C | 30.17 | 31.4 | 3.9 |
| Exit dry – bulb temperature | $T_{db,e}$ | °C | 30.05 | 31.2 | 3.7 |
| Exit wet– bulb temperature | $T_{wb,e}$ | °C | 25.98 | 27.1 | 4.1 |
| Outlet air relative humidity | $\varphi_{a,e}$ | % | 72.64 | 75.5 | 3.8 |

It can be seen that errors between estimated and experimental values are below 5% (figures 3, 4). Valorile experimentale din tabelul 2 sunt folosite pentru a descrie caracteristicile apei şi aerului prin turnul de răcire.

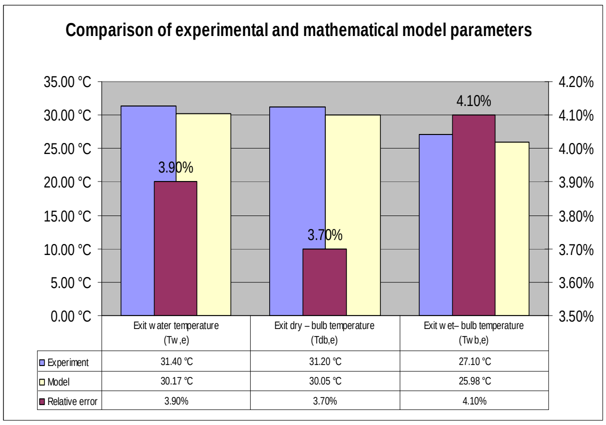


Figure 3 Comparison between experimental and mathematical model values

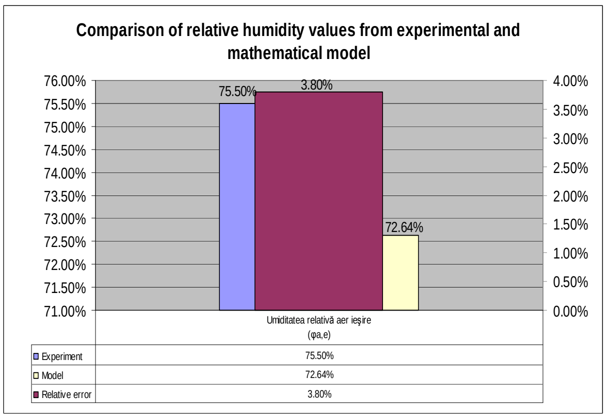


Figure 4 Comparison of relative humidity values from experimental and mathematical model

The formula result are shown below.

Figure 5 illustrates the water temperature, air temperature and absolute humidity along the tower height. Air enters through the bottom, move upwards from the bottom and goes out at the top. Since air receives moisture from the cooled water, its absolute humidity is increasing to near saturation and thus the dry bulb temperature and the wet bulb temperature are getting closer. Water temperature, $T_w$,, decreases continuously as it flows down towards the bottom.

It is known that heat energy of the water is removed both by convective heat transfer and evaporation into air.

Evaporation effect can be measured depending on air humidity ratio, $x_a$, and wet bulb temperature, $T_{a,wb}$. One can also notice that $T_{a,wb}$, that increases continuously from bottom to top, is always smaller than $T_w$. Consequently, on the entire tower height, latent heat passes from water to air.

Thus, in the cooling tower the heat transfer occurs mainly through evaporation, which makes that due to enthalpy difference, heat to pass always from water to air, aspect revealed also by the enthalpies of the two fluids shown in figure 6.

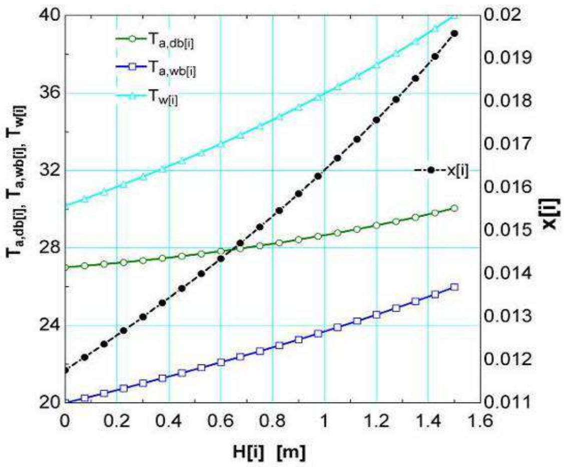


Figure 5 Temperature profiles of water and air, and humidity ratio profile along the cooling tower height

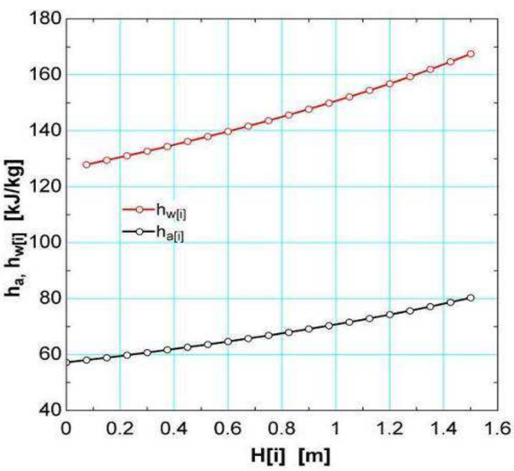


Figure 6 Water and air enthalpy along the cooling tower height

At the entrance of water in the tower through the upper part, both water cooled flow and evaporated water flow are big. Once the water start flowing, due to evaporated water flow, the cooled water flow is dropping continuosly - figure 7.

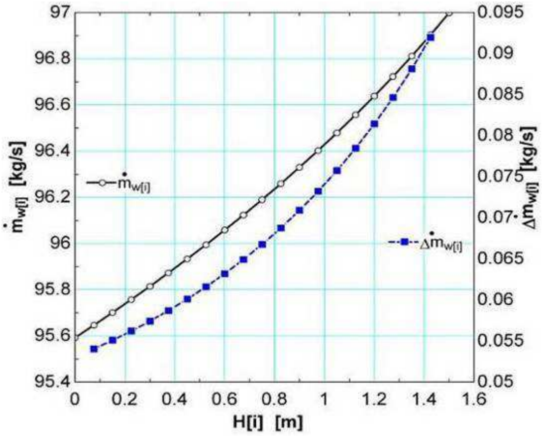


Figure 7 The cooled water flow variation and the evaporated water flow on the height of the cooling tower

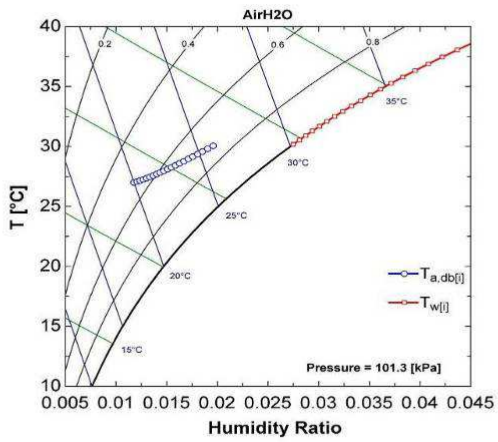


Figure 8 Mollier diagram with the change of air status in contact with cooled water

Due to the complex heat and mass exchange between water and air, air condition features a complex evolution, tending to saturation at the tower outlet.

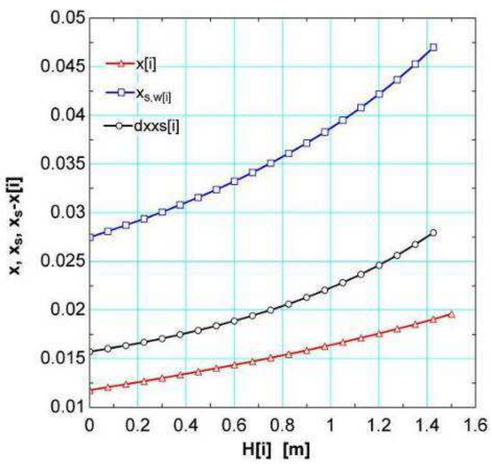


Figure 9 Humidity ratios ($x$ - $x_{sat}$) along the cooling tower height

In chart number 9 we can see that at upper part of the cooling tower both absolute humidity and absolute humidity to saturation are increasing.

In the cooling tower, the mass transfer driving force is the gradient of absolute humidity between absolute humidity at saturation (air in contact with film / spray water at temperature $\underline{T}_w$) and absolute humidity of cooling air flow (humid air at $T_{a,db}$ şi $\phi_a$ ) ($\Delta x = x_{s,w} - x_a$). This gradient is low when air enters the device, at first it slightly decreases due to air cooling, and then further increase due to distance of the two corresponding conditions (air and water).

## 4. EXERGY CALCULATION

The specific exergy in psychometric process, such as the cooling tower operating mechanism, without considering the effect of kinetic and potential energy, can be generally represented for steady states by the relation:

$$ex = ex_{tm} + ex_{ch} \tag{9}$$

The specific thermo-mechanical exergy can be written as [5]:

$$ex_{tm} = (h - h_0) - T_0(s - s_0) \tag{10}$$

For an ideal gas with constant specific heat cp:

$$ex_{tm} = c_p(T - T_0) - T_0(c_p \ln(T/T_0) - R \ln(P/P_0)) \tag{11}$$

The specific chemical exergy according to Wark [6] is:

$$ex_{ch} = \sum_{k=1}^{n} x_k(\mu_{k,0} - \mu_{k,00}) \tag{12}$$

where $x_k$ is the mole fraction of substance k in the mixture.

For an ideal gas mixture, integrated chemical potential between the dead (zone) state and the ambient temperature state $T_0$ is given by:

$$\mu_{k,0} - \mu_{k,00} = RT_0 \ln(P_{k,0}/P_{k,00}) \tag{13}$$

It should also be noted that the specific exergy "ex" the psychometric process is a measure of thermo-mechanical exergy, modified from the current state to the prohibited/dead state, plus the chemical exergy modified from the prohibited to the environment state.

Thus,

$$ex = (h - h_0) - T_0(s - s_0) + \sum_{k=1}^{n} x_k(\mu_{k,0} - \mu_{k,00}) \tag{14}$$

Since the air and water are the only fluids flowing in the counter current cooling towers, we will write exergy equations for these fluids. If water is considered as an incompressible fluid [6], based on equation (14), one can write water flow rate exergy $Ex_w$ as:

$$Ex_w = \dot{m}_w \left[(h'_w - h'_0) + v_{f,T}(P - P_{sat}) - T_0(s_{f,w} - s_{f,0}) - R_v T_0 \ln \phi_0\right] \quad (15)$$

In practice, the second term on the right side of the above equation is usually neglected, so the equation becomes:

$$Ex_w = \dot{m}_w \left[(h'_w - h'_0) - T_0(s_{f,w} - s_{f,0}) - R_v T_0 \ln \phi_0\right] \quad (16)$$

Air is considered as a mixture of ideal gases (dry air and water vapor), and it's specific exergy „$ex_{aer}$” can be written as [7]:

$$ex_{aer} = x_a[\bar{h}_a - \bar{h}_{a,0} - T_0(\bar{s}_a - \bar{s}_{a,0}) + \bar{\mu}_a - \bar{\mu}_{a,0}] + x_v[\bar{h}_v - \bar{h}_{v,0} - T_0(\bar{s}_v - \bar{s}_{v,0}) + \bar{\mu}_v - \bar{\mu}_{v,0}] \quad (17)$$

The over-bar ( ̅ - de ex. $\bar{h}_a$, $\bar{s}_a$, $\bar{\mu}_a$) represents the mole basis. considering constant specific heats $\bar{c}_{p,a}$ and $\bar{c}_{p,v}$, in Eq (17) we can use the following replacements $\bar{h}_a = \bar{c}_{p,a}(T - T_0)$, $\Delta s_a = \bar{c}_{p,a} \ln(T/T_0) - R \ln(P/P_0)$ and also $\bar{\mu}_a - \bar{\mu}_{a,0} = \bar{R} T_0 \ln(x_a/x_{a,0})$. As a result we have,

$$ex_{aer} = (x_a\bar{c}_{p,a} + x_v\bar{c}_{p,v})\left(T - T_0 - T_0 \ln\frac{T}{T_0}\right) + \bar{R} T_0 \ln\frac{P}{P_0} + \bar{R} T_0\left(x_a \ln\frac{x_a}{x_{a\,0}} + x_v \ln\frac{x_v}{x_{v\,0}}\right) \quad (18)$$

For an dried air flow rate and neglecting pressure loss ($P = P_0$), air flow rate exergy $Ex_{aer}$ becomes

$$Ex_{aer} = \dot{m}_{air}\left[(c_{pa} + x_a c_{pv})\left(T - T_0 - T_0 \ln\frac{T}{T_0}\right) + R_a T_0\left((1 + 1.608x_a) \ln\frac{1+1.608x_{a00}}{1+1.608x_a} + 1.608xa \ln\frac{x_a}{x_{a00}}\right)\right] \quad (19)$$

For determining the rate of exergy destruction I, the loss potential of air to recover exergy supplied by water, can be obtained from the control-volume exergy balance equation. The relation is applied at steady state conditions and undergoes an adiabatic process with no work delivered. Assuming that air–water thermodynamics properties are known at discrete points along the tower height, the exergy destruction for each incremental tower height dH is:

$$Ex_{in} = Ex_{out} + I \Leftrightarrow [Ex_{w,H_{(j+1)}} + Ex_{aer,H_{(j)}}] = [Ex_{w,H_{(j)}} + Ex_{aer,H_{(j+1)}}] + I \quad (20)$$

After rearrangement, the exergy destruction for the discrete height dH will be:

$$I = [Ex_{w,H_{(j+1)}} - Ex_{w,H_{(j)}}] + [Ex_{aer,H_{(j)}} - Ex_{aer,H_{(j+1)}}] \quad (21)$$

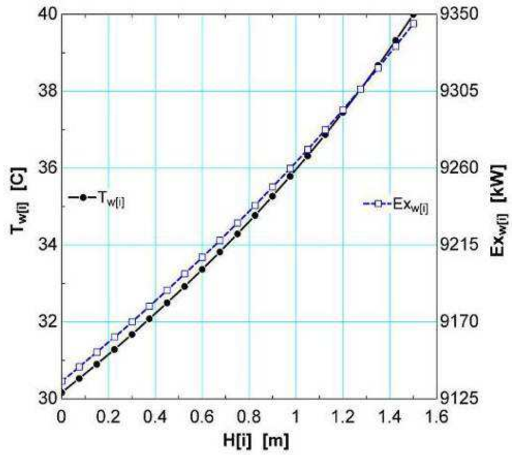


Figure 10 Temperature and water exergy variation along the cooling tower height

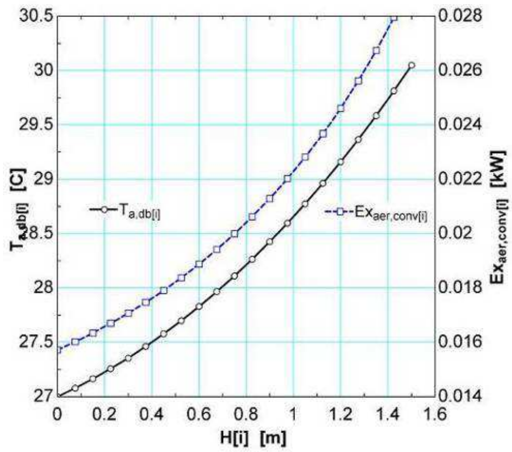


Figure 11 Air temperature and convection heat transfer air exergy variation along the cooling tower height

Figure 10 shows water flow rate exergy, $Ex_w$, and water temperature $T_w$. Water exergy, defined as available energy carried by water, decreases continuously from top to bottom. This can be explained by the fact that water temperature decreases from top to bottom as a result of supplying its exergy to air.

Figure 11 shows the exergy air by means of convective heat transfer and dry bulb temperature along the cooling tower. From bottom to a certain height it can be observed a decrease in the exergy air flow through convection, $Ex_{aer,conv}$ and dry bulb temperature, $T_{db}$. The point of intersection of dry bulb temperature, $T_{db}$ and water temperature, $T_w$ indicates a zero temperature difference, hence the lack of convective heat transfer from air to water for a minimum dry bulb temperatures, $T_{db}$. This also leads to a minimum value of $Ex_{aer,conv}$. Above this point, the exergy air flow through convection, $Ex_{aer,conv}$ contained by air allows the incoming heat energy, and thus the dry bulb temperature, $T_{db}$ increases.

Exergy via evaporation heat transfer, $Ex_{aer,evap}$, and air absolute humidity are shown in figure 12. Both increase continuously along the tower. This shows that $Ex_{aer,evap}$ contained in air allows receiving of thermal energy.

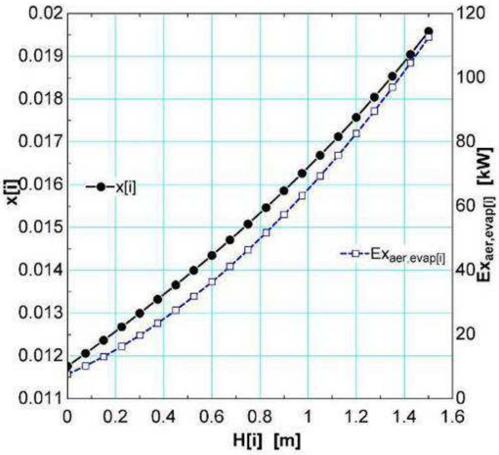


Figure 12 Humidity ratio and air exergy via evaporative heat transfer vs. cooling tower height

Air exergy via convective heat transfer and evaporation, $Ex_{aer,conv}$ and $Ex_{aer,evap}$, and also air exergy $Ex_{aer} = Ex_{aer,conv} + Ex_{aer,evap}$, are presented in figure 13 against tower height. In figure 13 is also clearly represented that the process is dominated by de exergy air due to evaporative heat transfer.

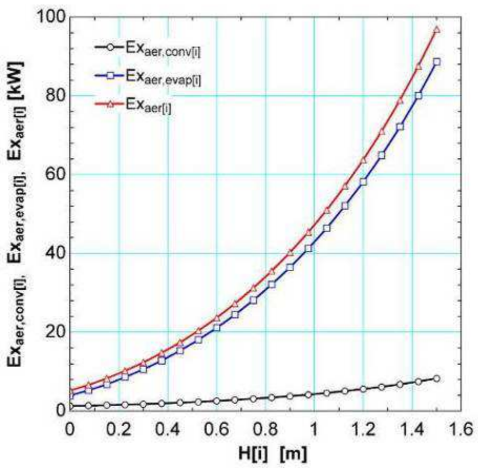


Figure 13 Total air exergy and exergy components due to convective heat transfer and evaporation vs. cooling tower height

Exergy consumption is always accompanied by entropy generation, and so generated entropy must be constantly removed from water. Generated entropy is proportional to de exergy destruction. Exergy variations of the two fluids and exergy destruction I, computed as difference between water exergy variation $\Delta Ex_w$ and air exergy variation $\Delta Ex_{aer}$, is represented in figure 14. This distribution shows that water exergy is much bigger air exergy, and that exergy losses are bigger at the bottom and gradually decrease to the top. The minimum I locates at the top.

Figure 14 shows cooled water exit temperature vs air entry status, characterized by wet bulb temperature ($T_{a,wb,i}$) and dry bulb temperature ($T_{a,db,i}$). One can notice that wet bulb temperature (therefore relative humidity) strongly influences cooled water temperature, but air dry bulb temperature have almost no influence.

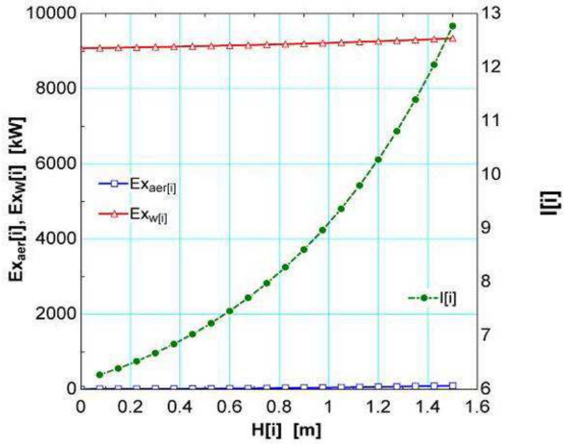


Figure 14 Fluids exergies and exergy destruction vs. cooling tower height

## 5. CONCLUSIONS

The described mathematical model for the prediction of water and air proprieties along the counter current cooling tower height is based on heat and mass transfer principles. The model estimated accurately enough (error less than 5%) the operation of a forced-draft counter-current cooling tower. Exergy analysis is used to explain the performances of the cooling tower. Numerical results show that:

- water energy, defined as available energy carried by water decreases continuously from top to bottom;
- in the cooling tower, the heat transfer occurs mainly through evaporation;
- air energy is the exergy available to receive the exergy supplied by water. Air exergy is made of exergy due, on one hand, to convective heat transfer and, on the other hand, to evaporative heat transfer which has the major contribution;
- exergy destruction is is high at the bottom and reduced at the top.

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# COMPUTER SIMULATION OF AN EMERGENCY SITUATION

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**ABSTRACT:**

The paper presents a computer simulation, using POTENTIAL INCIDENT SIMULATOR EVALUATION AND CONTROL SYSTEM (Pisces II) software, especially designed for assessing the consequences of oil pollution on sea water.

**Keywords:** *pollution, hydrocarbon, Black Sea*

## 1. INTRODUCTION

The paper consists in interpreting the results obtained from computer simulation of an accidental discharge of a quantity of crude oil in the Black Sea due to a crack in the oil pipe that connects the central oil platform and tank park at Midia Oil Terminal.

## 2. UNFOLDING EVENTS

On 05.01.2008 respectively 21.06.2008 at 01.00, a foreign-flagged vessel transits and anchoring without approval (about 26 km from the Oil Terminal Midia) in the area where the pipeline was carrying crude oil from the Central Oil Platform to Oil Terminal Midia. The anchor of the ship damages the pipe, so a part of the crude oil is pumped out into the sea. When observing the pollution, the master of the ship decides to lift anchor and leave the scene without letting know the authorities.

Since the accident takes place at night and the pressure at the receiving station at Midia Terminal oil has not dropped below 1 bar, the accident goes unnoticed so at 05.00 according to the Midia Terminal protocol, is drawn the volumes of oil transported through the pipeline, so one could saw a difference of 83 t. The decision was taken to order the Central oil platform to stop pumping so in 10 minutes the pumping is stopped and authorities are announced on the accident and pollution that took place. [3]

## 3. DATA ENTRY

To simulate the emergency situation generated by the crack in the pipeline that carries crude oil, authors have used the POTENTIAL INCIDENT SIMULATOR CONTROL AND EVALUATION SYSTEM (Pisces II) software, product of TRANSAS, fitted to the Department of Environmental Engineering at the Constanta Maritime University, on a simulator designed to handle real situations such as oil sea pollution. [2], [3]

The PISCES is an incident response simulator designed for preparing and conducting command centre exercises and area drills. The application is developed to support exercises focusing on oil spill response. Therefore, the oil spill mathematical model should take into account human response activities in addition to such environmental factors as coastline, field of currents, weather, sea state, ice conditions and environmentally sensitive areas. [1]

The main point of the method is to extend the Lagrangian approach by introducing interactions between oil particles. This innovation allows some essential disadvantages of the traditional Lagrangian method to be compensated, in particular the impossibility of describing oil interaction with different kinds of natural and artificial barriers like coastlines and booms. The tuning of the interparticle interaction was made via multi-stage parametric optimization with the aid of the alternating-variable descent technique, and includes the verification with known semi-empirical solutions as well as with different logical tests. [1]

The model takes into account the main physicochemical processes occurring in the oil slick, which include evaporation, dispersion, emulsification and viscosity variation. Simulation is carried out with regard to the following environment factors: coastline, field of currents, weather, sea state, ice conditions and environmentally sensitive areas. In addition, models of response resource application including booming and recovery have been developed. [1]

The following input data were used for the simulation:

a) Hydrometeorological observations:
- water temperature [$^{\circ}$C]
- air temperature [$^{\circ}$C]
- wind speed and direction [m/s; $^{0}$]
- current speed and direction [m/s; $^{0}$]
- sea state [m]

Hydrometeorological observations were taken from the Research Laboratory for Danube, Delta and the Sea, for Gloria Platform between 05.01.-08.01.2008 (Table 1) and 21.06.-24.06.2008 (Table 2).

b) Physical characteristics of oil:
- density: 830 kg/m$^3$
- surface tension: 0.0173 N / m
- viscosity: 15 cP
- maximum water content: 40%
- pour point: -10 $^{0}$C
- flash point: -4 $^{0}$C

Physical characteristics were taken from The Oil Laboratory of Câmpina.

c) Other features:

4. - Midia Teminal distance: 26 km
- inner diameter pipe: 291.95 mm
- average speed of movement of oil through the pipeline: 0.32 m/s
- water density: 1015 kg/m$^3$

The calculations revealed that the total volume of oil discharged is 85.2 tons - in these conditions the volume is rather small so it is cathegorised as a medium pollution, which can still degenerate into a large-scale environmental issue.

Table 1. Hydrometeorological observations for 05.01.-08.01.2008

| Date | Hour | Wind | | Sea surface conditions (degrees) | Wave elements | | | | Temperature | | Current | | Visibility (km) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Direction | Speed (m/s) | | Direction | Length (m) | Period (s) | Height (m) | Air ($^0$C) | Water ($^0$C) | Direction | Speed (m/s) | |
| 05.01.2008 | 1 | 340 | 14 | 6 | N | 40 | 5,4 | 4,5 | -7,0 | 5,5 | S | 26,3 | 10 |
| | 7 | 360 | 12 | 5 | N | 35 | 5,0 | 3,5 | -6,4 | 5,5 | S | 25,0 | 10 |
| | 13 | 340 | 11 | 5 | N | 35 | 5,0 | 3,3 | -5,2 | 5,5 | S | 25,0 | 1.5 |
| | 19 | 340 | 10 | 5 | N | 30 | 4,5 | 2,8 | -5,2 | 5,5 | S | 18,5 | 10 |
| 06.01.2008 | 1 | 360 | 10 | 4 | N | 30 | 4,3 | 2,2 | -2,0 | 5,5 | S | 14,7 | 20 |
| | 7 | 90 | 5 | 3 | NE | 50 | 6,7 | 1,2 | 1,0 | 5,5 | V | 15,2 | 20 |
| | 13 | 140 | 6 | 3 | NE | 50 | 6,8 | 1,2 | 3,0 | 5,5 | V | 15,9 | 20 |
| | 19 | 140 | 6 | 3 | NE | 50 | 6,7 | 1,0 | 4,0 | 5,5 | V | 13,5 | 20 |
| 07.01.2008 | 1 | 140 | 9 | 4 | SE | 25 | 3,8 | 1,6 | 3,0 | 5,5 | NV | 14,1 | 20 |
| | 7 | 140 | 13 | 4 | SE | 30 | 4,2 | 2,4 | 5,0 | 6,0 | NV | 25,0 | 20 |
| | 13 | 290 | 10 | 5 | SE | 40 | 6,9 | 3,2 | 5,3 | 6,0 | N | 25,0 | 10 |
| | 19 | 320 | 8 | 4 | NV | 20 | 3,4 | 1,5 | 2,6 | 6,0 | ESE | 13,5 | 10 |
| 08.01.2008 | 1 | 320 | 9 | 4 | NV | 20 | 3,5 | 1,5 | 0,7 | 6,0 | SE | 13,5 | 4 |
| | 7 | 340 | 9 | 4 | NV | 25 | 3,8 | 1,8 | 1,5 | 6,0 | SE | 20,0 | 10 |
| | 13 | 20 | 9 | 4 | N | 35 | 4,4 | 2,4 | 4,1 | 6,0 | S | 20,0 | 10 |
| | 19 | 20 | 9 | 4 | N | 35 | 4,6 | 2,2 | 4,0 | 6,0 | S | 20,0 | 10 |

Table 2. Hydrometeorological observations for 21.06.-24.06.2008

| Date | Hour | Wind | | Sea surface conditions (degrees) | Wave elements | | | | Temperature | | Current | | Visibility (km) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Direction | Speed (m/s) | | Direction | Length (m) | Period (s) | Height (m) | Air ($^0$C) | Water ($^0$C) | Direction | Speed (m/s) | |
| 21.06.2008 | 01 | 360 | 4 | 2 | VV | N | 10 | 2.2 | 0.3 | 21.2 | 20.5 | S | 10.0 |
| | 07 | 360 | 6 | 2 | VV | N | 15 | 2.7 | 0.5 | 21.6 | 20.5 | S | 12.0 |
| | 13 | 90 | 5 | 2 | H | NE | 40 | 5.7 | 0.5 | 24.6 | 20.5 | V | 10.0 |
| | 19 | C | 0 | 2 | H | NE | 45 | 6.4 | 0.3 | 25.4 | 20.5 | E | 25.6 |
| 22.06.2008 | 01 | 290 | 7 | 3 | VV | V | 15 | 2.4 | 0.6 | 22.6 | 20.5 | E | 25.0 |
| | 07 | 360 | 8 | 3 | VV | N | 20 | 3.3 | 0.8 | 22.6 | 20.5 | S | 20.0 |
| | 13 | 20 | 3 | 2 | VV | N | 10 | 2.2 | 0.3 | 25.0 | 20.5 | SV | 10.0 |
| | 19 | 230 | 3 | 1 | - | - | - | - | - | 26.6 | 21.0 | SV | 8.5 |
| 23.06.2008 | 01 | 270 | 6 | 3 | VV | V | 15 | 2.4 | 0.6 | 23.6 | 21.0 | E | 10.0 |
| | 07 | 90 | 7 | 2 | VV | NE | 10 | 2.2 | 0.3 | 23.4 | 21.0 | NE | 17.2 |
| | 13 | 140 | 6 | 2 | VV | SE | 15 | 2.7 | 0.5 | 26.4 | 21.0 | V | 15.6 |
| | 19 | 180 | 8 | 3 | VV | S | 20 | 3.4 | 1.0 | 27.2 | 21.0 | N | 15.6 |
| 24.06.2008 | 01 | 200 | 9 | 3 | VV | S | 25 | 3.6 | 1.4 | 23.6 | 21.0 | NNE | 17.2 |
| | 07 | 290 | 6 | 4 | HVV | SV | 50 | 6.7 | 1.4 | 23.8 | 21.0 | SSE | 15.6 |
| | 13 | 320 | 3 | 2 | H | S | 50 | 6.7 | 0.4 | 26.8 | 21.0 | V | 14.3 |
| | 19 | 180 | 6 | 2 | VV | S | 15 | 2.8 | 0.5 | 26.0 | 21.0 | N | 12.0 |

## 4. RESULTS

The pollution development scenario obtained from the PISCIS Simulator:

a) An hour after the start of pollution:

- 05.01.-08.01.2008, amount spilled: 20.6 tons;- amount floating: 15.8 tons;- amount evaporated: 1.2 tons;- amount dispersed 3.6 tons;- amount floating mixture: 23.9 tons;- maximum oil film thickness: 4 mm;- spill area: 37979 $m^2$;- viscosity: 71.9 cP. (Fig. 1.)

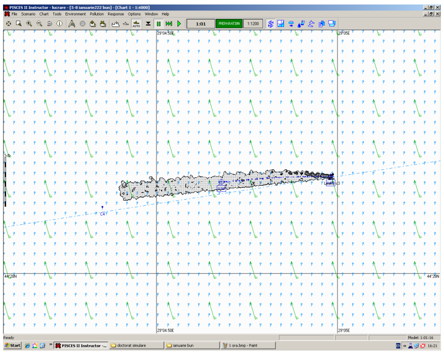

Figure 1 Evolution of oil spill one hour after the accident (05.01.-08.01.2008)

- 21.06.-24.06.2008, amount spilled: 20.6 tons;- amount floating: 20.2 tons;- amount evaporated: 0.4 tons;- amount dispersed 0 tons;- amount floating mixture: 25.5 tons;- maximum oil film thickness: 12.1 mm;- spill area: 11310 $m^2$;- viscosity: 8.9 cP. (Fig. 2.)

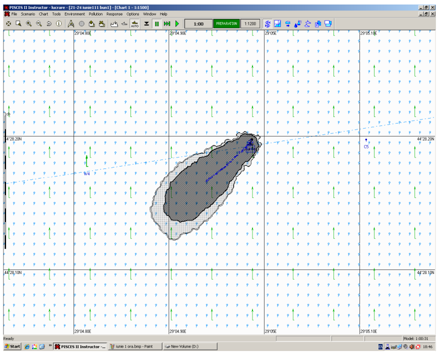

Figure 2 Evolution of oil spill one hour after the accident (21.06.-24.06.2008)

b) At 4 hours after of the start of pollution:

- 05.01.-08.01.2008: amount spilled: 83 tons;- amount floating: 53.7 tons;- amount evaporated: 11 tons;- amount dispersed 18.3 tons;- amount floating mixture: 90.7 tons;- maximum oil film thickness: 5.8 mm;- spill area: 203353 $m^2$;- viscosity: 210 cP. (Fig. 3)

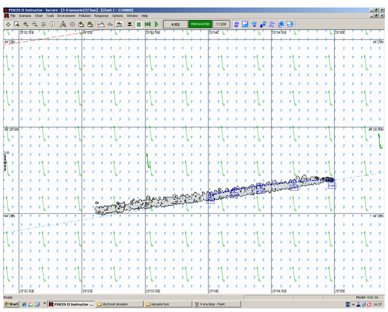

Figure 3 Evolution of oil spill 4 hours after the accident (05.01.-08.01.2008)

- 21.06.-24.06.2008, amount spilled: 83 tons;- amount floating: 75.3 tons;- amount evaporated: 6.7 tons;- amount dispersed 0.9 tons;- amount floating mixture: 108 tons;- maximum oil film thickness: 13.2 mm;- spill area: 77109 $m^2$;- viscosity: 32.1 cP. (Fig. 4.)

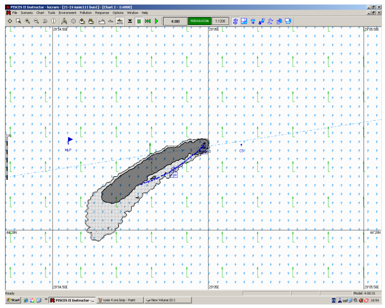

Figure 4 Evolution of oil spill 4 hours after the accident (21.06.-24.06.2008)

c) After 6 hours of the start of pollution:

- 05.01.-08.01.2008: amount spilled: 85.2 tons;- amount floating: 44.7 tons;- amount evaporated: 16.1 tons;- amount dispersed 24.3 tons;- amount floating mixture: 79.7 tons;- maximum oil film thickness: 1 mm;- spill area: 242396 $m^2$;- viscosity: 449 cP. (Fig. 5)

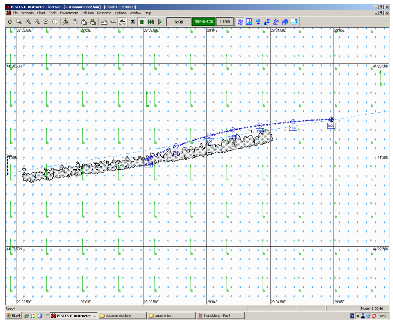

Figure 5 Evolution of oil spill 6 hours after the accident (05.01.-08.01.2008)

- 21.06.-24.06.2008, amount spilled: 85.2 tons;- amount floating: 69.5 tons;- amount evaporated: 13.3 tons;- amount dispersed 2.2 tons;- amount floating mixture: 118 tons;- maximum oil film thickness: 2.5 mm;- spill area: 145288 $m^2$;- viscosity: 112 cP. (Fig. 6.)

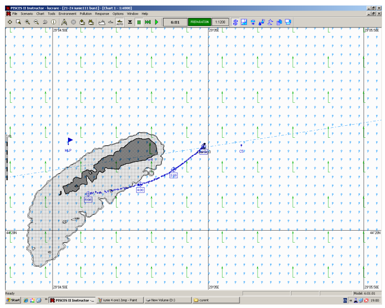

Figure 6 Evolution of oil spill at 6 hours after the accident (21.06.-24.06.2008)

d) After 12 hours of the start of pollution:

- 05.01.-08.01.2008: amount spilled: 85.2 tons;- amount floating: 31.2 tons;- amount evaporated: 20.7 tons;- amount dispersed 33.3 tons;- amount floating mixture: 55.4 tons;- maximum oil film thickness: 0.9 mm;- spill area: 278516 m$^2$;- viscosity: 780 cP. (Fig. 7)

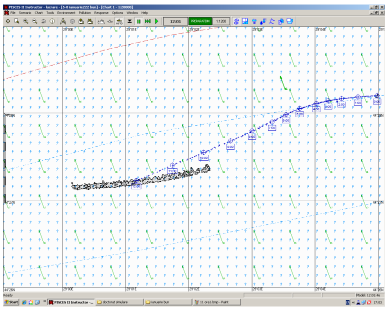

Figure 7 Evolution of oil spill at 12 hours after the accident (05.01.-08.01.2008)

- 21.06.-24.06.2008, amount spilled: 85.2 tons;- amount floating: 56.1 tons;- amount evaporated: 23.5 tons;- amount dispersed 5.4 tons;- amount floating mixture: 99.7 tons;- maximum oil film thickness: 1.4 mm;- spill area: 221101 m$^2$;- viscosity: 456 cP. (Fig. 8.)

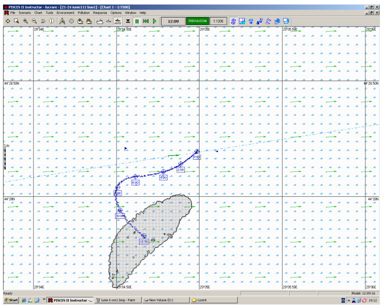

Figure 8 Evolution of oil spill at 12 hours after the accident (21.06.-24.06.2008)

e) After 24 hours of the start of pollution:

- 05.01.-08.01.2008: amount spilled: 85.2 tons;- amount floating: 24.9 tons;- amount evaporated: 23.5 tons;- amount dispersed 36.8 tons;- amount floating mixture: 41.1 tons;- maximum oil film thickness: 0.5 mm;- spill area: 337970 m$^2$;- viscosity: 1094 cP. (Fig. 9)

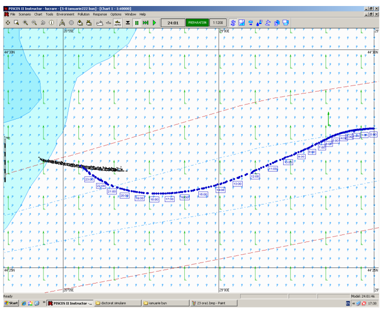

Figure 9 Evolution of oil spill at 24 hours after the accident (05.01.-08.01.2008)

- 21.06.-24.06.2008, amount spilled: 85.2 tons;- amount floating: 46.1 tons;- amount evaporated: 29.5 tons;- amount dispersed 9.5 tons;- amount floating mixture: 81.6 tons;- maximum oil film thickness: 0.7 mm;- spill area: 302550 m$^2$;- viscosity: 940 cP. (Fig. 10.)

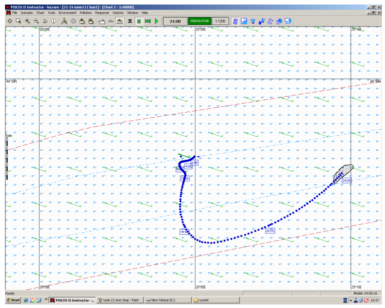

Figure 10 Evolution of oil spill at 24 hours after the accident (21.06.-24.06.2008)

f) After 48 hours of the start of pollution:

- 05.01.-08.01.2008: amount spilled: 85.2 tons;- amount floating: 22.6 tons;- amount evaporated: 25.4 tons;- amount dispersed 37.2 tons;- amount floating mixture: 39.9 tons;- maximum oil film thickness: 0.5 mm;- spill area: 247458 m$^2$;- viscosity: 1365 cP. (Fig. 11)

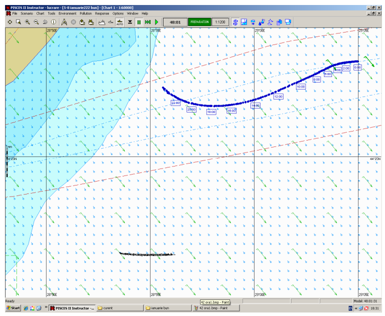

Figure 11. Evolution of oil spill at 48 hours after the accident (05.01.-08.01.2008)

- 21.06.-24.06.2008, amount spilled: 85.2 tons;- amount floating: 6.6 tons;- amount evaporated: 33.8 tons;- amount dispersed 44.7 tons;- amount floating mixture: 11.7 tons;- maximum oil film thickness: 0.3 mm;- spill area: 200376 m$^2$;- viscosity: 1504 cP. (Fig. 12.)

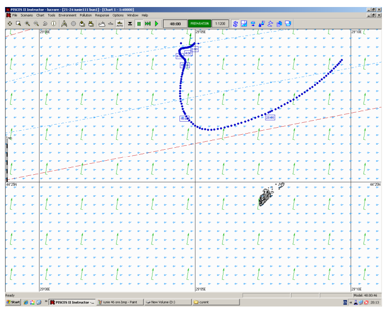

Figure 12 Evolution of oil spill at 48 hours after the accident (21.06.-24.06.2008)

g) After 60 hours of the start of pollution:

- 05.01.-08.01.2008: amount spilled: 85.2 tons;- amount floating: 20.3 tons;- amount evaporated: 26.3 tons;- amount dispersed 38.6 tons;- amount floating mixture: 35.9 tons;- maximum oil film thickness: 0.4

mm;- spill area: 287430 m$^2$;- viscosity: 1467 cP. (Fig. 13)

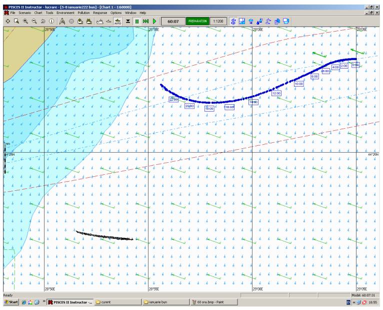

Figure 13 Evolution of oil spill at 60 hours after the accident (05.01.-08.01.2008)

- 21.06.-24.06.2008, amount spilled: 85.2 tons;- amount floating: 3.2 tons;- amount evaporated: 36.5 tons;- amount dispersed 45.3 tons;- amount floating mixture: 5.7 tons;- maximum oil film thickness: 0.2 mm;- spill area: 116307 m$^2$;- viscosity: 2078 cP.

h) After 70 hours of the start of pollution:

- 05.01.-08.01.2008: amount spilled: 85.2 tons;- amount floating: 19.4 tons;- amount evaporated: 26.9 tons;- amount dispersed 38.9 tons;- amount floating mixture: 34.3 tons;- maximum oil film thickness: 0.3 mm;- spill area: 392949 m$^2$;- viscosity: 1564 cP. (Fig. 14)

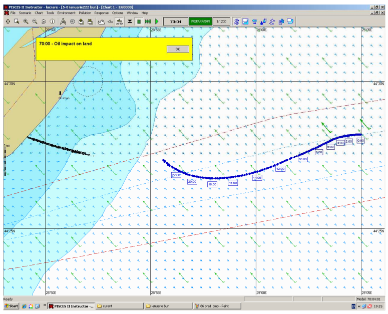

Figure 14 Evolution of oil spill at 70 hours after the accident (05.01.-08.01.2008)

- 21.06.-24.06.2008, amount spilled: 85.2 tons;- amount floating: 0.7 tons;- amount evaporated: 36.7 tons;- amount dispersed 47.6 tons;- amount floating mixture: 1.3 tons;- maximum oil film thickness: 0.2 mm;- spill area: 39074 m$^2$;- viscosity: 2125 cP.

i) After 72 hours of the start of pollution:

- 21.06.-24.06.2008: amount spilled: 85.2 tons;- amount floating: 0.5 tons;- amount evaporated: 36.7 tons;- amount dispersed 47.8 tons;- amount floating mixture: 0.9 tons;- maximum oil film thickness: 0.2 mm;- spill area: 29033 m$^2$;- viscosity: 2129 cP.

j) After 74 hours of the start of pollution:

- 05.01.-08.01.2008: amount spilled: 85.2 tons;- amount floating: 0.1 tons;- amount evaporated: 27 tons;- amount dispersed 39 tons;- amount floating mixture: 0.3 tons;- maximum oil film thickness: 0.2 mm;- spill area: 6052 m$^2$;- viscosity: 1585 cP;- amount stranded: 19 tons. (Fig. 15)

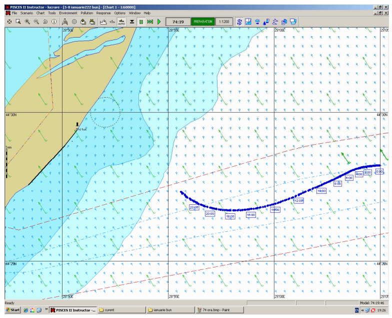

Figure 15 Evolution of oil spill after 74 hours after the accident (05.01.-08.01.2008)

## 5. CONCLUSIONS

For the first analyzed period, respectively 04.01.-01.08.2008, as the simulation results are confirming, the shoreline pollution is imminent, but it can not reach the shore earlier than 70 hours after the discharge, so that the entity with responibilities in the matter, Romanian Agency for Rescue of Life on Sea (in romanian: Agenția Română de Salvare a Vieții Omenești pe Mare) has enough timefor remediation interventions -collect waste oil, to avoid an ecological disaster in Grindu Chituc Natural Reserve. Unless timely intervention is not organized, the shore of Grindu Chituc Natural Reserve ist o be polluted with 19 tons of oil.

Possible evolution of oil spill after 72 hours of discharge is shown in Figure 16.

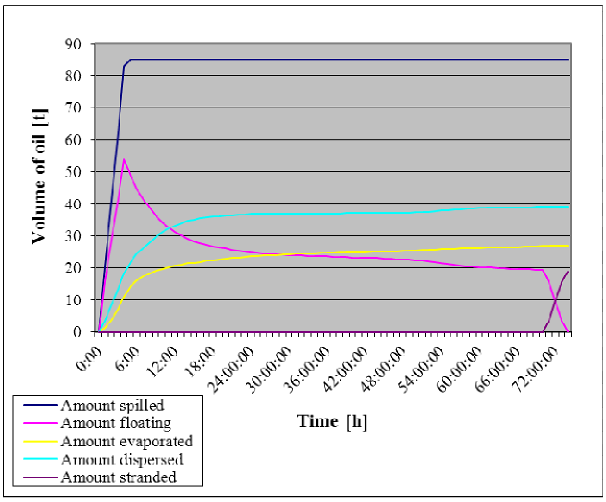


Figure 16 Evolution of oil spill at 72 hours after discharge

For the second analyzed period, 21.06.-06.24.2008, the simulation results show that the oil slick will not pollute the shore as hydrometeorological observations give strong data on moving it towards the center of the Black Sea. Possible evolution of oil spill for the second period 21.06.-24.06.2008 is shown in Figure 17.

One of the most important factors that make a difference when talking about the shoreline pollution and operative intervention of the Romanian Agency for Rescue of Life on Sea is the minimum distance at which the oil is discharged into the sea. Other factors that influence the size of pollution are: speed and direction of the wind and of the current, temperature of water and air, the height of the waves.

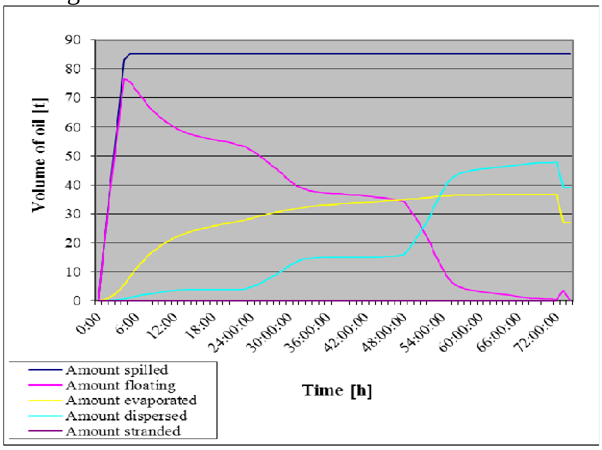


Figure 17 Evolution of oil spill at 72 hours after discharge

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# SECTION III

## ELECTRONICS, ELECTRONICAL ENGINEERING AND COMPUTER SCIENCE

# OPTIMAL SELECTION OF STATOR TURNS NUMBER AT PERMANENT MAGNET SYNCHRONOUS GENERATOR

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**ABSTRACT**

The optimization of permanent magnet synchronous generator is a current issue. This paper develops an original method of multi-criteria optimization of stator turns number based on Poynting algorithm [14]. Based on the design theme requirements and initial estimation of electromagnetic stress has been deduced an analytical relationship of the total number of stator windings as a linear function geometric factor. The benefits of this approach is related to the possibility of developing of a global optimization criteria, optimizing the total turns number of stator windings in parallel with specific consumption of active materials, or specific economic cost.

**Keywords:** *stator turns number, permanent magnet synchronous generator, optimization, thermal flow.*

## 1. INTRODUCTION

Electric machines are found in a growing number of applications, both in power systems (conventional plants and some unconventional (renewable energy), industrial drives, etc.), domestic applications and other applications in the field of microcosm (special applications, the high precision one etc.).

The machine optimal operation process is largely dependent on the design phase approach [8]. These aspects are both important for the industry, and scientific research. Current issues related to structural-functional optimization were always in researchers' attention. Thus, over the time more global optimization problems has been performed, as well: economic optimization, functional optimization (thermal), optimization of dynamic regimes, etc. ; and as well as intimate optimization problems of integrated components of machines such as: slots, yoke, slot number per pole and phase etc.

Machine design involves, in general, several design steps [9]: electromagnetic computing, thermal computing, mechanical computing etc. Electromagnetic computing phase has the objective to determine the geometric dimensions of machine under the claim of electromagnetic stress imposed (magnetic induction in air gap, current density or current liniar desity). Thermal computing is refers to sezing machine in the order to avoid the maximal admisible temperature in various parts of machine. Initial design stage is ending once with mechanical computing, where is taken into account that both f of mechanical and electromagnetical forces does not cause damage of mechanical structure of the machine, especially in dynamic conditions. Design usually ends by analyzing the machine dynamic regimes.

There are, in general, two classes of electric machine design methodologies: traditional methods (based on the equivalent circuit diagram) and methods based on FEM Maxwell electromagnetic field equations solving. The latter has a wider applicability today, especially due to the possibility of detailed solutions obtaining on magnetic or thermal field distribution in various parts of the machine, but those methods are strongly dependent on numerical software (a complete solution need, in general, more time for hardwere solving).

Design methods based on the electric circuit equivalent scheme are known since the early of XX century [2]. Benefits are related primarily of simplicity in explaining the complex phenomena that occur in cars, which necessitates the use of simple design relationships. In work [13-14] has shown that traditional methods can be successfully improved thanks to the heat flow estimate of losses in the stator winding, leading to the definition of a new approach of electrical machine optimization.

Although the literature have treated an important number of optimization issues, the optimization of the stator turns number on the electrical machines with cylindrical simetry has not been large discussed. In the order to solve this important issue, an analytical realtionship based on Poynting vector algorithm has been developed.

## 2. ANALYTICAL EXPRESSON OF RIGHT SLOT AREA. PRINCIPLES

The design phase of electrical machines - based on equivalent scheme circuit - involves usually a lot of steps, is an iterative processes until the desired solution

In the designing process of electrical machines - based on traditional methods- must be taken into consideration that electrical demands as current density $J[A/mm^2]$ and linear current density $A[A/mm]$, and that magnetic air gap induction magnetic flux density $B_\delta[T]$ must be incadrated in specific limits according to the application type where the machine is involved [9].

Based on rated data, the electromagnetical inner power is expressed by relationship [14]:

$$S_e = S_p \cdot \pi DL \tag{1}$$

where $D$ is the inner stator diameter and $L$ is the stator lenght.

The Poynting vector can be representated as a function of a global geometric factor [14]:

$$S_p = S_{p0} \cdot k_{f1} \quad (2)$$

where $S_{p0} = \dfrac{Q_{1T}}{k_s \cdot p_{j1n}}$ is the limit Poynting vector,

and $k_f = 1 + \dfrac{L_f}{L}$ is the global geometric factor (fig. 1).

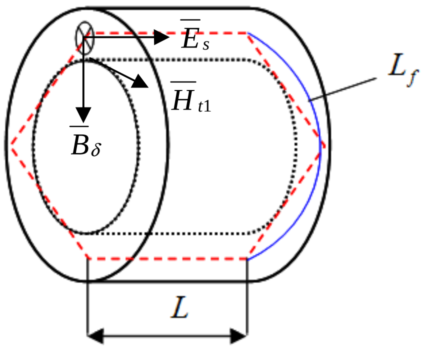


Figure 1 Elements of geometric factor $k_f$

But in the some time the natural definition of Poynting vector is field measurements one [13], [14]:

$$S_p = E_s(k_{f1}) \cdot H_{t1}(k_{f1}) \quad (3)$$

where $E_s(k_{f1}) = \dfrac{v_1(k_{f1}) \cdot B_\delta}{\sqrt{2}}$ is the main electrical field intensty computed by induction low of Faraday, $H_{t1}(k_{f1}) \cong A_1(k_{f1})$ is the magnetic intensity of field which is considerate to be equal with linear current density.

Using relationship (3) the linear current density can be expressed by:

$$A_1(k_{f1}) = \frac{S_p(k_{f1})}{E_s(k_{f1})} \quad (4)$$

A detalied form of this expresion is gived by:

$$A_1(k_{f1}) = \frac{\sqrt{2} \cdot Q_{1T}}{k_s \cdot p_{j1n} \cdot v_1(k_{f1}) \cdot B_\delta} k_{f1} \quad (5)$$

A common expression of linear current density is gived in literature survey by [14]:

$$A_1(k_{f1}) = \frac{m_1 \cdot 2w_1 \cdot I_1}{\pi D(k_{f1})} \quad (6)$$

Using this relationship the stator turns number can expressed by:

$$w_1(k_{f1}) = \frac{A_1 \cdot \pi D(k_{f1})}{2 \cdot m_1 \cdot I_1} \quad (7)$$

From relationships (5) and (7) the stator turns number become:

$$w_1(k_{f1}) = \frac{\sqrt{2} \cdot \pi \cdot Q_{1T} \cdot D(k_{f1})}{2 \cdot k_s \cdot m_1 \cdot I_1 \cdot v_1(k_{f1}) \cdot p_{j1n} \cdot B_\delta} \cdot k_{f1} \quad (8)$$

The linear velocity can be expressed by [14]:

$$v_1(k_{f1}) = \frac{\pi \cdot f_{1n} \cdot D(k_{f1})}{p} \quad (9)$$

Finally, the stator turns number is described by the next relationship:

$$w_1(k_{f1}) = \frac{p \cdot Q_{1T}}{\sqrt{2} \cdot k_s \cdot m_1 \cdot I_{1n} \cdot f_{1n} \cdot p_{j1n} \cdot B_\delta} k_{f1} \quad (10)$$

A compact form of the last realtionship is described by:

$$w_1(k_{f1}) = w_{10} \cdot k_{f1} \quad (11)$$

where by $w_{10} = \dfrac{p \cdot Q_{1T}}{\sqrt{2} \cdot k_s \cdot m_1 \cdot I_1 \cdot f_{1n} \cdot p_{j1n} \cdot B_\delta}$

is denoted the stator turns number for a machine with an infinitive length:

$$\lim_{L \to \infty} w_1(k_{f1}) = w_{10} \quad (12)$$

The relationship (10) is compose from two types of measurements: those which are imposed by some rated data from the design process starting (number of phase and number of poles pairs), and those which are adjustable (all the others measurements).

An important feature according relationship (11) is related by the linear variation of the stator turns number with the variation of the geometric factor. As is well-knowing from literature survey, the stator turns number must be a minimal one [8], thus according to relationship (11) - where de stator turns number varies linearly - the geometrical factor $k_{f1}$ must have a minimal value. This is one of the reason for which the literature - through other thermal considerations - require a minimal value of this factor [13].

With the help of relationship (11) can be defined two global optimization criteria. The first criteria aim to compute the stator turns number in parallel with active materials specific consumption optimization:

$$\begin{cases} w_1 = f(k_{f1}) \\ c_m[kg/VA] = f(k_{f1}) = \min \end{cases} \quad (13)$$

The second one aims to compute the stator turns number in parallel with specific cost optimization:

$$\begin{cases} w_1 = f(k_{f1}) \\ k_m[m.u/VA] = f(k_{f1}) = \min \end{cases} \quad (14)$$

Those criteria give the possibility to optimize the machine through a global approach. From both optimal criteria must be used that who is more favorable by applications type.

The contribution developed in this work paper leads to improve the general logical scheme of the vector electrical machines Poynting design algorithm [14], as can be seen in Figure 2.

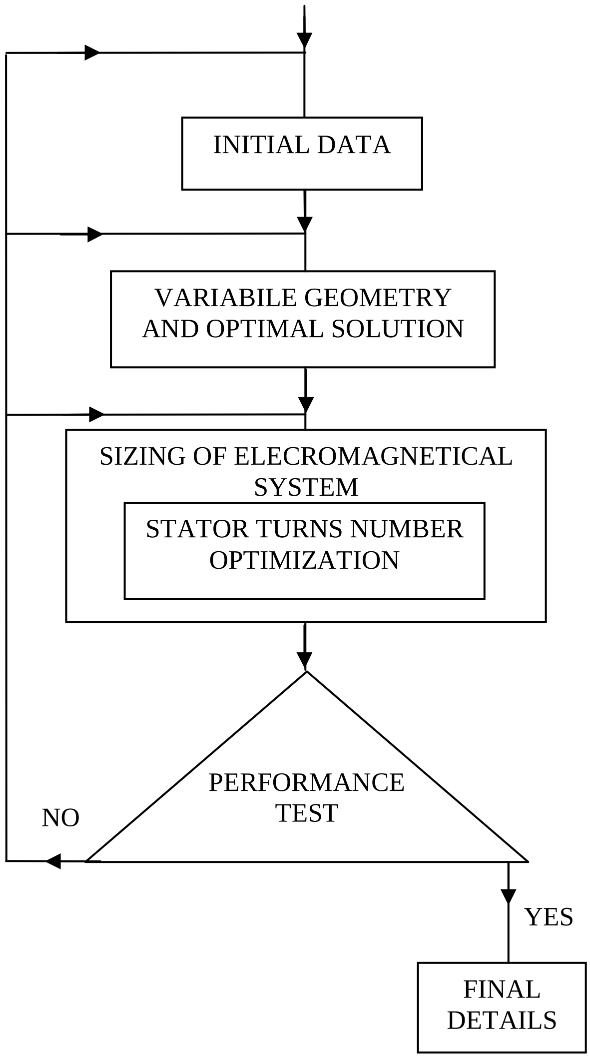


Figure 2 Improved algorithme for generator design

Electromagnetic sizing block has been improved by introduceing the criteria developed in this work, reprentated by red color line, which means the system (13) or (14).

### 3. STATOR TURNS NUMBER OPTIMIZATION. PERMANENT MAGNET SYNCHRONOUS GENERATOR CASE STUDY

From design theme for a permanent magnet synchronous generator with radial flux the next requirments has been considerated:

- Rated power: $P_n = 50 \ [kW]$
- Rated voltage: $U_n = 400 \ [V]$
- Rated frequency: $f_n = 50 \ [Hz]$
- Rated power factor: $\cos\varphi_n = 0.9$
- Rated efficiency: $\eta_n = 0.92$
- Pairs poles number: $p = 14$
- Overload factor of torque: $M_m = 2.5$

A permanent magnet synchronous generator with magnets mounted on the surface of the rotor has been used.The cross section all definting geometric elements of the generator have been represented in fig.3.

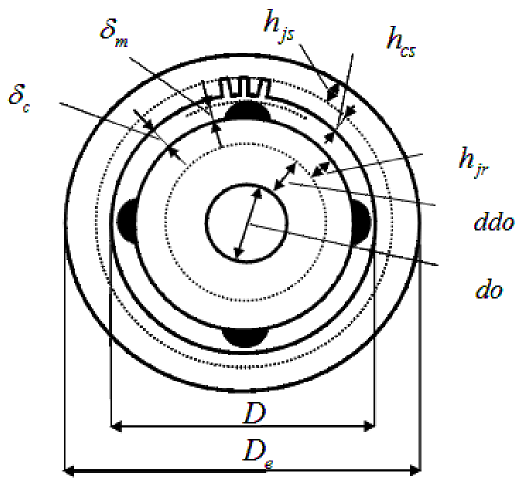


Figure 3 Cross section of generator

In the first step of design phase were representated the estimated performance characteristics bulid with the help of design requirments and per-unit parameter estimation (stator resistance and leakage reactance). Two types of characteristics: those based on scheme equivalent circuit (denoted by "T") and those based on analytical relations which allow losses separate (denoted by "P" or "A") [14]. The electromechanical characteristics were represented in fig. 5:

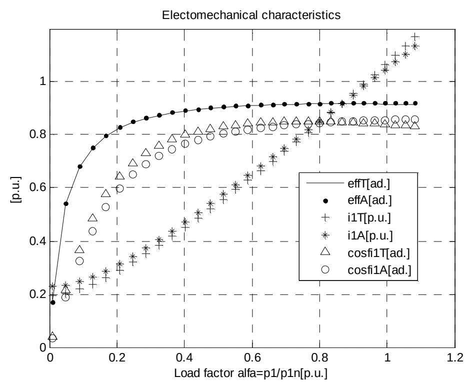


Figure 4 Estimated electromechanical characteristics

Angular characteristics of permanent magnet synchronous were represented in fig. 5. Based on these characteristics, the internal angle of machine has been done at value by $\theta \approx 30^o$ according to several steps: simultaneously the torques (in T approach or P (Poitier of A (analytic)o ) must be the rated one, the currents must be the rated one, and the voltage on the magnetising electric T circuit must be positive $u_m$ <1 (generator regime).

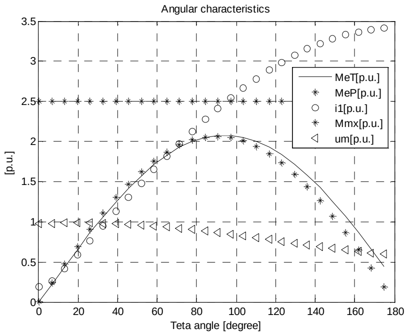


Figure 5 Estimated angular characteristics

The geometric main dimensions of stator were representated in fig. 6.

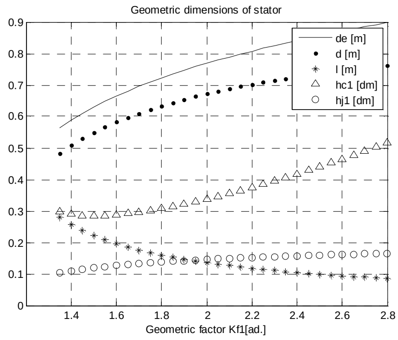


Figure 6 Geometric dimensions of stator

Main geometric dimensions of rotor were representeted in fig.7.

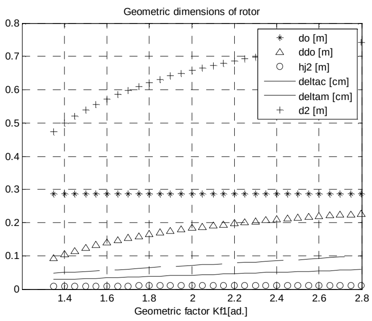


Figure 7 Geometric dimensions of rotor

The specific statoric consumption of active material (Cu, Fe, total one), and specific statoric cost were representated in fig. 8.

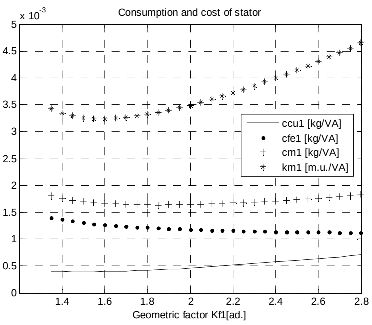


Figure 8 Consumption and cost of stator

The total specific consumption of active materials (Fe, Cu and PM), and the total specific cost were represented in fig. 9.

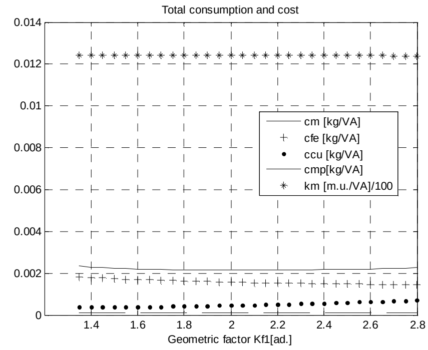


Figure 9 Total consumption and cost

In the order to optimize de stator turn number it was used the proposed method described by systems (12) and (13). Due to the fact that there are two option, we will analyze everry case, and after that we will chosed the best version method one.

From the point of view of stator slot number it is desirable to optaine a low number of stator turns. As the relationships (11) shows very clearly that stator turns number is a linear function, in fig.10 was represented this function:

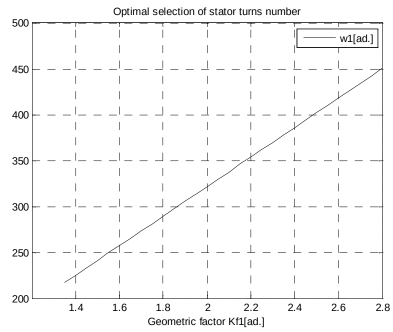


Figure 10 Optimal selection of slots per phase and pole

In the order to achieve a good solution of the optimization problem, was representated the detailes of economical characterstics. The zoom detailed characteristics of active materials consumption was representated in fig. 11:

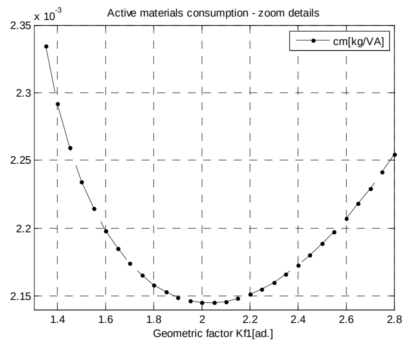


Figure 11 Real angular characteristics for consumption optimization

It was observed that around value $k_{f1} \approx 2$ is obtained the lower cosumption of active materials.

The zoom detailed characteristics of specific economic cost was representated in fig. 12:

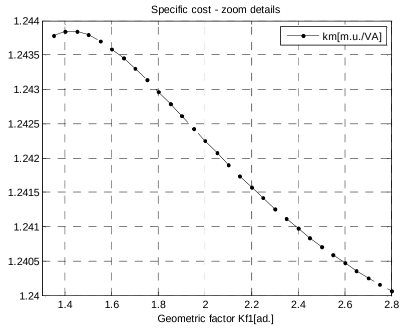


Figure 12 Real angular characteristics for consumption optimization

This characteristic is a deacreasing one and does not allow choosing an optimal point (an extremium one). From this reason the chosen point has the value $k_{f1} \approx 2.6$ ($k_{f1} < k_{f1\max} = 3$ given by literature [14] as a maximal limit). The optmization characteristics are presentated in table no. 1:

Table no. 1. Optimization characteristics

| Parameter | Consumption optimization | Cost optimization |
|---|---|---|
| $k_{f1}$ | 2 | 2.6 |
| $w_1$ | 322 | 417 |
| $c_m[kg/VA]$ | 0.0021 | 0.0022 |
| $k_m[m.u/VA]$ | 1.2423 | 1.2405 |

Note that the results obtained from optimization procedure are very close by using this procedure.

Circuit parameters of equivalent scheme and some performances were given in table no. 2 for three situations: estimated parameters, active materials consumption optimization and economic cost optimization.

Table no. 2. Optimization parameters

| Parameter | Estimated | Consumption optimization | Cost optimization |
|---|---|---|---|
| $r_1[p.u.]$ | 0.0413 | 0.0449 | 0.0347 |
| $x_m[p.u.]$ | 0.4301 | 0.4135 | 0.4201 |
| $\cos\varphi$ | 0.8358 | 0.7942 | 0.8569 |
| $\cos\varphi_c$ | 0.8579 | 0.8570 | 0.8203 |
| $\eta_T$ | 0.9145 | 0.9063 | 0.9210 |
| $\eta_P$ | 0.9197 | 0.9199 | 0.9199 |
| $i_{1T}[p.u.]$ | 1.1284 | 1.1593 | 1.0843 |
| $i_{1P}[p.u.]$ | 1.0994 | 1.0743 | 1.0724 |
| $M_{mT}[p.u.]$ | 2.0730 | 2.0590 | 2.0184 |
| $M_{mP}[p.u.]$ | 2.0646 | 2.0646 | 2.0543 |

As can be seen from table no.2 the parameters are closed. The power factor is low then the one imposed from design theme requirments (0.92) due to large number of pairs of poles involved. From those two optimization can be selected the one which coresponds to applications requirments (low weight, low lenght, low economic cost, low active materials consumption).

The characteristics obtained from optimal design of active materials consumption were represented in fig. 13 and fig. 14.

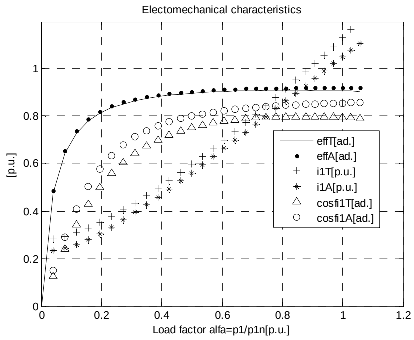


Figure 12 Real electromechanical characteristics for consumption optimization

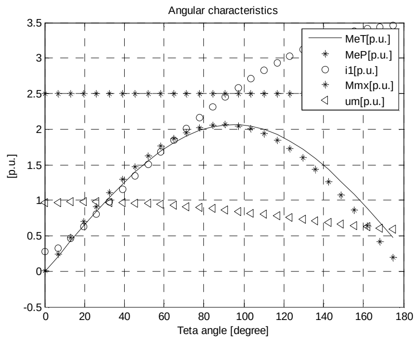


Figure 13 Real angular characteristics for consumption optimization

Performance characteristics for optimization case of specific costs were represented in fig. 14 and fig. 15.

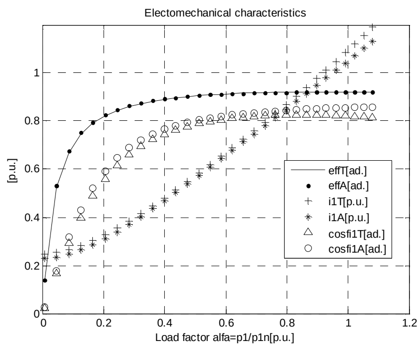


Figure 14 Real electromechanical characteristics for cost optimization

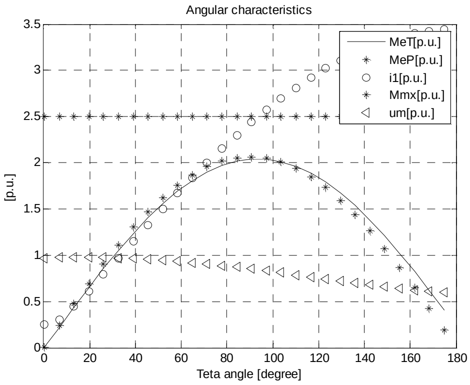


Figure 15 Real angular characteristics for cost optimization

## 4. CONCLUSIONS

The optimization of stator turns number with a multi-criteria approach - thermal and economic criteria - lead to a simple optimal design procedure in the order to find the desirable solution.

An analytical relationship of stator turns number has been developed. This represent the stator turns number as a linear function of geometric factor; from this point of view it is desirable to obtain a lower geometric factor which leads to a lower number of stator turns. With the help of this relationship a global optimization criteria has performed which has viability for all electrical machines with cylinder symmetry.

Numerical simulations performed for a permanent magnet synchronous generator case study show the effectiveness of the work proposed in this paper. The selection of the best option from both economical one (active materials consumption or economic cost) depends on the applications types where the machine will be incadrated.

Future work involve a complete analyse of the machine take into account the influence of stator right slot area on the machine performances.

## 5. ACKNOWLEDGMENTS

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# OPTIMAL SELECTION OF RIGHT SLOT AREA AT PERMANENT MAGNET SYNCHRONOUS GENERATOR

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**ABSTRACT**

A large class of current approaches is dedicated to permanent magnet synchronous generator optimization. In this paper is proposed an alternative method in the order to compute the optimal right slot area at permanent magnet synchronous generators based on the electrical circuit equivalent scheme method. For this purpose, the optimal area of right slots has been expressed as a function of thermal flows from active and frontal part of stator winding. This approach takes into account both criteria as thermal and economical one, based on the Poynting vector algorithm [14]. This proposed solution is an important one due to the multiple aspects involved in the order to find the desired optimal solution.

**Keywords:** *right slot area, permanent magnet synchronous generator, optimization, thermal flow.*

## 1. INTRODUCTION

Today a large class of applications includes electrical machines, as: power plant energy sources, non-conventional energy resources conversion, electrical drives and other special applications. This is a consequence of the multiple aspects required by these applications, where these can be machine are a reliable solution.

The most important aspects related to electrical machines are usually related to several types of approaches as: optimization, stability, dynamical regimes, environmental impact etc. All this important aspects are founded in research's attention of various fields and are always improved in the order to continuous increasing the performance level. Moreover, the design phase can decisively influence all the other regimes, and that is why the design phase of machine s from a large attention is the current approaches [6], [9].

On the time, the design phase of electrical machine has been involved different types of approaches as design based on: circuit equivalent scheme, magnetic circuits, Maxwell field equations etc. The design methodology based on circuit equivalent scheme is one of the well-known methods from traditional one, and have some majors benefits by using, as [2]: well-known for a long time (more than one century) – which involves the existence of a large experience in din field, an important simplification of description of the more complex machine phenomena by related the machine at a electric circuit, an intuitive mode to understand the effect of all interventions. The drawback are related to the no-existence of the possibility to fined fine details, only some magnitudes are available about magnetic field, no information about the distribution of magnetic field, and so on. All these shortcomings lead to new approaches development.

Filed equations allowed more precious design methods. This possibility arises due to numerical software development based which solves de partial differential equation with the help of finite elements methods.

Nowadays, there is a tendency developed in the order to perform a coupling between methods based on circuit equivalent scheme and that based on filed equations. In this sense are combined multiple advantages as: simplicity, accuracy and finesse.

In literature survey [6], [9], the optimization problem is an important one due the multiple aspects involved as: economic, thermal, geometric one etc. The aspects of global optimization have been studied for more time, and are still an important issue.

Permanent magnet synchronous generator (PMSG) becomes an attraction for wind energy conversion system at all power levels, in special at low power system development for insulated grid. Several important features arise with the help of PMSG development: direct drive (no gearbox using), small geometric dimensions, a good adaptation to wind speed variation and gusts etc.

In the order to solve one of the multiple aspect, in the paper has been developed a simple and practical methods based on circuit equivalent scheme [14] for optimal selection of right slot area at PMSG in parallel with an economical criteria development.

## 2. ANALYTICAL EXPRESSON OF RIGHT SLOT AREA. PRINCIPLES

The design phase of electrical machines - based on circuit equivalent scheme - involves usually a lot of steps, is an iterative processes until the desired solution is founded. It follows that different measurements must be includes in specific limits [6], as: $B_\delta$- air gap magnetic flux density, $J$ -current density, $A$ -linear current density etc. Starting from current density and linear current density it was established that the product of these measurements must be includes in the next limits [14]:

$$A_1 \cdot J_1 \approx 3000(I.P.44) \div 3200(I.P.23)\left[\frac{A^2}{mm^2}\right] \quad (1)$$

With the help of this electrical demands product can be expressed the active part losses thermal flow by relationship [14]:

$$Q_{1T} \approx 3000(I.P.44) \div 8000(I.P.23)\left[\frac{W}{m^2}\right] \quad (2)$$

where $Q_{1T} = \rho_1 \cdot J_1 \cdot A_1\left[\frac{W}{m^2}\right]$; and the resistivity of copper was considered at the value: $\rho_1 = \rho_{Cu_{115^oC}} = 2.46 \cdot 10^{-8}[\Omega m]$.

The losses thermal flow of frontal part of winding can be expressed as a part of active part losses thermal flow by the next relationship [14]:

$$Q_{1c} = \frac{Q_{1T}}{2(1-k_{z1})(1-\gamma_1)} < Q_{1T}\left[\frac{W}{m}\right] \quad (3)$$

where the slot factor is included, in practice, between the next limits: $k_{z1} = \frac{B_{d1}}{B_{z1}} \approx 0.4 \div 0.6$.

The architectural elements of stator right slot are expressed as a function of electrical and magnetically demands by relationships [14]:

$$h_{c1} \cong \frac{A_1}{J_1 k_{U1}(1-k_{z1})}[m] \quad (4)$$

$$\gamma_1 = \frac{h_{c1}}{b_{c1}} \geq 3 \quad (5)$$

Based on previous relationships, the slot area can be expressed by relationship:

$$S_{c1} = h_{c1} \cdot b_{c1} = \frac{h_{c1}^2}{\gamma_1} \quad (6)$$

The architecture factor of slot factor is computed by relationship [8]:

$$\gamma_1 = \frac{Q_{1T} - 2(1-k_{z1})Q_{1c}}{2(1-k_{z1})Q_{1c}} \quad (7)$$

where $Q_{1T}$ the active losses thermal flow must be includes in certain limits (2), and $Q_{1c}$ is expressed by the drop temperature in slot insulation [14] according to relationships:

$$Q_{1c} = \frac{\lambda_{iz1}}{\Delta_{iz1}} \cdot \theta_{iz1} \quad (8)$$

$$\theta_{iz1} \cong \frac{\Delta_{iz1}}{\lambda_{iz1}} \cdot Q_{1c} \leq \theta_{izad}(30^0 \div 40^0) \quad (9)$$

According to relationships (6) and (7) the right slot area becomes:

$$S_{c1} = \frac{2A_1^2 Q_{1c}}{J_1^2 k_{u1}^2 (1-k_{z1})[Q_{1T} - 2(1-k_{z1})Q_{1c}]} \quad (10)$$

This relationship gives the possibility to express de right slot area as a function of multiple variables; the most important are related by thermal flow variables.

As has been shown in various works by developing Poynting vector algorithm [13], [14], both all-important geometric dimensions and other electrical demands can be expressed as a function of a global geometric factor:

$$k_f = 1 + \frac{L_f}{L} \quad (11)$$

The geometric factor can be expressed as a function of the winding primitive turn elements, as is showed in fig.1:

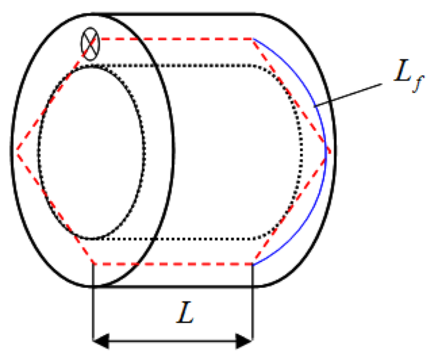


Figure 1 Elements of primitive winding turns

Finally, the right slot area is expressed as a function of geometric factor:

$$S_{c1} = \frac{2A_1^2(k_{f1})Q_{1c}}{J_1^2(k_{f1})k_{u1}^2(1-k_{z1})[Q_{1T} - 2(1-k_{z1})Q_{1c}]} = f(k_{f1}) \quad (12)$$

This representation has an important impact, because with the help of this can be defined two new global criteria in the order to achieve a simultaneous optimization of right slot area and an economic criteria.

The first criteria take into account the right slot area optimization in parallel with consumption of active materials:

$$\begin{cases} S_{c1} = f(k_{f1}) \\ c_m[kg/VA] = f(k_{f1}) = \min \end{cases} \quad (13)$$

The second criterion aims to determinate the right slot area in parallel with specific cost optimization:

$$\begin{cases} S_{c1} = f(k_{f1}) \\ k_m[m.u/VA] = f(k_{f1}) = \min \end{cases} \quad (14)$$

The proposed work contribute to the Poynting vector algorithm through a multi-criteria approach as thermal one (expressed by thermal flow involved in slot area relationship), and economical one (expressed by a common geometric factor). The solution of the optimization problem consists into the founding of the desired geometric factor. This criterion is global one, and contributes to global performances conservation.

The design algorithm based on Poynting vector involves several steps in the order to find the optimal solution. All this steps are illustrated in fig. 2.

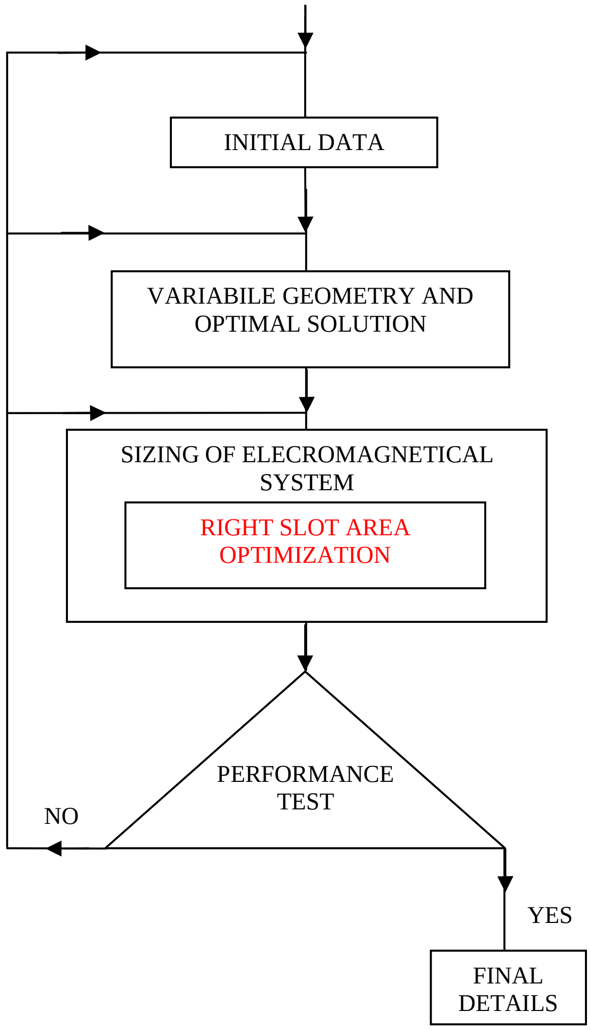


Fig. 2. Improved algorithm for generator design

The electromagnetic sizing block was developed by introduce this criteria developed in this work paper (red colour writing) as criteria system (13), or (14).

## 3. CASE STUDY. NUMERICAL SIMULATIONS

From the design theme are imposed the next requirements measurements as rated data:

- Rated power: $P_n = 50\ [kW]$
- Rated voltage: $U_n = 400\ [V]$
- Rated frequency: $f_n = 50\ [Hz]$
- Rated power factor: $\cos\varphi_n = 0.9$
- Rated efficiency: $\eta_n = 0.92$
- Pairs poles number: $p = 12$
- Torque overload factor: $M_m = 2.5$

A PMSM type with magnets mounted on rotor surface has been considerate. Through a cross section of the generator it was represented all important geometric dimensions of machine (fig. 2).

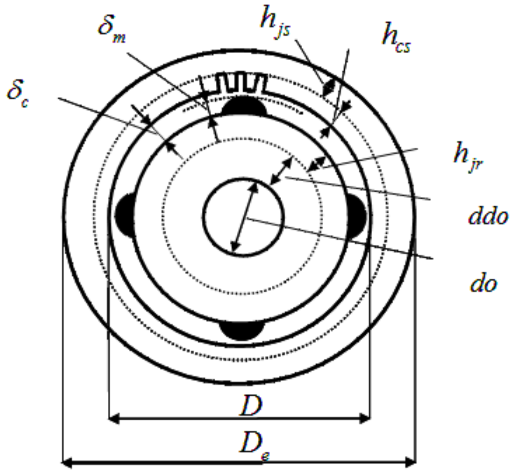


Figure 3 Cross section of generator

In the order to impose the drop temperature (according to relationship on the slot insulation was considerate the next measurements:

- the thermal conductivity copper was considerate at the value $\lambda_{iz1} = 0.16\left[\frac{W}{m^oK}\right]$
- thickness of insulation is $\Delta_{iz1} = 0.5[mm]$ (specific for low voltage)
- imposed drop temperature on the slot insulation at value $\theta_{iz1} = 20^oC$.

This work is based on Poynting vector algorithm developed in [14]. First of all was represented the estimated performance characteristics based on rated data. The characteristics are divided in two types [14]: the first one are based on scheme circuit (denoted by "T") and the second one are based on analytical relations which allow losses separate (denoted by "P" Potier or "A" from analitic). Electromechanical characteristics (efficiency, power factor and stator current) were represented in Figure 4:

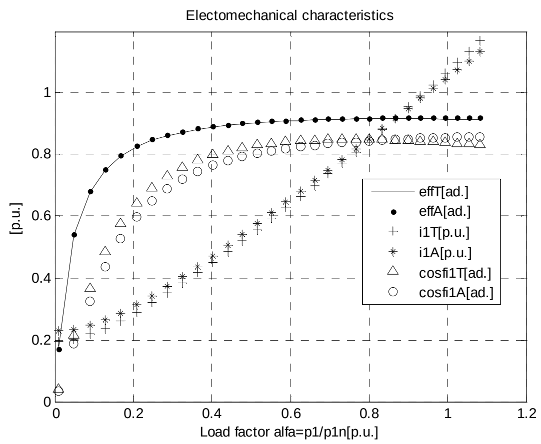


Figure 4 Estimated electromechanical characteristics

From angular characteristics (fig. 5) will be determinate the rated inner angle. The involved steps [14] are the next:

- the stator current must be unitary ( $i_1 = 1[pu]$ )
- the electric voltage on the magnetising leg must be lower than unitary value ( $u_m < 1$ )
- an intersection of both characteristics (stator current and electric voltage) must be taken into consideration.

Applied all this steps, the desired angle obtained has the value $\theta \approx 30^o$.

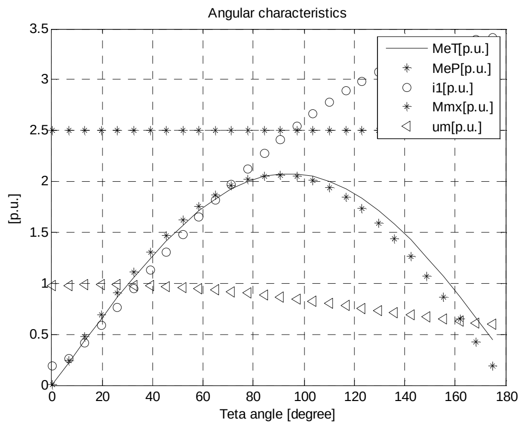


Figure 5 Estimated angular characteristics

Geometrical dimensions of stator have been represented in fig. 6, as a function of geometric factor.

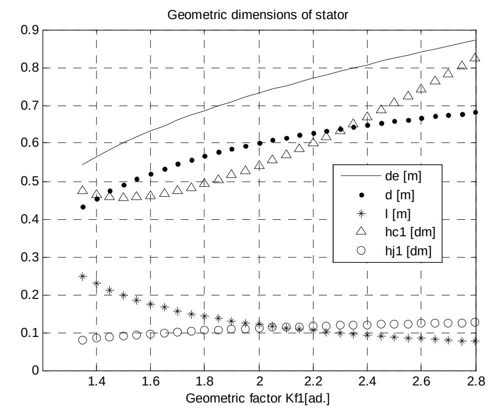


Figure 6 Geometric dimensions of stator

The geometric dimensions of rotor, as a function of geometric factor, were represented in Figure7.

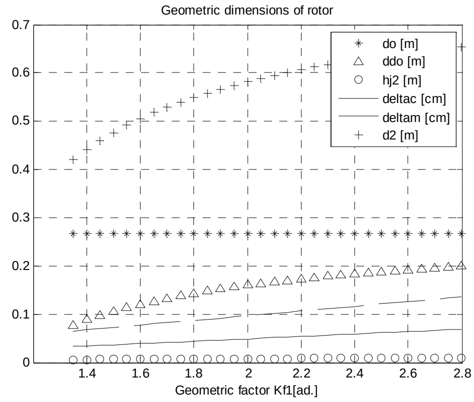


Figure 7. Geometric dimensions of rotor

In Figure 8 were represented the specific statoric consumption of active material (Cu, Fe, total one), and specific statoric cost.

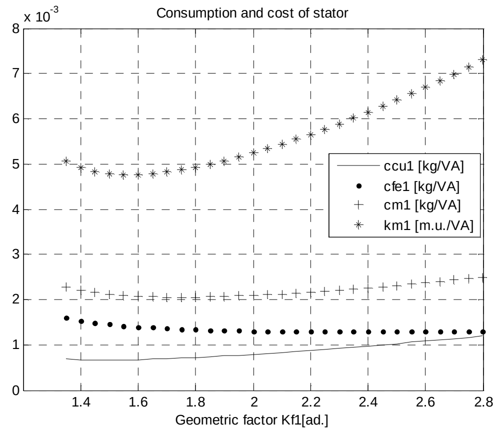


Figure 8 Consumption and cost of stator

The characteristics of total specific consumption of active material (Fe, Cu and PM), and total specific cost were represented in Figure 9.

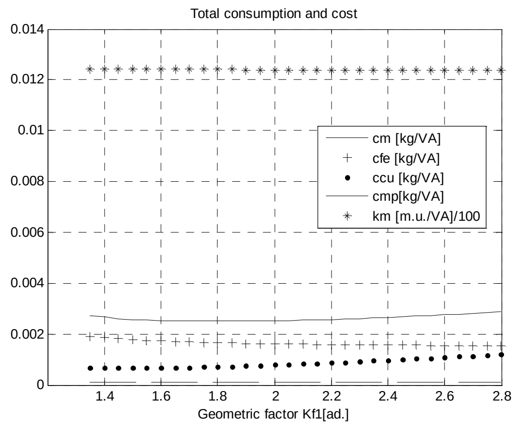


Figure 9 Total consumption and cost

Right slot area is represented according relationship (12) as a function of geometric factor in fig. 10. In the interval [1.4÷1.6] of geometric factor has been obtained the minimal value.

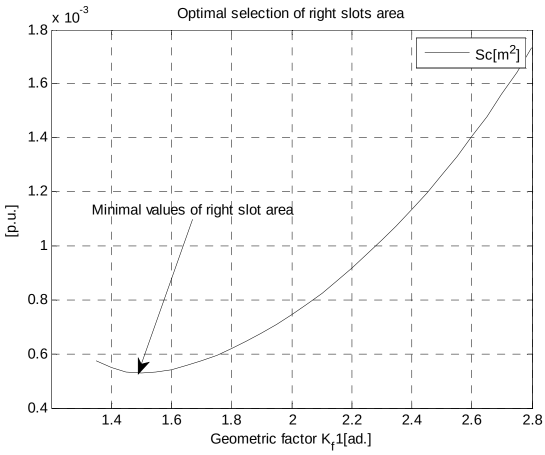


Figure 10 The right slot area variation by geometric factor

In Figure 11 was represented the zoom details of active materials consumption. As can be seen from this figure, the consumption curve has a minimal point at value of geometric factor by 1.8.

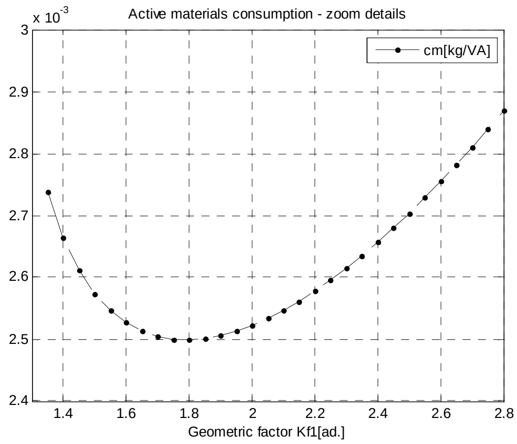


Fig. 11. The zoom details of total active materials consumption

The detailed zoom characteristic of specific cost was represented in fig. 12. This characteristic is a decreasing one, and from this point of view it is required to selecting the longest geometric factor.

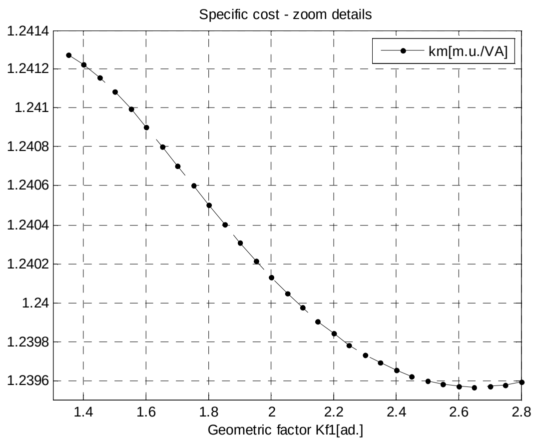


Fig. 12. The zoom details of total economic cost

The developed optimization criteria are a graphic-analytical method one. In table no. 1 were represented the results obtained from optimization process.

Table no. 1. Optimization characteristics

| $k_{f1}$ | 1.4 | 1.45 | 1.5 | *1.55* | *1.6* |
|---|---|---|---|---|---|
| $\gamma_1$ | 4 | 4 | 4 | 4 | 4 |
| $S_c[m^2]$ | 0.0005 | 0.0005 | 0.0005 | 0.0005 | 0.0005 |
| $c_m[kg/VA]$ | 0.0027 | 0.0026 | 0.0026 | **0.0025** | 0.0025 |
| $k_m[m.u/VA]$ | 1.2412 | 1.2412 | 1.2411 | 1.2410 | **1.2409** |

It is searching only the values of geometric factor which lead to a minimal value of slot area (fig. 10). The results obtained from optimization are very close, and has been bolded the economical requirements.

In table no. 2 are presented the parameters of circuit equivalent scheme, and other performances were also given. The results are closed. Only the power factor resulting is lower due to the large number of pole pairs involved of generator, which means that the value impose by design theme is bigger.

Table no. 2. Optimization parameters

| Parameter | Estimated | Consumption optimization | Cost optimization |
|---|---|---|---|
| $r_1[p.u.]$ | 0.0413 | 0.0400 | 0.0377 |
| $x_m[p.u.]$ | 0.4328 | 0.4177 | 0.4152 |
| $\cos\varphi$ | 0.8358 | 0.8081 | 0.8056 |
| $\cos\varphi_c$ | 0.8579 | 0.8574 | 0.8575 |
| $\eta_T$ | 0.9145 | 0.9135 | 0.9160 |
| $\eta_P$ | 0.9197 | 0.9198 | 0.9198 |
| $i_{1T}[p.u.]$ | 1.1284 | 1.1526 | 1.1573 |
| $i_{1P}[p.u.]$ | 1.0994 | 1.0863 | 1.0873 |
| $M_{mT}[p.u.]$ | 2.0730 | 2.0520 | 2.0431 |
| $M_{mP}[p.u.]$ | 2.0646 | 2.0646 | 2.0646 |

For all both case optimization was represented the performances characteristics.

In fig. 13 and fig. 14 were represented the characteristics obtained from optimal design of active materials consumption.

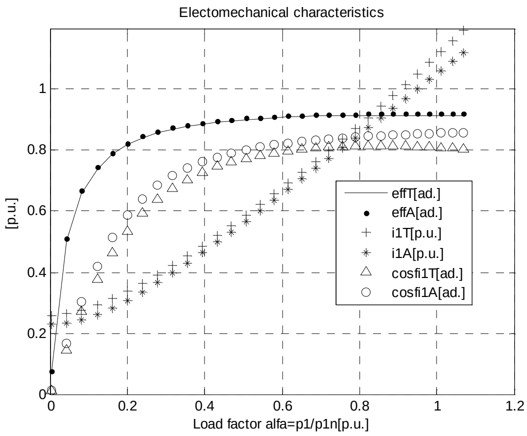


Figure 13 Real electromechanical characteristics for consumption optimization

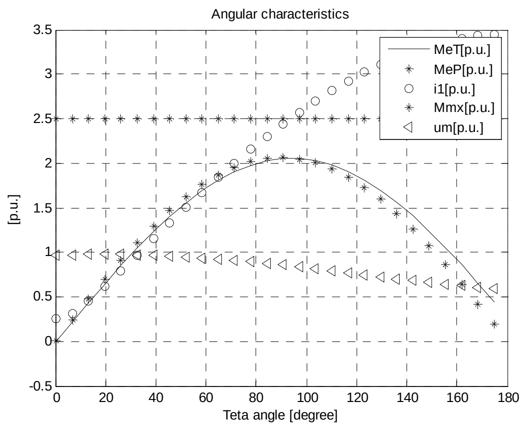


Figure 14 Real angular characteristics for consumption optimization

Performance characteristics for optimization case of specific costs were represented in figure 15 and figure 16.

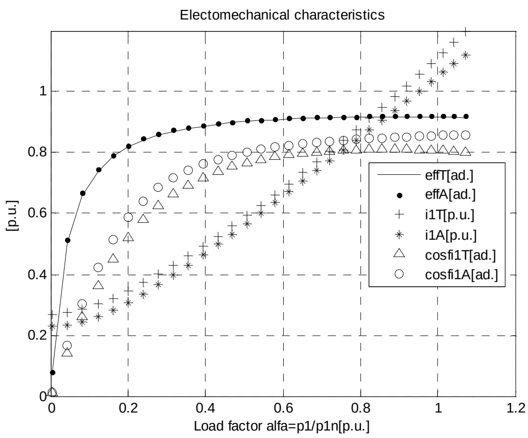


Fig. 15. Real electromechanical characteristics for cost optimization

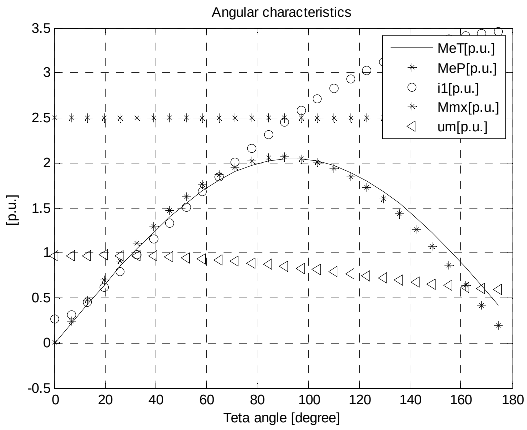


Figure 16 Real angular characteristics for cost optimization

## 4. CONCLUSIONS

The optimization problem of right slot area selection has been performed by a multi-criteria approach development. For this aim, the analytical relationship developed leads to defining global criteria as active materials specific consumption or economic specific cost.

The right slot was represented as a function of multiple measurements: electrical demands by density and linear density of current, magnetic one by slotted factor, thermal one by winding active part losses thermal flow and winding frontal part losses thermal flow, and technological one by using factor.

Numerical simulations made for permanent magnet synchronous generator case study prove de effectiveness of the work developed.

Future work involve a complete analyze of the machine take into account the optimization problem of stator turns number thermal influence of frontal part of winding to output performance of machine.

## 6. ACKNOWLEDGMENTS

The work of Madalin COSTIN was supported by Project SOP HRD - EFICIENT 61445.

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# DISTRIBUTED COMMUNICATION SYSTEMS MONITORING AND PROACTIVE SECURITY

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**ABSTRACT**

As more and more services are moving into the cloud, the complex infrastructures that administrators have to handle each day go far beyond the number of physical servers that are used. This large scale architecture has the same security issues as traditional clusters, but risks reach for a whole new level when remote deployment and live migration come into place. This paper investigates the automated solutions that can help maintain a high level of security and quickly respond to service issues in order to minimize downtimes.

**Keywords:** *monitoring, complex networks, distributed services, security scanning, vulnerability assessment, intrusion detection and prevention, cloud solutions*

## 1. INTRODUCTION

In order to offer the clients a high level of availability and to reduce costs, solution providers are taking into account the new technologies that recent advances in OS virtualization and server consolidation have made available. This involves an increased number of machines that run on the same hardware, each one with its own set of services, raising the amount of administration work required to keep the whole architecture running smoothly. This new approach, sometimes called *datacenter in a box*, should be handled by the same number of people that were used to manage a few physical servers and thus, new tools have to be used in order to simplify and help the system administrator have a general view of the system without manually checking everything periodically.

Same old rules apply for securing the individual machines, but automation is crucial for managing an entire fleet of distributed systems. New concepts, such as *cyclical service checking*, *remote vulnerability scanning* and updating, *network-wide intrusion detection* come into attention.

## 2. SERVICE MONITORING

In order to know at each moment which of the managed services running on his servers are operational, one needs to deploy a special surveillance tool that is able to perform remote checks at specified amounts of time and report the issues immediately via a web interface, send alerts via instant messaging, email or even SMS. We call this activity *Real-time Analysis of Large Unit Computer Architectures*.

Fortunately, there are many such applications, like *SysMon*, *OpenNMS*, proprietary *HP OpenView* and the independent commercial alternative *Big Brother*. But the most popular is the one called *Nagios*, actually offered in two versions (*Core*, which is still open source, and *XI*, which comes for a price), as indicated in [2].

We will concentrate on the free version, and explain how this software can make the tedious task of comprehensive monitoring a lot simpler. It's worth mentioning that *Nagios* is not just a host and service watcher, its open architecture allows it to respond to problems as soon as they appear, and execute predefined tasks remotely, without human intervention. When 24/7 support is not possible, such an ability could solve situations without downtime even when the operator is not present. System monitoring is described in [4].

*Nagios* runs as a daemon on the designated machine and launches scheduled scripts to communicate with the predefined targets. These scripts are usually written in Perl and can contain any actions the administrative person considers necessary, there is no limit in what can be achieved. The application itself should not be modified in order to extend monitoring plugins, as they are completely independent. The only condition for *Nagios* to work is that its hosting machine should have unrestricted visibility to all monitoring targets (firewalls and VPNs should be configured accordingly).

Along with the return code (*0 – OK*, *1 – WARNING*, *2 – CRITICAL*, *3 – UNKNOWN*), plugins can offer actual performance data, like response time, number of received bytes or the server response string.

All the data from the plugins is passed to the web interface for display to the user, and logged down for further reference. On demand, *Nagios* can build detailed performance statistics and uptime trend reports to help spotting the occurring issues.

The logic of plugin execution is presented below:

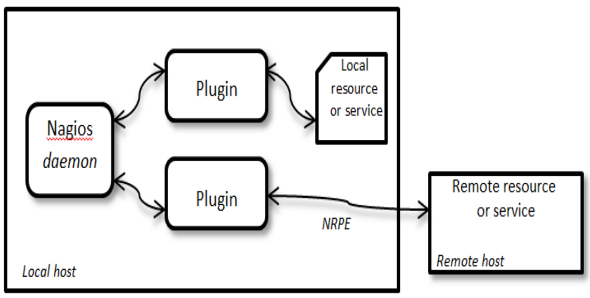


Figure 1 Plugin execution diagram

If the security policy requires, *Nagios* has the flexibility to adapt by executing scripts remotely after logging in via SSH and calling the *Nagios Remote Plugin Executor* (*NRPE*), or act passively and wait for the plugins to send data to the *Nagios Service Check Acceptor* (*NSCA*). This mechanism is detailed in [1].

Before the beginning of the monitoring activity, the network diagram must be known to *Nagios*, with all details about IP addresses, running services and their respective ports. Besides these, *Nagios* is able to monitor local resources of a server (free disk space, processor load or available memory) and act when predefined thresholds are reached, as mentioned in [3].

Plugins are not written by the author of *Nagios*; they arise from community effort and are available separately at *http://exchange.Nagios.org/*.

*Nagios* relays on Apache to display its web interface, and is driven by a great number of configuration files, where hosts and services are defined, along with people to announce in case of problems, checking intervals and response commands. *Nagios* supports *MySQL* logging and SSL encryption to protect the control panel from intruders. At least a secure alias should be used in Apache in order to prevent unauthorized access to the interface.

If e-mail alerting is desired, one should configure an MTA on the hosting server. As *Nagios* runs on Linux, we used *Exim4* for this example (direct SMTP, listen on *localhost* only).

The configuration files relationships are presented below (source: the product documentation, [2]):

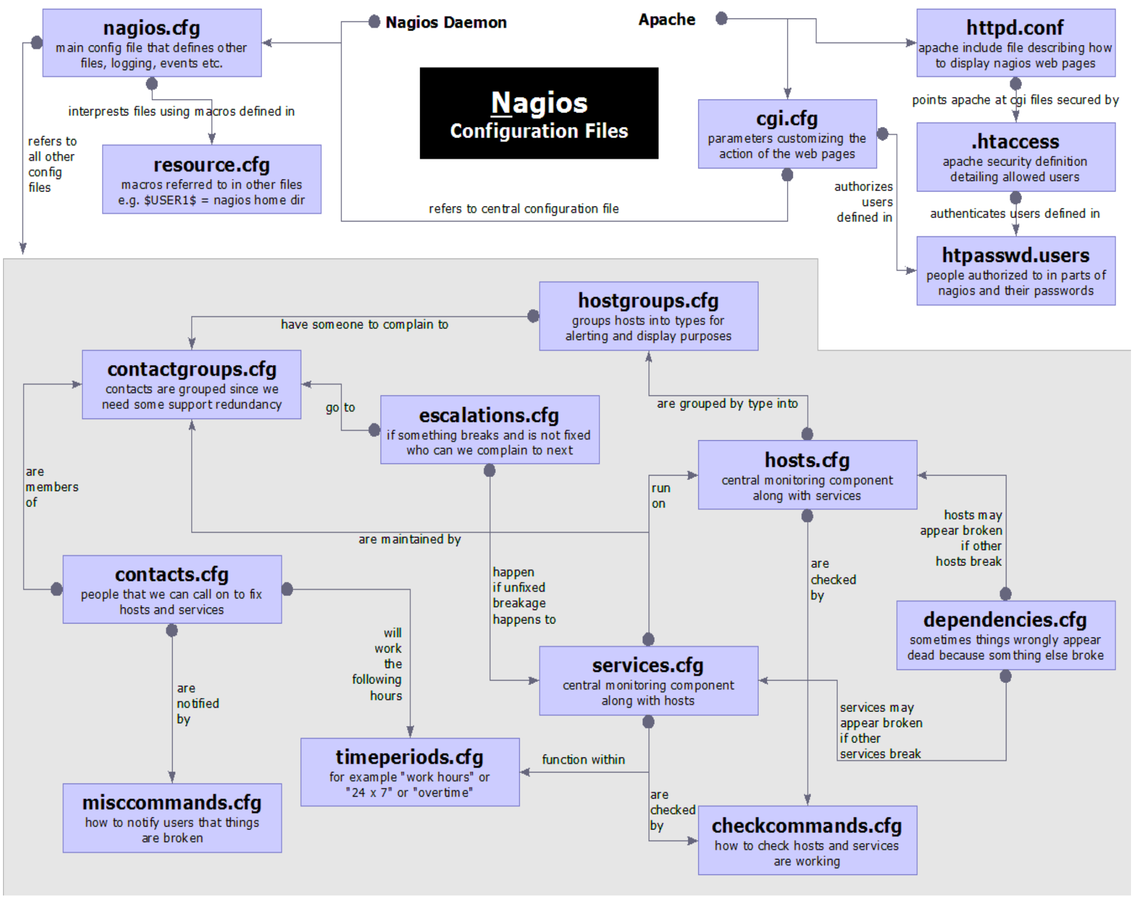


Figure 2 Nagios configuration files

Writing each one by hand it's a tedious and time-consuming task, but it's the only way to know exactly what is defined and where to add changes. For complex networks, there are a few automated generation utilities, which ask questions to the user and write settings. Such applications are *Nagmin*, *Monarch*, *NagiosWeb*, *NagiosQL* and *Fruity*. For this example, we chose not to use them, but to define entities manually, to have better control on everything.

The main configuration file (*Nagios.cfg*) is the one loaded first, as it calls all others. It contains global working parameters (paths and access rights, logging, timeouts and retries, notifications, flap detection, performance data processing, naming conventions etc.).

Network status is spread across multiple files (*services.cfg*, *hosts.cfg*, *hostgroups.cfg*, *dependencies.cfg* and *hostextinfo.cfg)*, each one with an exact destination. For ease of access, services and host can be grouped. An object definition begins with the keyword *define* and is contained within braces; it has basically an attribute-value dictionary structure.

For a host, the only available check is aliveness, based on *ICMP Echo Request* (ping). For a service, any of the protocol methods could be used, including a short dialog (e.g. HTTP or FTP transaction). Before a service can be assigned to a host, that host should previously be defined. To bypass temporary failures, a number of retries at regular intervals is used, before an alarm is triggered. Also, separate groups of admins can be defined for each event category.

An important aspect in defining a network structure is *dependencies*. Regarding the tree hierarchy, when a node fails, everything after that node will instantly be invisible to the observer above the failing node. Thus, services and hosts behind a crashed router are not down, but *unavailable*. This subtle difference could spare a lot of email alerts and investigation time.

A general view of an international VoIP test-bed monitored by *Nagios* is given below:

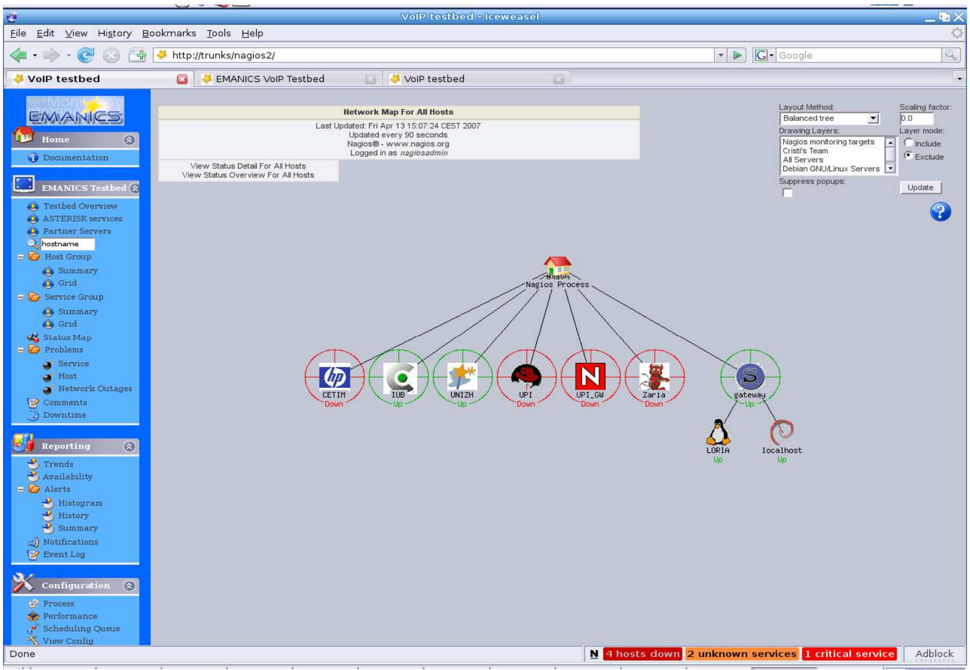


Figure 3 Nagios interface

The communication and alerting subsystem works regarding the following scheme:

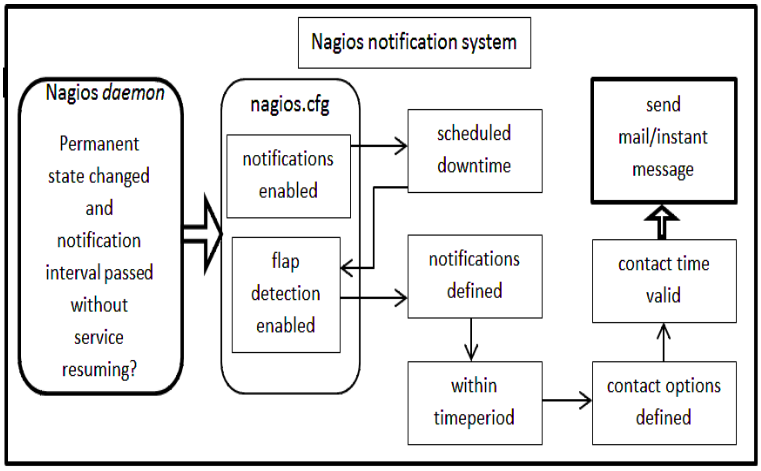


Figure 4 Alerts and escalations

All data required for this to work is contained within the following files: *contacts.cfg*, *contactgroups.cfg*, *escalations.cfg* and *timeperiods.cfg*.

They define *who*, *when* and *how* (email, jabber, sms) should be alerted and *when* to send messages to a superior level if problem has not been solved in a timely manner (escalate). For ease of management, support staff can also be grouped.

Everything that *Nagios* does is defined in the commands files (*commands.cfg*, *checkcommands.cfg* and *misccomands.cfg)*.

Sending an e-mail, drawing performance graphs – all are general commands. Service verification tasks are accomplished by *check* commands, each one with a special set of parameters. The result of a service failure is the following e-mail:


Figure 5 E-mail alert

Macros used across all files are defined in a dedicated file, called *resource.cfg*.

The most complex file remains though *cgi.cfg*, as it contains all information required to run the web interface. To protect the server from external attacks, plugin authentication is mandatory. Else, Apache accepts any requests.

Access privileges are also defined here.

Before starting the system, a pre-flight check and performance suggestions request are recommended, to detect misconfigurations. If everything is correctly done, the tactical view should be accessible via browser:

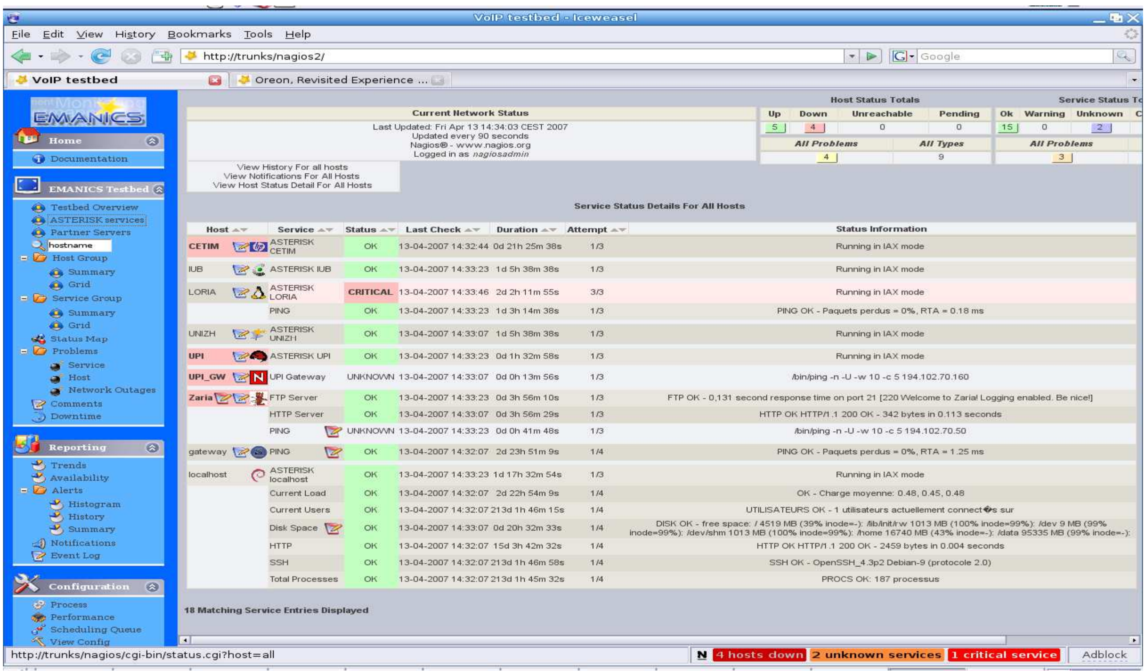

Figure 6 Main control-panel

Here the problems are displayed in red, indicating their origin, start time and details.

If one requires a more elegant interface, a web-based configuration system and a more reliable storage for log data (using *MySQL*), a separate layer can be installed on top of *Nagios*. It is called *Centreon* (former *Oreon*) and it installs everything automatically, running on *PHP* and some *Pear* packages. The result is a more maintainable system, with support for performance graphs and simplified backup.

## 3. VULNERABILITY SCANNING

As discussed earlier, a large number of different-OS servers are stacking together in an easy-to-manage virtual infrastructure, giving the admin a lot of security issues to deal with every day, as each one has its own set of vulnerabilities. A way to automatically scan and assess those would be a great improvement for the reliability of the whole platform.

Fortunately, such applications do exist, but usually they are very expensive (GFI *LanGuard*, eEye *Retina* or *Saint*, with Core *Impact* as the leader with ~$30k for a license). Along with above solutions, a free-for-non-commercial alternative that's worth considering is Tenable *Nessus* (and its free fork *OpenVAS*).

*Nessus* is a two-component system vulnerability scanner, with a server that runs on *nix and a GUI client that can be used on almost all platforms [9]. The communication between them is secured by logging in to the server, in order to avoid unauthorized scans. After installing the server, a set of plugins must be installed and this requires a free registration for an activation code that is used to authorize the download, as shown in [8].

There aren't many settings to be done on the server, after the plugins have been updated, we can connect the client and begin the scan:

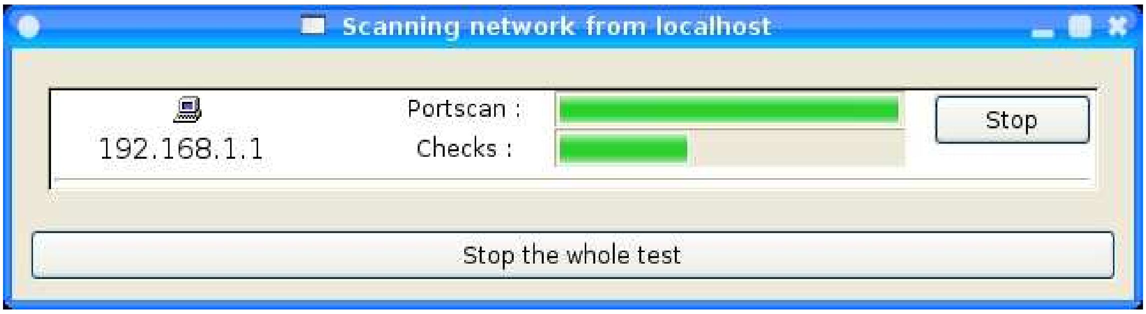


Figure 7 Nessus scanning on Linux

After the process is complete, a report is generated and vulnerabilities are detailed, along with information on how to fix them and available patches. Such a report can be saved in PDF or displayed on screen directly from the application.

An example report for a Linux server is given below (*Samba* issue):

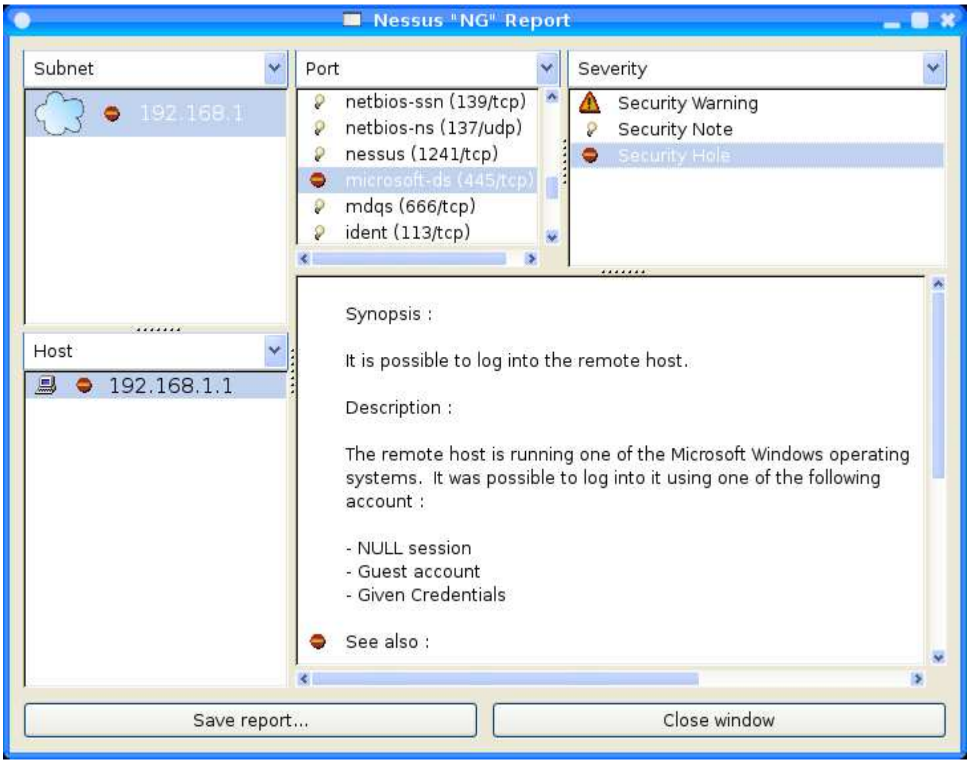


Figure 8 Scan report

Each discovered problem should be thoroughly analyzed and fixed before a remote attacker could exploit it and gain control over the machine. Plugins and operating systems are updated daily; this maintenance process limits the exposed surface.

## 4. INTRUSION DETECTION

Even if vulnerability scanning is done periodically and updates are applied as soon as they're available, the potential of a successful attack on the services that the platform is offering is still high. To lower the risks, a dedicated type of network traffic analysis should be considered. Manual inspection (with *Wireshark*) is far too slow to be taken into account as a proactive measure. Although useful for post-incident response, software that should run continuously and scan traffic for known vulnerabilities is a much more elegant option.

Many free solutions are available, such as *Samhain*, *Aide* (*Tripwire* replacement), *OSSec* or *ACARM-ng*. But, the most popular remains Sourcefire *Snort*, the standard in IDS industry.

*Snort* engine is based on *tcpdump* traces and Perl regular expressions for log analysis.

It works somehow like an antivirus, with a database of known patterns used as signatures in comparison with live traffic. When a match is detected, events are logged for further analysis. Rules need to be downloaded separately. More details can be found in [11] and [12].

Though, reading *Snort* logs is not a simple task, and analyzing large quantities of data can be very time-consuming. Thus, a web interface that extracts and presents the results in a more easy to understand manner has been developed. It is called *Basic Analysis and Security Engine* (*BASE*), and it comes freely from *SecureIdeas*. It relays on *MySQL* (via *AdoDb*) for data storage and on *Apache* with SSL (new virtual host with defined *SSLCertificateFile /etc/apache2/Snortcert.pem*) for display.

An SSL certificate can be obtained from an official certification authority (like *VeriSign* or *Thawte*) – for a fee, or from an open source implementation, like *OpenSSL*. We have generated our own for this setup, with the following command line:

*openssl req $@ -new -x509 -days 365 -nodes*
*-out /etc/apache2/Snortcert.pem*
*–keyout /etc/apache2/Snortcert.pem*

After it has been installed and configured (including *snort.conf*), with necessary user accounts, database tables and web server aliases created, the setup process is web-based.

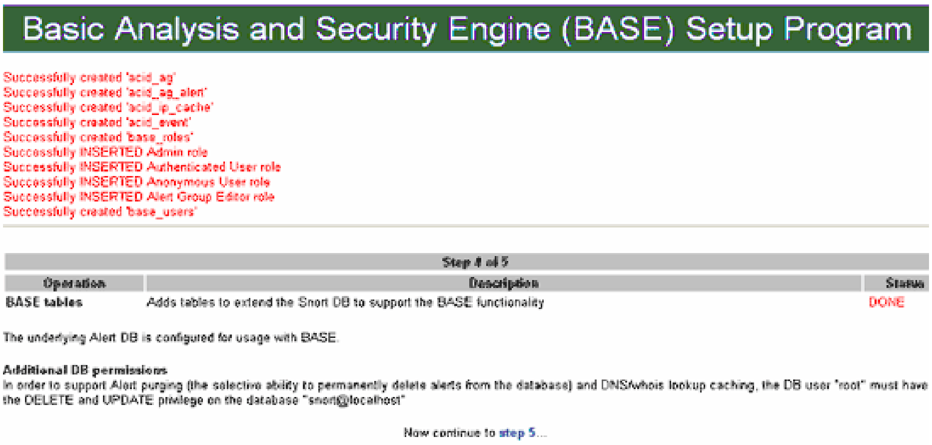


Figure 9 Installing BASE

If everything worked correctly, after a certain amount of time when *Snort* was operational, collected data can be displayed.

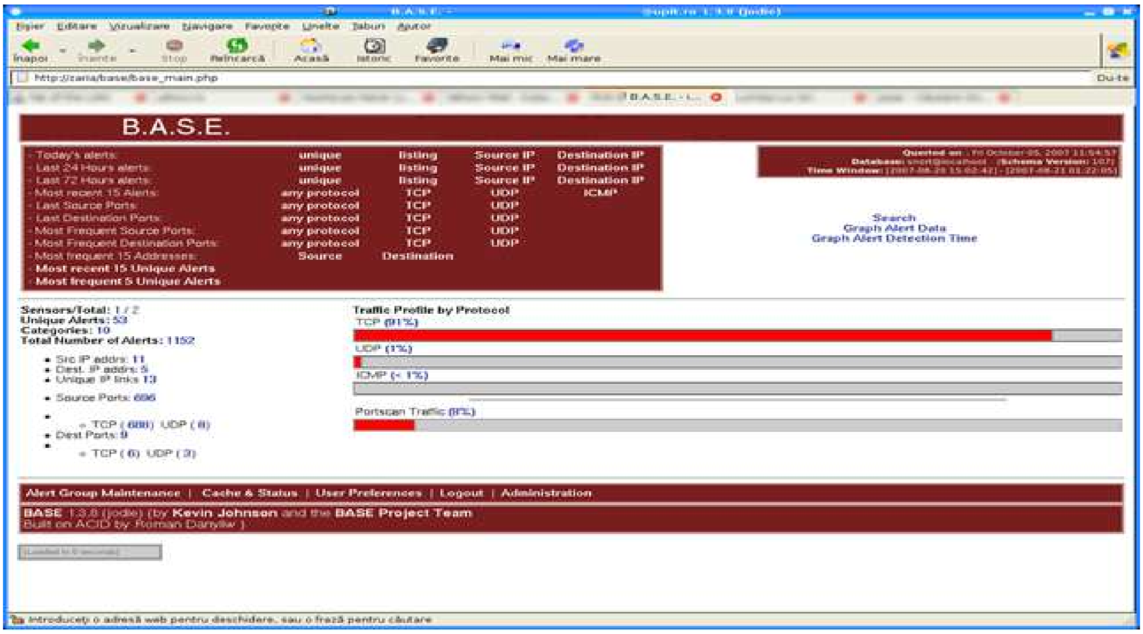


Figure 10 BASE interface for *Snort*

In the above example, only non-dangerous port-scan traffic can be observed (8%, last red row).

By observing on the interface, problems can be easily sorted by source and destination IP and port, or by category. More use cases are presented in [13].

There are many types of attacks that *Snort* can detect, ranging from backdoors and *DDoS* attacks to spyware, viruses and even VoIP vulnerabilities. Also, it has a set of rules for web applications, SQL attacks (*Oracle*, *MySQL*) and botnet-like behavior.

A great advantage is that *Snort* and *Nessus* platforms are easily extensible by the user, as they allow the development of plugins that can be added to the repository, covering this way specific situations for each environment that and administrator is faced with.

For *Nessus*, there is a special (limited functionality) scripting language that allows writing tests for less-common use-cases. It is called *NASL* and, for security reasons, it cannot send packets to other hosts than the target host, and it cannot run local commands.

For *Snort*, the rules are very similar in syntax with *tcpdump* filters that are used by other tools, like Wireshark traffic analyzer or *iptraf*.

After the pattern, the following options allow definition of specific payloads, offering the ability to detect *shellcodes* or virus messages. Any part of the IP packet can be analyzed, and rules can be chained together in order to filter complex patterns in a data stream.

Each rule has an action that could be a message, a *syslog* entry or a database insert. If needed, the packet can be discarded.

## 5. CONCLUSIONS

A set of tools that help the network administrator deal with a large number of distributed systems was presented. Functionality and installation details were given, in order to better understand their abilities, limitations and role in the proactive security infrastructure that one needs to set up in order to secure a large distributed architecture.

Examples were given, displaying the most common usage scenarios, experimental results obtained and ways to facilitate everyday tasks.

The desired security level is not something that could be achieved by buying a single dedicated product and installing it. Security, from this point of view, is a complex, on-going process. New threats appear daily and the documentation work to keep up is mandatory. Awareness is the most important aspect of network security, in this continuous cat-and-mouse game that the attackers and the industry play.

This three-direction approach compares favorably to the traditional solutions that involve a single security product, be it a firewall, an antivirus or hand-made script that sends alert messages in case of resource unavailability.

Automation is an aspect of paramount importance when working with large populations of systems spread across long distances. Adding the periodical vulnerability scanning to the solution offers the administrator a lower risk factor, as the uptime of the services depends intimately on the security of the host operating system. Thus, when a regular basis update policy is combined with scheduled security scans, the general level of platform trustworthiness is increasing greatly.

In order to further enhance the reliability of the network, a third component, permanent intrusion detection, is considered. More than a regular firewall with strict rules, this approach offers a more flexible way of supervision of the network traffic. Incidents can be detected rapidly, and correction measures can be applied even before an attack could become dangerous.

With these layers of protection combined, any other standalone solution will be surpassed. Of course the need for an antivirus/anti-malware and anti-spam filter is still present, but in comparison, our approach covers more aspects in an independent, third-party (dedicated machine) implementation. This dedicated security server can be operated in the DMZ and managed from the web, in order to minimize the risk of being itself compromised, as it offers no user-oriented services.

It is worth noting that all presented tools are available at *no cost* and run on the free Linux operating system, and this is an important aspect in choosing a security solution by a company, being known that the costs for commercial tools in this area are usually very high. The savings from this sector should allow the company to focus on further investments and achieve a solid growth without the hassle of expensive security experts.

Also, extensive documentation can be easily found on the web, with sample configuration files, detailed usage scenarios and installation instructions. Thus, being informed on how to leverage the advantage of each presented tool becomes an easy task, in comparison with close-source commercial products that offer only user manuals. Many books (as indicated by the References) cover all necessary aspects of implementing and managing a high-performance, high-availability open-source security platform.

As a *future work*, a performance comparison between tools in the same category (network monitoring, vulnerability scanning, intrusions detection and prevention) should be conducted. Also, a more complex scenario, with many server OS versions, and many services (web, ftp, VoIP) could be built and tested.

## 6. ACKNOWLEDGMENTS

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# APPLICATION OF BAYESIAN ALGORITHMS IN LOCALIZATION AND TRACKING OF MOVING DEVICES IN WSNs

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**ABSTRACT**

Localization of moving devices (MD) plays an essential role in wireless sensor networks (WSN). Most of WSN applications need the knowledge of the node's location. Localization algorithms with high accuracy and low complexity are very important for WSN. This paper focuses on mobile wireless sensor networks localization techniques based on Bayesian method and target tracking based on Extended Kalman filter and particle filter algorithm (PF). The properties of Extended Kalman Filter (EKF) and particle filter (PF) are described, simulated on MATLAB and analyzed. Then their performance are compared from the aspects of localization accuracy and sample number.

**Keywords:** *Mobile Wireless Sensor Networks, localization, Extended Kalman Filter, particle filter, tracking.*

## 1. INTRODUCTION

Localization represents a special issue in wireless sensor networks (WSN). Most of WSN applications need the knowledge of the node's location. Localization algorithms with high accuracy and low complexity are very important for WSN.

Nonlinear filtering problems exists in many fields including statistical, signal processing, economics, statistics, biostatistics and engineering such as communications, team in field management and target tracking.

In wireless systems, the mobile devices (MD) localization is established by estimating the radio propagation parameters related to the MD location. These parameters are obtained by exchanging radio signals with *N* reference nodes (RN) which are fixed sensor nodes placed in known positions. Usual propagation parameters are: time of arrival (TOA), time difference of arrival (TDOA), angle of arrival (AOA) and received signal strength (RSS). The relationship between these parameters and the MD position can be found by analytical models or through real environment measurements. These measurements are processed to evaluate the RD-RN distances: this step is called ranging.

A localization approach may be computed by MD; this approach is known as terminal based localization. For this model no wireless network modification is required but more complex hardware at the terminal node is needed. Network based localization is performed when localization algorithm is carried out by network itself. This is obtained by using specialized synchronous network reference nodes. This localization scheme is more complex than the previous one and is employed in cellular radio systems.

Positioning accuracy is crucial for the localization algorithms. False localization often appears in ranging methods due to errors in the MD-RN ranging step. These unwanted effects are due to parameter estimations errors over simplified assumptions about the propagation environment, multipath effects and non-line-of-sight (NLOS) conditions. MD may not be visible from RN. Indoor radio localization scenarios are characterized by dense multipath and/or NLOS conditions.

The most common localization techniques consist in exploiting redundant measurements (large N), merging different measurement types with data fusion techniques, combining analytical models with map measurements, or using Bayesian methods to estimate the entire MD trajectory better than estimating one position at a time.

In this work, from an algorithmic perspective is analyzed a set of sequential estimation techniques, so called Bayesian filters. In particular, Gaussian filters and particle filters were studied and compared in nonlinear setup.

## 2. BAYESIAN FILTERING

The general formulation of the tracking problem is represented by two equations, one describing the dynamics of the state variable (variable to be tracked) and the other one relates the state variable with some measurement.

The problem of interest consists in the estimation of an unobserved discrete-time random signal in a dynamic system.

A dynamic system can be described by two equations - the state transition or evolution equation and the measurement equation:

$x_t = f_{t-1}(x_t, u_t)$, $t = 1,2,..$ state transition equation (1)

$y_t = g_t(x_t, n_t)$, $t = 1,2,..$ observation equation/measurement equation (2)

Where: $x_t$ describes the evolution of the state with time, $y_t$ (measurement model) defines the relationships between noisy observation and the state.

$f(.)$ and $g(.)$ are nonlinear functions that describes the behavior of the state, $u_t$ and $n_t$ are the possibly non-Gaussian system noise and process respectively. Because the sates evolves according to Markov process, the future state is only dependent upon the current state.

Both the measurement noise and the process noise are assumed to be white, independent, and to have probability density functions.

A particular case, defines the state variable to be composed of the current MD position and velocity and the previous position. The inclusion of the previous MD position into the state variable has been done in order to incorporate the information coming from the joint estimation process.

The state equation (1) characterizes the state transition probability $p(x_t / x_{t-1})$ whereas the measurement equations (2) describes the probability $p(y_t / x_t)$ which is further related to the measurement noise model.

The initial a priori probability density function (PDF) for the initial state $p(x_0)$, the ability to sample the transition PDF $p(x_t / x_{t-1})$ and the ability to evaluate the likelihood function $p(y_t / x_t)$ are considered known.

Bayesian filtering [2],[4] involves the recursive estimation of states $x_t \in \Re^{n_x}$ given measurements $y_t \in \Re^{n_y}$ at time $t$ based on all available measurements $y_{1:t} = \{y_1,\ldots,y_t\}$. For that aim are interested the filtering distribution $p(x_t / y_{1:t})$ and its recursive computation given $p(x_{t-1} y_{1:t-1})$ as well as $p(y_t / x_t)$ and $p(x_t / x_{t-1})$ referred to as the likelihood and the prior distribution respectively.

*2.1. Extended Kalman Filter*

The Kalman Filter is an efficient recursive filter, which estimates the state of a dynamic system out of a series of incomplete and noisy measurements by minimizing the mean of the squared error. If the process to be estimated or the measurement relationship to the process is specified by a nonlinear equation, the Extended Kalman Filter (EKF) is applied. The Extended Kalman Filter (EKF) is a Bayesian technique known for its low-complexity, performance and stability as a tracking algorithm. The filtering is based on transforming a non-linear system model in linear around the previous estimate using partial derivates of the process and measurement function. Linearization approximates the non linear function *f* by a linear function that is tangent to *f* at a mean to the Gaussian. Projecting the Gaussian through this linear approximation results in a Gaussian density, $y = f(x)$.

To model the MD position we need to know its x and y coordinates and its orientation. These three parameters can be combined into a vector called a state variable vector. If trigonometry is used to calculate the MD's position large errors can occur. The Kalman Filter is a smarter way to integrate measurement data into an estimate by recognising that measurement are noisy and that sometimes should be ignored or have only a small effect on the state estimate.

The extended Kalman Filter (EKF) is suitable to track the x - and y – position of a mobile system using measured distances to the artificial anchors. The suitable algorithm describes the complete operation of the EKF[6].

**Algorithm:** Extended Kalman Filter

1: Project the state: $\hat{X}_t = AX_{t-1} + BU_t$

2: Project the error covariance:

$$\hat{P}_t = AP_{t-1}A^T + Q$$

3: Compute the Kalman gain:

$$K_t = \hat{P}_t H^T (H\hat{P}_t H^T + R)^{-1}$$

4: Update estimation with measurements:

$$X_t = \hat{X}_t + K_t(z_t - H\hat{X}_t)$$

5: Update the error covariance:

$$P_t = (I - K_t H)\hat{P}_t$$

6: Go to Step 1 and repeat.

Where X is the initial state matrix, A is the state transition matrix, Q is the process noise covariance matrix, H is measurement matrix, *z* is the observation vector, J is the Jacobian.

The position estimation from Kalman tracker yields the conditioned mean defined as follows:

$$\hat{x}_{t/t-1} = E\{x_t / z_{t-1}\} \tag{3}$$

*2.2 Standard Particle Filter*

Particle filtering (PF) has successfully applied in many nonlinear and /or non Gaussian problems [1],[2]. It is a sequential Monte Carlo approach using particles and associates weights to approximate the posterior distribution of interest.

In PF two essential steps recursively proceed: *prediction* and *update* using latest measurements to evaluate particles weights [3], [5], [7].

Particle filters represent beliefs by sets of samples of particles:

$$Bel(x_t) \approx S_t = \left\{\left\langle x_t^{(i)}, w_t^{(i)} \right\rangle\right\}, \qquad / i = 1,\ldots\ldots N \tag{4}$$

Each $x_t^{(i)}$ is a state and the $w_t^{(i)}$ are nonnegative weights called *importance factors* which sum up to one. Particle filters realize Bayes filter updates often called Sequential Importance Sampling with Resampling (SIR).

We consider the standard particle filter (SPF) based on the SIR concept [7]. In this case $\pi(\cdot) = p(x_t / x_{t-1}^{(i)})$ is the transitional prior and weights can be expressed in terms of the likelihood distribution, $\tilde{w}_t^{(i)} = p(y_t / x_t^{(i)})$. After particle generation, weighting and normalization ($w_t^{(i)} = \tilde{w}_t^{(i)} / \sum_i \tilde{w}_t^{(i)}$), a minimum mean square error MMSE estimate of the state can be computed as [6]:

$$\hat{x}_t = \sum_{i=1}^{N_{particle}} w_t^{(i)} x_t^{(i)} \tag{5}$$

**Algorithm**: SIR

1: Set $t=0$, generate N samples $\{x_0^{(i)}\}_{i=1}^{N}$ from the initial distribution $p_{x_0}(x_0)$ .

2: Compute the weights $\tilde{w}_t^{(i)} = p\left(y_t / x_i^{(t)}\right)$ and normalize $w_t^{(i)} / \sum_i \tilde{w}_t^{(i)}$ , $i=1,..N$

3: Generate a new set $\{x_t^{(i)}\}_{i=1}^{N}$ by resampling with replacement N times from $\{x_t^{(i)}\}_{i=1}^{N}$

Where $\text{Prob}\left(x_t^{(i)} = x_t^{(j)} = \tilde{w}_t^{(j)}\right)$

4: Predict ( simulate) new particles

$x_{t+1}^{(i)} = f\left(x_t^i, w_t^i\right)$, $i=1,\ldots.N$ where $w_t^{(i)}$ is drawn from the process noise with PDF

$p_{w_i}(w_t)$.

5: Increase $t$ and continue from step 2

## 3. SIMULATIONS

The MD can be placed at any arbitrary position in the network area.

To track a mobile device (MD) in the WSN we advance to use the extended Kalman filter and particle filter algorithms proposed above.

In order to analyze the performance of the proposed approach we have run several simulations with synthetic data. A WSN network was generated.

The roots mean square error calculated for both EKF and PF are:

$RMSE_{EKF} = 9.5618$

$RMSE_{PF} = 2.7106$

PF can estimate the real state with more accuracy than EKF.

In Figure 1 it can see that PF approximates the PDF better than EKF.

If the number of particles increases (Figure 3), PF can approximate better PDF but the computation time increases. EKF is faster then PF.

As it can be observed in Figure 2 and Figure 4, when perfect knowledge about the nodes positions is available, the particle filter provides better results than the EKF.

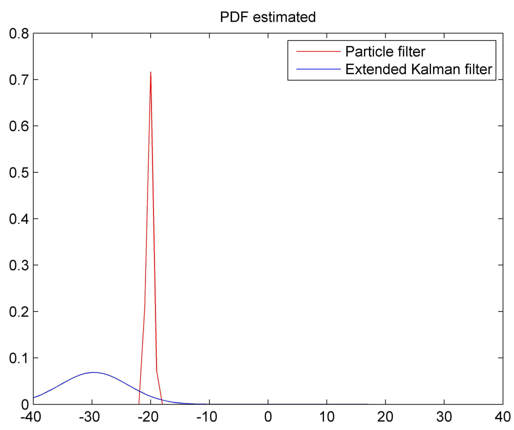


Figure 1 Probability density functions (PDF) estimated throw extended Kalman filer and particle filter

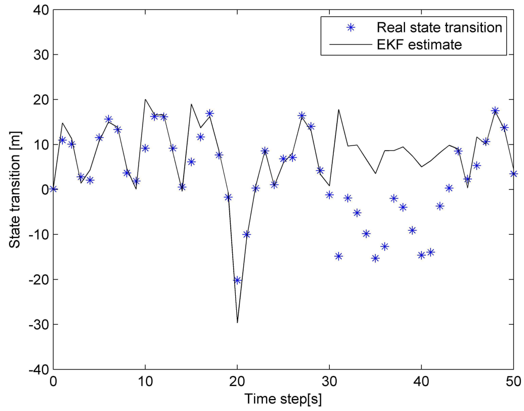


Figure 2 The Kalman Filter estimate

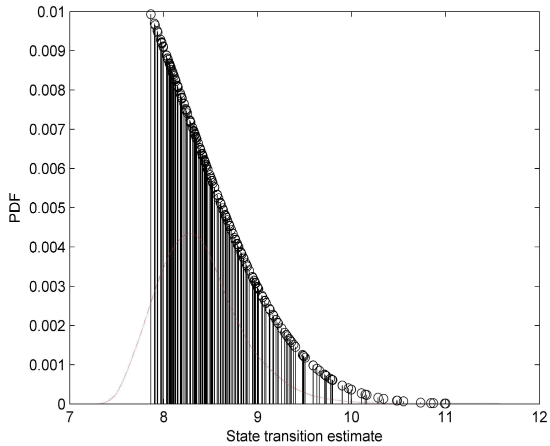


Figure 3 PF discrete PDF and the continuous PDF at a specific time moment

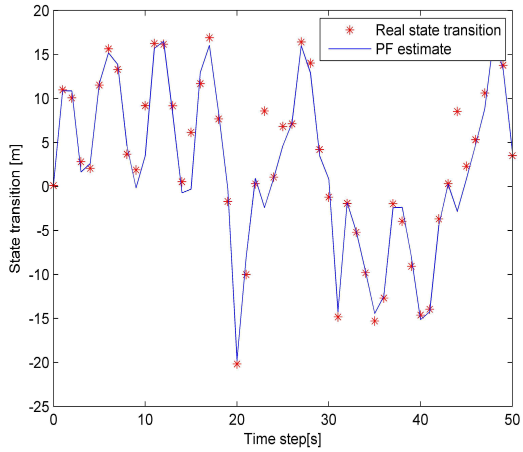


Figure 4 The particle filter estimate.

## 4. CONCLUSIONS

In this work, the performance of an EKF and a PF to localize a mobile device (MD) is analyzed and compared through simulation using MATLAB.

The extended Kalman filter and the particle filter are important methods in tracking applications. The extended Kalman filter (EKF) operates on the basic premise that the true state is suficiently close to the

estimated state. The EKF is restricted by its assumption that the posterior PDF is Gaussian. Models with severe nonlinearities will result in increased errors due to this assumption. PF is more accurate than EKF and could be a realistic option in practice given its excellent statistical performance. EKF is faster than PF and could be an optimal choice too, if the errors distribution is normal.
PF can compenstate the nonlinearities in the received measurements as long as EKF performs well with a good initial estimate.

As a conclusion, for non-linear and non – Gaussian problems as in the real cases, the performance of PF is superior to EKF.

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# SECTION IV
## MATHEMATICAL SCIENCES AND PHYSICS

# STRUCTURAL ANALYSES OF SUPERFICIAL LAYERS OBTAINED BY ELECTRICAL DISCHARGE IMPULSES

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**ABSTRACT**

The superficial layers obtained using electrical discharge technology in impulses is part of surfaces engineering domain.

In this paper we analyze phase quality using X-ray diffraction on superficial layers after the sparkling process with wolfram, titanium, and aluminum and graphite electrode.

The phase quality analyses through X – ray diffraction for deposition layers with electrical discharge method using wolfram, titanium, aluminum and graphite electrodes on no alloy steel proofs, suppose the obtain and interpretation of diffractions X-ray pattern.

Diffraction analysis was shown the phases, which is part from the proofs structure and a superficial layers obtain through these experiment on no alloy steel proofs.

**Keywords:** *superficial layers, electrical discharge technology in impulses, X-ray diffraction, analysis of phases*

## 1. INTRODUCTION

The efficient and rational use of metallic materials is a problem of present interest in most factories. The superior capitalization of metallic materials into products is obtained by application of the most efficient bulk – and / or surface – thermal treatments.

In most cases, the pieces are made by carbon steel, low-alloy steel or rich-alloy steel and in some cases by irons.

In order to increase the wear resistance and the hardness, major properties of pieces, these are subject to superficial hardening treatments: thermal (superficial chilling), thermo chemical treatments.

For some purpose of increasing the endurance of pieces intensely subject to wear, in the last time a series of unconventional superficial treatments were imposed. One can remember the thermal treatments with laser beam, thermal treatments with electron beams and, last but not the least, the PVD and CVD. All these methods confer very high hardness to superficial layers, yielding to a considerable enhancement of the treated piece lifetime.

An important disadvantage of these treatments is the high-price since expensive installations and devices are needed. Recently, in the field of surface engineering a new kind of superficial thermal treatment of micro alloying and spark deposition was imposed.

Some tests it was made on naval steel because of our university domain of interest.

## 2. EXPERIMENTAL WORK

The structure investigations will be made with X-rays diffraction techniques. This kind of techniques has two components, both are as important: experimental system configuration (this being the instrument) and the theoretical model for experimental data interpretation. In many cases, the fine structure investigations use diffraction analysis with goniometric montage Bragg – Bretano type.

X-rays diffraction, in classic theory, means the interference between electromagnetic waves with waves of length situated within 0.5 – 3.0 $\dot{A}$ domain. The interference of waves is produced if they are coherent, then in one direction their phase difference is an integer (number) from $2\pi$ radians or the waves way difference is a number of wave length. This condition is known as Bragg equation law and has the expression:

$$2d_{hkl} \cdot \sin\theta_i = n \cdot \lambda \tag{1}$$

where:

$d_{hkl}$ is distance between two planes with (hkl) indexes:

$\theta_i$ is diffraction angle

n is diffraction order

$\lambda$ is waves length for X – radiation

Crystalline phase’s analysis using X-ray diffraction has the following aspects:

a.each structure phase will generate a specific diffraction specter because each has its own crystalline network.

b. geometric form and intensity of a diffraction maximums depends on the structure factors and on the phase quantity which generates the maximums.

The diffraction image of metallic sample, polyphases, will be the result of diffraction specters, produced from components phases overlap.

The most used method for quality structure analysis is the comparison of information between the analyzed structure extracted from sample diffraction X-ray pattern (the image of diffraction) and well known crystalline substances, organized in data bases. Usually diffract meters are used for recording of diffraction results. The investigations for superficial layers obtained by using electrical discharge method was made with DRON 3 diffract meter which has a radiation tube with molybdenum anode, under the following working conditions: radiation $MoK_{\alpha}$, with $\lambda_{Mo}$ = 0.7107 $\dot{A}$; the acceleration tension on the tube: 40 KV; cathode current supply: 15 mA; sample rotation speed: $\omega_1 = 4^o / \min$ inscription band speed: 1800 mm/h; working slit: 1 mm and 0.5 mm.

The determinations were made on plane surfaces $20 \times 20$ mm, of the samples sparkling with W, Ti, Al and graphite electrodes.

By using Bragg equation it was determined that the structure interplanes distances, which was generated by the diffraction maximums and the crystalline phases which compose the superficial layers were identified.

## 3. RESULTS AND DISCUSSIONS

The qualitative analysis of phases by X- ray diffraction for superficial layers obtained by the electrical discharge method with W, Ti, Al and graphite electrodes requires obtaining and interpreting diffractions X-ray pattern as it results from OLC 45 samples.

Qualitative analysis using X – ray diffraction of obtained layers was made by using a radiation tube with Mo anode and $\lambda_{Mo}$ = 0.7107 $\dot{A}$, on DRON 3 diffractometer.

After the sparkling process, new superficial layers were obtained by using 4 regime an Elitron 22. Diffraction analysis was made on these layers.

Diffractions X-ray pattern and diffraction dates obtained an superficial layers as result of sparkling process with W, Ti, Al and graphite are presented in figure 1, 2, 3, 4.

Qualitative phase analysis using X rays on superficial layers obtained using sparkling method with W electrode (figure 1) shows the W existence in the layer (the maximum from $2\theta_1 = 18.48^o$, $2\theta_2 = 31.90^o$ and $2\theta_3 = 37.64^o$) close to C.V.C. structure phase and C.F.C. structure phase.

During the sparkling process on the surface of the sample the material is thaws and a faster solidification follows. If we consider the difractometer result we can see that in superficial layers, after the processing using W electrode, martensite and residual austenite is to be found.

At $2\theta = 31.50^o$ angle there is an overlap on diffraction maximum generated from (211) planes from W, with maximum from (220) planes from $\gamma$ phase (residual austenite).

We can mention that W can be dissolved in iron till at 7.16%, then it will form a solid solution which as it grows the W percentage the C.V.C network constant of the iron will grow. The presence of W carbide in the layer it less probable; the W carbide does not appear in X ray diffraction.

Because the discharge between the sample and the electrode takes place in the air, the nitrogen is divided and will form nitrogen compounds in the superficial layers. In this case on diffractions X-ray pattern we can see the maximum at $2\theta = 16.88$ which corresponds to $Fe_2N$ compound, for d = 2.42 $\dot{A}$ between crystalline planes with (110) (020) indexes.

X-ray analysis of superficial layer as result of sparkling with titanium electrode on steel sample OLC 45 is shown in figure 2.

Superficial processing using titanium electrode in normal atmosphere is very difficult because the Ti interacts with the oxygen in the air, and the titanium oxides are formed very fast.

Then, after the sparkling processed in the air using Ti electrode it is possible that it doesn't have free Ti. This was confirmed by diffraction analysis which shows the presence of the Ti oxide layer at $2\theta = 38.25^o$ with maximum from planes with crystallographic indexes (222) for $d_{(222)}=1.89\,\dot{A}$.

The diffraction X-ray pattern from figure 2 shows the presence in the layer structure of a new triple chemical compound $Fe_2Ti_4O$ with a complex cubic structure which appears at $2\theta = 32.25^o$. Close to these phases in superficial layer the presence of an "$\alpha$" type phase with bigger network parameters was detected a phase which is in fact martensite and an "$\gamma$" type phase which is residual austenite.

The sparkling in the air using Ti electrode when nitrogen is dissociated will determine the forming of the $Fe_xN$ in superficial layer composition. In our sample case after analysis it was shown at angle position $2\theta = 19.52^o$ for interplanes distance calculated at $d = 2.09\,\dot{A}$ which corresponds to (101) planes. From these planes is the diffraction maximum and $Fe_3N$ phase was identified characterized from interplanes distance $d(101) = 2.09\,\dot{A}$.

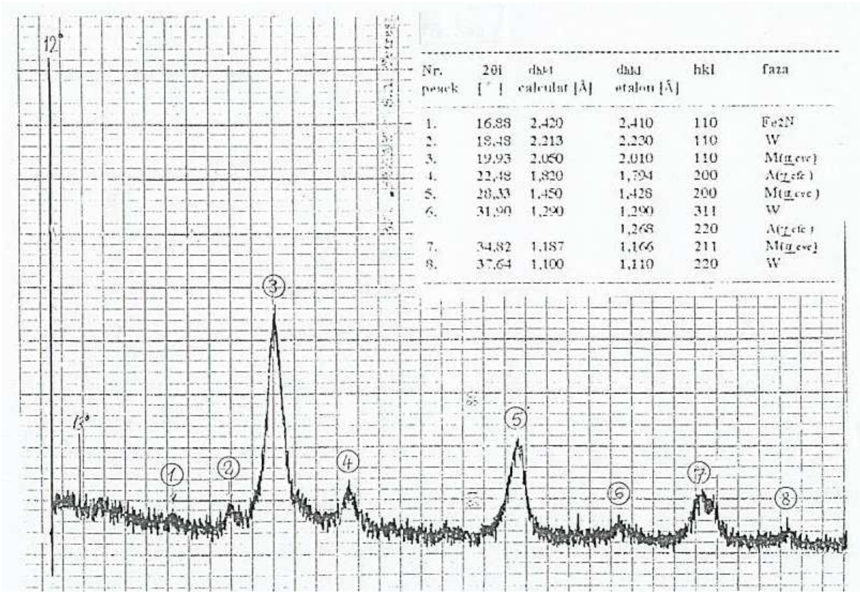
$Fe_xN$ are characterized from diffraction maximum at different angle positions but on sample diffraction X-ray pattern this maximum does not appear or overlaps with another diffraction maximum (at $2\theta = 33.14^o$ maximum for $\gamma$ phase with $Fe_3N$ compound is overlapped).

X ray diffraction analysis includes the samples from steel OLC 45 sparkling with Al electrode. The diffractions X-ray pattern and the dates of diffraction from one of these samples is presented in figure 3.

The principal maximum from diffraction X-ray pattern are from Al and from C.V.C. type structure phase which due to the thermal condition applied to metallic material from superficial layer is martensite. Close to these maximums we can see at $2\theta = 14.07^o$ maximum for AlFe compound from the planes (100). The maximum which corresponds to '$\gamma$" phase (residual austenite) is weak but it can be seen at $2\theta_1 = 22.64^o, 2\theta_2 = 32.38^o$ and also at $2\theta_3 = 38.45^o$. At angle position $2\theta = 20.06^o$ where the most intense maximum appears of the diffraction X-ray pattern is an overlap of maximums of diffraction from "$\alpha$" type phase from planes (110) from Al planes (200) and FeAl compound planes (220). On this diffraction X-ray pattern we can see maximum of diffraction from compounds as $Fe_XN$ type, even if the processing through electrical discharge that was made in the air.

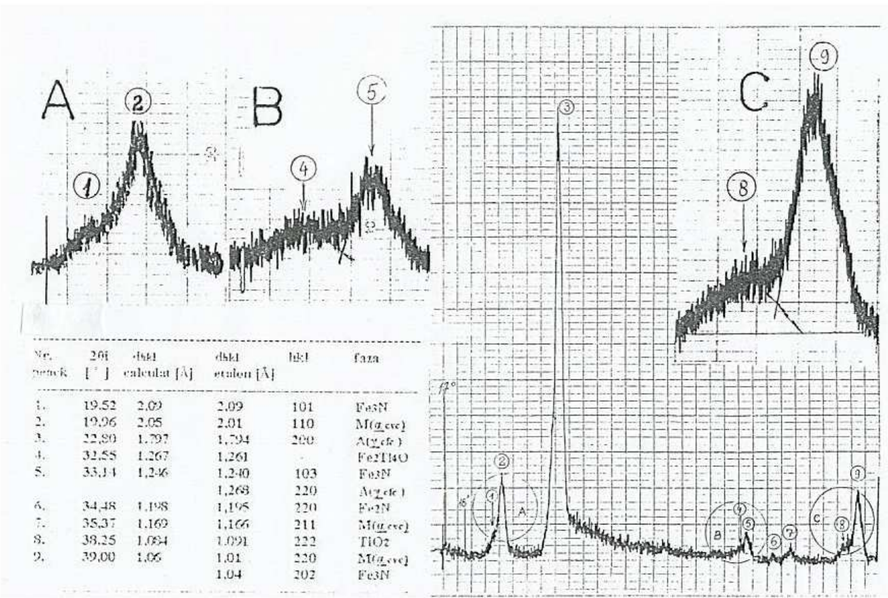
The most complex diffraction X-ray pattern from the superficial layer series was recorded from the surface of OLC 45 steel sample processed with graphite electrode (figure 4).

For the same angular domain $2\theta = 14^O - 40^O$, the diffraction X-ray pattern from figure 4 has more diffraction maximums. Thirteen maximums were indicated which come from different cementite crystalline planes. In the layers structure this phase is predominant.



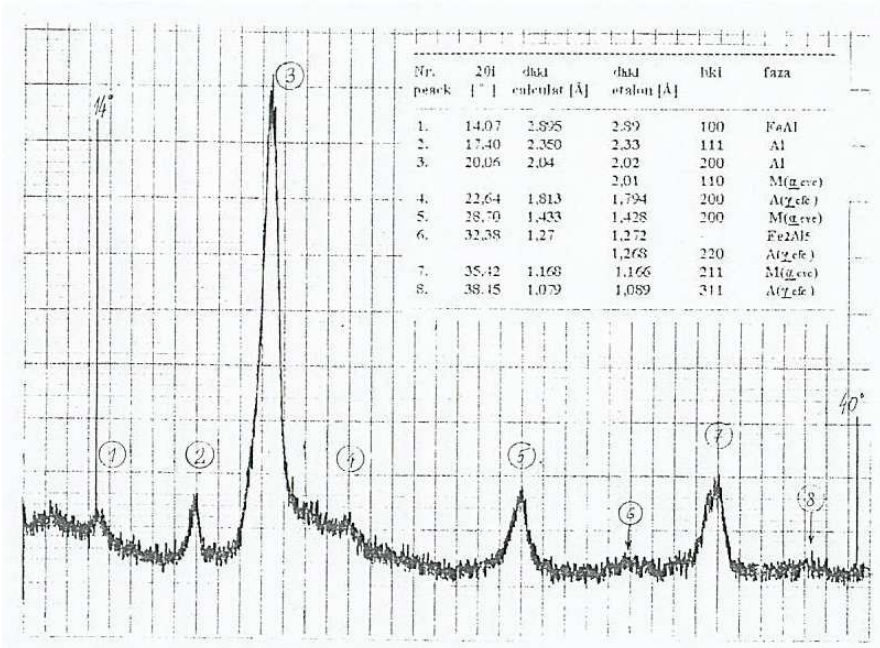
| Nr. peack | 2θi [°] | dhkl calculat [Å] | dhkl etalon [Å] | hkl | faza |
|---|---|---|---|---|---|
| 1. | 16.88 | 2,420 | 2,410 | 110 | Fe2N |
| 2. | 18,48 | 2.213 | 2.230 | 110 | W |
| 3. | 19,93 | 2,050 | 2,010 | 110 | M(α cvc) |
| 4. | 22,48 | 1,820 | 1,794 | 200 | A(γ cfc) |
| 5. | 28,33 | 1,450 | 1,428 | 200 | M(α cvc) |
| 6. | 31,90 | 1,290 | 1,290 | 311 | W |
| | | | 1,268 | 220 | A(γ cfc) |
| 7. | 34,82 | 1,187 | 1,166 | 211 | M(α cvc) |
| 8. | 37,64 | 1,100 | 1,110 | 220 | W |

Figure 1 Diffraction X-ray pattern and diffraction dates obtained an superficial layers as result of sparkling process with W electrode



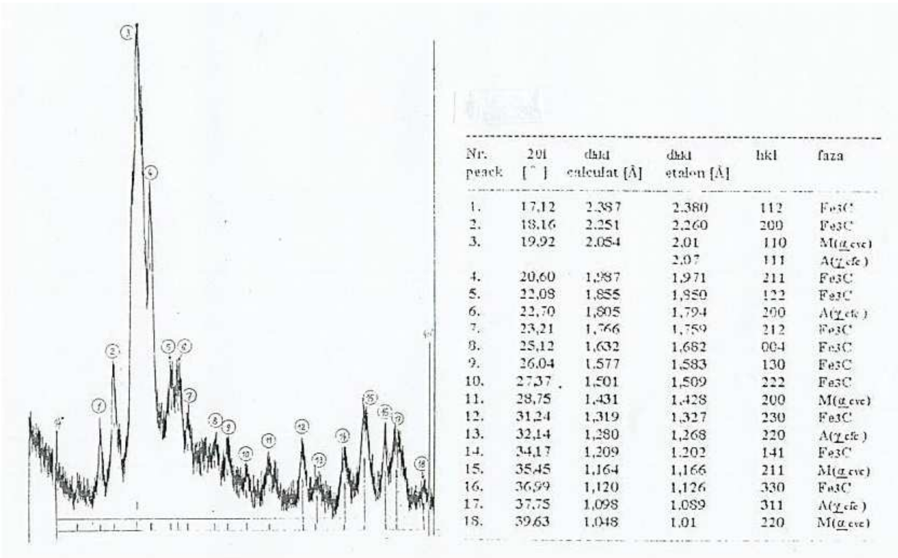

| Nr. peack | 2θi [°] | dhkl calculat [Å] | dhkl etalon [Å] | hkl | faza |
|---|---|---|---|---|---|
| 1. | 19.52 | 2.09 | 2.09 | 101 | Fe3N |
| 2. | 19.96 | 2.05 | 2.01 | 110 | M(α cvc) |
| 3. | 22,80 | 1.797 | 1,794 | 200 | A(γ cfc) |
| 4. | 32,55 | 1.267 | 1,261 | - | Fe2TiO |
| 5. | 33,14 | 1,246 | 1,240 | 103 | Fe3N |
| | | | 1,268 | 220 | A(γ cfc) |
| 6. | 34,48 | 1,198 | 1,195 | 220 | Fe2N |
| 7. | 35,37 | 1.169 | 1,166 | 211 | M(α cvc) |
| 8. | 38.25 | 1.094 | 1.091 | 222 | TiO2 |
| 9. | 39,00 | 1.06 | 1.01 | 220 | M(α cvc) |
| | | | 1.04 | 202 | Fe3N |

Figure 2 Diffraction X-ray pattern and diffraction dates obtained an superficial layers as result of sparkling process with Ti electrode




| Nr. peack | 2θ [°] | dhkl calculat [Å] | dhkl etalon [Å] | hkl | faza |
|---|---|---|---|---|---|
| 1. | 14.07 | 2.895 | 2.89 | 100 | FeAl |
| 2. | 17.40 | 2.350 | 2,33 | 111 | Al |
| 3. | 20,06 | 2,04 | 2,02 | 200 | Al |
| | | | 2,01 | 110 | M(α cvc) |
| 4. | 22,64 | 1,813 | 1,794 | 200 | A(γ cfc) |
| 5. | 28,70 | 1,433 | 1,428 | 200 | M(α cvc) |
| 6. | 32,38 | 1,27 | 1,272 | - | Fe2Al5 |
| | | | 1,268 | 220 | A(γ cfc) |
| 7. | 35,42 | 1,168 | 1,166 | 211 | M(α cvc) |
| 8. | 38.15 | 1,079 | 1,089 | 311 | A(γ cfc) |

Figure 3 Diffraction X-ray pattern and diffraction dates obtained an superficial layers as result of sparkling process with Al electrode



| Nr. peack | 2θ [°] | dhkl calculat [Å] | dhkl etalon [Å] | hkl | faza |
|---|---|---|---|---|---|
| 1. | 17,12 | 2.387 | 2.380 | 112 | Fe3C |
| 2. | 18.16 | 2.251 | 2,260 | 200 | Fe3C |
| 3. | 19.92 | 2.054 | 2.01 | 110 | M(α cvc) |
| | | | 2,07 | 111 | A(γ cfc) |
| 4. | 20,60 | 1,987 | 1,971 | 211 | Fe3C |
| 5. | 22,08 | 1,855 | 1,850 | 122 | Fe3C |
| 6. | 22,70 | 1,805 | 1,794 | 200 | A(γ cfc) |
| 7. | 23,21 | 1,766 | 1,759 | 212 | Fe3C |
| 8. | 25,12 | 1,632 | 1,682 | 004 | Fe3C |
| 9. | 26.04 | 1.577 | 1,583 | 130 | Fe3C |
| 10. | 27,37 | 1,501 | 1,509 | 222 | Fe3C |
| 11. | 28,75 | 1,431 | 1,428 | 200 | M(α cvc) |
| 12. | 31,24 | 1,319 | 1,327 | 230 | Fe3C |
| 13. | 32,14 | 1,280 | 1,268 | 220 | A(γ cfc) |
| 14. | 34,17 | 1,209 | 1.202 | 141 | Fe3C |
| 15. | 35,45 | 1,164 | 1,166 | 211 | M(α cvc) |
| 16. | 36,99 | 1,120 | 1,126 | 330 | Fe3C |
| 17. | 37,75 | 1,098 | 1,089 | 311 | A(γ cfc) |
| 18. | 39,63 | 1,048 | 1,01 | 220 | M(α cvc) |

Figure 4 Diffraction X-ray pattern and diffraction dates obtained an superficial layers as result of sparkling process with graphite electrode

Close to cementite the presence of austenite was found at $2\theta = 19.81^{O}$ , $2\theta = 22.70^{O}$ $2\theta = 32.14^{O}, 2\theta = 37.75^{O}$, and ferrite at $2\theta = 20.11^{O}$ $2\theta = 28.75^{O}, 2\theta = 35.45^{O}$.

The most evident maximum from $2\theta = 20^{O}$ is an composed maximum which contains "reflections" from (111) crystalline planes which correspond to austenite.

Because the diffraction X-ray pattern is very complicated it was not possible to identify the maximum from $Fe_xN$ phases taking into consideration that these phases should appear in the layer.

As conclusion we can assert that after the sparkling with graphite electrode on hypoeutectoid steel this will harden superficially, as a consequence of a white cast iron layer on the surface of the processed sample that contains cementite.

## 4. CONCLUSIONS

X ray diffraction structural investigations show on diffractions X-ray pattern obtained from superficial layers an abnormal radiation fund because of non-crystaline metallic material zones from layer structure.

Because in the superficial layer from steel with 0.45% C the material thaws and is followed by an ultra rapid solidification. If we consider the diffraction X-ray pattern and diffraction dates, we will see martensite and residual austenite in the new formed layer.

The diffraction X-ray pattern obtained from the superficial layers sparkling by Ti electrode don't show the Ti in the layer; this can be found just in combination with oxygen and iron ( $Fe_2Ti_4O;TiO_2$ ).

On the diffraction X-ray pattern obtained from the graphite electrode sparkling layer on steel sample a lot of maximums were identified belonging to cementite which explains the forming of white cast iron in new formed layer.

## 5. ACKNOWLEDGMENTS

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# DETECTING ORDER AND CHAOS IN SOME DYNAMICAL SYSTEMS BY THE 0-1 TEST

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**ABSTRACT**

The purpose of the paper it was to apply the 0-1 test for distinguishing between regular and chaotic motion in the case of some time series associated with deterministic dynamical systems. To achieve this, we investigated the Tinker bell map and the double pendulum system, two dynamical systems studied by the author in other papers. We founded that the test succeeds in every case to give the correct answer whether the dynamical system is chaotic or non-chaotic.

**Keywords:** *Deterministic dynamical system, time series, chaos indicator.*

## 1. INTRODUCTION

Investigating dynamical systems, one of the most important questions is to distinguish between the ordered or chaotic behaviour of their orbits. This distinction is very important because in ordered motions we have predictability while in chaotic motions we are unable to predict the time evolution of the system even after a short time period. For this reason, over the years, numerous methods distinguishing regular from chaotic motion in dynamical systems have been proposed and applied, with varying degrees of success. The first methods were the Poincare section of surface, the time series analysis, the Lyapunov exponents, the frequency-map analysis, phase-space method, Kolmogorov entropy, correlation dimension and so on. In the recent years, other analytical or numerical indicators have been introduced. They are more efficient and faster than the older ones, especially for multidimensional dynamical systems. We just remember the well-known methods (tools) like Lyapunov characteristic exponents (LCE, Benettin et al., 1980), the Fast Lyapunov Indicator (FLI, Froeschle et al., 1997), the Spectral Distance (SD, Voghis et al., 1999), the Relative Lyapunov Indicator (RLI, Sandor et al., 2000), the Mean Exponential Growth factor of Nearby Orbits (MEGNO, Cincotta and Simo, 2000), the Smaller Alignment Index (SALI, Skokos, 2001), the Orthogonal Fast Lyapunov Indicator (OFLI, Fouchard et al., 2002), the Generalized Alignment Index (GALI, Skokos et al., 2007) and the Dynamic Lyapunov Indicator (DLI, saha et al., 2007).

Recently, Gottwald and Melbourne have introduced a binary test for chaos, the 0-1 test, designed for the analysis of deterministic dynamical systems. The test has been applied to Hamiltonian systems, to experimental data, to noisy numerical data, to fluid dynamics and to quasi-periodically forced systems.

In this paper, 0-1 test has been discussed and its application on two dynamical systems has been studied. The paper is organized as follows. In Section 2 we briefly review how the test is implemented. In Section 3 we apply the test on the Tinker bell map and on the double pendulum system. We make a few remarks in Section 4 concerning our conclusions about 0-1 test and its advantages.

## 2. THE 0-1 TEST

Let consider a scalar observable $\Phi(j)$ for $j = 1,2,...,N$. To apply the 0-1 test perform the following sequence of steps:

Step 1: For a fixed $c \in (0, \pi)$, compute the translation variables:

$$p_c(n) = \sum_{j=1}^{n} \Phi(j) \cos jc \,,\ q_c(n) = \sum_{j=1}^{n} \Phi(j) \sin jc \qquad (1)$$

for $n = 1,2,..,N$. The variables $p_c$ and $q_c$ are bounded if the underlying dynamics is regular (i.e. periodic or quasi-periodic) and they behave asymptotically like Brownian motion for the large classes of chaotic dynamical systems [11].

Step 2: Compute the mean square displacement of the translation variables $p_c$ and $q_c$:

$$M_c(n) = \lim_{N\to\infty} \frac{1}{N} \sum \left\{ \left[ p_c(j+n) - p_c(j) \right]^2 + \left[ q_c(j+n) - q_c(j) \right]^2 \right\} \qquad (2)$$

for $n << N$. This step is necessary for analyzing the diffusion or non-diffusion behaviour of $p_c$ and $q_c$. The mean square displacement is a bounded function if the investigated dynamics is regular whereas it grows linearly in time if the dynamics is chaotic [12

For estimation of the limit involved in (2) we need $n \le n_{cut} = N/10 << N$. It seems that this maximal value, $n_{cut}$, gives good results in practical applications. In [?], it was proposed a modified mean square displacement, $D_c(n)$, which behaves as $M_c(n)$ in the chaotic case but with better convergence properties. Its definition is

$$D_c(n) = M_c(n) - \frac{1-\cos nc}{1-\cos c} \left( \lim_{N\to\infty} \frac{1}{N} \sum_{j=1}^{N} \Phi(j) \right)^2 \qquad (3)$$

The subtraction of the oscillatory term (the second term in rhs of (3)) regularizes the linear behavior of $M_c(n)$.

Step 3: Determine the asymptotic growth rate $K_c$ of the mean square displacement

$$K_c = \lim_{n\to\infty} \frac{\log M_c(n)}{\log n} \quad (4)$$

Numerically, $K_c$ can be determined by linear regression of $\log M_c(n)$ versus $\log n$, so

$$M_c(n) = A \cdot \log n + B \quad , \quad K_c = A \quad (5)$$

An alternative definition of $K_c$ utilizes the modified mean square displacement $D_c(n)$:

$$K_c = \lim_{n\to\infty} \frac{\log \widetilde{D}_c(n)}{\log n} \quad (6)$$

where

$$\widetilde{D}_c(n) = D_c(n) - \min_{n=1,2,\ldots,ncut} D_c(n) \quad (7)$$

Step 4: Perform again the step 1-3 for other values of $c$ chosen randomly in the interval $(0, \pi)$. For practical purposes $N_c = 100$ values for $c$ are sufficient.

Step 5: Compute the diagnostic variable

$$K = median(K_c) \quad (8)$$

$K$ has values close to 0 for regular dynamics and close to 1 for chaotic dynamics. In our study, definition (4) was implemented.

## 3. NUMERICAL RESULTS

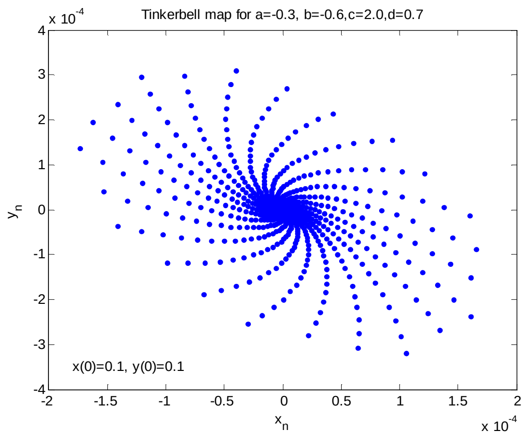
### *3.1 Tinker bell map*

The Tinker bell map is a discrete-time dynamical system given by the difference equations

$$x_{n+1} = x_n^2 - y_n^2 + a\,x_n + b\,y_n \;,\; y_{n+1} = 2\,x_n\,y_n + c\,x_n + d\,y_n \quad (9)$$

This map admits a wide variety of patterns depending on the parameters *a*, *b*, *c* and *d* involved. For our purpose, we choose four of them:

a) $a = -0.3$; $b = -0.6$; $c = 2.0$; $d = 0.7$ - fixed point
b) $a = 0.9$; $b = -0.6$; $c = 2.0$; $d = 0.11$ - six-period orbit
c) $a = -0.3$; $b = -0.6$; $c = 2.0$; $d = 0.65$ - quasi-periodic
d) $a = 0.9$; $b = -0.6$; $c = 2.0$; $d = 0.5$ - chaotic orbit.



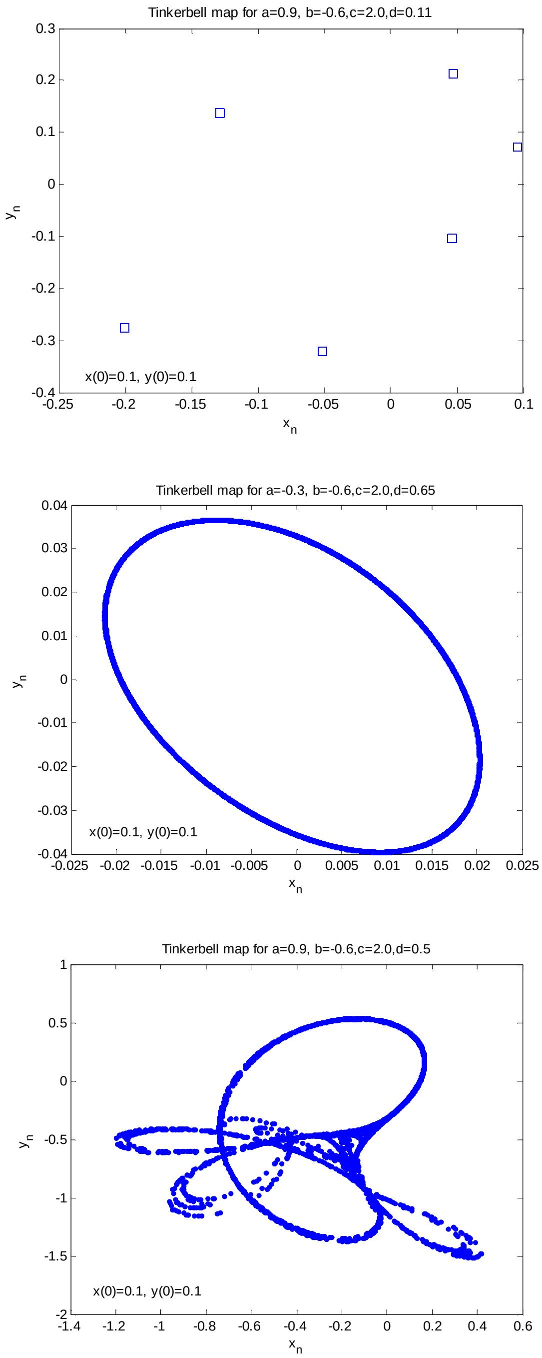




Figure 1 Phase plots of Tinker bell map

This is clearly observed through the phase plots given in Figure 1.

We calculated the translation variables $p_c(n)$ and $q_c(n)$ and the mean square displacement $M_c(n)$ for $\Phi(j) = x_j$, $j = 1,2,\ldots,N$, $c = 2\pi/5$ and N=5000. Plots of $q_c$ versus $p_c$ are displayed in Figure 2 (the same order as in Figure 1).

Figure 3 shows the mean square displacement $M_c(n)$ only for six-period orbit (upper panel) and chaotic orbit (lower panel). It is obvious that $M_c(n)$ is bounded for regular orbit and grows linearly for chaotic orbit.

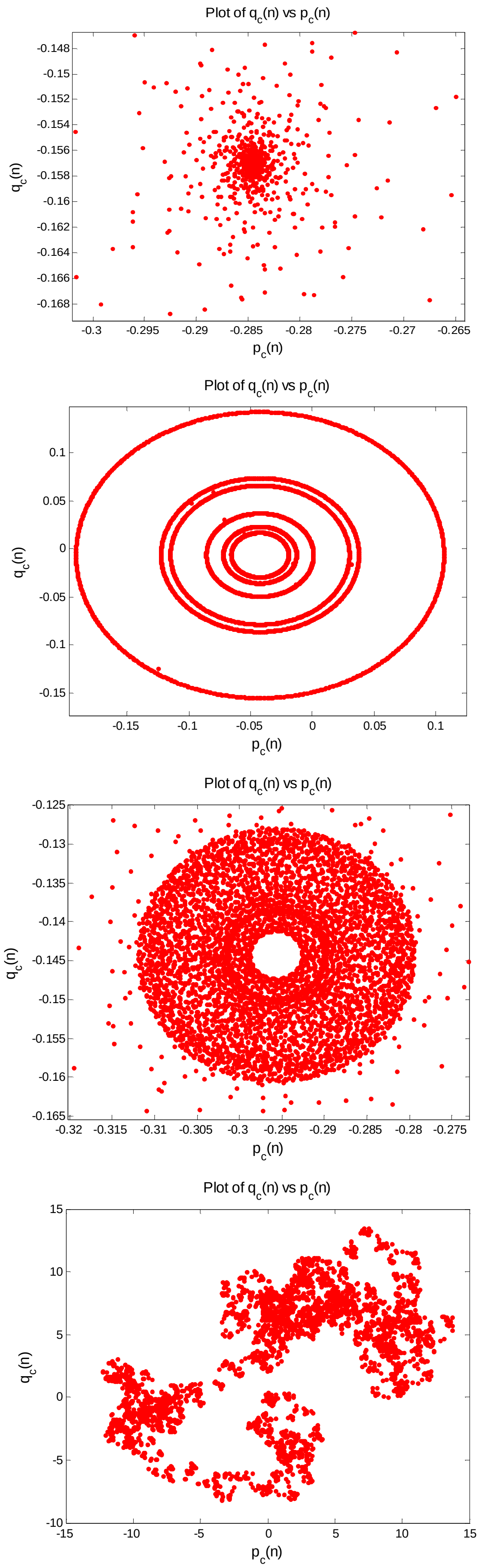



Figure 2 Plot of $q_c$ versus $p_c$ for Tinker bell map

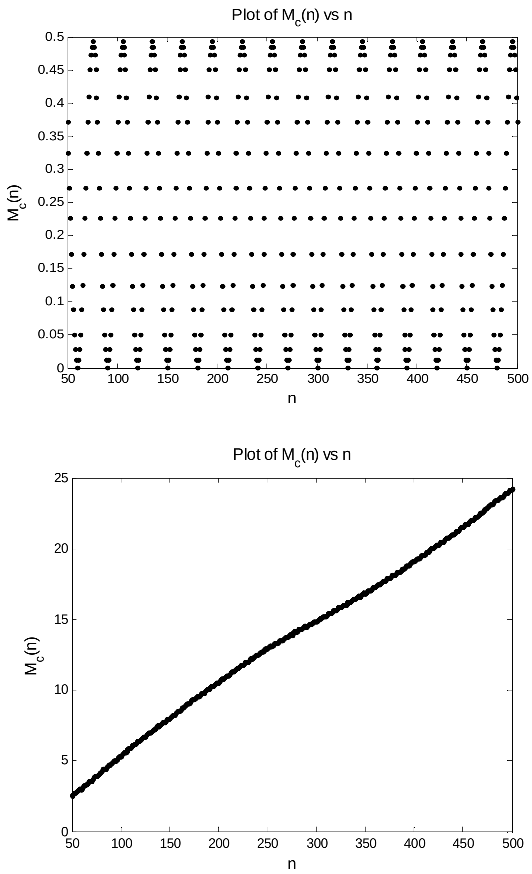



Figure 3 Plot of mean square displacement $M_c(n)$

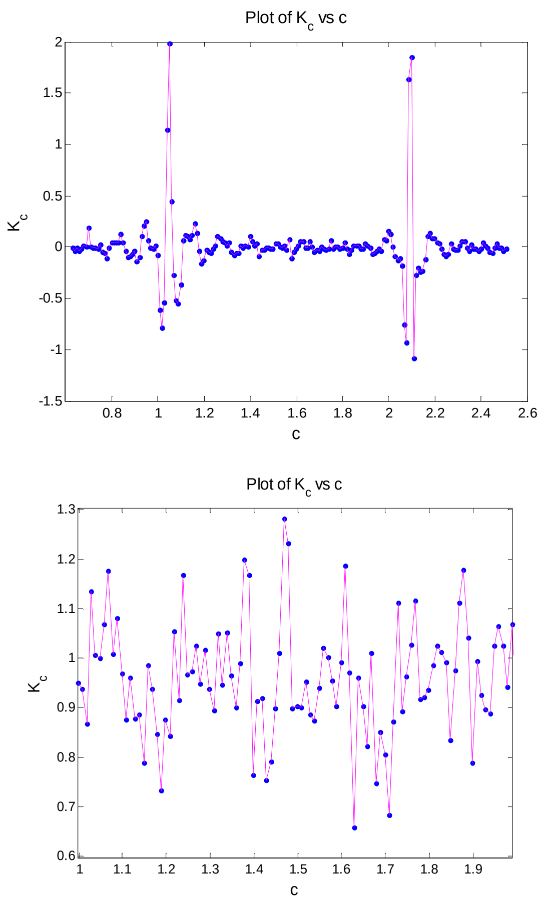



Figure 4 Plot of the asymptotic growth rate $K_c$

In Figure 4 is displayed the asymptotic growth rate $K_c$ as a function of $c$ for six-period orbit (upper panel) and chaotic orbit (lower panel). We used 188 equally spaced values of $c$ between $\pi/5$ and $4\pi/5$, with step 0.01. The values for $K_c$ was obtained from (4) by fitting a straight line to the graph of $\log M_c(n)$ versus $\log n$ through minimizing the absolute deviation. That means we applied the regression method.

The values of $K_c$ are around 0 or 1, depending on the type of orbit. The isolated values of c for which $K_c$ is large (in the regular case) are in conection with the Fourier decomposition of scalar observable $\Phi$.

The final output of the 0-1 test is the median value of $K_c$ (see (7)). We obtain $K=-0.0362\approx 0$ for fixed point, $K=-0.0051\approx 0$ for six-period orbit, $K=-0.0047\approx 0$ in the case of quasi-periodic orbit and $K=0.9503\approx 1$ for the chaotic orbit.

To understand how the value of $K$ depends on the amount of data used, we considered other value for $N$, namely $N$ = 500, $N$ = 2000 and $N$ = 20000. The results are summarized in Table 1. It is obvious that the values of $K$ converge toward the asymptotic values $K=0$ and $K=1$ (for regular and chaotic dynamics) if the amount of data $N$ is increased.

Table 1 Dependence of K with the length of time series

| **N** | **(a)** | **(b)** | **(c)** | **(d)** |
|---|---|---|---|---|
| 500 | -0.124 | -0.123 | -0.098 | 0.797 |
| 2000 | -0.065 | -0.026 | -0.018 | 0.902 |
| 5000 | -0.036 | -0.005 | -0.004 | 0.950 |
| 20000 | -0.003 | -0.0004 | -0.0002 | 0.978 |

Another effect of increasing N consisted in diminishing the effect of resonant points. Thus, Figure 5 show the asymptotic growth rate $K_c$ as a function of c for the case of fixed point in variants N = 5000 (upper panel) and N = 20000 (lower panel).

Till now, the values of $c$ are equally spaced. The test 0-1 works well with randomly sampled values of $c$. To see this and to show how the results for K depend on the number $N_c$ of values of $c$ we make another numerical simulation, which are presented in Table 2.

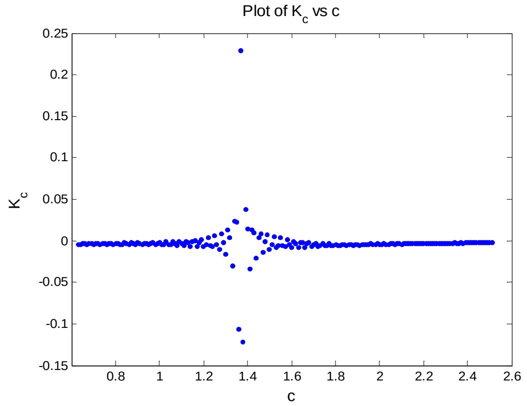



Figure 5 Influence of length of amount of data on the behaviour of $K_c$ near the resonant points

The value N was fixed at N = 5000.

As Gotwald and Melbourne said, there is no measurable gain in increasing $N_c$ too much. They founded that $N_c=100$ different values of c is sufficient for test to work.

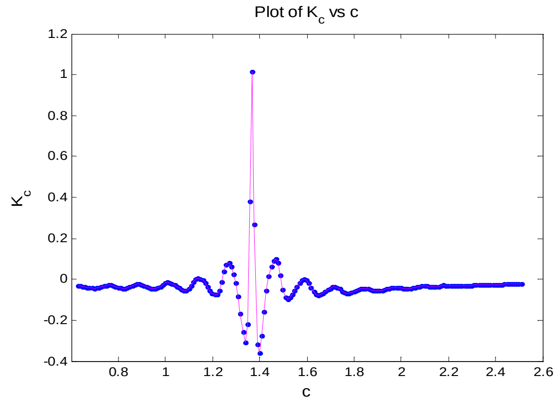



Table 2 Dependence of K with number $N_c$

| $N_c$ | (a) | (b) | (c) | (d) |
|---|---|---|---|---|
| 25 | -0.0427 | -0.0421 | -0.0085 | 0.8946 |
| 100 | -0.0376 | -0.0115 | -0.0061 | 0.9180 |
| 500 | -0.0363 | -0.0046 | -0.0058 | 0.9325 |

### *3.2 The double pendulum*

The double pendulum is simply one pendulum fixed to the end of another pendulum. The inner pendulum is modelled as a mass less rod of length $l_1$ with a mass $m_1$ on the end. The outer pendulum is attached to the mass of the inner pendulum and is similarly a mass less rod of length $l_2$ and of mass of $m_2$. The equations of motion have as time-dependent variables the displaced angles from vertical $\theta_1$ and $\theta_2$ [26]:

$$\begin{aligned} \frac{dw_1}{dt} &= w_2 \\ \frac{dw_2}{dt} &= \frac{ed-bf}{ad-be} \\ \frac{dw_3}{dt} &= w_4 \\ \frac{dw_4}{dt} &= \frac{af-ce}{ad-bc} \end{aligned} \tag{10}$$

where we use the variables

$$w_1=\theta_1,\ w_2=\dot{\theta}_1,\ w_3=\theta_2,\ w_4=\dot{\theta}_2 \tag{11}$$

and the substitutions

$$\begin{aligned} a &= (m_1+m_2)l_1 \quad , \quad b=m_2 l_2\cos(w_1-w_3) \\ c &= m_2 l_1 \cos(w_1-w_3) \quad , \quad d=m_2 l_2 \\ e &= -m_2 l_2 w_4^2 \sin(w_1-w_3)-(m_1+m_2)g\sin w_1 \end{aligned} \tag{12}$$

$$f = -m_2 l_1 w_2^2 \sin(w_1 - w_3) - m_2 g \sin w_1$$

The double pendulum exhibits a rich dynamic behaviour which varies from regular motion at low energies, to chaos at intermediate energies, and back to regular motion at high energies. By choosing $m_1 = 2$, $m_2 = 1, l_1 = 1, l_2 = 2, g = 9.8$ and varying only the initial conditions we get:

a) $\left(\theta_1, \dot{\theta}_1, \theta_2, \dot{\theta}_2\right) = (0.157, 0, 0.342, 0)$ - periodic orbit;

b) $\left(\theta_1, \dot{\theta}_1, \theta_2, \dot{\theta}_2\right) = (0.78, 0, -0.156, 0)$ -quasi-periodic orbit

c) $\left(\theta_1, \dot{\theta}_1, \theta_2, \dot{\theta}_2\right) = (1.57, 0, 1.57, 0)$ - chaotic orbit.

The phase-plane $(x_2, y_2)$, representing the motion of outer bob, reinforces the previous observation (see Figure 6).

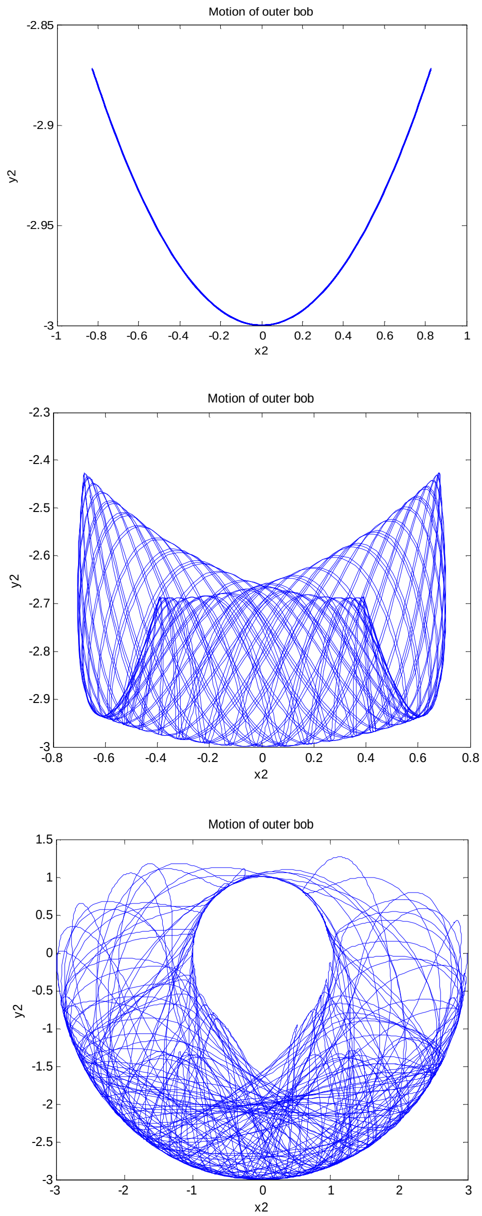



Figure 6 The phase-plane $(x_2, y_2)$

We have integrated the system (10) with Matlab package and recorded N=250000 data points with a step $\delta t = 0.001$ (i.e. 250 time units). The dependences $q_c = q_c(p_c)$, for $c = \pi/5$, were calculated for $\Phi(t) = w_1(t), t = j \cdot \delta\tau, j = 1,2,..,$ $\delta\tau = 0.025$ and displayed in Figure 7. They are in good agreement with theory.

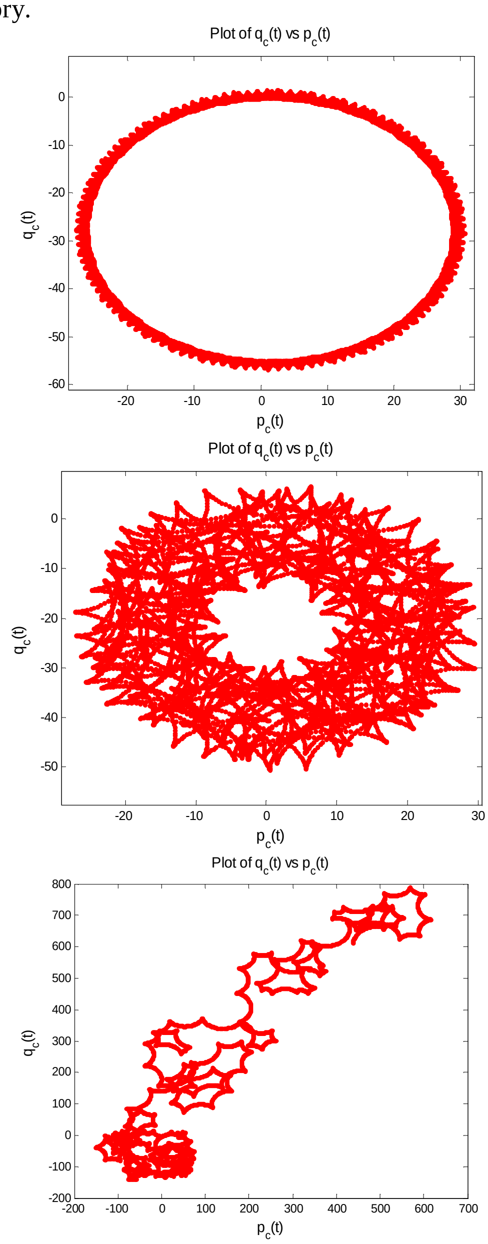
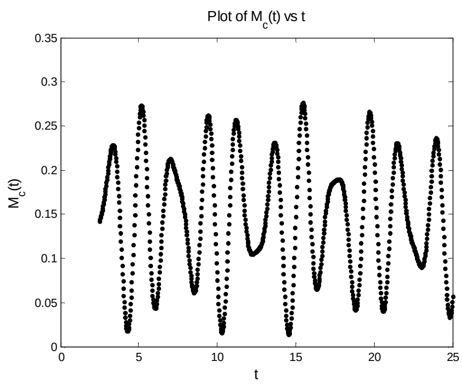



Figure 7 Plot of $q_c$ versus $p_c$ for double pendulum



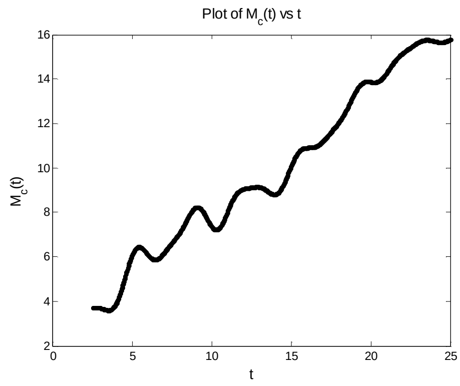



Figure 8 Plot of mean square displacement $M_c(t)$

The function $M_{\pi/5}(t)$ is bounded for regular orbits (see Figure 8 for quasi-periodic orbit, first panel) and scales linearly with time for chaotic orbit (see Figure 8, second panel).

By choosing equally spaced values for $c$ in the interval $(\pi/5, 4\pi/5)$, with step 0.01, we computed and represented in Figure 9 the asymptotic growth rate $K_c$ of the mean-square displacement. $K_c$ is shown in this figure for the case where the dynamics is quasi-periodic and chaotic, respectively.

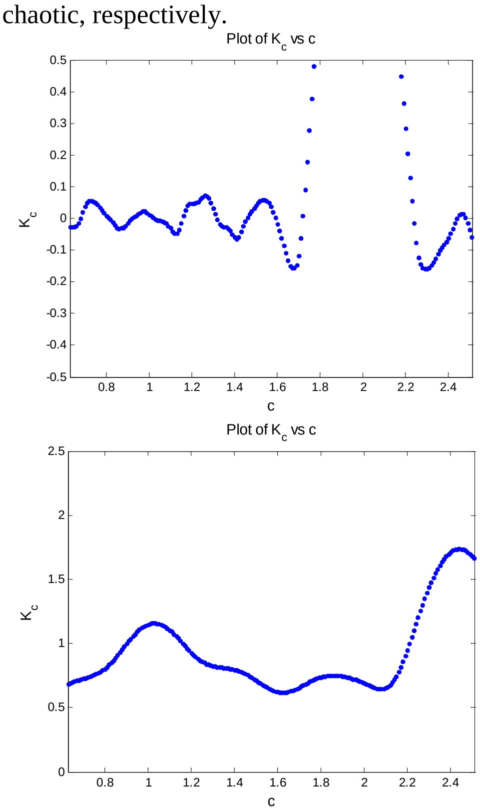



Figure 9 Plot of the asymptotic growth rate $K_c$

The $K_c$ values yield $K = 0.0136 \approx 0$ for quasi-periodic orbit and $K = 0.8019 \approx 1$ for chaotic orbit.

In Section 6 of [13] the reader can find a useful analysis of the influence of an oversampled observable $\Phi$ on the diagnostic variable $K$ values. Changing the sampling time $\delta\tau$ it is possible to obtain values for $K$ far away from 0 or 1. A good choice of the sampling time requests either a careful inspection of observable $\Phi$ or the use of the mutual information [13]. Figure 10 shows the entire set of data obtained by integration for observable $\Phi = w_1$ and the data set used for diagnostic variable's calculation.

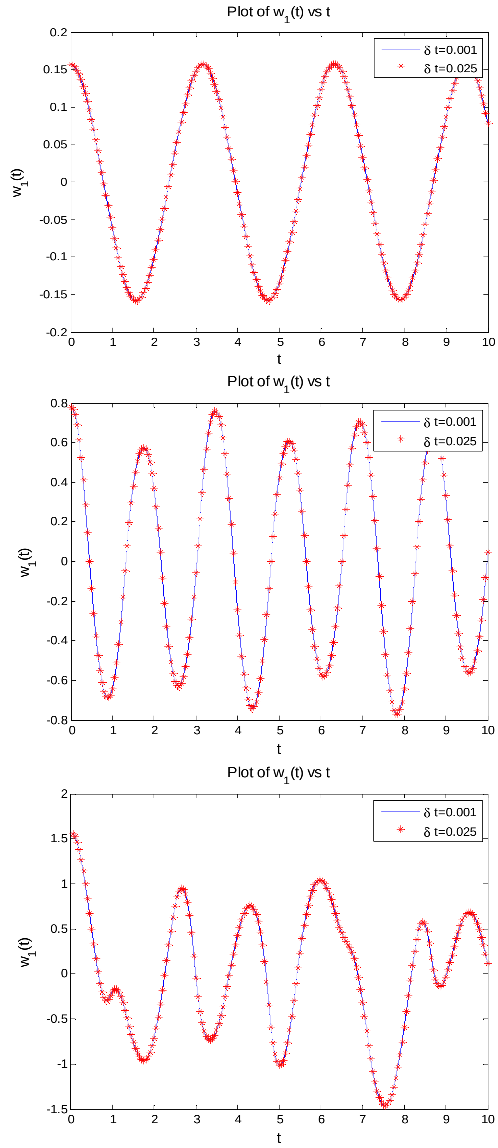



Figure 10 Plot of the observable $\Phi(t) = w_1(t)$

## 4. CONCLUSIONS

The 0-1 test for chaos is a new test that has been recently proposed for distinguish between order and chaos in time series associated with deterministic dynamical system. The input is the time series data and the output is either a „1" or a „0", depending on whether the investigated orbit is chaotic or non-chaotic. The main advantages of the 0-1 test are:

a) The nature of the dynamical system is irrelevant for the implementation of the test. The test is applicable to data generated from maps, ordinary differential equations and partial differential equations;
b) The dimensionality of the vector field has not practical limitations;
c) The equations of the underlying dynamics do not need to be known;

d) The test does not require phase space reconstruction;
e) The test is binary. The distinction between regular and chaotic dynamics is extremely clear by means of a diagnostic variable, which has values close to zero for regular orbits and close to one for the chaotic orbits;
f) The computational effort is of low cost, both in terms of programming effort and in terms of computational time.

In the paper, we applied this test succesfully to the Tinker bell map and to the double pendulum system, demonstrating its applicability to discrete dynamical systems, as well as continuous dynamical systems. For numerical integration and other calculus, Matlab package was used.

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# DISTRIBUTION RULES IN SEAPORT ACTIVITIES MODELING

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**ABSTRACT**

In this paper we demonstrate how to monitor operations with the aid of the queueing theory and how to determine the optimal berth numbers in a port container terminal.

**Keywords:** *Poisson distribution, optimal berth numbers*

## 1. INTRODUCTION

Ports are complex organisations where multiple activities take place, with a large variety of agents. Furthermore, port activities and services differ in such aspects as the nature of the operations carried out the objectives sought, the degree of competition in which they take place. The goal of studies that analyse port efficiency is varied and ranges from establishing a relation between efficiency, type of ownership, and port management to generating rankings of ports and evaluating the impact of port reform processes on efficiency.

It is often suggested in port literature that the largest ports must have the highest levels of efficiency due to the learning effect offered by the greater activity levels. On the other hand, to provide for future demand growth, ports are obligated to invest large amounts in infrastructure and equipment, which leads to ports having excess capacity at the moment of making the investment and, therefore, difficulty in achieving high levels of efficiency from the point of view of scale efficiencies. Meanwhile, some large ports are at the physical limit of their growth, which makes it difficult for them to increase their efficiency, while smaller ports may find it easier to grow and reach optimum scales. The consideration of all these factors makes it difficult to find an only relation between efficiency and port size.

## 2. LAWS OF DISTRIBUTION

### *2.1 Poisson distribution*

The Poisson distribution is a discrete distribution. It is often used as a model for the number of events (number of customers in waiting lines, number of defects in a given surface area, ships arrivals) in a specific time period. The major difference between Poisson and Binomial distributions is that the Poisson does not have a fixed number of trials. Instead, it uses the fixed interval of time or space in which the number of successes is recorded.

Let $P_n(k) = C_n^k p^k (1-p)^{n-k}$

where we suppose $n$ very big and $p$ very small.

If we note $np = \lambda$, we get:

$$P_n(k) = \frac{n\cdot(n-1)\cdot(n-2)\cdot\ldots\cdot(n-k+1)}{k!}\cdot\left(\frac{\lambda}{n}\right)\cdot\left(1-\frac{\lambda}{n}\right)^{n-k}$$

$$P_n(k) = \frac{n\cdot(n-1)\cdot(n-2)\cdot\ldots\cdot(n-k+1)}{k!}\cdot\left(1-\frac{\lambda}{n}\right)^{n-k}\cdot\frac{\lambda^k}{\alpha!} \tag{1}$$

But

$$\lim_{n\to\infty}\frac{n\cdot(n-1)\cdot(n-2)\cdot\ldots\cdot(n-k+1)}{k!} = \lim_{n\to\infty}\left[\left(1-\frac{1}{n}\right)\cdot\left(1-\frac{2}{n}\right)\cdot\ldots\cdot\left(1-\frac{k-1}{n}\right)\right] = 1$$

$$\lim_{n\to\infty}\left(1-\frac{\lambda}{n}\right)^{n-k} = \lim_{n\to\infty}\frac{\left(1-\frac{\lambda}{n}\right)^{n}}{\left(1-\frac{\lambda}{n}\right)^{k}} = e^{-\lambda}$$

For $n$ very big, replacing the first two factors from (1) by their limits, we get:

$$P_n(k) \approx \frac{\lambda^\alpha}{\alpha!}\cdot e^{-\lambda}.$$

*Definition 1* If a random variable take the values $0,1,2,\ldots$ with probabilities $\frac{\lambda^\alpha}{\alpha!}\cdot e^{-\lambda}$, where $\lambda$ is a parameter, we say that the variable $X$ is a Poisson random variable.

*Properties:*

1. The mean value of a Poisson variable is $\lambda$.

$$M(X) = \sum_{k=0}^{\infty} kP_n(k) = e^{-\lambda} \sum_{k=0}^{\infty} k \frac{\lambda^k}{k!} = \lambda e^{-\lambda} \sum_{k=1}^{\infty} \frac{\lambda^{k-1}}{(k-1)!} = \lambda$$

2. The characteristic function of a Poisson variable is:

$$\psi(t) = \sum_{k=0}^{\infty} e^{itk} \frac{\lambda^k}{\alpha!} \cdot e^{-\lambda} = e^{-\lambda} \sum_{k=0}^{\infty} \frac{(\lambda e^{it})^k}{k!} = e^{-\lambda} \cdot e^{\lambda e^{it}}$$

3. The variance of a Poisson variable is $\lambda$.

$$var(X) = M(X^2) - (M(X))^2$$

$$M(X^2) = -\left[\frac{d^2\psi}{dt^2}\right]_{t=0} = -\left[(-\lambda^2 e^{2it} - \lambda e^{it}) \cdot e^{\lambda(e^{it}-1)}\right]_{t=0} =$$

$$= \lambda^2 + \lambda$$

$$\Rightarrow var(X) = \lambda$$

Many events may be modeled as a Poisson distribution, for example:
- the number of ships arriving at a seaport
- the number of phone calls arriving at a call center per hour
- the number of goals in sports involving two competing teams
- the number of deaths per months in a given age group

*2.2. The exponential distribution*

*Definition 2* A random variable $X$ has an exponential distribution if the density of distribution is:

$$\rho(x) = \lambda e^{-\lambda x}, \ x \geq 0, \ \lambda > 0.$$

*Properties:*
1. The mean value of an exponential random variable $X$ is :

$$M(X) = \frac{1}{\lambda}$$

2. The characteristic function is:

$$\psi(t) = \int_0^{\infty} e^{itx} \rho(x) dx = \lambda \int_0^{\infty} e^{-x(\lambda - it)} dx = \frac{\lambda}{\lambda - it}$$

3. The variance of an exponential random variable $X$ is:

$$var(X) = \frac{1}{\lambda^2}$$

## 3. EXAMPLES

In a port container terminal the ships upon arrival may be attended to immediately or may have to wait until the server is free. With queueing theory we can suggest ways to improve the efficiency of a service and we can say if the port container terminal has a optimal berth numbers.

Efficiency indices for queueing system are:

$\rho = \frac{\lambda}{\mu}$ - traffic density

$l_q$ - expected number of ships in queue

$w_q$ - expected waiting time in queue

$\lambda$ - represents the average number of container ships witch arrive at a terminal during a day.

We suppose that the service time is exponential with mean $\mu = 15$ ships/hour. The arrival rate of ships at one berth be approximated by Poisson distribution with arrival rate of one in 10 minutes means average number of ships arriving is 6 /hours.

We calculate the various performance measures:

$$\rho = \frac{\lambda}{\mu} = \frac{6}{15} < 1$$

which means that one berth is sufficient.
In this event the number of berth should not be increased until the service system stability condition that the utilization coefficient of the system $\rho = \frac{\lambda}{\mu} < 1$ has been satisfied.

$$w_g = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{6}{15 \cdot 11} = \frac{2}{55} \text{ hour}$$

$$l_q = 6 \cdot \frac{2}{55} = \frac{12}{55} \approx 0{,}2$$

Determination of the optimum number of berths needed in a port container terminal is very important because that will minimize the total port usage costs.

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# CONVERGENCE RITZ GALERKIN METHOD DISTURBED

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**ABSTRACT**

Ritz approximated $\{\hat{x}_n\}$ are projections of the element $\hat{x}$ corresponding subspaces $\{H_n\}$ but reported a variable scalar product $[x,y]_{\theta_n}$ .

**Keywords:** *F.E. Browder's projection methods and W.V. Petryshyn.*

## 1. INTRODUCTION

The present document contains the results of FE's Browder, W.V. Petryshyn [1] - [6] for the projection methods.

Galerkin method was used for convergence result perturbed Galerkin method [13] and the result given by GM Vainikko of [14].

For the numerical solution of equations cvasilinear Ritz-Galerkin methods (projection) used the work of RS Varga, MH Schultz and PG Ciarlet [7], [8].

The notion of topological degree, useful in screening methods, is found widely exposed in G.Marinescu [12].

For monotony and elements of functional analysis we used [12].

For recent results on the problem of eigen values for nonlinear operators send to [9], [10], [11].

## 2. RITZ-GALERKIN METHODS

For A-proper operators we define a generalized concept of topological degree in relation to a scheme for approximating the time.

Let be $X$ and $Y$ a real Banach spaces, $D$ a lot bounded open in $X$, $\overline{D}$ its closure, $FrD$ its boundary.

*Definition 1.1.* Let $T$ be a continuous map from $D$ to $Y$, A-proper with respect to time approximation scheme

$$\Gamma_n = \{X_n, Y_n, P_n, Q_n\}$$

with $Q_n$ linear operators.

Let $g$ be a point of $Y-T$ ($FrD$); $D_n = D \cap X_n$; $T_n = Q_n T \big| D_n$, and $Z$ is the set of integers.

We define $Grad(T,D,g)$ - degree of $T$ on $D$ in $g$ of relation to the approximation scheme $\Gamma_n$ as a subset of the set $Z \cup \{\pm\infty\}$.

1. The entire $m \in Grad(T,D,g)$ if there is an infinite sequence of integers $\{n_k\}$ such that $Grad(T_{n_k}, D_{n_k}, Q_{n_k} g)$ be defined and equal to $m$ (see Brower's degree).

2. $\pm\infty \in Grad(T,D,g)$ if there is an infinite sequence of natural numbers $\{n_j\}$ such that $Grad(T_{n_j}, D_{n_j}, Q_{n_j} g)$ defined and $Grad(T_{n_j}, D_{n_j}, Q_{n_j} g) \to \pm\infty$ when $n_j \to \infty$.

*Observation* . There is an index $N$ such that $n > N$, $Q_n g \notin T_n(FrD_n)$ then $Grad(T_n, D_n, Q_n g)$ is defined.

Otherwise, there is sequence of integers $\{n_k\}$ and sequence $\{x_{n_k}\}$ with $x_{n_k} \in FrD_{n_k}$ such that $T_{n_k} x_{n_k} = Q_{n_k} g$ .

As $T_{n_k} x_{n_k} = Q_{n_k} g \to g$ when $k \to \infty$ and $T$ is A-proper, exist sequence $\{x_{n_{k(l)}}\}$ that converges to $x \in X$ when $l \to \infty$ and $Tx = g$. But $x \in FrD$ because $x_{n_{k(l)}} \in FrD_{n_{k(l)}} FrD$, i.e. $Tx = g$ equation has solution on the boundary of $D$, in contradiction with what we assumed.

Properties of generalized topological degree defined above are similar to those of Brower's classic degree. So we:

*Theorem 1.2.* If $Grad(T,D,g) \neq \{0\}$, equation $Tx = g$ is in the $D$ at least one solution.

*Theorem 1.3.* If $T$ is a continuous map of $\overline{D} \times [0,1]$ in $Y$, noting $T_t x = T(x,t)$, suppoze that $T_t$ is uniformly continuous in $t \in [0,1]$ in relation to $x \in \overline{D}$, and $T_t$ is A-proper in relation to the approximation scheme $\Gamma_n$ for any $t$. In this case, if $g \notin T(FrD \times [0,1])$, results that $Grad(T_t, D, p)$ is independent of $t$ in the interval $[0,1]$.

$X$ and $Y$ be two real Banach spaces and $T: X \to Y$ operator A-proper in relation to an approximation scheme $\Gamma_n = \{X_n, Y_n, P_n, Q_n\}$ and equation $Tx = g$. Let $D$ be a set bounded in $X$, $\overline{D}$ be its closure, $FrD$ - its boundary, $g$ a point of $Y-T(FrD)$. Suppose that $Grad(T,D,g)\neq\{0\}$.

Approximated equations are

$$T_n x = Q_n g \quad (T_n = Q_n T/_{D_n}).$$

Perturbed equations will be

$$T_n x + S_n x = Q_n g. \qquad (1)$$

Suppose that the operators of disturbance, $S_n$, are continuous in $X_n$ and in addition

$$\sup_{x\in \bar{D}_n}\|S_n x\| \to 0 \quad when \quad n\to\infty \qquad (2)$$

(where $\overline{D}_n$ is the set resulting from $X_{n\cap\bar{D}}$) .

In these circumstances we have the following result:

*Theorem 1.4.* For large enough $n$, perturbed equations (1) admit at least one solution, in addition

$$\sup_{x\in K_n}\rho(x_n,K_0)\to 0 \quad when \quad n\to\infty \qquad (3)$$

where $\{K_n\}$ are the sets of solutions of equations (1.1), $K_0$ is the set of solutions to equation $Tx=g$, and $\rho(x_n,K_0)$ is distance from a point a lot.

## 3. CONVERGENCE GALERKIN METHOD

Using the above data we have the following result:

*Theorem 1.5.* If the conditions of Theorem 1.4 are satisfied and the equation $Tx=g$ has the isolated solution $x_0\in D$ nonzero index, there is a $\delta_0>0$ and a $N_0$ with the property that $n>N_0$, perturbed equations admit at least one solution and there is

$$\|x_n - x_0\|\to 0 \quad when \quad n\to\infty.$$

Indeed it suffices to consider instead the set $D$ sphere $\|x-x_0\|<\delta_0$ sufficiently small radius $\delta_0$.

Note that a completely continuous operator (see [5]) which turns a lot bounded in a compact set is A-proper.

Next we apply previous results to nonlinear integral equations.

Following nonlinear integral equation be:

$$x(t)=\int_a^b K(t,s,x(s))ds \qquad (4)$$

with kernel continuous.

Consider the following quadrature formula

$$\int_a^b z(s)ds = \sum_{j=1}\alpha_{jn} z(s_{jn}) + R_n(z) \qquad (5)$$

with $(a\le s_{1n}<s_{2n}<\ldots<s_{nn}\le b)$.

We consider the solution $x_0(t)$ of equation (5) its values in $s_{jn}$ interpolated nodes. Approximate values $\xi_{jn}=x_0(s_{jn})$ will be determined from the system of equations

$$\xi_{jn}=\sum_{j=1}^n \alpha_{jn}K(s_{in},s_{jn},\xi_{jn}) \quad (i=1,2,\ldots,n) \qquad (6)$$

System of equations (1.6) was obtained from the relation (1.4) using (5) with court that the rest $R_n(z)$ and giving of $t$ the sequence of values ... $s_{1n},\ldots,s_{nn}$.

We have the following result:

*Theorema 1.6.* For each $n$ are coefficients $\alpha_{jn}$ $(j=1,\ldots,n)$ in the quadrature formula (5), positive, involving relations (1.5) converge, ie:

$$R_n(z)=\int_a^b z(s)ds - \sum_{j=1}^n \alpha_{jn} z(s_{jn}) \to 0 \qquad (7)$$

when $n\to\infty$.

Then, if equation (4) has an isolated solution $x_0(t)$ and kernel $K(t,s,u)$ is continuous in all variables in region

$$a\le t,s\le b,\ x_0(s)-\delta\le u\le x_0(s)+\delta,\ \delta>0 \qquad (8)$$

for $n$ large enough, the set equations (1.6) admits solutions $\xi_{in},\ldots,\xi_{nn}$ and

$$\max_{1\le j\le n}\|\xi_{jn}-x_0(s_{jn})\|\to 0 \ when\ n\to\infty \qquad (9)$$

Indeed the relation (7) for $z(s)=1$ it follows

$$\sum_{j=1}^n \alpha_{jn}=(b-a)+\gamma_n, \quad \gamma_n\to 0\ when\ n\to\infty.$$

Let be

$$\beta_{jn}=\frac{b-a}{b-a+\gamma_n}\alpha_{jn}$$

and

$$\gamma_{jn}=\alpha_{jn}-\beta_{jn} \quad (j=1,\ldots,n). \qquad (10)$$

We have $\beta_{jn}>0$, $\sum_{j=1}^n\beta_{jn}=b-a$ and

$$\sum_{j=1}^n|\gamma_{jn}|=|\gamma_n|\to 0\ cand\ n\to\infty \qquad (11)$$

(all $\gamma_{jn}$ have the same sign with $\gamma_n$) .

Divide the interval $[a,b]$ by points as follows:

$$a,\ a+\beta_{1n},\ a+\beta_{1n}+\beta_{2n},\ldots,\ a+\sum_{j=1}^n\beta_{jn}=b$$

in $n$ intervals do not intersect

$$J_{1n}=[a;a+\beta_{1n}),\ J_{2n}=[a+\beta_{1n},a+\beta_{1n}+\beta_{2n})+ \\ +\ldots+,\ J_{nn}=[b-\beta_{nn},b].$$

We form subsets $D_{jn}\subset[a,b]$ $(j=1,\ldots,n)$ if $s_{jn}\in J_{jn}$ ($j=1,\ldots,n$) where

$$D_{jn}=J_{jn} \quad (j=1,\ldots,n)$$

such that the point $s_{jn}$ is transferred to $J_{jn}$:

$$D_{jn} = \left( J_{jn} / \bigcup_{i=1}^{n} s_{in} \right) \bigcup s_{jn} \quad (j = 1,...,n)$$

( $s_{jn}$ is a unique).

We have

$$s_{jn} \in D_{jn}, \bigcup_{j=1}^{n} D_{jn} = [a,b], \ D_{jn} \bigcap D_{in} = \Phi,$$

for $i \neq j$

$$mas(D_{jn}) = mas(J_{jn}) = \beta_{jn} \quad (j = 1,2,...,n).$$

$$d_n = \max_{1 \le j \le n} \sup_{s', s'' \in D_{jn}} |s' - s''| \to 0 \ when \ n \to \infty \qquad (12)$$

Relation (12) is not true in the following hypothesis:

- $J_{jn}$ intervals lengths do not converge to zero when $n \to \infty$.

If the square above does not converge, which contradicts the assumption made.

Interval length $J_{jn}$ is equal to $\beta_{jn}$. Exist $\beta_{j_k n_k}$ so that

$$\beta_{j_k n_k} \ge \eta \quad (k = 1,2,...,) \qquad (13)$$

where $\eta$ is a positive constant.

Suppose that

$$s_{j_k n_k} \to s_0 \in [a,b] \ when \ n \to \infty.$$

For a continuous function $z(s)$ on $[a,b]$, $z(s) = 1$ when $|s - s_0| \le \eta / 4$, and $z(s) = 0$ when $|s - s_0| \ge \eta / 2$, linear when $\eta / 4 \le |s - s_0| \le \eta / 2$, we have

$$\int_a^b z(s) ds = 3/4\eta \qquad (14)$$

(consider $s_0(a,b)$ and $\eta > 0$ i.e. $(s_0 - \eta, s_0 + \eta) \subset [a,b]$ when $s_0 = a$ or $s_0 = b$, the function $z(s)$ is built similar).

On the other hand for sufficiently large $k$ points $s_{j_k n_k}$ belong to the interval $|s - s_0| \ge \eta / 4$, where $z(s) = 1$, therefore

$$\sum_{j=1}^{n_k} \alpha_{j_k n_k} z(s_{j n_k}) \ge \alpha_{j_k n_k} .$$

Using relations (11), (13) for large enough we have

$$\sum_{j=1}^{n_k} \alpha_{j n_k} z(s_{j n_k}) \ge \beta_{j_k n_k} - \eta / 8 \ge \frac{7}{8}\eta .$$

Comparing the last relation with $\int_a^b z(s) ds = 3/4\eta$, it follows that the square (5) does not converge to the function $z(s)$ as built.

Let $A$ be Banach space of measurable bounded functions $x(s)$ on $[a,b]$ with $\|x\| = \sup_{a \le s \le b} x(s)$. Operator

$$Tx = \int_a^b K(t, s, x(s)) ds$$

Is completely continuous, because $K(t,s,u)$ is continuous (8) on sphere $\overline{\Omega}(\|x - x_0\| \le \delta)$ as an operator $A$ in space $C$ of continuous functions on $[a,b]$.

Let $\chi_{jn}(s)$ crowd $D_{jn}$ characteristic function, i.e.

$$\chi_{jn}(s) = \begin{cases} 1 & when \ s \in D_{jn} \\ 0 & when \ s \notin D_{jn}, \ (j = \overline{1,n}) \end{cases} .$$

Let $A_n$ covering linear functions $\chi_{jn}(j = \overline{1,n})$, which is a closed linear subspace $A$.

We define the operator $T_n$ on $\overline{\Omega_n} = \overline{\Omega} \cap A_n$ as follows:

$$T_n z_n = \sum_{i=1}^{n} \left( \sum_{j=1}^{n} \alpha_{in} K(s_{in}, s_{jn}, \xi_j) \right) \chi_{in}$$

$$(z_n = \sum_{j=1}^{n} \xi_j \chi_{jn} \in \overline{\Omega_n}).$$

Functions $\chi_{in}(i = \overline{1,n})$ are linearly independent, then system (6) is equivalent to the operational equation

$$x_n = T_n x_n \qquad (15)$$

in space $A_n$.

Vector $(\xi_{1n},...,\xi_{nn})$ will be a solution of system (6) if and only if the element

$$x_n = \sum_{j=1}^{n} \xi_{jn} \chi_{jn}$$

is a solution of equation (15).

Introducing the operator $P_n$ as follows:

$$P_n x = \sum_{j=1}^{n} x(s_{jn}) \chi_{jn}.$$

Obviously $P_n(A) = A_n$ si $P_n z_n = z_n$ for $z_n \in A_n$, so $P_n$ is the linear projection on $A_n$, $P_n$ is bounded, $\|P_n\| = 1$, furthermore, for any function $x(s)$ continue on $[a,b]$ .we have

$$\max_{a \le s \le b} \left| x(s) - \sum_{j=1}^{n} x(s_{jn}) \chi_{jn}(s) \right| \to 0$$

when $n \to \infty$, according to (12).

The sequence of operators $P_n$ is strongly convergent to the operator's dive $C$ in space $A$.

The equation $x_n = T_n x_n$ can be written as

$$x_n = P_n T x_n + S_n x \qquad (16)$$

($S_n = T_n - P_n t$). The operator $S_n$ is completely continuous $\overline{\Omega_n}$ (is continuous on a finite-dimensional space).

For $z_n = \sum_{j=1}^{n} \xi_j \chi_{jn} \in \Omega_n$ using (10) and (12) we have

$$S_n z_n = T_n z_n - P_n T z_n =$$

$$= \sum_{i=1}^{n} \left\{ \sum_{j=1}^{n} \alpha_{jn} K(s_{in}, s_{jn} \xi_j) - \int_0^b K(s_{in}, s, z_n(s)) \right\} \chi_{in} =$$

$$= \sum_{i=1}^{n} \left\{ \sum_{j=1}^{n} \int_{D_{jn}} \left[ K(s_{in}, s_{jn}, \xi_j) - K(s_{in}, s, \xi_j) \right] dy \right\} \chi_{in} +$$

$$+ \sum_{i=1}^{n} \left\{ \sum_{j=1}^{n} \gamma_{jn} K(s_{in}, s_{jn}, \xi_j) \right\} \chi_{in}.$$

For $y_n = \sum_{i=1}^{n} \eta_i \chi_{in}$ we have $\|y_n\| = \max_{1 \le i \le n} |\eta_i|$, and $v_n = \sum_{i=1}^{n} \left\{ \sum_{j=1}^{n} \int_{D_{jn}} v_{ij}(s) ds \right\} \chi_{in}$ we have

$$\|v_n\| \le \max_{1 \le i \le n} \left| \sum_{j=1}^{n} \int_{D_{jn}} v_{ij}(s) ds \right| =$$

$$= \max_{1 \le i, j \le n} \sup_{s \in D} |v_{ij}(s)| \sum_{k=1}^{n} \int_{D_{jn}} ds =$$

$$= (b-a) \left( \max_{1 \le i, j \le n} \sup_{s \in D} |v_{ij}(s)| \right).$$

When

$$\|S_n z_n\| \le (b-a) \max_{1 \le i, j \le n} \sup \Big| K(s_{in}, s_{jn}, \xi_j) -$$

$$- K(s_{jn}, s, \xi_j) \Big| + \sum_{k=1}^{n} |\gamma_{kn}| \max_{1 \le i, j \le n} |K(s_{in}, s_{jn}, \xi_j)|.$$

Using relations (11) and (13) and uniform continuity of the kernel $K(t,s,u)$ in relation (1.8) we have

$$\sup_{x \in \overline{\Omega}_n} \|S_n x\| \to 0 \quad when\ n \to \infty \qquad (17)$$

Applying Theorem 1.5. and Theorem 1.6. and considering the

$$\max_{1 \le j \le n} |\xi_{jn} - x_0(s_{jn})| = \|x_n - P_n x_0\| \le \|x_n - x_0\| \quad (18)$$

have obtained the desired result.

## 4. CONCLUSIONS

Ritz approximated $\{\hat{x}_n\}$ are projections of the element $\hat{x}$ corresponding subspaces $\{H_n\}$ but reported a variable scalar product $[x, y]_{\theta_n}$.

It shows that convergence of elements $\hat{\omega}_M(x)$ the solution $\varphi(x)$ made the problem much simpler initial results and the strength of these results given by R.S. Varga, M. H. Schultz and P.G. Ciarlet accounts work the way chosen by the authors in [7].

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# SECTION V
## ENGLISH FOR SPECIFIC PURPOSES

# DEVELOPING A GRAMMAR BOOK FOR SEAFARERS

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**ABSTRACT**

The problem of developing a grammar book for seafarers arises in connection with preparing teaching/learning materials for Maritime English learners at each and every stage of their training. Should Maritime English teachers leave grammar to general English teachers? What could be the contents of a specialized grammar book? How could we arrange the materials in it? How should it correspond to the general English grammar syllabus? All these questions must be solved in order to avoid mismatches or simplifications in the process of ME training. For ESP teachers the GE grammar topics are obviously the basis in producing a purely ESP grammar material aiming to meet the students' needs. This work presumes a substantial linguistic research in ME texts involving the study in theory and practice of ESP. The paper presents the primary notions on the problem and suggests a sample of the grammar topic "Passive Voice" developed for the students of Maritime English at ESP Department of Kyiv State Maritime Academy.

**Keywords:** *EGP, ESP, A Grammar Book for Seafarers.*

## 1. INTRODUCTION

It is well known that one of the biggest differences between general English (GE) course books and ESP course books is that GE books tend to be driven by a traditional grammar syllabus: *Unit 1: Present Simple and Continuous; Unit 2: Past Simple; Unit 3: Present Perfect; Unit 4: The Future* ... Not so with ESP course books. In ESP the syllabus is very much topic-driven. What's more, the grammar is often field-specific, i.e. covering grammar topics that are unique to that ESP field. According to some practitioners, there's so much specific grammar work that does need to be taught in ESP books [Grammar syllabuses for ESP:1. In case of Maritime English we come across very specific grammar items, for example, imperatives in the texts of SMCP, abundance of N+N constructions and compound nouns ('lifeboat', 'life-boat', 'life boat'), specific applications of modal verbs ('shall'), conditional sentences in 'The Rules of the Road', etc. The grammar topic 'Comparisons' in ESP context will be quite different from EGP practice: it is more sensible to compare vessels, or marine diesel engines instead of apples or books.

Thus, the solution comes with the project of creating a specialised Grammar Book for Seafarers which must

- be designed to our own students' needs;
- be field-specific, i.e. covering grammar topics that are unique to that ESP field;
- based on authentic materials which belongs to a particular ESP field;
- combine traditional grammar + difficult things like original language work;
- contain all the target grammar structures making a certain system;
- actually integrate a whole grammar syllabus into an ESP course;

foresee a strong, systematic grammar syllabus.

## 2. GRAMMAR SYLLABUS FOR MARITIME ENGLISH

The grammar syllabus has been worked out on the basis of the following principles: taking into account students' regular mistakes, statistical data on language peculiarities in Maritime texts, communicative value.

The list of topics is given below:

1. A sentence. Types of sentences
2. Word order
   1.1 Basic structures
   1.2 Imperative mood
   1.3 Capitalization
   1.4 Sentence borders
   1.5 Punctuation
   1.6 Types of questions
   1.7 Auxiliary verbs
   1.8 Question words
3. Parts of speech
4. Numerals and numbers
5. Noun area
6. Names and nominations
7. N+N (+N) Compound nouns
8. Geographical names
9. Conversion V – N
10. Derivation. Affixes
11. Word formation.
12. Set expressions.
13. Verb area
14. S and P coordination
14. 4 forms of the verb
15. Irregular verbs
16. Infinitive. Participles
17. Time and Tense
18. System of English tenses
19. Active and passive voice
20. Verb and object coordination
21. Phrasal verbs
22. Modal verbs
23. Objects
24. Modifiers

25. Sequence of tenses
26. Reported speech
27. Types of texts
28. Text connectors
29. Writing
30. Spelling
31. Misspelled words
32. Abbreviations and Acronyms
33. Telexes at sea. Emails. Notes. Letters
34. Supplements: grammar tables.

The attention has been given to the fact that much of grammar work goes beyond traditional sentence-level grammar practice to encompass awareness of the use of the grammatical forms in a specific context. The context determines what aspects of grammar is appropriate. Certain very specific contexts will involve very particular uses of grammar, and the ESP teacher needs to be sensitive to these contexts [Dudley-Evans 1998:80].

## 3. SAMPLE GRAMMAR MATERIAL

The grammar sample suggested in this paper has been worked out after substantial text selection and thorough vocabulary analysis. It is spread among students as a worksheet and serves as a reference both in vocabulary and grammar. This synthetic material has been proven to be rather efficient in the language classroom activities.

ACTIVE VOICE: Engineers *design* new vessels
PASSIVE VOICE: New vessels *are designed* by engineers

TENSES IN PASSIVE VOICE
Present The new vessel/vessels is/ are designed.
Present perfect The new vessel/vessels has been/ have been designed.
Past The new vessel/vessels was/ were designed.
Past perfect The new vessel/vessels had been designed.
Future The new vessel/vessels will be designed.
Future perfect The new vessel/vessels will have been designed.
Present progressive The new vessel/vessels is being/ are being designed.
Past progressive The new vessel/vessels was being/ were being designed.

VERBS MOST FREQUENTLY USED IN ME TEXTS:
- to abandon, to be abandoned; to add, to be added; to access, to be accessed; to apply, to be applied; to analyze, to be analyzed; to anticipate, to be anticipated; to avoid, to be avoided; to assemble,to be assembled; to assess, to be assessed; to assign, to be assigned; to balance, to be balanced; to bring, to be brought; to buy, to be bought; to blow, to be blown; to break /down/, to be broken /down/; to blast, to be blast; to boil, to be boiled; to block, to be blocked; to build, to be built; to carry, to be carried; to cancel, to be cancelled; to clean, to be cleaned; to close, to be closed; to create, to be created; to cut /off/, to be cut /off/; to clear, to be cleared; to cover, to be covered; to construct, to be constructed; to cross, to be crossed; to combine, to be combined; to count, to be counted; to calculate, to be calculated; to correct, to be corrected; to change, to be changed; to charge, to be charged; to conclude, to be concluded; to compile, to be compiled; to complete, to be completed; to catch, to be caught; to confuse, to be confused; to consider, to be considered; to cool, to be cooled; to discover, to be discovered; to dissolve, to be dissolved; to damage, to be damaged; to drill, to be drilled; to design, to be designed; to destroy, to be destroyed; to demolish, to be demolished; to define, to be defined; to deny, to be denied; to drain, to be drained; to dry, to be dried; to dredge, to be dredged; to drag, to be dragged; to demonstrate, to be demonstrated; to decrease, to be decreased; to delete, to be deleted; to do, to be done; to defreeze, to be de-frozen; to dismantle, to be dismantled; to disable, to be disabled; to draw, to be drawn; to distinguish, to be distinguished; to delay, to be delayed; to export, to be exported; to enter, to be entered; to enlarge, to be enlarged; to embark, to be embarked; to evaluate, to be evaluated; to establish, to be established; to engine, to be engined; to evapourate, to be evapourated; to gear, to be geared; to grant, to be granted; to guarantee, to be guaranteed; to gather, to be gathered; to fire, to be fired; to finish, to be finished; to fine, to be fined; to free, to be freed; to find, to be found; to found, to be founded; to finance, to be financed; to form, to be formed; to foul, to be fouled; to fix, to be fixed; to fit, to be fitted; to fight, to be fought; to frighten, to be frightened; to fasten, to be fastened; to freight, to be freighted; to freeze, to be frozen; to fuel, to be fueled; to gain, to be gained; to give, to be given; to generate, to be generated; to govern, to be governed; to gear, to be geared; to hold, to be held; to hoist, to be hoisted; to hinder, to be hindered; to harm, to be harmed; to hear, to be heard; to hire, to be hired; to handle, to be handled; to house, to be housed; to heel, to be heeled; to invent, to be invented; to invest, to be invested; to innovate, to be innovated; to instruct, to be instructed; to increase, to be increased; to insert, to be inserted; to introduce, to be introduced; to impact, to be impacted; to injure, to be injured; to incinerate, to be incinerated; to inform, to be informed; to incline, to be inclined; to include, to be included; to involve, to be involved; to insure, to be insured; to inquire, to be inquired; to initiate, to be initiated; to induce, to be induced; to import, to be imported; to install, to be installed; to jettison, to be jettisoned; to jet, to be jetted; to join, to be joined; to jam, to be jammed; to knot, to be knotted; to lease, to be leased; to lower, to be lowered; to lose, to be lost; to loose, to be loosen; to light, to be lighted; to level, to be leveled; to load, to be loaded; to lubricate, to be lubricated; to let, to be let; to link, to be linked; to measure, to be measured; to mend, to be mended; to man, to be manned; to manufacture, to be manufactured; to misunderstand, to be misunderstood; to moor, to be moored; to meet, to be met; to mention, to be mentioned; to move, to be moved; to maneuver, to be maneuvered; to mix, to be mixed; to mount, to be mounted; to note, to be noted; to notice, to be noticed; to notify, to be notified; to negotiate, to be negotiated; to neglect, to be neglected; to near, to be neared; to open, to be opened; to oil, to be oiled; to own, to be owned; to oversee, to be overseen; to overdo, to be overdone; to pack, to be

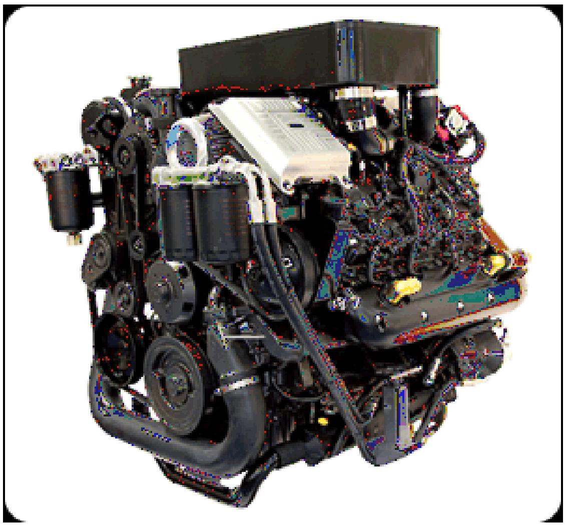
packed; to put, to be put; to plug, to be plugged; to push, to be pushed; to pull, to be pulled; to press, to be pressed; to prevent, to be prevented; to praise, to be praised; to power, to be powered; to post, to be posted; to plunge, to be plunged; to purify, to be purified; to pump, to be pumped; to pick up, to be picked up; to qualify, to be qualified; to quench, to be quenched; to restore, to be restored; to range, to be ranged; to rank, to be ranked; to reconstruct, to be reconstructed; to renew, to be renewed; to regenerate, to be regenerated; to rule, to be ruled; to roll, to be rolled; to recommend, to be recommended; to rinse, to be rinsed; to rescue, to be rescued; to rebuild, to be rebuilt; to run, to be run; to require, to be required; to report, to be reported; to send, to be sent; to store, to be stored; to stow, to be stowed; to stop, to be stopped; to sponsor, to be sponsored; to survey, to be surveyed; to simulate, to be simulated; to switch, to be switched; to supply, to be supplied; to spoil, to be spoiled; to search, to be searched; to start, to be started; to smell, to be smelled; to steer, to be steered; to stabilize, to be stabilized; to sell, to be sold; to ship, to be shipped; to select, to be selected; to spend, to be spent; to secure, to be secured; to save, to be saved; to salvage, to be salvaged; to support, to be supported; to spoil, to be spoiled; to smash, to be smashed; to separate, to be separated; to see, to be seen; to speak, to be spoken; to trade, to be traded; to transfer, to be transferred; to transmit, to be transmitted; to transport, to be transported; to transform, to be transformed; to turn, to be turned; to troubleshoot, to be troubleshot; to treat, to be treated; to try, to be tried; to test, to be tested; to use, to be used; to utilize, to be utilized; to unload, to be unloaded; to understand, to be understood; to violate, to be violated; to visit, to be visited; to wear, to be worn; to work out, to be worked out; to watch, to be watched; to weigh, to be weighed; to wreck, to be wrecked; to welcome, to be welcome.

*Analyse verb forms in passive voice in the following texts:*

*Text 1.*

Today, the vast majority of non-bulk cargo is transported in intermodal containers. The containers

arrive at a port by truck, rail or another ship and are stacked in the port's storage area. When the ship that will be transporting them arrives, the containers that it is offloading are unloaded by a crane. The containers either leave the port by truck or rail or are put in the storage



area until they are put on another ship. Once the ship is offloaded, the containers it is leaving with are brought to the dock by truck. A crane lifts the containers from the trucks into the ship. As the containers pile up in the ship, the workers connect them to the ship and to each other.

*Verbs used in passive*: to be transported, to be stacked, to be unloaded, to be offloaded, to be brought

*Text 2.*

All Marine diesel VGT Common-Rail engines are based on the 6.6L V8 configuration and are designed to be as compact and light weight as possible while maintaining durability and serviceability. The VGT350 is intended for medium to high speed vessels and has a light duty rating (Medium Duty as option). Laptop based diagnostics tool is available for all VGT and TSC engines.

*Verbs used in passive*: to be based, to be designed, to be intended

*Text 3.*

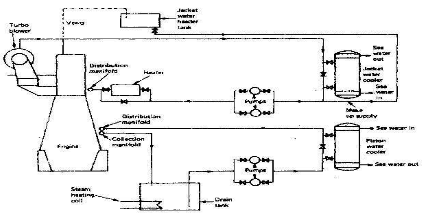
*What Is Scavenging?* For a better combustion of fuel oil inside a marine diesel engine, an adequate supply of fresh air is needed. The method by which sufficient amount of air is provided to the engine's cylinder is known as *scavenging.* Scavenging is generally provided by the engine's turbo-charging system. Turbochargers are provided with the engine to use the exhaust gases in order to supply a consistent flow of fresh air inside the main engine. Scavenging is not the same for both two stroke and four stroke engines. This is mainly because in the four- stroke engine there is adequate overlap between the opening of the inlet valve and closing of the exhaust valve. But in a two-stroke engine this overlap is limited and for this reason a slight mixture of exhaust gases and incoming air occurs inside the cylinder. Also, in a four stroke engine the air is induced during a downwards stroke of one of the two cycles, i.e per power stroke, and the exhaust gases are removed in the preceding stroke. But in a two stroke engine there is no specific cycle of scavenging. Air is introduced during the end of power stroke when the exhaust gases are removed. The time of scavenging is too less in two stroke engines, as greater the exhaust valves stay open lesser the time the piston gets for compression. To prevent the effects due to this phenomenon, more amount of fresh air is supplied. Thus, greater the scavenging better the combustion of fuel.

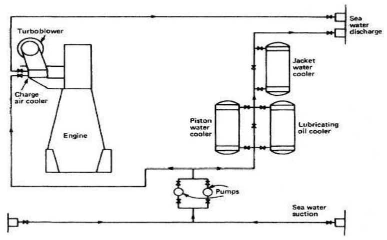
*Scavenging methods.* The different types of scavenging methods are based on the location of scavenge ports and design and shape of engine's exhaust arrangement. There are mainly three types of scavenging systems :1) Cross flow 2) Loop 3) Uni-flow . The main difference between the first two system and the uni-flow system is that the former ones require the movement of piston to open and close ports, while the later one requires an exhaust valve for the scavenging to take place. The sudden release of pressure from the cylinder is known as blowdown and its effects can be seen on the power card towards the end of the cycle. The piston moves further downward and opens the inlet port to let a fresh stock of air enter the cylinder. The piston again moves up, compressing the fresh air for the next combustion cycle.

*Verbs used in passive:* to be needed, to be provided, to be limited, to be induced, to be introduced, to be supplied, to be based, to be known.

*Text 4.*

MARINE ENGINE COOLING SYSTEM





*Fresh water cooling system (Figure 1)* A water cooling system for a slow-speed diesel engine is shown in Figure. It is divided into two separate systems: one for cooling the cylinder jackets, cylinder heads and turbo-blowers; the other for piston cooling. The cylinder jacket cooling water after leaving the engine passes to a sea-water-circulated cooler and then into the jacket-water circulating pumps. It is then pumped around the cylinder jackets, cylinder heads and turbo-blowers. A header tank allows for expansion and water make-up in the system. Vents are led from the engine to the header tank for the release of air from the cooling water. A heater in the circuit facilitates warming of the engine prior to starting by circulating hot water. The piston cooling system employs similar components, except that a drain tank is used instead of a header tank and the vents are then led to high points in the machinery space. A separate piston cooling system is used to limit any contamination from piston cooling glands to the piston cooling system only.

*Sea water cooling system (Figure 2)* The various cooling liquids which circulate the engine are themselves cooled by sea water. The usual arrangement uses individual coolers for lubricating oil, jacket water, and the piston cooling system, each cooler being circulated by sea water. Some modern ships use what is known as a 'central cooling system' with only one large sea-water-circulated cooler. This cools a supply of fresh water, which then circulates to the other Individual coolers. With less equipment in contact with sea water the corrosion problems are much reduced in this system. From the sea suction one of a pair of sea-water circulating pumps provides sea water which circulates the lubricating oil cooler, the jacket water cooler and the piston water cooler before discharging overboard. Another branch of the sea water main provides sea water to directly cool the charge air (for a direct-drive two-stroke diesel).

*Verbs used in passive*: to be shown, to be divided, to be pumped, to be used, to be led, to be cooled, to be circulated, to be reduced

## 4 CONCLUSIONS

a) The teaching/learning materials in general grammar are intended for Maritime students who have different levels of their general language proficiency. It makes the Course of traditional English grammar necessary as a basic subject.
b) The teaching/learning materials in grammar for specific purposes accompany the Course of Maritime English aiming the considerable increase of the students' motivation . This very fact shows how specific the Maritime Course is.
c) Being very time-consuming in prior researches and selection of the most appropriate samples, the work on preparing A Grammar Book for Seafarers is awarded in development of students' communicative skills. Where students have grammatical difficulties that interfere with the essentially productive skills of speaking and writing, or the essentially receptive skills of listening and reading , it is necessary to pay attention to those difficulties [Dudley-Evans 1998:74].
d) A Grammar Book for Seafarers is a systemic Course which in its turm presumes a systemic practical realisation according to the scheme: 1. analysis of a particular grammar phenomenon, 2. description of its form, 3. practice in use through excercises, 4. study of a context/contexts, 5. practice in reproductive activities, 6. stability in gramatical accuracy and fluency when using Maritime English.

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# PARTICULARITIES CONCERNING THE STUDY OF MARITIME ENGLISH AS A NECESSITY FOR NOWADAYS APPRENTICES

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**ABSTRACT**

Maritime English proved to be a very important part of a future navigating officer's training and it will still gain in importance as long as the shipping industry is in progress. It's only up to young seafarers to get acquainted with Maritime English as their lives, other crew members' lives and the ship's integrity might depend on this particular aspect. When students that are not native English go on board merchant vessels for the first time to be Apprentice Deck Officers they find it hard to learn anything from experienced Officers who are speaking to them in English and also these Officers are not always speaking the most correct English. As it is well known, most of maritime accidents happen due to human errors and these occur especially because of bad communication. This is a result of not using standard Maritime English that should be well known by all crew members of a ship, with a special attention drawn towards young Apprentices. Because the concept of a single nationality crew is no longer met in the world shipping industry, proper communication can be achieved only by using Maritime English focusing especially on young Apprentices as they are the mistakes sensitive ones.

**Keywords:** *maritime English, apprentice, ship, maritime university, communication.*

## 1. INTRODUCTION

Nowadays it is well known all around the shipping industry that English is the main and only language that should be used in any type of maritime communication. Even so, more and more people, especially students of Maritime Universities from countries where a different language is used for teaching, have trouble understanding the importance of speaking English. Their English language should also be fluent and easily understandable by all the other members of the team or crew that are not native English.

English is the international language that is used worldwide and therefore the shipping industry accepted it as the main language on board ships and in communications ship-to-ship and ship-to-coast. In this era of globalisation, the Apprentice Deck Officers wishing to go on board merchant ships cannot afford to be left out for not mastering English. This is the main reason for which teachers from Maritime Universities all over the world should try to explain to their students the importance of knowing Maritime English. It does not matter the subject that the teacher has to teach during his/her classes as long as the specific maritime courses would have the key words attached in English.

It is worth noting that the new learners (in this case students from a Maritime University) of a language (English language) really do need to build a solid foundation of knowledge and it is useful for them that all of their teachers know and control Maritime English. It should become really easy for them to use some important maritime terms used daily on board ships and in any type of communications.

During the last years, it has been noticed the appearance of an important system inside Maritime Education and Training and that is training the Deck Apprentices by using the simulators. It has been generally agreed that the graduates of Constanta Maritime University need a proper training regarding Maritime English during the study years by using simulators in order to keep up with the changes that occur on board a merchant ship due to: advances made in Maritime Education and Training as a direct result of equipment development, smaller crews that can operate ships exactly in the same way and at the same level of professionalism as the larger crews used until recently, reduced time spent in ports for ship's operations and so on. The modern Deck Officer must understand the basic concepts of the navigation systems used nowadays and in order to accomplish this they need a proper Maritime English to evaluate their output's accuracy and finally getting the right possible navigational decisions. For a new Deck Apprentice embarked onboard a merchant ship for the first time it is important to know an adequate Maritime English and this can be obtained only by a proper training including training on simulators.

## 2. SEA LANGUAGE – MARITIME ENGLISH

The need for effective communications at sea and ashore is internationally well known by all the shipping industry and the seafarers are obliged to gain the appropriate skills and knowledge to communicate effectively and efficiently.

Communication is an essential part of human interaction. The benefits of effective communication are many and obvious as they enhance all aspects of our personal and professional lives.

Ineffective or misunderstood communications in our personal lives may give rise to problems or embarrassment but in our professional lives the results of misunderstandings may have much more serious results. In the world of international shipping, with seafarers from many countries sailing on ships all over the world, effective communication ship-to ship and ship-to-coast is vitally important.

Today it is quite normal for ships around the world to sail with a compliment of twelve able crew members. It is also possible for this very same vessel to sail around with twelve completely different nationalities, all speaking English daily, all communicating, socializing and swearing in that one common language. All of them have learnt and maybe most of them are still learning to use English on a daily basis at work and as the communication language.

Twenty years ago a certain vessel ended up aground not five minutes after exiting Falmouth dry dock. Whilst the damage was not great and the vessel managed to scrape herself off the mud to proceed on her way (after suitable inspection and a new Master), the event occurred simply due to the language barrier on board. The very frustrated Chinese Captain was at the moment of the grounding, spitting hysterically into the mouthpiece of the bridge phone in Mandarin. He was obviously trying to educate the Nigerian Chief Engineer below, who was by then shrivelled in fear underneath the console, that he needed an astern movement on the engine. Due to the serious lack of a common language, regulations, like the one produced by IMO, came into being.

It can also be pointed out that many ships floating around today are filled from top to bottom with some weird speaking Scotsmen that even a Scottish lowlander cannot understand (some say this is not English, more like a group of people clearing their throats in a loud and unapologetic fashion) and others have noted that some ships sail around with Singaporeans who have created their own English language which again nobody can understand and that comes without a dictionary, but this anomaly might have to be accepted without question.

No law in this world, no dictionary, translator or reduction in salary is going to make a Scotsman or Singaporean talk in understandable English so whilst all other nations have made great effort to learn the language and to use it in favour of their own tongue, they will just have to accept the fact that half of those whose mother tongue is English can't be understood by anybody else.

IMO analyses reports of casualties and accidents in order to see if there are any lessons to be learned for the future. Many accidents are found to be due mainly to operational issues of proper procedure, maintenance and design, rather than to proper implementation of regulations, but effectiveness of bridge resource management and particularly ineffective relationships between Master, crew and pilot are recurrent themes. Communication difficulties often occur in these areas due in part to cultural differences but also due to language 'barriers' which seem to be a big problem as the crew members do not want to acknowledge the fact that communication (especially a proper one which implies using an English language that can be understood by anybody) is very important if you want a safe voyage from point A to point B.

Because most maritime accidents are caused by human error, notably breakdowns in communication or cooperation, the legislation nowadays emphasizes the importance of the English language proficiency in relation to safety at sea. Instruction and practice of maritime English for communication and cooperation is an important element in maritime education.

Maritime English is to a great extent restricted to IMO Standard Marine Communication Phrases, which builds on a basic knowledge of English and has been drafted in a simplified version of maritime English. It includes phrases for use in routine situations such as berthing as well as standard phrases and responses for use in emergency situations. Under the STCW 1978, as amended, the ability to understand and use the SMCP is required for the certification of officers in charge of a navigational watch on ships of 500 gross tonnage or above.

An integrated bridge simulation system is primarily designed and introduced to train and develop potential cadets and officers with the necessary knowledge and skills in properly and correctly stipulating and managing a vessel.

Whereas a new and alternative use of the integrated bridge simulation system has been discussed and proven to be suitable and effective in training and assessing communication skills, especially in contextualizing the practice of the mandatory part of the IMO SMCP, reinforcing the trainees to play different roles in a realistic atmosphere and environment.

It has been decided that most of the scenarios and contents in SMCP can be flexibly designed or tailored and properly practiced in an integrated bridge simulation system based environment. The key task then is how to organize and implement the syllabus of maritime English teaching and learning via this effective learning by pedagogic methodology.

A multitude of new methodologies have been explored and discussed in recent years in an attempt to approach the training and testing the proficiency of maritime English that meets the international standards laid out in STCW.

Among those trendy guidelines, utilizing integrated bridge simulation system in a bridge activities context is deemed as one of the most effective experiential learning and training methods, which will allow the trainees accustomed to a workplace environment to expand their practice little by little, so that they may communicate and pass messages with confidence when taking up their future jobs onboard.

In the light of many previous discussions in the aspect of using integrated bridge simulation system in maritime English practice, it can be concluded that affirmativeness in the possibilities is obvious.

However, solutions in combining this technology with operational teaching and assessing maritime communications especially with coursework deign has not much been referred to. Using the integrated bridge simulation system can assist maritime English teaching, training and assessing.

Collaborated operation of the system can be of benefit in facilitating communication and maritime English training and practice, as well as enhancing mutual understanding of the navigation customs and culture background among cadets and seafarers from different countries.

## 3. THE STUDY OF MARITIME ENGLISH ON SIMULATORS

An integrated bridge simulation system is primarily designed and introduced to train and develop potential cadets and officers with the necessary knowledge and skills in properly and correctly handling and managing a vessel. Whereas a new and alternative use of the integrated bridge simulation system has been discussed and proven to be suitable and effective in training and assessing communication skills, especially in contextualizing the practice of the mandatory part of the IMO SMCP, reinforcing the trainees to play different roles in a realistic atmosphere and environment. It has been decided that most of the scenarios and contents in SMCP can be flexibly designed or tailored and properly practiced in an integrated bridge simulation system based environment. The key task then is how to organize and implement the syllabus of Maritime English teaching and learning via this effective learning by pedagogic methodology.

In the past years there have been many discussions regarding an attempt to approach the training and testing the proficiency of Maritime English that meets the international standards pointed out in STCW. Using integrated bridge simulation system in a bridge activities context seems to be one of the most effective experiential learning and training methods, which will allow the future Deck Officers to get accustomed to a workplace environment and to expand their practice little by little, so that they may communicate and pass messages with confidence when taking up their future jobs onboard.

Taking into account many discussions regarding the use of integrated bridge simulation system in Maritime English practice, it can be concluded that affirmativeness in the possibilities is obvious. However, solutions in combining this technology with operational teaching and assessing maritime communications especially with coursework design has not much been referred to. Using the integrated bridge simulation system can assist Maritime English teaching, training and assessing. Collaborated operation of the system can be of benefit in facilitating communication and Maritime English training and practice, as well as enhancing mutual understanding of the navigation customs and cultural background among cadets and seafarers from different countries.

Constanta Maritime University is training future Deck Officers in accordance with the national standards developed by the Ministry of Education, Research and Innovation, and to the international standards elaborated by IMO (International Maritime Organisation). Apart from the evaluations made by the Ministry of Education, Research and Innovation, the University's curricula are assessed and approved by the Romanian Naval Authority considering the legislation and recommendations of the International Maritime Organisation, and of the European Agency for Maritime Safety and thus, the certificate of competency has international recognition.

Constanta Maritime University is fitted with simulators and laboratories with software for each specialty discipline thus every student gets the best theoretical training before going on board merchant ships as Apprentices. On these specific simulators, all the instructors are trying to use as much Maritime English as possible during the communication situations that appear inside the scenarios performed and in this way making the students understand the importance of using a proper Maritime English that could eventually help them in their future career. Constanta Maritime University is applying communication in Maritime English for future Deck Officers by using the following simulators: Simulator for Navigation and Ship's Manoeuvre TRANSAS NT Pro 4000, GMDSS Simulator – Global Maritime Distress and Safety System and the Simulator for Handling Bulk Liquid Cargo, certified by Det Norske Veritas, Class A, B, C – Cargo Handling.

During the simulator classes the instructors are using different scenarios where a proper Maritime English should be used. The instructor who supervises the scenarios will initially allow the students to familiarise with the instruments and controls found on the bridge of a merchant ship. The student will be able to locate and use the bridge equipment in normal operating conditions.

The exercises get more and more difficult and the students get accustomed with the procedures used for turning on the navigation equipment. Every exercise is preceded by a briefing and followed by a group discussion - debriefing, in which the actions and decisions taken by the student are analysed and it is important to mention that these discussions are performed in English.

During exercises, every student will play different roles within the bridge team and will have the possibility of taking part in all the operations done during the watch, covering all the steps in the chain of command of the navigational bridge and in this way also getting acquainted with all the aspects of a proper communication performed in Maritime English on the bridge and during a navigational watch. The purpose of these exercises is to achieve the following goals:

- Familiarisation with the use of instruments and controls from the navigational bridge;
- The ability of making decisions;
- Organising the bridge/engine team;
- Understanding the individual role in the chain of command while working in a team;
- Understanding the specific tasks according to certain situations;
- Understanding the necessity of a good planning, following step by step the check lists, and the scheduling of each specific procedure;
- Good understanding of the watchkeeping procedures;
- Getting the expertise in identifying the operational problems and solving them;
- Familiarizing with communication in Maritime English.

## 4. MARITIME ENGLISH A NECESSITY FOR APPRENTICES INSIDE A MULTINATIONAL CREW

The multinational crews appear on the shipping market as a result of different economical reasons. First of all there is the necessity to reduce the costs with personnel, but also to keep the requested standards onboard.

In this way, owners change their crew resource option to work force markets from Asia and Eastern Europe mainly. At the beginning they take position onboard as O/S or A/B in the deck compartment and as motormen in the engine department, and latter on, owners start to accept them also as deck and engineer officers, even at the managerial level, as Master, Chief Officer and Chief Engineer.

Changing from a single nation crew to a multinational crew has not been avoided by problems and difficulties, mostly due to different concepts applied by the owners onboard related to multiculturalism and working relationships. An ideal solution will be to have seafarers' from the same nationality in one department and if possible to provide the operational officers from the same nation. To satisfy the owner's certitude that everything is alright onboard and his property is used in good condition, the ship management will be covered by the owner's people, same nationality with the owner or very confident persons. In present, many companies apply this concept, even better, onboard ship the operational crew is covered by one nationality crew members and only the ship management is from a different one, in case of impossibility to be from the same nation.

Until 2004 Constanta Maritime University students' practice has been developed onboard of scholar ship "Neptun", but due to a lot of engine and hull problems this activity had to be suspended.

Afterwards, the solution found was to send our students in international voyages with different shipping companies, local or international, and for this action the local crewing agencies or owners offices have been contacted. This was only the first step to the present situation, when over half of our students cover their requested onboard training on ships of different owners, most of them, international shipping companies with a great rename on the world shipping market, as NYK Ship Management, Japan, Peter Dohle from Germany, Maersk, Denmark, CMA-CGM from France and many others, totally 22 shipping companies being part of the partnership.

Taking account of the present regulations regarding onboard training period as cadet, 12 months for deck cadet and 6 months for engineer cadets, our University took the decision to help and facilitate students' onboard practice. In this way, in the present there are agreements signed between shipping companies', their local representatives and the University, where there are stipulated the requested training objectives, onboard live and work condition and schedule for students and the level of theoretical knowledge necessary to be acquired by students before proceeding to onboard practice.

Adopting this solution, in time, the number of shipping companies' interested to take cadets has increased and the number of students trained has increased also. Through this protocol, companies have the possibility to offer to our students scholarships during their study years and other facilitations in order to create their own group of future company's officers. In the present there are ship owners who select students, through tests and interviews, from the first study years and include them inside of future companies' personnel development program, offering students monthly scholarships, opportunity to cover the necessary onboard cadets' practice and the certainty at the end of their studies of a position inside the company.

## 5. CONCLUSIONS

Nowadays most maritime education and training institutes have installed integrated bridge simulation systems, based on which maritime teaching and training have been designed and experimented. In response to these changes, course and syllabus design and organization as well as instruction and evaluation have thus undergone reforms since the attention of simulator training has been particularly drawn to.

Maritime English course design and organization is critically important throughout the whole training program. It ought to take into account the emphasis IMO guidelines on ship management lays in the need for good communication. The major concepts and skills with this aspect are: Understanding culture differences; Situational awareness; Close loop communication; Briefing and Debriefing; and Communication procedures. Effective communications are an essential ingredient to safe and efficient ship operations.

Communication can be achieved in many ways but the main method for operational communications is through speech. And when in an operational situation such as berthing a ship or fighting a fire, it is vitally important that those involved can communicate effectively.

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# GENERAL ISSUES IN TEACHING ENGLISH FOR SPECIFIC PURPOSES

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**ABSTRACT**

The process of teaching/learning English for Specific Purposes depends both on the teacher and on the students. The teacher has to know that his/her role is not just of teaching language, but also of teaching different skills, being also responsible for selecting the materials for the class. However, the students are the partners of the teachers in the process, being also responsible for the learning outcomes.

**Keywords:** *English for Specific Purposes, learners' needs, assessment, skills.*

## 1. INTRODUCTION

This paper deals with some general issues related to the process of teaching English for Specific Purposes (ESP). The paper presents some characteristics of the learners, as ESP has to meet the specific needs of the learners, but it also presents the role of the teacher who does not only teach a language but also some skills.

English can definitely be considered a "lingua franca" as it is widely used as a means of communication between people whose native language is different from each other's. Thus, English is often viewed as the language of international communication.

Hutchinson and Waters (1987) gave three reasons for the emergence of ESP: the demands of a brave new world, a revolution in linguistics and a new focus on the learner. The demand for ESP really increased and expended a lot throughout the world.

## 2. THE PROCESS OF TEACHING ESP

### *2.1. Characteristics, skills and roles*

Dudley-Evans and St John (1998:4) defined ESP with the help of some absolute and variable characteristics:

*Absolute Characteristics:*

1. ESP is defined to meet specific needs of the learners.
2. ESP makes use of underlying methodology and activities of the discipline it serves.
3. ESP is centred on the language appropriate to these activities in terms of grammar, lexis, register, study skills, discourse and genre.

*Variable Characteristics:*

1. ESP may be related to or designed for specific disciplines.
2. ESP may use, in specific teaching situations, a different methodology from that of General English.
3. ESP is likely to be designed for adult learners, either at a tertiary level institution or in a professional work situation. It could, however, be for learners at secondary school level.
4. ESP is generally designed for intermediate or advanced students.
5. Most ESP courses assume some basic knowledge of the language system.

ESP deals with learning, especially with *what* people learn than with *how* they learn. Based on basic knowledge of the language system, ESP is generally designed for adult learners at intermediate or advance levels.

We cannot speak of a single, unique way of teaching people to learn as there are multiple different styles and strategies of teaching. Still, the decisions on what and how to teach should be taken according to the age of the students because the skills and the needs of the learners depend on their age. It is said that in general children learn faster than adults, having also no difficulty in learning without too much effort a foreign language.

Adults, on the other hand, are believed to be slow and not very successful in their language acquisition process. They complain, hesitate and expect to use the foreign language in the same way as they use their mother tongue. They may be critical of teaching methods, they may worry about diminishing learning power with age or they may just be less confident about language learning. Still, they have a lot of life experience, they are more disciplined than young learners and more motivated since they establish some goals and know exactly what they expect to achieve. All these aspects make the teaching process of adult learners easier (Harmer, 2000:40).

A good teacher has to consider both negative and positive aspects when deciding what and how to teach because an effective adult learning involves self-direction, lifelong orientation, cooperation and interaction with peers. Nevertheless, the process of teaching/learning also depends on the attitude and responses of learners since they may be regarded as the partners of the teachers in this process. Thus, learners are responsible for the learning outcomes.

For ESP teachers it is as important as difficult to know exactly how their students will use the specific purpose English they study and that is why they must be very careful of choosing the right teaching methods and materials.

For instance, if the English they study is for professional purposes, the teacher should find out what the job entails; if they study English at the academic level, learners will need to develop certain skills such as writing skills or listening comprehension skills, etc.

Therefore, the teacher has to know that his/her role is not just of teaching language, but of teaching different skills, being also responsible for selecting the materials for the class. The selection of the materials must be made according to the learners' needs, skills and study level.

The teaching methods should be learner oriented, because the teaching/learning process is not about revealing the knowledge of the teacher but meeting the students' needs. The classroom activities should be chosen by the ESP teacher according to the age, needs, expectations and present or future career of the learners. Both traditional and innovative methods should be chosen as each of them is relevant for the learning situation of the students.

### *2.2. Assessment*

An important element in the process of teaching/ learning is assessment. It sets explicit students' expectations, giving them the opportunity to monitor themselves and receive feedback.

Assessment leads to making important decisions for the future process of teaching and learning. Thus, teachers have the possibility to find out about their students' progress, knowledge and abilities and have to make a decision concerning their future progress. By means of assessment students will understand their potential and will be able to establish some goals for the future.

The evaluation should be done during and at the end of the course, the results having to be valid and with no place for misinterpretation. The teacher has to know why, what and who is being assessed. The assessment tasks should be representative of the knowledge, skills, and attitudes identified by the purpose of assessment. However, even when mistakes are made, they show teachers that their students are actually on the move towards learning. In order to reiterate what has been said so far, assessment must be regarded as a positive aspect of the evaluation process.

## 3. CONCLUSIONS

This paper has addressed key notions about ESP courses which will probably continue to evolve in the future. Still, designing and implementing a successful ESP program is not an easy task, the ESP practitioner having to make several choices along the way for the best interest of the learners.

In conclusion, there should be a continued focus on individual learning, learner centeredness, and learner autonomy as there are many aspects to be considered when teaching ESP but it is essential to pay attention to the needs of the language learners.

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# "THE STUDENT'S DICTIONARY OF MARITIME TERMS"- RICHER VOCABULARY, SAFER SAILING

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**ABSTRACT**

The purpose of this paper is to bring forward the idea of creating an online bilingual dictionary of maritime terms and expressions to be used by Romanian nautical students as a means of enriching their mental lexicon and solving their vocabulary problems. The dictionary comprises standardized terms and expressions about navigation, engineering, safety, communication, chartering, etc which are all used in the seafaring world. We consider that this dictionary is an outstanding tool that will enhance the quality of communication and safety in the maritime sector.

**Keywords:** *maritime software, maritime vocabulary, maritime communication*

## 1. INTRODUCTION

The use of English is increasingly becoming a mandatory requirement for many categories of seamen. Apart from the revised STCW Convention's stress on the English language training, there are also other various IMO requirements which set out the need for seafarers to speak a common language in order to avoid communication errors and promote safety of shipping. Avoiding communication errors and promoting safety of shipping would be hardly, if ever possible without a proper command of maritime English terms and expressions. This led us to consider the idea of storing such terms and expressions in a special dictionary, namely a special software that addresses maritime students with different knowledge of Maritime English.

We believe that this software will give each student the possibility to develop his/her own vocabulary for practicing genuine English in a maritime setting because the mastery of Maritime English vocabulary support Romanian seafarers in communicating with other foreign seafarers (Visan & Georgescu 2011, 2012).

*The Student's Dictionary of Maritime Terms* is a bilingual dictionary for both average and advanced users. At present, the dictionary comprises 5000 words, terms and terminological expressions. However, the software is still under construction. The sources of research material are multiple: Maritime English Courses, Mass Media samples (Loyds Lists), IMO documents (Conventions and Regulations), the Internet information on the subjects involved, text books, etc. reflecting the major characteristics of Maritime English in use.

## 2. THE SOFTWARE DESIGN

The dictionary is designed as a cross-platform application, being accessed as online application or compiled to run under Windows operating system. This feature of design enables maritime users to access the application as a simple website by means of computers connected to internet and without having to download anything. The application uses a database that stores the words and terms in both Romanian and English, categories that include the words and terms into specific sections. For instance, audio sections are accompanied by pronunciation and images which stand for several terms that denote on board and outboard devices, types of ships, maritime related activities, etc. The database can be easily edited using the application administration panel, making it possible to continually update the dictionary's content. Figure 1 below shows the search algorithm used by this software in order to display the words, terms and expressions together with their translation, audio pronunciation and pictures (actually, the software will also include a pictionary):

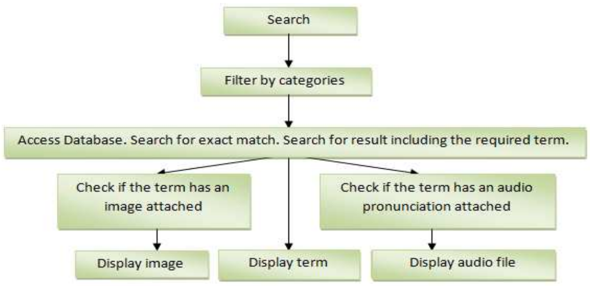


Figure 1 Search algorithm.

### 2.1 Software features

Our software has been designed as an easy to use tool for an average user. The features provided by this dictionary are as follows:

- Exact match of the search term is displayed and highlighted first.
- Audio pronunciation for terms. This feature gives learners the possibility to study the way a term should be pronounced in order to improve their pronunciation skills.
- There are images attached to denote several dictionary terms.

*2.2 Software interface and operation*

Even if the user interface is provided with a minimum of push buttons and functions, the application's good functionality is not restricted. On the top side of the window there is the main menu which features the search mode selectors: English to Romanian and Romanian to English, as well as an informational page.

Once the search mode is selected below the main menu, the search bar will immediately appear. After the required term is introduced into the search input bar and the button "Search" is pressed, the application will provide the exact counterpart in the target language (TL), together with the expressions containing the term in question. In case the result is positive, the application will display the filter categories on the left side, and the results found on the right side. Figure 2 shows the user interface template (see below):


Figure 2. User Interface

For each specific term or expression, the application will verify whether there are any pronunciation audio files or images attached. The terms provided with such extensions will have additional icons displayed which allow playing the audio file or displaying the image.

## 3. THE IMPORTANCE OF SEAFARERS' VOCABULARY ACQUISITION

The need for clear verbal communications between parties in the commercial marine environment is multi faceted as the ship is the working environment, learning environment and social environment for its personnel (Pynn & Koester 2005). Those on board must have an adequate vocabulary to be able to communicate between ship and shore when in coastal waters, between ships in areas of congestion or where avoiding action is required, or even during search and rescue activities. During periods of pilotage, English is frequently used as a common language and both Pilot and crew must be able to communicate effectively to ensure safety. Those working onboard passenger vessels must also have a strong command of English in order to communicate with passengers. Therefore, vocabulary acquisition is a vital aspect in language learning, since it appears in each of its skills: listening, speaking, reading and writing skills. Many seafarers realize that their vocabulary is limited and they have difficulties in getting their messages across Demydenko (2011: 249). Thus, the present dictionary can be used as an important part of Maritime English classroom activities in order to develop students' motivation and their communicative skills. Using the dictionary will also enable learners to turn their passive vocabulary into their active one.

## 4. FUTURE RESEARCH

In an attempt to expand our area of research, the dictionary will also comprise a specific section of terms accompanied by their explanations in English and the context of use. We believe that the introduction of this contextualized dictionary section will help Romanian seafarers gain fluency in English and produce adequate texts.

## 5. CONCLUSIONS

Based on the descriptions given in the preceding sections, and bearing in mind that effective communication between seafarers is vital for the safety of the ship, crew and cargo, the conclusion can be drawn that an online dictionary will be a valuable resource for maritime learners, especially if it combines general and specialised language. In full agreement with Kahveci and Samson (http://www.itfseafarers.org), we consider that fluency in maritime English is crucial for both maritime officers and ratings in order to safely operate multilingually crewed vessels and thus, the purpose of this dictionary is to come in the aid of maritime students as a means of bridging their vocabulary gaps and expanding their professional vocabulary.

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# METHODS FOR IMPROVING MARITIME ENGLISH TEACHING AND LEARNING: AN EXPERIMENTAL CASE STUDY

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**ABSTRACT**

English as the official language used in communication at sea is a pre-requisite for quality learning in maritime higher education. The organization of such courses must have in view general English knowledge, specialized structures and the vocabulary necessary to the future officers specialized in navigation, engineering and radio-telegraphy, on military and civilian vessels. Maritime studies in English have the purpose of forming reading, writing, communication, listening and taking notes skills, reinforcing the technical and navigation vocabulary, broadening the students' general ship knowledge. Our experimental data have revealed that, in terms of the approached psycholinguistic methods (contrastive, communicational and in contextual conditions similar to the working conditions of future naval officers), the teaching/learning process of the maritime code in English can be improved.

**Keywords**: *ESP, skills, mistakes, psycholinguistic, contrastive, communicational, contextual conditions*

## 1. INTRODUCTION: THE NEED FOR GOOD MARITIME COMMUNICATION IN ROMANIAN AND ENGLISH

Communication in the Navy and the Merchant Marine has certain particularities, as a result of the complex situations which may arise in military and civilian seamen's activities, both on land and at sea, for instance when towing a vessel or when crossing narrows and channels, during the medical inspection and control of ships arriving in a foreign port, when buying food and supplies or when asking for assistance in various situations (repairs etc.).

## 2. TEACHING A SPECIALIZED CODE IN ENGLISH

Teaching a specialized code in English should consider the following aspects: on the one hand, the similarities and differences between learning Romanian (the mother tongue) and English language (as a foreign language), and, on the other hand, the interweaving of the English general knowledge with English for specific purposes (ESP). The language to be acquired is the same (in terms of language), both when assimilating the mother tongue as well as when learning a foreign language; moreover, the positive or negative social influence hallmarks communication and language learning (Nădrag, 1999, p. 52).

The methods used in teaching/learning a foreign language should contribute to the development of language knowledge, skills and auxiliary systems, such as gesticulation and mimicry (T. Slama-Cazacu, 1968, p. 338). Language learning implies a communication process, including both the "linguistic skill" (for building grammatical sentences) and the "communicative skill" (production of statements suitable to communication situations) (S. Guberman, 1989, p. 5;C. J. Brumfit, 1981, 1987). The "communicative skill" is equivalent to the skills for creating an interaction in the target language and assumes that both the speaker and the receiver understand the meaning of words and the social importance of the expression (C. B. Paulston, 1992, p. 38). A person participating in the social life of a community should learn how to use the language according to the situation and, in addition, to resort to other means of communication, such as gestures, facial expressions etc. (D. Hymes, 1985, p. 18). This communicative skill consists in knowing the rules governing the use of various language forms and of various nonverbal codes, in different social situations (J. Prucha, 1970, p. 215; see also P. Ilieva-Baltova, 1994). Language learning implies taking into account all its contextual, social and cultural factors; as shown by S. Guberman (1989, p. 49), acquiring a foreign language involves the collaboration of factors related to linguistics, psychology, pedagogy and sociology. Linguistic phenomena are analyzable "both in the context of the language itself, and in the broader context of social behavior" (J. Gumperz, 1971, p. 114). The person using a language is free to choose the message form and channel, but, at the same time, he/she must comply with grammatical and social constraints; the grammatical ones refer to the intelligibility of sentences, while the social ones refer to their acceptability (J. Gumperz, 1971, p. 152). It is known that, for example, in English, a sentence can be grammatically correct, possible, and suitable for one context and yet not used (C. J. Brumfit, K. Johnson, 1979, p. 14). It differs from grammatically and lexically incorrect sentences: "Thank you very much" / "With pleasure".

Referring to the special task of the English for specific purposes teacher (ESP teacher), Tom Hutchinson and Alan Waters (1992, p. 163) state that the latter should have a positive attitude towards all knowledge relating to the respective specialty; he/she should know its fundamental principles and be aware of his/her knowledge in that area (see T. N. Huckin, L.A. Olsen, 1983, P. Strevens, 1980). By complying with these requirements, the ESP teacher will be able to produce intelligent questions (for example, when talking about a device, it is not necessary to know how it works, but he/she can ask: "What is this device used for?"; "What are its main components? "; "What can it do?”. Therefore, the ESP teachers should not become specialized in the technical subject they teach, but they should be like a student interested in that subject and be able to teach a minimum vocabulary of specialized terms in the respective foreign language (the target language).

The same authors (Tom Hutchinson and Alan Waters, 1992) start from the needs analysis that the teacher has to take into consideration before the course: forming speaking, reading, listening and writing skills, using certain types of texts (e.g. technical manuals, face to face conversations, phone conversations, magazines and newspapers), using some devices (such as tape recorders, video recorders), carrying out extracurricular activities, assessing the students’ English language training level and their training level at the specialized subjects, being aware of the students’ preoccupations during their free time, taking into account the social and economic base necessary to the course, the course duration and place, the daily schedule, the teaching methods and techniques, working in groups and in pairs (see also H. G. Widdowson, 1983). Pauline Robinson (1991) considers that the needs refer to the study and job requirements, the institution or society requirements, to what the student needs to do in order to acquire language knowledge and skills and what he/she would like to learn from an English course. The same author states that the needs analysis can be viewed as a combination of the analysis of the target situation and the present situation (ibid. p. 9).

English is the official language used in sea communication. Studying it is a pre-requisite for quality learning in maritime higher education. The instructors who are organizing such courses must have in view general English knowledge, certain linguistic structures and specialized vocabulary necessary to the future officers specialized in navigation, engineering and radio-telegraphy, on military and civilian vessels. The maritime student should be able to make the transition from general English knowledge to consulting various technical books and manuals, at school or on board vessels. Maritime studies in the English should improve reading, writing, communication, listening and taking notes skills, reinforce the technical and navigation vocabulary, broaden the general ship knowledge (T. N. Blakey, 1987, p. XII). Students should be able to interpret drawings, graphics (see V. Maier, 1997), nautical charts and tables, to communicate and write short messages. All these goals can be achieved by choosing the most appropriate methods, primarily the communicative one, and using available materials. In this regard, the procedures for good conversation and the recommendations on the message structure in correlation with the radiotelephone procedures stated in national and international regulations are particularly important (G. Albu, 1995, p. 15).

## 3. LEARNING ENGLISH IN INTERNATIONAL CONTEXTS SPECIFIC TO SEAMEN’S ACTIVITIES. IMPROVED METHODS AND LEARNING STRATEGIES

### *3.1. Learning strategies*

A strategy is a mental activity or behavior related to a particular phase in the overall process of language acquisition or use (T. Ellis, 1994, p. 529). The individual differences related to emotional states, beliefs, experience in learning, together with various situational factors (formal and informal framework, learning motivations etc.) determine the choice of learning strategies (T. Ellis, 1994, p. 529). These, in turn, influence the learning rate and the maximum level that can be achieved (S. D. Krashen, 1981, p. 19).

J. O. 'Malles and A. Chamot (A. Chamot, et al. 1987) distinguish between three groups of strategies:

1) cognitive (defining or expanding the definition of a word or concept by using a referential material in the target language; the direct physical response, translation, the grouping-reordering or reclassification of the material, taking notes, inference, exemplification by the use of images, auditory representation, sound or similar sound retention (with a particular word, phrase or language sequence), keywords, contextualization, transfer);

2) meta-cognitive (directed or selective attention, “self-management”, understanding the specific conditions that help people learn and prepare for those new conditions, the correct automation of speech for accuracy in spelling, grammar, vocabulary, according to the assessment made by other people);

3) socially affective (cooperation in order to get feedback and other information; questions to clarify issues - a teacher or a native speaker is asked to repeat, paraphrase or explain by giving examples).

The students in the maritime field, by the very nature of their future profession, should take into consideration the International Maritime Law and the International Regulation for Preventing Collisions at Sea when taking decisions, giving orders or when expressing themselves. For this reason, they are always in an international context, even when sailing in territorial waters. This context has an impact on their English learning motivation and methods. The messages (most often standardized) in maritime communication must be clear, accurate, concise, unequivocal and fast. There are many situations when marine officers must take a decision on the spot and transmit it as soon as possible (see Nădrag, 1999, p. 83).

### *3.2. Internal and external factors that influence English language learning by the students in the maritime field*

According to R. Ellis (1994, p. 193), learning a foreign language is influenced by three major factors: social factors (age, sex, social class and ethnic identity), language processing mechanisms and individual factors.

According to R. Buhlmann (1982, p. 369-370), the ESP teacher's role in organizing and conducting English classes is very important; he/she chooses the texts, the equipment (tape recorder, stereo, video, video projector), the place; he/she should know the students' English language training level and the specialty disciplines they are studying; he/she should know the necessary economic and social basis, the time and location of the activity, the daily schedule, the methods, techniques and exercises that may rise the students' interest (including working in groups and in pairs): expressing scientific and technical symbols in verbal form, filling in tables, verbalizing graphics, interpreting schemes, vocabulary systematization according to logical order principles for making up series or hierarchies, naming the parts of a drawing, defining and interpreting processes and operations, comparing data, objects, devices, procedures, solving exercises for predicting the content of a text in relation to its title, reading illustrations, formulas and giving numerical examples, finding the meaning of words from the context, using synonyms, antonyms, causal and final relationships relative to consequences.

The teacher should plan the lessons and select the material based on what he/she is going to teach (curriculum), how he/she is going to teach (method), the environment and the social relations that he/she wants to encourage (see R. W. Blair, 1982, p. VII). He/she should take into account the individual variables (some students have special skills: a "good ear", "power of imitation", "superior verbal memory"): students' linguistic experience, personal level of optimum learning (slow, normal or fast), preferred learning style, desire to be praised and encouraged (P. Strevens, 1980, p. 10), motivation (instrumental, defined as "the desire to achieve high performance in learning a language for practical or utilitarian purposes (S. D. Krashen, 1981, p. 22).

## 4. AN EXPERIMENTAL CASE STUDY

### *4.1. Premises*

According to the dynamic-contextual approach in psycholinguistics, teaching English on contrastive and communicational basis and in contextual conditions similar to the working conditions of future maritime officers can improve the teaching/ learning of the maritime code in English (Nădrag, 1999, p. 85).

Students in the maritime field can better acquire specific terms in less time when the teaching/ learning process is focused on:

1) similarities and differences between the two languages (Romanian and English);

2) communicative activities;

3) working conditions similar to those on board vessels.

Starting from the research methods and procedures for data collection and interpretation based on the principles of the psycholinguistic methodology proposed by T. Slama-Cazacu (see T. Slama-Cazacu, 1968, p. 107-131), we conducted a research on teaching and assessing the the maritime code learning in conditions similar to the working conditions of future naval officers. The research included teaching five themes in English and assessing the knowledge taught by experimental exercises; the teaching process was based on contrastive (focusing on similarities and differences between the newly learned English words and their Romanian equivalents), communicative (the students were given the opportunity to discuss and work in groups) and contextual aspects, close to those specific to their activities (in the maritime field).

The subjects undergoing the examination were 12 students having an average level of English language training. These students were not yet experts in the chosen field. For them, the effective use of specialized vocabulary in English "implies more than an extension of their linguistic competence, which, in turn, requires an extension of the professional competence. In addition, they need to acquire study skills, to develop certain ways of thinking and it is also possible to change some learning habits (R. Buhlmann, 1982, p. 369).

### *4.2. Establishing the situational contexts*

Throughout this research, we aimed at teaching five (maritime) themes in situational contexts (specialized laboratories) similar to the working conditions of the future graduates: "Vessel types", "Navigation hazards. Warnings. Assistance", "Draft. Speed. Handling", “Route. Piloting. Position. Radar”, "Anchoring. Arrival. Departure".

After teaching each theme, five experimental tests were organized. They included an essay on a given topic, a fill-in- the gaps exercise (6-10 sentences), a translation (6-10 sentences) exercise, dictation and a ten-minute dialogue between two to four students.

### *4.3. The Results of the Experimental Tests*

#### *4.3.1. Sources of Students' Mistakes*

After analyzing the students' mistakes in the five experimental tests, there was found that, in part, the sources of students' mistakes were:

**1)** R-E (Romanian-English), when the mistake is explained by the influence of the mother tongue (such as "bombardament" instead of "bombardment", "bridge suprastructure" instead of "bridge superstructure";

**2)** E-E, when the mistake is explained by the influence of the previously acquired vocabulary in the target language (e.g. "aircrafts", "war" instead of "were", "precision" instead of "precise";

**3)** R-E, when the mistake is explained by the influence of a third language, usually French (F-E), for example: "entre" instead of "enter";

**4)** other factors: lack of attention, fatigue (for example): "contanier ships" instead of "container ships".

Table 4. The percentage of mistakes

| Mistake type | Percentage |
|---|---|
| S | 36% |
| G | 17% |
| L | 19% |
| T | 6% |
| M | 21% |

S - spelling mistakes;
G - grammar mistakes;
L - lexical mistakes;
T - word order mistakes;
M - mixed mistakes

*4.3.2. Spelling Mistakes*

The spelling mistakes (63, i.e. 37%) are explained by the influence of the Romanian language or pronunciation (in English) on the graphic form: ”passanger” or “pasangers” instead of “passenger” or “passengers”, ”feerys” instead of “ferries”, “crussers” (correct “cruisers”), “dutyes” (“duties”), “fregates” (“frigates”), "batelships” (“battleships”), “comercial” (“commercial”), “tags” (“tugs”), ”responsabilities” (“responsibilities”), “proced" (“proceed”), “surch” or “serch” (“search”), ”comand” (“command”) ,”possition” (“position”), “bord” (“board”), ”runing” (“running”), ”signaling mirrer” (“signalling mirror").

*4.3.3. Grammar Mistakes*

Grammar mistakes (29, i.e. 17%) were related to:
1) the use of prepositions: “Alter course of/by/on”(correct: ”Alter course to”), “He drives with high speed“ (“He drives at high speed”), “divided in” (“into”). “I participated at” (“in”), “The pilot boat is approaching to/by/of your vessel”(correct: without preposition),”Is the pilot boat in station?” (“on station”), “He congratulated him for” (correct form “on”);
2) tense formation and use: verb agreement with the subject: simple present tense (“he ask”, instead of “he asks”, ”the ship get permission” instead of ”the ship gets permission”); continuous present tense (”My radar doesn’t work” instead of “My radar is not working”);
3) the use of the singular instead of the plural form and the other way round (“aircrafts” instead of “aircraft” - noun “singularia tantum”);
4) the use of articles (including the "zero article"): “a icebreaker” instead of “an icebreaker”;
5) the use of the possessive adjective: “in his voyage” instead of “in her voyage”;
6) the shift to indirect speech: “He confirmed that there is a vessel ahead” (instead of “was”).

*4.3.4. Vocabulary (lexical) Mistakes*

32 lexical mistakes (19%) were recorded. The words “bulk carrier” (“vrachier”) and “tug/tug-boat” (“remorcher”), learned with difficulty by students, together with other words, would be easier to learn if learning were based on their origin: “fire fighting assistance” (“asistenta în lupta contra focului”), ”the rules of the road” (“reguli pentru siguranta navigatiei”), ”training ship” (“nava-□coală”), “sternway” (“spre pupa”).

*4.3.5. Word order mistakes*

Word order mistakes can be explained by the influence of the mother tongue: "Every ship has holds where is carried cargo"; "where is stored the cargo" ("unde este stocată marfa"), instead of: "where cargo is stored", "an order very strict ("o ordine foarte strictă"), in English: "a very strict order"; "what time will be the pilot available?" ("La ce ora va fi disponibil pilotul?"); correct form: "what time will the pilot be available?"; "are used tugs" ("sunt utilizate remorchere") correct form: "tugs are used".

*4.3.6. Mixed mistakes*

Mixed mistakes rank second (21%), after the spelling mistakes and include the following types:
1) grammar and lexical mistakes: "aircrafts" (instead of "aircraft carriers"), "precision job" ("precise job"), "How does the cable is?" ("How does the cable grow?");
2) lexical and spelling mistakes: "bridge suprastructure" ("bridge superstructure"), "engineer room" ("engine room"), "approximativly" ("approximately"), "hight" ("height"), "compulsatory" ("compulsory"), "brakewater" ("breakwater");
3) grammar and spelling mistakes: "ferry's ("ferries"), "actualy position" ("actual position");
4) grammar, lexical and spelling mistakes: "passangers ships" ("passenger ships"), "I must rich Constantza" ("I must reach Constantza"), "We advice you" ("We advise you"), the noun "relief" (uşurare, alinare) instead of the corresponding verb "to relieve".

*4.3.7. Dialogue mistakes*

The five dialogues have highlighted that the English maritime terms were learned and did not raise any problem.

The students in the experimental group made up dialogues very close to those recommended in the Standard Maritime Vocabulary. In dialogues, there were grammar mistakes related to:
1) formation of direct and indirect questions: "You liked the parade?") instead of: "Did you like the parade?", "What armament they are carrying?" ("Ce armament transportă?"), correct form: "What armament are they carriying?" "There are any injured people aboard?" ("Exista răniţi la bord?"), the correct form being: "Are there any injured people aboard?", "Let,s see how many do we recognize" ("Să vedem câte recunoaştem") – referring to vessel types;
2) subject and verb: "Maybe is a trawler" ("Poate că este un trauler") - "Maybe it is a trawler", "I never saw" ("Nu am văzut niciodată") instead of "I have never seen such ships before", "Now is coming a tanker" ("Acum urmează un petrolier"), correct form: "Now a tanker is coming";
3) prepositions: "participated at" instead of in, "Their armament consists in" ("Armamentul lor constă în") - of; "thought at" instead of “of”;
4) articles: "The frigates ... " instead of "frigates ... ", "The smoking is not allowed there" ("Fumatul nu este permis acolo"), correct: without the definite article.

## 5. CONCLUSIONS

The results of our experiments revealed that, in terms of the approached psycholinguistic methods on contrastive, communicational basis and in contextual conditions close to the working conditions of future naval officers, the teaching/ learning of the maritime code in the English language could be improved. Four questions should be taken into consideration when using this approach in preparing the materials for knowledge teaching and assessment: "What do I aim at?", "What do I teach?", "In what framework?", "What will I ask the students?" (Nădrag, 1999, p. 110).

This research revealed the following conclusions:

1) The activity conducted in conditions close to the graduates' future working conditions (specialized laboratories and ships), led to:

- understanding the utility of the English classes;
- increasing motivation;
- emphasizing the link between theory and practice;
- increasing responsibility;
- creating the habit of expressing messages according to the right order of the activities on board vessels;
- imposing (by the context) the repetition and automatism (due, for example, to the direct communication with the "Port Control" station);
- compliance with the mandatory international discipline when transmitting messages at sea, in English;
- increasing the attractiveness of lessons and the degree of memorizing English words and decreasing the reaction time by using pictures, layouts, panels, diagrams, the equipment provided by laboratories and ships.

2) The group activity led to:

- increasing the courage in communication and confidence in one's knowledge;
- more initiative in solving exercises (the students did not wait anymore to be urged or assigned by the teacher);
- learning from the colleagues' mistakes;
- each student had the possibility to receive and perform concrete tasks and to play a certain role (commander, watch officer, etc.).

3) Teaching/ learning the maritime code in English should take into account both vocabulary and grammar in order to form correct communication habits, so as not to distort the meaning of the expressions set out in the Standard Marine Navigational Vocabulary and to enrich the individual linguistic system.

4) It turned out that the teacher should:

- know the exact conditions under which students will work after graduation, the requirements of their future profession, and the use of studying the maritime code in English;
- be convinced that the content which they teach in English is familiar to students in the Romanian language;
- make a hierarchy of the newly taught knowledge, in order to help students rank the information received;
- be aware of how language is closer to actual speech, but, at the same time, allow the practice of structures and the acquisition of some skills;
- allow a variety of social interactions by changing the context and roles;
- pay attention to the means of presenting the material (printed, audio-visual, computer-assisted instruction etc.) and to the teaching/ learning place.

5) Establishing and meeting the objectives imply increased cooperation, negotiation and interdependence between all stakeholders in the process of organizing such courses: English and "content" teachers (T), students (S), organizers (O) and sponsors (Sp.), taking into account the following scheme (where M.N.D. stands for the Ministry of National Defense, and S.C. stands for "shipping companies") (Nădrag, 1999, p. 112):

**English courses in higher marine education**

$$\begin{tikzcd} & \mathbf{O} \arrow[d, leftrightarrow] & \\ \mathbf{T} \arrow[r, leftrightarrow] & \mathbf{S} \arrow[r, leftrightarrow] & \textbf{Sp. (M.N.D. or S.C.)} \end{tikzcd}$$

Therefore, learning the English language by the students in the maritime field is influenced by the following factors:

1. the student's specialization (navigation, engineering or radio-telegraphy);
2. motivation (which can also undergo family influence);
3. knowledge of their mother tongue;
4. level attained (high school) in English learning;
5. other languages studied at school or individually (especially under the influence of television);
6. location of classes (class, laboratory or ship, in conditions close to those in which they are going to work after graduation);
7. working in groups or individually;
8. authentic, interesting (which meet the wishes and interests of students) materials (texts) and audio-visual means;
9. teaching methods;
10. specialized training in the maritime field;
11. the student's daily schedule;
12. maritime training.

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# A PSYCHOLINGUISTIC APPROACH TO MARITIME VERBAL COMMUNICATION AND MARITIME VOCABULARY

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**ABSTRACT**

The study of oral maritime communication, especially through the English language, has become a very interesting and useful field of research. The use of correct and effective verbal components of communication by seafarers may be, in many cases, a vital question. A psycholinguistic approach, through its specificity and complexity, can highlight the features of oral communication in this specific activity- seamanship, the factors which can influence it and the ways of improving communication at sea. Communication in the Navy and the Merchant Marine has certain particulars as a result of the complex situations which may arise in military and civilian seamen's activities, both on land and at sea. Day-to-day activities at sea require the compliance with well established rules, and standard orders. The message formulation and transmission through words, signs and signals are under linguistic and psycholinguistic scrutiny.

**Keywords**: *verbal communication, maritime communication, message, communication components, VHF communication*

## 1. INTRODUCTION: CONDITIONS REQUIRING MARITIME COMMUNICATION AND ITS ACCOMPLISHING IN GOOD CONDITIONS

English is the official maritime language adopted by the International Maritime Organization (IMO). Accordingly, the study of oral communication, especially through this language, in a maritime environment, has become a very interesting and useful field of research. The use of correct and effective verbal and nonverbal components of communication by seafarers may be, in many cases, a vital question.

A psycholinguistic approach can highlight the features of verbal and nonverbal communication in this specific activity- seamanship, the factors which can influence it and the ways of improving communication at sea.

Due to disturbances (noise, fog) which may occur at sea in the process of conveying messages, the need for secret keeping (in the Navy) and the necessity of preserving traditions, sailors use both verbal and nonverbal components of communication, all of them being regulated nationally and internationally. Messages are typically doubled or tripled to secure their correct transmission and leave no room to another interpretation.

Communication in the Navy and the Merchant Marine has certain particulars as a result of the complex situations which may arise in military and civilian seamen's activities, both on land and at sea. Day-to-day activities, but also the occasional ones require the compliance with well established rules, learning standard orders, their safe formulation and transmission along with some other information verbally and through "signs" and "signals" used with the intention of communication: semaphores, the salute between ships, the military uniform, acoustic, optic, radio telegraphic, and radio means. Present marine communications requirements are established under the SOLAS (Safety of Life at Sea) Convention (see Manolache, 2000: 113-114; 2004).

Maritime communication is influenced by the following factors: navigation on seas and oceans or in narrow places, in fine weather or storm, when the ship is alone or in a formation (Munteanu, 1973: 178), in conditions of noise, long distance, fog, reduced visibility, when secrecy (in the Navy) and keeping tradition are required, and when transmission of messages is crucial to safe navigation.

Communication takes place between ships, on board a ship, between ships and seashore stations, between a ship and airplanes or helicopters (Blakey, 1987: 173).

The states which own maritime fleets have focused their attention on the means of communication at sea. Consequently, communication through satellite and telex has evolved. Any competent person can effectively exploit these means of communication, but many other factors must be taken into account: the code used, the physical channel through which messages are transmitted (congestion, interference), the receiver, etc. Despite all the measures taken by the countries which own merchant fleets, difficulties are encountered because of incorrect use of VHF (Very High Frequency) procedures, busy frequencies, problems in encoding and decoding messages, etc.

## 2. THE MAIN TYPES OF MARITIME COMMUNICATION

### *2.1. Communication between ships*

Communication between ships is conducted through VHF radio communication, in English, and it is required by the following groups of factors: types of information (e.g. hazard, fire, collision, etc.) the need to identify each vessel, asking for a pilot to come aboard (the ship's master requires the presence of an authorized person, "the pilot", to lead the ship to the berth), transmission of warnings under very different and complex circumstances (when there are fog banks, unidentified floating objects, mines, oil spills, fishing boats in the area, search and rescue operations, military operations, pipelines, when water is shallow or when there are wrecks, rocks, bridges which won't open and impede navigation), granting assistance when a ship is sinking, damaged, on fire, running aground, running into collision, etc. and the ship requires: rescue boat, helicopter, medical and fire-fighting assistance, tugboat or ice boat (Munteanu: 1973; Manolache, 1999).

*2.2. Communication aboard ships*

Communication aboard a ship is performed through an internal telephone system or by sending commands through a speaking tube / voice pipe) (Beziris et al., 1985: 522), in mother tongue or in English, most of the time, when crews are multinational or multilingual.

Orders (Popa, 1992) for the engine room are transmitted from the bridge through the ship's telegraph or an amplification system. For clear, fast, effective, and unambiguous communication, several conditions must be met. The master's orders - most times, the message sender - depend largely on the degree of crew's training (officers, NCOs, sailors) who receive the messages, and orders and carry them out on time and in an efficient way. Specific to the Navy is the dialogue needed in the transmission and performance of orders.

*2.3. Communication used for other purposes (commercial, medical, to require assistance, to resolve disputes, to ask for technical repairs, etc.)*

Another type of communication, on all seas and oceans of the world and in all foreign ports, occurs in English (both for common NATO military drills, including those on the Black Sea, and in international waters). Navigation involves exchanging information; call for a "pilot" to come on board to lead the ship to berth; passage through straits and channels supervised by certain coastal stations; towing; medical inspection and control of the vessel on entering a foreign port; signing contracts with agents from different countries for loading, unloading; receiving and distributing cargo; purchase of food and technical supplies; technical assistance request in certain cases; repairs; resolving disputes relating to collisions, the quality of goods, the conditions under which cargo was delivered.

## 3. INSTANCES OF VERBAL COMPONENTS IN MARITIME COMMUNICATION

As already stated at the beginning of this article, English has become the official language adopted by the IMO (International Maritime Organization). It is therefore the duty of commanders, masters and officers charged with "navigational watch" to know and be able to use the radiotelephone procedures. VHF communication technology includes distinct steps to be followed strictly: training, obedience, respect for discipline and repetition, etc. (G. Albu, 1995, p.36). The prior preparation of the information to be communicated avoids unnecessary interruptions and loss of valuable time on that radio channel. The person who wants to send a message must first listen if the channel is busy. Observance of discipline involves the proper use of the VHF equipment in accordance with the Maritime Radio Regulation ("List of radiodetermination and special service stations", 1979). Communications relating to distress and emergency are a priority. Non-essential, unnecessary transmissions must be avoided (i.e. superfluous redundancy, transmission without proper identification, use of insulting language, repeated words and expressions if they are requested by the receiving station). "Addressing" is made so that to indicate exactly to whom it refers and, consequently, the words "I" and "you" have to be used cautiously (see G. Albu, 1995) .

Correctly receiving the message is vitally important at times. When receiving a message and only the confirmation of reception is required, the receiver answers "received". If confirmation of the correct message is required, the receiver answers: "received, understood" and repeats the message:

"Your berth will be clear at 10.30 hours."
"Received-understood. Berth clear at 10.30 hours."

During the exchange of messages, the vessel should invite the response saying "over". When there is difficulty in decoding the message, the use of the "Standard Marine Navigational Vocabulary " is required; for example: "Please use the Standard Marine Navigational Vocabulary". If difficulties persist, the "International Code of Signals" is used (G. Albu, 1995, p.7).

When the message contains instructions or recommendations, it is resumed:

"Advise you pass astern of me".
"I will pass astern of you."

If the message is not received properly, its repetition is required: "Say again";"Message not understood" or the channel change is requested: "Change to channel.." and wait for confirmation. All these messages are standard. The end of the message is indicated by the word "out". Messages sent at sea consist of information exchanges and, therefore, the use of standard messages is recommended: messages of contact, arrival, ETA (estimated time of arrival), ETD (estimated time of departure), demanding the pilot boat, radar identification, anchoring, departure, changing the channel, incident etc. They have the following structure: addressee, nationality, vessel name, call sign, position, route, speed, last port, destination, ETA, piloting details, gross tonnage/length, draught cargo (type and quantity), damage, intentional route, ETA on the next point of the route, VHF channel, agent. The order of these components is strict, but the presence of some of them is optional, depending on the vessel type, as proved by the following example from the "IMO Guide for the VHF use at sea. Seaspeak in maritime communications" (G. Albu, 1995, p.9):

"Port City, this is United Country ship Seaship

(addressee) (nationality)
Seaship, call sign Alpha Bravo Charlie Delta
(emitter) (indicative)

Lake Town to harbour no. 2 ETA 1400
(last harbor) (destination) (estimated time of arrival)

I require a river pilot, my length is 150 meters
(piloting details) (gross tonnage / length)

My draught is 9 meters, I am carrying dangerous
(draught (cargo)

cargo 300 tons IMDG Class 4.1. in No 4 hold
(stowage)

my forecastle is damaged and my radar is not working
(defections)

my agent is Cargo Services Company, over."
(agent)

Messages that transmit information relating to incidents at sea are of three types: distress, emergency and safety (the Annual summary of admiralty notices to mariners, 1974).
They contain the call and the message itself. Distress messages repeat the prefix MAYDAY and the ship's name three times:

"MAYDAY, MAYDAY, MAYDAY, this is
(prefix 3X)
SEASHIP, SEASHIP, SEASHIP,
(emitter 3X)
Mayday, Seaship, my position is 180 degrees one mile from buoy number 10.
(position)
I am sinking, I require immediate assistance, over."

Emergency and safety messages repeat the prefixes "PAN PAN", respectively "SECURITÉ" (derived from the French word "Sécurité") (T. N. Blakey 1987, p.194) three times.

"PAN PAN, PAN PAN, PAN PAN, Hello all stations
Hello all stations, Hello all stations, this is Seaship, Seaship, Seaship
My position is 180 degrees one mile from buoy number 10.
I have been in collision and need the assistance of a tug."

"Sécurité, Sécurité, Sécurité, Hello all stations
Hello all stations, Hello all stations,
this is Seaship, Seaship, Seaship
My position is 180 degrees one mile from buoy
Number 10
My engines are broken down and I am anchoring in the north bound traffic lane.
Request ships keep clear, over".

Verbal communication, in the case of these messages, includes "expresis verbis" or "message markers" (G. Albu, 1995 p.15), and their use should exclude any misunderstanding of the communication intent. These message indicators are: question, instruction, advice, request, information, warning, and purpose. Here are some examples of standard messages provided by G. Albu (1995):

Question : "What is your position?"
or "Is visibility expected to change?"
Instruction: "Do not overtake!"
Advice: "Advise you pass astern of me."
Request: "Please send medical assistance."
Information: "My ETA at East Pier is ..."
Warning: "I am maneuvering with difficulty."
Intention: "I intend to reduce speed, new speed: five knots."

Questions recommended by "Seaspeak" ("Seaspeak" is also an international project which lasted four years and extracts from it were incorporated into the IMO standard vocabulary of maritime navigation) are of three types: "wh-" questions (how, what, when, where, how many, many etc.), alternative questions (Are you loading or unloading?) and "Yes" or "No" questions. Disjunctive questions (tag questions) are not recommended. Answers are preceded by the words: "positive" (yes), "negative" (no) or "I don't know":

"Are there any survivors?
Positive, there are four survivors".
or "Negative, there are no survivors".
or "I don't know if there are any survivors".

Instructions are given by verbs in the imperative: "Turn!", "Do not anchor!", and the agreement or disagreement is expressed by "Positive" or "Negative", after resuming the instruction. If there is a negative answer, the reason has to be explained:

"Stop your engines!
Stop my engines, negative, reason: the tide is too strong."

Recommendations are made by verbs in the imperative or by "Advise you". Solicitations start by "Please" and are followed by the appropriate verb ("Please deliver!", "Please send!" etc.). Warnings have an affirmative form, and the verbs are in the simple and continuous present tense. Although in English intention is usually expressed by "to be going to", "Seaspeak" recommends the use of "I intend to". The words "because", "as", "so that", "in order to" are avoided and the word "reason" is used instead: "Please keep clear of me, reason: my steering gear is defective".

Message indicators are used by the so-called "method of prefixing" and are completed with "response indicators". They must anticipate the sequence of information by means of message markers, for example:
Instruction: "Stop your engines" - The imperative verb "stop", at the beginning of a sentence, marks this communicative activity and hence it is clear that this is a command.

Question: "What is your position?" – the interrogative pronoun "What" is an indication of the intention to ask. The use of "message markers" during the complex act of communication can lead to less ambiguity in communication. Checking the message intent (e.g., if the "request" is answered by "request received" and the information is repeated, the "advice" is answered by "advice received" etc.) removes problems that would result from poor reception, disturbances on the channel or misinterpretation. "Seaspeak" is in English, but the "techniques of messages, message indicators, message verification system and standard procedures can be used equally well in any language" (G. Albu, 1995, p.17), such as French, German, Italian, Russian etc.

Communication during labor is necessary, firstly, for transmission or retransmission of information, when one partner does not have certain knowledge or data and calls the other, when a person cannot perceive an entire situation (the crane operator), when someone has some knowledge, gives orders, provides information, collaborates with others. Someone may have some theoretical, technical, practical knowledge and, in this case, is asked to help by means of communication or have additional knowledge about the whole process or about previous or future issues. Sometimes, information exchange is required, when each team member possesses some knowledge, when communication control has to be performed etc.

Communication can be generated by the need to adjust movements in a team, when an action must be executed synchronously or with a certain tempo, with a certain intensity, or where some great mobilization of attention, motor effort etc. should be done at a certain time (Slama-Cazacu 1970, p. 39-40). There are cases where the lack of communication may result in damage, accidents. Sometimes discussions, counsels are necessary, team members transmitting their knowledge, jointly examining the situation; sometimes communication can be reduced, it can become even null if there is too much noise. Some other times, ample instructions, starting data or the anticipated setting of different movements make direct communication unnecessary during such activity. Communication is, therefore, necessary in order to receive or give information, to make a joint decision, to start an action at the right time and with certain intensity, in order to communicate the work results.

Communication through language has a role in learning or instruction, in work planning and management process, in the work results assessment (Nădrag, 1999, p. 21). Various activity conditions can affect, in turn, language communication when selecting a particular speech-reception system, a certain mode of communication distribution and in the formal changes that occur in the message. Work has an impact on the choice of the code or signal and on the actual encoding and decoding process.

## 4. CONCLUSIONS: THE REGULATING ROLE OF COMMUNICATION

Language may play a self-regulating and cognitive role, especially in the work process, when each person has many problems to solve; but also a regulating or inter-regulating role in other people's activities and in receiving information from others. Inter-human communication involves various learning, planning, coordination, assessment aspects, which are embedded in the general role of regulating the activities during the working process. The regulating and mobilizing effects of communication are also illustrated by the coordination of actions during labor. The adjustment is made either by getting strict information or through dynamic mobilization. Through strict information, the cognitive elements are activated to cause different actions. "The dynamic or directly or stimulating mobilization is more direct" (Nădrag, 1999, p. 22); this is the case of short, rhythmic orders. Regulating actions in communication is based on information uniformity, on the understanding of the special characteristics of a profession, with the purpose of achieving maximum accuracy.

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# THE STCW MANILA AMENDMENTS AND THEIR IMPACT ON MARITIME ENGLISH

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**ABSTRACT**

The review of the IMO International Convention on Standards of Training, Certification and Watchkeeping (STCW) as amended in 1995/97 reached its climax at the International Diplomatic Conference held in Manila in late June, 2010 when the amendments were adopted. The result of that process, which had been on-going since 2006, will have a significant impact on Maritime Education and Training in general, and explicitly in the context of English for Specific Purposes, as the "new" convention entered into force already at the start of 2012. Although the fundamental principles of the 1995 edition were retained, many regulations have been tightened and new areas included; with the outcome that the new edition reflects the higher standards to be met in the field of Maritime Education and Training (MET) in general, and in Maritime English communication competency, and thus on Maritime English instruction and research, in particular. With regard to Maritime English this paper observes IMO's decision-making process, identifies and comments on the new provisions in the Convention and the existing provisions that have been invested with a stricter and higher degree of commitment, and gives selected examples demonstrating the impact of the revised STCW Convention upon Maritime English course design, material development and instruction.

**Keywords:** *Communication, Maritime English, Competence, revised STCW Convention*.

## 1. INTRODUCTION

The revision of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, (STCW), 1978 has now been completed. On June21, 2010, after more than four years of intensive and worldwide discussions and debates at conferences, workshops, within the International Maritime Organization (IMO) and on various other occasions, the Manila Diplomatic Conference on the STCW Convention approved a number of significant amendments to the STCW 1978 (as previously revised in 1995) Convention. The so-called "Manila Amendments", has undergone the prescribed IMO ratification procedure ending July 01, 2011, and entered into force on January 01, 2012.

The 18-month *period of grace* is designed to allow member states and their institutions time to prepare for the changes. This naturally also applies to the Maritime English community that is well advised to carefully and in depth consider the corresponding new or amended requirements regarding Maritime English and maritime communication of which there are many. The sooner the greater demands on Maritime English instruction and research are identified, the better the new provisions will be satisfied and thus the complex requirements of the maritime industry. This in turn will impact on the design of Maritime English courses, their curricula, the materials development and assessment tools to be used, and even the training of Maritime English teachers, many of whom may need to update their knowledge and skills.

In this context it is worth noting that the predecessor to the Manila Amendments (STCW 1978/95) made higher demands primarily on the nautical and technical fields. It emphasised, for example, the importance of the competency-oriented approach rather than purely knowledge-based Maritime Education and Training and assessment [1], which left the door ajar for improvements as far as Maritime English instruction for deck and engineer officers is concerned.

Thus it is interesting and gratifying to note that as far as Maritime English is concerned this important skills-based issue has played an ever growing part regarding the three major successive versions of the Convention, i.e. the original STCW 1978, via STCW 1978 as amended in 1995, and culminating with the Manila Amendments of 2010, which are dealt with in greater detail below

The authors feel that experienced Maritime English lecturers worldwide will welcome the challenge to consider and realise the tasks to be accomplished in order to meet the requirements of the Convention as defined by and detailed in the Manila Amendments.

Thus, with the above in mind, this paper will observe the IMO's decision-making process, identify and comment on the new provisions in the Convention and the existing provisions that have been invested with a stricter and higher degree of commitment, and give selected examples demonstrating the impact of the revised STCW Convention upon Maritime English course design, material development and instruction; all within the context of English for Specific Purposes (ESP).

## 2. THE IMO DECISION-MAKING PROCESS

The International Maritime Lecturers' Association (IMLA) was represented at all stages of the STCW review process, and has such been able to monitor and influence the decision-making process. At the Sub-Committee on Standards of Training and Watchkeeping meetings all the 170 IMO member states have had political, legal and technical representatives present as have most of the consultative 61 Intergovernmental Organizations and 78 NGOs (Non-governmental

Organizations); often around some 500 experts present at any one time.

It is not an easy task for the outsider to fathom out the procedures, search for the relevant documents being discussed and understand the terminology. Even locating the various sessions with plenaries, working groups drafting groups and the topics they are dealing with can be a challenge. At times decisions are made at great speed, at times an hour or so is spent on one seemingly small detail. However, despite the enormity and complexity of the task, decisions are inevitably realised and the day's agenda completed, even if this means early starts and late finishes. The secret to success, is the vast amount of preparatory work done between STW (Sub-Committee on Standards of Training and Watchkeeping) meetings where agreements are made and co-sponsors identified in order to facilitate the decision making process.

There are times, nonetheless, when decisions are not straightforward, and groups gather during the breaks and after the sessions to hammer out acceptable solutions. In the event of a non-conclusive resolution and this occurs occasionally, the matter is forwarded to the next meeting, and finally to the Diplomatic Conference, with the hope that unanimity is reached within the meantime.

At the 41st STW meeting, held in January 2010, IMLA had tabled a Note *Communication on board* to strengthen Regulation 1/14 *Responsibilities of Companies.* At the first days plenary this was referred to the Working Group dealing with Chapter 1 *General Provisions*. Worth noting perhaps is the Working Group for Chapter 1 began its task on the Monday afternoon, resuming sharp at 09.00 the following morning, and reaching the tabled item at 19.34 in the evening, where the Note was referred to, but further discussion regarded unnecessary since the previously accepted amendment from STW 40 was seen to be sufficient (c.f. section see 3.1 below). Clearly, if IMLA wishes to have a real impact in fashioning change "co-sponsorship" is essential, namely through lobbying Member States in order to guarantee their support in writing; proposals from NGOs alone being rare. Nonetheless, it is worth mentioning that IMLA's ideas have in principle been allowed for as reflected in the revised Convention and especially by the reference made to the SOLAS Convention (2004). Furthermore, there were a number of amendments accepted that directly refer to or imply competence in Maritime English, as presented below.

One further item worth noting was the inclusion in the agenda of lunchtime presentations of which one contribution from Poland was entitled *Do we need standards for Maritime English?* This possibility clearly provides a window of opportunity to influence decision makers at the highest levels and should be considered by IMLA's Committee on Maritime English for future occasions.

Finally, in order to impact on the IMO decision making process it is invaluable to have experienced IMLA delegates present at meetings who are familiar with the process. Thus, for those interested in gaining experience and understanding the procedures of their national representatives in fashioning the legal background behind the standards of maritime education and training which guide our daily endeavours, IMLA as a consultative NGO at IMO, opens the door.

## 3. THE MANILA AMENDMENTS

In the following first sub-section the Manila Amendments resulting in the new or amended requirements to Maritime English in general are introduced and discussed. In the second sub-section the specific requirements regarding Maritime English as laid down in the amendments are identified and commented on. Only the sections involving the STCW Operational and Management level of the Code Part A are considered. The chapters of the Convention covering tanker operations, passenger ships, crisis management, medical care and security duties are not included here even though they are also of importance and should thus not be neglected.

### *3.1 The new Maritime English requirements: in general*

Despite certain attractions it was never the intention of the IMO to create an entirely new Convention. The philosophy for the review as developed at STW 38 [2] included eight principles, two of which read:

- retain the structure and goals of the 1995 revision
- not to amend the articles of the Convention.

This infers that the parties involved in the reviewing process were not given an absolutely free hand in this respect, but were conditioned or guided, and their ideas and initiatives channelled.

At least one of the eight basic principles mentioned above was highly relevant for our subject: *Requirements for effective communication.*

IMLA, and especially its Committee on Maritime English, also felt challenged and saw that certain shortcomings in the STCW 1978/95 Convention identified by the Maritime English teaching community were worthy of the IMO's consideration, and the Conference enriched the corresponding discussions with purposeful suggestions.

The following amendment in particular entails far reaching advantages for Maritime English as a subject of instruction and research and its reputation as a comparatively newly established knowledge area. The corresponding extracts read:

*Regulation I/14*

*1 Each Administration shall … require every … company to ensure that:…*

*.7 at all times on board ships there shall be effective oral communication in accordance with chapter V, regulation 14, paragraphs 3 and 4 of the SOLAS Convention* [3].

There are at least two items in these tersely worded lines which, however, will have an immense impact on Maritime English as a subject of instruction and research.

Firstly, the modal verb *"shall"* as used in the regulation mentioned above postulates the highest degree of commitment in legal contexts, e.g. conventions, laws, decrees, regulations, provisions, etc., indicating orders or instructions. This means that the clientele to which this regulation applies has to meet the requirements set out as it is not a matter of discretion whether to do so or not. Consequently, Regulation I/14/.7 essentially strengthens the position of Maritime English lecturers and indeed the role of the subject as well.

Secondly, the reference to the SOLAS Convention of 2004 made above is of utmost importance for the future development of Maritime English, both for MET institutions and for the maritime industry and here especially for the complements of the active fleets and their shorebased services such as Vessel Traffic Services (VTS) and allied emergency services. The SOLAS regulation referred to reads:
*English shall be used on the bridge as the working language for bridge-to-bridge and bridge-to-shore safety communication as well as for communications on board between the pilot and bridge watchkeeping personnel* [4].

Here again the modal verb *"shall"* is wisely used, with the implication described above, and thus is entirely in line with the policy of the IMLA Committee on Maritime English since it provides a solid legal foundation both for curriculum design and for research. Furthermore, it does away with the occasionally advanced argument that IMO has avoided specifically naming English as the binding language of seafaring in its legal documents. As a result, this essential regulation is highly usable at MET institutions and elsewhere, whenever the legal authority of Maritime English, its teaching and its teachers come into question.

Analysing the wording of the regulation the idea suggests itself, that a simple editorial amendment could have given the whole regulation a more comprehensive impact. Inserting a comma or alternatively the conjunction *"and"* after the words *"communications on board"*, this regulation would then have covered, together with the corresponding Manila Amendments, the most important fields where English is used in ship-to-ship and ship-to-shore-to-ship communications, in on-board communications and in ports. This, quite possibly, was the original intention of the authors of SOLAS, however, implementing it at IMO, where the issue had already been raised, would have required a new work programme item sponsored by a Member Government. IMLA, as a Non-governmental Organization, is unable to propose such an amendment and would thus have to hand it to an interested Member Government to be accommodated in a paper to the Maritime Safety Committee as a new work programme item; this being the tenor of drafting documents within the Organization.

Moreover, the SOLAS regulation advises the use of the IMO Standard Marine Communication Phrases (SMCP) in the contexts outlined. This advice goes back to a proposal of the USA delegation to IMO and strengthens furthermore, the part the SMCP plays in maritime communication and thus in promoting safety at sea and in ports. Moreover, it also speaks well for the editorial amendment highlighted above.

*3.2 The new Maritime English requirements: in detail*

In the new document there are a number of amendments or requirements that directly refer to or imply competence and proficiency in Maritime English. These are all derived from the more general requirements dealt with before and have to be allowed for in Maritime English course design and instruction. They will also provide the essential impetus for research and challenge the international Maritime English community long into the future.

The requirements in question are laid down in the Tables to the STCW Code Part A retained from the structure in STCW 1978/95:

- Column 1: Competence
- Column 2: Knowledge, understanding and proficiency
- Column 3: Methods for demonstrating competence
- Column 4: Criteria for evaluating competence

In the following, a number of the most important items are identified and discussed.

The necessity to ensure *effective communication* in its diverse manifestations in various nautical and technical spheres is explicitly expressed in the amendments. Whenever the term *"communication"* appears it can be taken for granted that language communication using English is meant recalling that multilingual crews, where English is the working language, are the rule and rarely the exception in international shipping today. In the extracts from the revised STCW that follow the amendments are ***highlighted***.

***Table A-II/1***

- *Column 1: Maintain a safe navigational watch. Bridge resource management*
- *Column 2:* ***.2 effective communication***

- *Column 1:* ***Use the IMO Standard Marine Communication Phrases and use English in written and oral form***
- *Column 2****:*** *…to communicate with other ships, coast stations and* ***VTS centres***
- *Column 4:* ***Communications are clear and understood***
- *Column 1: Monitor the loading, stowage, care during voyage and the unloading of cargo*
- *Column 2:* ***Ability to establish and maintain effective communication during loading and unloading***

- *Column 1: Inspect and report defects and damage to cargo spaces, hatch covers and ballast tanks*
- *Column 2:* ***Ability to explain how to ensure reliable detection of defects and damage***
- *Column 1: Watchkeeping*

- *Column 2:* ***The use of reporting in accordance with the General Principles for Ship Reporting Systems and with VTS procedures***
- *Column 1: Application of leadership and team working skills. Knowledge and ability to apply effective resource management*
- *Column 2:* ***.2 effective communication on board and ashore***
- *Column 4:* ***Communication is clearly and unambiguously given and received***
- *Column 1: Coordinate search and rescue operations*
- *Column 4:* ***Radio communications are established and correct communication procedures are followed at all stages of the search and rescue operation***

Apart from the non-specified requirement of effective communication, at least four issues in the amendments are of great significance:

Firstly, besides the use of the SMCP, English in written and oral form has to be taught/learnt and mastered. In this way the communication skill of "writing" is given much higher priority than previously.

Secondly, communication with VTS centres is now wisely accommodated for in the Convention. That this has not been done in previous versions of the STCW is surprising since communicating with VTS centres is one of the most frequently performed exchanges of information on the radio for ships officers and is relatively demanding. Experience shows that this issue has been part of the Maritime English syllabi at many MET institutions although it has never been required by previous versions of the Convention.

Indeed, this issue plays an important part in the maritime industry itself. At the 15th GA of the Confederation of European Shipmasters' Associations (CESMA) held prior to the Manila Conference in Gijon, France, May 18-21, the participants requested that binding regulations on the language used on the ship's bridge in pilotage waters/VTS areas be provided [5].

The amendments also require Maritime English lecturers to familiarise themselves with Ship Reporting Systems (e.g. MAREP), the corresponding Radio Regulations and the decreed VTS procedures. To do this is reasonable and manageable for a Maritime English lecturer and is, in fact, facilitated through the corresponding chapter of the SMCP [6] where VTS communications are covered. An example of how to design a unit on VTS communication is given in Annex 1.

Thirdly, that effective communication ashore is also mentioned is a further plus in the amendments as the communicative mastering of the interface "ship x shore" is now on the agenda; for example, in cargo handling operations and cargo care, where for the latter descriptive communication skills are required.

Fourthly, the clear reception of communication is furthermore mentioned thus emphasizing the skill of listening, the importance of which has been underestimated in the past.

***Table A-II/2***

- *Column 1: Respond to navigational emergencies*
- *Column 4:* ***Communications are effective and comply with established procedures***

The technological/procedural aspects of radio communication and its Maritime English requirements now appear as one complex, thus reflecting the reality of seaborne radio traffic. Here again, for Maritime English instruction the appropriate Radio Regulations and the procedures as laid down in the IAMSAR Manual [7] have to be allowed for. As far as SAR operations are concerned, the SMCP provides a comprehensive set of corresponding communications [8].

***Table A-II/5***

- *Column 1: Contribute to a safe navigational watch*
- *Column 2:* ***Ability to understand orders and to communicate with the officer of the watch in matters relevant to watchkeeping duties***
- *Column 4:* ***Communications are clear and concise***

It is appreciated that the complex face-to-face bridge conversation is at last given attention in the amendments. This may well be extended to, for example, the watch officers' conversations performed during cargo handling operations. The SMCP could be helpful in this respect. [9].

***Table A-III/1***

- *Column 1: Maintain a safe engineering watch. Engine-room resource management*
- *Column 2:* ***.2 effective communication***
- *Column 4:* ***Communication is clearly and unambiguously given and received***
- *Column 1: Application of leadership and teamworking skills*
- *Column 4:* ***Communication is clearly and unambiguously given and received***

***Table A-III/2***

- *Column 1: Use leadership and managerial skills*
- *Column 2:* ***.2 effective communication on board and ashore***
- *Column 4:* ***Communication is clearly and unambiguously given and received***

***Table A-III/5***

- *Column 1: Contribute to a safe engineering watch*
- *Column 2:* ***Ability to understand orders and to communicate with the officer of the watch in matters relevant to watchkeeping duties***
- *Column 4:* ***Communications are clear and concise***

***Table A-III/6***

- *Column 1: Use English in written and oral form*
- *Column 2:* ***Adequate knowledge of the English language to enable the officer to use engineering publications and to perform the officer's duties***
- *Column 4:* ***English language publications relevant to the officer's duties are correctly interpreted. Communications are clear and understood***
- *Column 1: Use internal communication systems. Operation of all internal communication systems on board*
- *Column 4:* ***Transmission and reception of messages are consistently successful. Communication records are complete, accurate and comply with statutory requirements***

- *Column 1: Application of leadership and teamworking Skills*
- *Column 2:* ***.2 effective communication on board and ashore***
- *Column 4:* ***Communication is clearly and unambiguously given and received***

Summing up the requirements of Table A-III dealing with engineering duties, it is noted that the improvement of the communication proficiency among the engineering staff is laudably given sufficient attention. The corresponding requirements cover all the four communication skills (reading, writing, listening and speaking) which is of enormous benefit compared to the preceding versions of the Convention where Maritime English instruction for engineering officers played a minor part - this was one reason why Maritime English for engineering students has been badly underestimated at many MET institutions.

Having welcomed and appreciated the new requirements regarding Maritime English it must, however, be stated that any kind of systematic principles according to which communication skills, in whatever form, are assigned to the different nautical or engineering requirements, cannot be detected. It may be asked why, for example, for *"Berthing and unberthing operations"*, for "*Actions to be taken to protect and safeguard all persons on board in emergencies"* and for many other items, no communication requirements are explicitly listed. A kind of ideological fallacy might occur in this respect, especially among less experienced Maritime English teachers who could be left with the misleading idea that the explicitly mentioned requirements reflect the entire contents of their instruction. A more elegant and consistent approach would have been desirable, but one has to cope with the facts given and what now matters is the creative implementation of the Manila Amendments. The lengthy STCW Convention still requires careful study to further reveal any "hidden" requirements and interpretations where the need for a sound command of Maritime English is required. Nonetheless, the new version of the Convention demonstrates significant progress in tightening the communicative competence provisions when compared with its predecessors.

## 4. CONCLUSIONS

The Manila Amendments are the result of nearly five years of intensive debates and discussions on various occasions. Although the outcome is not the optimum, it is, however, an acceptable and practicable instrument suited to further develop Maritime English as an essential but relatively recent knowledge area required to satisfy the regulatory framework and thus the complex requirements of the maritime industry.

This paper has attempted to observe IMO's decision-making process, identify and comment on the new provisions and give selected examples demonstrating the impact of the revised STCW Convention upon Maritime English course design, material development and instruction.

Now that the revised STCW Convention has entered into force (January 01, 2012), it matters not to waste time but begin to adapt, update and develop the curricula of Maritime English courses, the teaching materials and the assessment tools in order to embrace the new or amended requirements set out in the Convention. Appropriate teaching/learning methods need to be applied as discussed and promoted by the relevant professional bodies and in IMO's Model Course 3.17 as, for example, content-based teaching/learning based on the communicative approach.

Furthermore, Maritime English lecturers, like many others working within the English for Specific Purposes sector, need also to become qualified to enable them to meet the demands set out [10], thus highlighting the need for certification through ESP teacher training courses.

Last but not least, an appropriate assessment tool has to be developed and a standard yardstick adopted [11] in order to make an instrument available to MET institutions and the industry suited to reliably assess and measure the communication performance of students and/or officers.

All this is no easy task but necessary not only to satisfy the new provisions but also to simply benefit students at maritime universities and colleges by enhancing their safety in the fleets they will serve and the safety of shipping in general.

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**Annex 1**

| | | |
|---|---|---|
| **Unit Overview** | **The students are briefly informed of the subject matter and the tasks involved. They are also told that the specific communication skills and procedures required are the focus of the unit rather than the technological aspects. Preparing the unit by "twinning" with a VTS technical specialist is advisable.** | |
| **Steps** | **Aims and Content** | **Methodological Aspects** |
| Step 1 | The students get to know the structure, the tasks and the three basic services of VTS. They learn from the material the general communication behaviour/requirements of the persons involved (ships officers, VTS Operators). | Videos, DVDs and other materials are available. A visit to a VTS Station is a good start. |
| Step 2 | The corresponding parts of the SMCP (A1/6) are introduced and their understanding checked. | The pronunciation of the SMCP, the meaning and application of the Message Markers are taught and practiced using isolated phrases/sentences. |
| Step 3 | The students become familiar with the VHF Radio Regulations for routine communication and practise selected examples. | The awareness to strictly comply with the VHF Radio Regulations is created. |
| Step 4 | The students listen to free dialogic VTS communications and to those applying Ship Reporting Formats, e.g. MAREP (IMO MSC Res. 43(64)) from CDs/cassettes and record (in writing) the information heard. | The students realise the advantage of Ship Reporting Formats; corresponding forms are provided and studied. |
| Step 5 | The students compose and send messages/reports in English to simulated VTS Stations applying the SMCP based on information given in their mother tongue or in English. | Avoid giving information that reflects the wording of the SMCP; the messages sent are recorded (on computers, CDs, cassettes) and analysed. |
| Step 6 | The students perform role play dialogue communications between their ship and the VTS Station based on the information given in the handouts; the dialogues may be free or use MAREP. The basic situations are covered requiring communication, e.g. when entering, leaving or transiting a VTS area or calling at/leaving a port within this area. | The VTS Station dialogue parts are given from a loudspeaker simulating close to real life situations, noise included. The students role-play as ships officers and/or as VTS Operators. The communications are recorded and debriefed |
| Step 7 Mini-Project | The students are provided with recorded or transcripts of examples of “real” VTS communications. They decide whether the language used is appropriate. If not, the wording has to be recast and a revised message sent. | The examples used may be recordings of voice communications or transcripts. In the recast scripts the SMCP is used when appropriate. The students' messages are recorded and discussed. |

# SECTION VI
## TRANSPORT ECONOMICS

# THE EVOLUTION OF THE ECONOMICAL FLOWS OF THE TRANSPORT ACTIVITIES IN THE GLOBALIZATION CONTEXT

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**ABSTRACT**

The transport activity and the commerce activity evolve in tandem. The commercial economic flows determine the flows of the transport activity and backwards. This study presents in a concise manner the evolution stages of these flows.

**Keywords:** *economic flow, transport activity, evolution.*

## 1. INTRODUCTION

Although the need for transport is a primary need, at a macroeconomic level, the demand for transport services is dependent on the volume, quantity, frequency and the geographical characteristics of the commercial exchanges.

Therefore the demand for transport may be assimilated into the market as being a derived demand from the commerce activity.

In this regard, through the double fatality (type GT-TG) that has manifested in the entire humankind history between the transport activity and the commerce activity, the two economic sectors have evolved in tandem in a more and more accelerated rhythm, the economic commercial flows determining the flows of the transport activity and backwards.

The component of the commerce activity with the most dynamic evolution in the last decades was represented by the international commerce.

This fact has determined the evolution of the global economy from the traditional economy to the global economy.

It is common to term the traditional economy as being the model of economy that characterized the biggest part of the economical exchanges in the early history until the recent history of the humankind society.

This type of economy is characterized by mobile markets, of regional level, localized or even landlocked.

In trade off, the global economy, which acquired a more and more pronounced nature in the period of contemporary historical evolution, may be defined as being a model of economy resulted from the integration at a global level of the production markets with the consumption ones.

## 2. THE EVOLUTION STAGES FROM THE TRADITIONAL TO GLOBAL TRANSPORTS

### *2.1. First phase: the fragmented transport networks phase (the immobile production factors phase)*

This phase is the most extended in terms of the historical period.

It survived at a quasi-global level for six to eight millenniums, having its origin in the early antiquity, along with the inactivity of the populations and the emergence of the first work division.

In the state-cities from Mesopotamia (Jericho, Ur, Nippur), on the Nile Valley, of the Hindu or in Ancient China, the balance of the commercial exchanges had a local character, the biggest part of the goods being destined to the consumers which belonged to an administrative-territorial unit.

Although the economy has evolved along the history, this phase had an important accent at a global level until after the Second World War and it can be said that it barely ended in the late 60s of the 20$^{th}$ century.

It was characterized by complex local exchanges, and in inverse ratio to the distance with other geographical regions.

At the level of the transport activity this type of economy was characterized by:

- the existence of some fragmented transport networks and with weak interregional connections
- the preponderance existence of some means of transportation intended for general cargo
- the existence of some terminals with a low degree of specialization.

At a global and regional level the commercial exchanges were limited especially for raw materials and for the staple end product.

These characteristics have reflected on the transport activity a domination of the means of transportation and of the terminals of this type:

- cargo (general cargo),
- liquid bulk (crude oil, refinery products),
- solid bulk (coal, ore, grain).

### *2.2. Second phase: the emergence of multimodal's (the mobile production factors phase)*

This phase is predominantly characteristic to the last three to four decades of the 20$^{th}$ century.

It emerged at the same time with the increase of the capital flows between the main international regional markets.

It was characterized by:

- the unprecedented development and the globalization of the international political relations,
- the introduction on a large scale of the computerization in the economical processes,
- the emergence and development of some new types of communication and data transfer: world-wide-web, satellite communications, GPS technologies, etc.

Due to the effortless interregional exchanges, in this phase of the economy, segmentations appeared in the production flows, determined by the geographical locations in which the work force, the raw material or the means of production are found at the lowest cost.

This segmentation had as a consequence the standardization of commodities, in order to be able to integrate them in the global production flow, to handle them, transport and assemble them in any given location at a global level.

At the transport activity level, the standardization of commodities had as a consequence the emergence of new specialized means of multimodal transportation, and the gradual replacement of the means of transportation and of the unspecialized terminals or specialized on general cargo with terminals with a high degree of specialization.

One of the most important trends in the global transportation was represented by containerization.

The containerization process led to the gradual replacement until the quasi-disappearance of the cargo type international transportation, and at the level of global flows of transport it led to the replacement of an important part of the tramp type transports with line transports.

*2.3. Third phase: the phase of the integration of the global transport system (the globalization of the economy phase).*

This phase is in a full process of evolution and it is characterized by the quantitative growth and the unprecedented diversification of the cargo and services exports.

The indisputable consequence of this phase is that of the creation of a unique type of worldwide consumer, having the same needs expressed by consumption from the east of Asia to the west of America, from the south of Africa to the north of Europe.

The relatively easy access to information and the communications with lower and lower costs have made possible the nurturing of the needs and preferences of the consumer.

At the same time, the construction of a larger number of transport terminals and the deployment of the means of access in previous inaccessible areas have made possible the access of specialized work force to any of the segments from the production flow.

Therefore, the means of transportation acquired gradually the first place in the balance of worldwide services, as it was seen in the previously presented statistics.

This growth tendency of the balance of transport services at a worldwide level within the services segment is still kept emphasized.

According to the present economic tendencies, an average annual growth of the international transport services is estimated around the 8% figure in the next decade.

## ***3.*** **THE BEHAVIOR OF TRANSPORT OPERATORS IN THE ACCELERATED GLOBALIZATION CONTEXT**

The accelerated globalization of the transport system led to new economical practices and to the emergence of a new type of behavior of the transport operators.

This type of behavior is characterized especially by the following major tendencies:

*3.1. The provision of complete solutions for customers by the transport operators:*

The tendency is manifested through the more and more pronounced concern of the big operators to turn from unimodal operators into multimodal operators.

The large international transport companies attempt through this type of behavior to offer integrated solutions of transport, supplied to clients by a unique operator.

This unique operator owns or has access, through preset commercial relations, to a logistic transport chain.

By reason of this access, the unique operator is capable of performing all over again the entire activity of contraction, transport service, transport and handling of the goods between any given two points on the globe, interconnected with one another through the medium of the global transport network.

*3.2. The expansion of the transport capacity of the vehicles fleet:*

The increasing flow of transported goods through the medium of the integrated system of global transport let to the growth of the transportation demand and – implicitly – of the pressure on the transport fleets.

The accommodation of the transport fleets to the more and more pronounced demand for transportation could only be accomplished in the last decades through major investments in the development of these fleets.

The main investment orientations of the transport companies targeted:

- the specialization and modernization of all the types of means of transportation previously existing and the emergence of new types of multimodal means of transportation;
- the increase of the transport capacity through three types of complementary developments: the increase of the number of commercial transport fleets, the increase of the number of vehicles of these commercial fleets and the increase of the transport capacity of the vehicles;
- the decrease of the operation costs by means of technology, computerization, the introduction of more effective management norms and the establishment of profitable relations between the players belonging to the transport market.

*3.3. The centralization of the transport capacity at a global level:*

This tendency can be viewed as being an evolutional tendency on the way to consequence.

The need for capital investments in the transport sector, in order to deal with the current demands, makes that the access of smaller companies in the provision of international transport services to be more and more difficult.

As a consequence the past twenty years were characterized by a pronounced process of taking-over, merging, and bankruptcy on the international transport services market.

For example, nowadays the first twenty companies of line containerized transport control that sector almost entirely, and the tendency of accentuation of the oligopoly is maintaining for the next decades.

## 4. CONCLUSIONS

All these major tendencies previously presented, as others with a less measurable character have as a consequence, on a short and medium term, the replacement and adjustment of the traditional production flows with integrated transport flows at a global level.

The evolution of these flows tends to the transcendence of the geographical limitations at a planetary level, through a pronounced process of trans globalization.

This process cannot be forecasted on a long term by the specialized literature, but only by the limitless imagination of the human kind.

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# THE ROLE OF GLOBAL ECONOMICAL AND REGIONAL POLITICS IN THE TRANS-GLOBALIZATION OF THE TRANSPORT ACTIVITY

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**ABSTRACT**

Politics has always played an important role in the development of the economy. The development of the transport infrastructure is determined directly by the economical politics of the states and of the great customs alliances.

**Keywords:** *global transports, regional transports, trans-globalisation*

## 1. INTRODUCTION

The globalization phenomenon of the economy, in conjunction with the simultaneous growth at a worldwide level of the transport services demand, is reflected on the evolution of the means of transportation in the direction of the development of these waters toward more courses, both quantitative and qualitative.

These courses mainly reflect a new way of behavior of the states, which are the main holders of the transport infrastructures.

This behavior has, especially, the role of *attracting capital in the great infrastructure investments* that are in progress in the states which they lead.

The need for capitalization has determined an evolution of the political behavior of the states, from the traditional isolationist objectives to integrated objectives of the political and ideological regionalism, and in the end to global objectives assumed by most of the world's countries.

## 2. THE REGIONALIZATION OF THE TRANSPORTS

The biggest revolution in the vision of the countries after the Second World War in terms of development of the transport infrastructure was represented by the *political will for regional economical integration.*

This phenomenon led to the creation of the great regional markets during the Cold Was: *The Common European Market*- in Western Europe, *CAER*- in the former communist republics, the *OPEC* countries, *USA, China,* etc.

These regional markets- under a powerful political control- developed from strategic reasons their own economical communities, and, for supporting the commercial exchanges, invested in the accomplishment of some important intra infrastructures, forming *regional transport networks.*

The political, ideological and military motivations had as a consequence the development of these regional transport networks in a *fractured global system* according to the regional positioning and the geographical extent of these political-economical blocks.

The rivalry between these blocks is manifested significantly in the direct plan of the international politics, having a powerful feeling of enclave, of competition and a separationist tendency of the areas of influence.

*The commercial exchanges* between the rival economical blocks *had a controlled nature* and – most of the times – scheduled for a medium and long term, according to the more or less scrupulous strategies of the political leaders.

The commercial barriers enforced by the *direct control of the countries in the international commerce documents* and, the difficult to pass, customs barriers determined the existence of some *poorly developed interregional transport networks.*

## 3. THE GLOBALIZATION OF THE TRANSPORTS

During the last three decades, especially after the fall of the Berlin Wall (1989) and the thaw of the international relations, without the threat of the Cold War, *the integration of the markets at a global level* became more and more visible.

In the transport infrastructure this phenomenon manifested through *the integration of the transport system at a global level* in a *multimodal global transport network* through *the interlinking of the regional transport networks.*

Although it seems paradoxical, by relaxing the local control of the great world powers, the phenomenon had as a consequence *the reconfiguration of some powerful regional markets.*

The global competition among the approximately 200 political competitors acquired the character of some competitions between approximately *10 global economical giants* represented either by the great customs or commercial unions: *E.U., N.A.F.T.A., A.S.E.A.N., O.P.E.C.*, or by the powerfully industrialized countries: *S.U.A., Canada, Great Britain, Japan,* or by the emerging countries with an accelerated economical growth: *BRIC.*

For all of these markets, *the global integrated transport system* represents *the optimum global integration solution,* through the exchange of people and goods that it provides, in the interior and between these markets.

The integration of this system represented a complex and long process, which was characterized by:

*The global interconnection* of the unimodal transport network into *a unique multimodal transport network.*

*The local diversification of the means of transportation, through the creation of some alternative ways of transport between any given populated positions on the globe by:*

- *introduction of regular commercial maritime lines* by the great container operators- Maersk, Hapag-Lloyd, Evergreen, etc.;
- *the construction of double road and rail corridors- the Pan European Corridors* system, *the Pan-American Corridor, The Trans-Siberian Corridor;*
- *the creation of some interior navigation corridors- The VII Pan-European Corridor* (Rhine-Main-Danube), *Inter coastal* (U.S.A.), *the Grand Canal* (China);
- *the development of the unimodal and multimodal terminals network* (railway, road, waterside, and airports, etc.)

*The organization of the transport corridors* after an established informational pattern: the *data integrated flow* pattern.

This pattern is characterized by *hubs*, represented by main terminals and *spokes*, represented by provisioning terminals or secondary ones.

The best examples of organized terminals, after the pattern *"hub and spokes"*, are part of the ones previously specified: the ten *Transport Pan-European Corridors, the Pan-American Transport Corridor, the Trans Siberian Corridor* or the great *transoceanic naval routes.*

*The growth of the global coverage degree* through *the development of the local transport networks,* which make possible the interconnection between any ends of the *transport flow,* no matter the geographical positioning.

*A transport flow* means a logistic system equivalent to a precise sequence of the global transport system between two different beneficiaries of the transport services:

- raw material supplier-precast / components manufacturer;
- components manufacturer-end products manufacturer;
- end products manufacturer-consumer, etc.

The technical investment capacity and the new management and political visions in terms of the development strategy of the transport network had as an effect a new type of approach of the investors in the transport infrastructure: that of making a *higher and higher range of infrastructure projects.*

Among this range of projects can be noticed:

- *road and rail tunnels: the Seikan Tunnel* in Japan (54 kilometers, finalized in 1988), *the Eurotunnel* which connects the European continent to Great Britain (50,5 kilometers, finalized in 1994), *the Lötschberg Basetransalpine tunnel* in Switzerland (34,5 kilometers, finalized in 2006);
- *the great viaducts* especially in China (*Danyang-Kunshan:* 165 kilometers, finalized in 2011, *Tianjin*: 114 kilometers, finalized in 2011, *WeinanWeihe*: 80 kilometers, finalized in 2010, etc.), and in the USA (*Lake Pontchartrain Causeway*: 38,5 kilometers, finalized in 1969, *Manchac Swamp*: 37 kilometers, finalized in 1970), but also Europe or Africa;
- *the railway transport lines through magnetic levitation-Maglev* in China (*Shanghai Transrapid*: in expansion phase up to 200 kilometers-the longest of this kind), Germany (*Emsland Transrapid*: 31,5 kilometers, finalized in 1987) or Japan (*JT-Maglev*: in expansion phase up to 50 kilometers, *Linimo*: 8,9 kilometers, finalized in 2005).
- the creation of new *waterways* or developing some historical waterways on interior waters: *The Rhine-Main-Danube Corridor* (approximately 4000 kilometers, including the waterways of the three watercourses and the artificial channels Rhine-Main-Danube and the Danube-Black Sea Channel), *Inter coastal* in the USA (almost 5000 kilometers, including natural segments of waterway courses- Mississippi, Alabama, Hudson, etc), *the Grand Canal in China* (almost 1800 kilometers- the largest artificial canal in the world), etc.
- great projects of *trans-continental transport pipes*, among the most important being the ones from China (*Xinjiang-Shanghai*: approximately 9000 kilometers), South America (*Bolivia-Brazil: Gasun*, approximately 5000 kilometers), Europe (*Russia-Germany: Yamal,* approximately 4200 kilometers), North America (*Trans-Canada*: approximately 3200 kilometers), etc.

## 4. THE TRANS-GLOBALIZATION OF THE TRANSPORTS

In the forecasted investments rhythm for the next decades, corroborated with an exponential increase of the global technical-economical capacities, projects, that seemed unimaginable not so long ago, both from a conceptual and technical point of view, will take shape:

- *The rail and road bridge over the Bering Strait,*
- *The Transatlantic Underwater Tunnel* between Europe and North America,
- *The Great Trans-Global Motorway*-which will interconnect all the world's continents with one another.

Only some of the projects, which were born at a certain moment only in the minds of some visionaries, were mentioned.

Nowadays these projects are seriously disputed by the great corporations and governments, and in the following decades there will be a chance to see them all put into effect.

All these projects will have, as a main long term effect, *the accentuation of the integrator role of the transport system,* increasing even more the mobility of goods and people and reducing, close to annihilation, the political, economical and cultural contradictions between the various regions of the world.

If there will be no major syncope in the evolution of the humankind society, by means of the effortless access to any location on the globe through the medium of the global transport network, the next century will definitely be a *century of extinguishment of the state borders* as they have been known for over 8000 years.

The main consequence will be that of the *development of pseudo-borders without a geographical* *character*, *caused mainly by the capital control* of the large groups of world political and economic interests.

These groups of interests will be represented by tripartite associations formed by the *Financiers* (banks, investment funds), *Contractors* (corporations, companies, investment groups, eventual mob and paramilitary groups) and *Governments* (local, state, regional) - *FAG Groups.*

A part of the FAG Groups will become, most definitely, the new *"zaibatsu"* of the future global economy.

They will evolve by having their own *captive work force*, their own social protective systems, medical insurance, public order and – why not? – their own citizenships.

The unprecedented concentration of the economic force under the control of these FAG groups will also have capital consolidation effects, phenomenon which will make possible *the accomplishment of unprecedented investments in technology and the creation of new business opportunities, which will transcend the globalization interest.*

*The expeditions and the exploration on other planets*, *the colonization and the exploitation of the resources of these planets*, *the terra-forming* and *the creation of extraterrestrial habitats* will develop a new *interdependence between the transport activity and the trans-globalization process.*

By *trans-globalization* can be understood-in the sense of the present study - the economical and political evolution of the human civilization through *overcoming the planetary limits* and by *developing political-economical communities in the extraterrestrial space – orbital stations, natural or artificial satellites, other planets* of the solar system or of other solar systems.

*The extraterrestrial transports will have an integrator role for the trans-global economy in the future*, similar to the one that it has nowadays the integrated global system of transport for the global economy.

In that new era of transports, the queen of international transports will definitely become the *space ship*, given that the share of interplanetary transports, in relation to the planetary ones, will increase exponentially.

Certainly, at that time, the huge current maritime ships (ULCC, ULCS, ULBC or ULPS) will seem to be small carts in contrast with the giant *interplanetary carriers.*

## 5. CONCLUSIONS

The capital infusions of the states and of the large multinational corporations will have as a main effect *the* long term *accentuation of the integrator role of the transport system*.

Along with the acceptance of this role, the economical and political evolution of the human kind civilization will grow beyond *the planetary limits.*

In that phase of evolution the transport activity will have a meaningful extraterrestrial balance, gaining an integration role of the new economy with a trans-global character.

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# COMPETIVITY ASPECTS ON ROMANIAN MARITIME TRANSPORTS

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**ABSTRACT**

In general, the shipping industry, complies mostly to competition rules. The only exceptions are the technical cooperation agreements between line shipping companies that are grouped in consortiums or alliances. Although the maritime industry is perceived, overall, as a competitive market, some components of the industry have a doubtful reputation in respecting the antitrust rules. Anticompetitive agreements were sanctioned by the European commission and competition authorities, especially the pool type arrangements that are so common in irregular maritime transport market. When it comes to Romania, the international orientation of maritime industry in our country necessitates the adaptation to the market economy imposed requirements. Considering the integration in the European Union, Romanian naval industry has to increase “the capacity to resist to the competition pressure and to the market forces which comes from the inside of the European Union” - as it is stipulated in-Accession Partnership with Romania - (2002/92 EC). In order to realize this, Romanian naval construction has to obtain a powerful investment support consisting in technology and equipments in order to increase its efficiency as closer as possible to the naval industry of the countries which are part of the European Union.

**Keywords:** *Romania, economy, maritime transport*

## 1. INTRODUCTION

In order to obtain information on Romanian seaports activities, the Competition Council carried out between June – August 2009 a survey on the market traders. Questionnaires were send to economic operators that were developing maritime transport activities like hiring ships, brokerage or maritime expeditions.

Because the number of ships operated under the Romanian flag is now insignificant, the maritime transport with this ships is very low compared to the total volume of goods loaded / unloaded at Romanian seaports, most economic operators that were interviewed were developing in 2009 auxiliary shipping activities like hiring boats, brokerage or freight maritime expeditions.

These economic operators do not provide shipping services, but they do have direct contact with those who do develop these kind of activities (ship-owners, shipping line companies) and with those who demand shipping transportations. A direct interview with foreign ship-owners or with foreign shipping companies would have been difficult to make, taking into account that their headquarters are in different parts of the world.

## 2. DEMAND OF MARITIME TRANSPORT ON ROMANIAN MARKET

The main categories of goods that have been the subject of maritime transport on the national market in 2008, highlighted by main economic sectors that produce or use them, are: cargo from energy sector (35%), mining sector specific cargo (22%), specific agriculture and forestry cargo (14%). Therefore, those who demand maritime transport are from the following sectors:

- Energy sector
- Agriculture
- Sylviculture
- Mining sector, oil extractions, or other extractive activities.

Operators in these sectors are mainly using the shipping transport in order to import or export feedstock like crude oil, liquefied petroleum gas, coal, grain, wood products, freight that are usually transported to the destination as a liquid or solid bulk. They use the irregular maritime transport for that.

Secondly, the maritime transport demand comes from manufacturing industry like food processing industry, automotive industry, light industry, wood industry, petro-chemical industry, steel industry, etc. Operators in these industries use maritime transportation both to procure the feedstock they need (e.g. Cereals) and also to sell their products through export (e.g. Auto industry).

Goods are transported either by signing renting contracts with different ship owners, or under different bills of lading issued by shipping line that have regular services at the Port of Constanta. In the third place, shipping demands come from:

- construction
- trade sector.

Economic operators from this sectors are using the maritime transport to import and sell on the Romanian market a range of general merchandise, food products, textiles, electronics and appliances.

## 3. THE MAIN CATEGORIES OF MERCHANDISE

Analyzing the main categories of goods operated in the Romanian ports in 2008, there were identified the main categories of merchandise:

- (25.8%) Coal and lignite, crude oil and natural gas.
- (15.5%), Metalliferous ores, mining products, quarrying, peat, uranium.

- (12.1%) Agricultural products, hunting, forestry and fish.
- (8.6%) Petroleum coke, refined petroleum.
- (6.5%) Basic metals, fabricated metal products.
- (5.9%) Chemicals, manufactured fibers, rubber and plastic products, nuclear fuels.
- (2.4%) Other non-metallic mineral products.
- (1.3%) Food, beverages and tobacco.
- (0.7%) Wood, wood products, cork, pulp, paper, printing, media.
- (1.6%) Other merchandise.
- (19.6%) Unidentifiable goods.

*Source: National Institute of Statistics*

Therefore, coal, lignite, oil and natural gas were in 2008 more than a quarter of the cargo loaded and unloaded in Romanian ports. In the Romanian maritime ports were made large quantities of basic metals and metal products (6.5%), but also chemicals, fibers, rubber and plastics (5.9%). A large proportion in the total volume freight was held by unidentifiable cargo (19,6%). In 2009, grain traffic has soared, exceeding 9 million tones, which, in the same period last year, it barely exceeded 5 million tons. Stagnation of the volumes were recorded for oil products, wood and cork.

There were, however, decreases of volume on scrap iron, metal products, solid mineral fuels and crude oil. Also, metal ores traffic decreased in 2009 by nearly two thirds compared to previous year.

## 4. ROMANIA’S INTERNAL OFFER ON MARITIME TRANSPORT

The number of ship-owners in Romania is very low. After 1989, the situation of Romanian ship-owners has known a strong involution. In the Romanian Naval Authority records there were registered in 2009 only 5 owners for a total of seven ships. Ships that today form the Romanian fleet, entered into service during 1980-1991, having a current average age of 24 years. Except the fact that they are old, the few Romanian flag vessels are technologically obsolete and they no longer correspond to international safety standards.

This is why some of them are used only for freight in the owner interest or just for short distance travel. As long as this ships will not be upgraded urgently, they will naturally be declared as being inoperative.

Statistics claim that the decreasing number of Romanian ship-owners is due to:

- Lack of a national strategy in the field;
- Lack of funding;
- Instable legislative regulations;
- Lack of interest from authorities concerning this sector.

According to the responses received from the market, by losing the Romanian ship-owners and the national commercial fleet, Romania loses an important economic sector that could have had a large contribution tot the state budget, generate job opportunities and also international prestige.

## 5. RESTRICTIONS WHEN IT COMES TO MARKET ENTRY

Restrictions that can be identified when entering the market are mainly:

- financial (large investments in constructing or purchasing ships);
- administrative (birocracy before getting the authorization).

The large investments that come with the purchase of a ship, and also the large costs of a ship maintenance makes the market entry very difficult. Because of the very high initial costs, most often the entry of a ship-owner on the market is supported by banks, even by the state applying measures that encourage the sector (tax breaks, financial support for building new ships or upgrading the old ones).

One of the few attempts designed for encouraging investments in this sector mate the subject of a government ordinance: *G.O. no. 116/1998 on development and modernization of Romanian flag vessels and fleet for public transport.* But this piece of legislation that could encourage investment in ships was amended in 1999, becoming unworkable and unattractive. Even if some of its provisions remained in force (funding 25% of new ships built or acquired), each time the state budget financial resources have not been established for this program.

According to the responses from market actors, Romanian ship-owners are not supported by the Romanian state. Also, the State does not encourage the entry into the market of potential ship owners. The general feeling in the market is that the state has a lack of interest in an economic sector that could generate a substantial income to the budget. As mentioned above, the only attempt to stimulate the construction and modernization of Romanian flagged vessels was made by *GO no. 116/1998 on development and modernization of Romanian flag vessels and fleet for public transport*, but the results were delayed because of lack of funds.

The general conclusion drawn until now is that development of this sector urgently needs state support, through a modern and coherent strategy, through financial support measures in accordance with national laws in force.

## 6. PLANS AND OBSERVATIONS FOR 2012

The Port of Constanta is set to experience another year of declining total tonnage throughput and a slowdown of container throughput growth in 2012 despite Romania's robust year-on-year economic growth. An increase in the country's private consumption will support freight volumes at the country's ports; however, it will not outweigh downward pressure on Romania's exports and the country's role in the transshipment of goods.

Over the medium term, we project growth at the port of Constanta which will be trying to recover its pre-downturn throughput volumes.

In 2012 Port of Constanta tonnage throughput forecast to grow 4% over the medium term.

The project focusing on the development of the railway capacity in the river-maritime area of Romania's main port, Constanta, is to go ahead, after the contract for the execution works was finally signed following the decision of the Bucharest Court of Appeal. Increasing the railway capacity for the transport of dry bulk cargoes to and from the port and boosting freight transit volumes on trans-European transport network (TEN-T) via Constanta are among the project's objectives. LNG And China's Products At Constanta.

The feasibility study of an AGRI project, involving transportation of liquefied gas from Azerbaijan to Romania via Georgia's Black Sea coast will be completed in September. As part of the project, a regasification terminal will be built in the Romanian port city of Constanta to receive gas supplies. In a separate development, the country wants to turn the port of Constanta into a gateway for China's exports to the EU. Risks To Outlook The potential for growth at the country's ports stems from BMI's positive outlook on the Romanian economy.

Container throughput will be driven by the country's consumers, with consumer demand in Romania forecast to slightly strengthen. The country's real GDP is estimated to increase by 1.4% in 2012.

A downside risk to our forecasts comes in the form of Romania's heavy exposure to the euro zone, with decreasing demand affecting the country's port's and freight transport network and the country's export growth forecast to slow to 4.9% in 2012. Constanta's role as a gateway for trade to and from landlocked Central Europe may also be affected.

## 7. CONCLUSIONS

The position on East-West route is giving to Romania the chance to play an important role in the future developments under the circumstances of increasing oil products and consumer goods flows.

It is clear that maritime transport in Romania has lots of upgrading to do, but now, we hope, that with the European Union and Council help, the government will find the necessary resources and interest to invest in development. We have a long and difficult road to pass, but our perspectives on maritime transport are optimistic even if right now the whole view looks full of issues. Changes are here to come.

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# DEVELOPMENTS OF MARITIME TRANSPORT ECONOMY IN EUROPE

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**ABSTRACT**

The Maritime transport is the shipment of goods (cargo) and people by sea and other waterways. Port operations are a necessary tool to enable maritime trade between trading partners. To ensure smooth port operations and to avoid congestion in the harbor it is inevitable to permanently upgrade the port's physical infrastructure, invest in human capital, fostering connectivity of the port and upgrade the port operations to prevailing standards. Hence, port operations can be defined as all policies, reforms and regulations that influence the infrastructure and operations of port facilities including shipping services.

**Keywords:** *Maritime transport, economy*

## 1. INTRODUCTION

It is widely recognized the importance of transport in the flow of goods and economic development. Under these circumstances the maritime transport play a key role, connecting the continents and covering the major part of the quantities of goods exchanged among different countries.

The maritime transport should be focused on sustainable development including implementation of all related new concepts.

This article includes some opinions related to major elements which should lead the maritime sustainable development in order to be able to answer to its important role in the economic development.

## 2. WHY ARE DEVELOPMENTS IN MARITIME TRANSPORT ECONOMY IMPORTANT

Year 2012 will mark 20 years since the Rio Earth Summit in 1992 which created the concept of sustainable development and it will also mark 40 years since the first United Nations Conference on Human Environment in 1972. Although sustainability of shipping has been widely discussed in the context of sustainable development over the last two decades, we have not yet developed a common concept for the sustainability of the maritime industries and, in particular, the shipping industry. The UN Conference on Sustainable Development (UNCSD) next year called as "Rio+20" will discuss the green economy and the institutional framework for the sustainable development and, therefore, give us all an opportunity to establish a new framework concept for "Sustainable Maritime Development" which should provide common objectives and guiding principles of future maritime developments in which IMO should play a major and significant role.

Governments, the shipping industry and the wider maritime community as a whole must be encouraged to consider the future of the shipping and maritime industries and generate together a new concept of "Sustainable Maritime Development" which should embrace, in my view, at least the following key fields of operation:

1. "Global Standards (GS)" for shipping at IMO covering safety, environmental protection, security and facilitation;
2. "Energy Efficiency (EE)" covering technical and operational measures for efficient fuel consumption based on the basic recognition that fossil energy resources are not infinite and every effort must be made to save energy resources;
3. "New Technology (NT)" for safety, environmental protection, security , clean energy and efficient operation of shipping to meet the present and future challenges;
4. "Education and Training (ET)" to ensure a continuous supply of quality seafarers and maritime experts required for all aspects of maritime industries including shipbuilding and maritime equipment manufacturing industries;
5. "Maritime Security (MS)" covering application of international measures for maritime security, anti-piracy measures, law enforcement mechanisms for maritime zone security and the supply chain security;
6. "Maritime Traffic Management (MTM)" in straits and sea areas of significant importance covering co-operative mechanisms of littoral States, public-private partnership for future systems and realization of the Marine Electronic Highways;
7. "Maritime Infrastructure (MI)", including aids to Navigation, Search and Rescue, port facilities and technical cooperation to ensure availability of proper maritime infrastructure in all parts of the world.

Maritime transport is fundamentally important for sustainable development and the world economy. Maritime transport is international in all aspects and not just the shipping industry and composed of various players and stakeholders including the shipbuilding industry, maritime equipment manufacturing industry, finance and insurance industries, classification societies, ship owners, seafarers, shippers, trade industry, oil and energy industries, ports, navigation infrastructures, maritime administrations, port State authorities, coast guards, Governments and international organizations.

In the preparation of the concept of "Sustainable Maritime Development", all these stakeholders should be involved and their views should be reflected in the concept. This suggestion towards the formation of the concept of the Sustainable Maritime Development will generate active discussion on the role of shipping in the world economy and sustainable development and will provide substantial contribution in the process towards UNCSD (Rio+20) next year.

Throughout its history, maritime transport has been an important catalyst f development concerning economics and prosperity for the European continent. Maritime transport ensures the security of energy supplies, food supplies and commodities. It also provides the main vehicle for imports and exports between Europe and the rest of the world. Maritime transport ensures trade and contacts between all European nations, being an important provider of income and employment for the European economy.

It is known, according to the European Commission site, that almost 90% of the EU external freight trade is seaborne, while short sea shipping represents 40% of internal European exchanges. There are over 400 million passengers that embark and disembark in the European ports. Islands and peripheral maritime regions depend their quality of life on good maritime transport services.

## 3. THE OBJECTIVES OF MARITIME TRANSPORT ECONOMY DEVELOPMENT

Development is very important in maritime transport when it comes to preventing sub-standards shipping, minimizing the environmental impact in maritime transport, and, of course, reducing the risk of maritime accidents. Social dimension, working conditions, health and safety issues, providing seafarers with professional qualification are another concern that must be taken care of. Finally, the protection of citizens as users of maritime transport services, ensuring safe and secure conditions, looking after their rights as passengers and examining the adequacy of the public service maritime transport connections proposed by Member States are issues that must be solved.

This can be done, as the European Commission is proposing, by adopting some strict safety rules, concerning this matters.

In January 2009, the European Commission presented the main strange objectives for the European maritime transport system up to 2018. It's purpose is to identify key areas where action by the EU will strengthen the competitiveness of the sector while enhancing its environmental performance.

While the Communication looks at the long term (10-years) horizon, the current economic context and the characteristics of shipping market cycles have been taken into account. It is set in the broader context of the EU Transport Policy, but also aims at supporting other relevant policies, in particular the EU's integrated maritime policy.

In broad terms, the strategic goals and recommendations of the Commission Communication refer to two main issues:

- The ability of the maritime transport sector to provide cost-efficient maritime transport services adapted to the needs of sustainable economic growth of the EU and world economies and
- The long-term competitiveness of the EU shipping sector, enhancing its capacity to generate value and employment in the EU, both directly and indirectly, through the whole cluster of maritime industries.

## 4. DEVELOPMENTS IN EUROPE

Improvement of transport activity followed the line of the European economic development. While GDP (measured in 1995 constant prices) grew at an average annual rate of 2.5% during 1995 to 2007, freight transport, measured in tone-kilometers, increased annually by 2.7%, and passenger transport, measured in passenger-kilometers, up 1.7% annually over the same period. *(Source: Eurostat - Energy and transport in figures – 2009)*.

The upward trend of performance of freight activity in the Europe in the period 1995 to 2007, was given by road transport and of maritime passenger transport. Road transport plays a predominant role in passenger transport activity, along with air transport. Evolution of maritime passenger transport followed a slightly descending trend during 1995 to 2007.

On the other hand, taking advantage of the rapid growth of international trade, shipping goods trade from Europe has grown considerably in recent years, with companies investing heavily in fleet renewal and expansion. Today there are over 1,200 commercial ports, spread over some 100 000 km of coastline and over 9000 commercial vessels under EU flag, totaling about 240 million deadweight tons (dwt), almost one quarter of world tonnage. European shipping industry has under control other 4000 ships flying foreign flags.

On January 1, 2007, EU control a number of 10,550 ships with tonnage over 1000 gto, totaling 368,486 million dwt. Out of these, 3,389 vessels are registered under national European flags and the rest by 7161 are registered under foreign flags (including those registered in other countries). Over 2 million vessels have operated in the main ports of the EU, in 2007, up 2.2% over the previous year. However, in terms of tonnage of vessels, the growth rate was 7%, reflecting an increase in size of vessels operating in EU ports.

Concerning the passenger ship safety, the European Commission upgraded its legislation, maintaining and upgrading reasonable objectives, in order to help developing this sector. The first main objective, relate namely, to identify and address within the current Directive 2009/45/EC on rules and standards for passenger ship safety any provisions that may need to be reviewed or updated and which lead to inefficiencies in the EU internal market for ships or maritime passenger services.

There is a second objective, for which the Commission's services seek stakeholder opinions, primarily from those with experience in the maritime field. Following the recent Costa Concordia cruise ship accident in January this year, some issues have been raised specifically addressing larger passenger ships. The Commission would like to use the opportunity of this consultation already planned as part of the review of the European legislation on passenger ship safety, to obtain stakeholder views on current arrangements.

European Council is interested to consult all citizens and organizations. They are welcome to contribute to this consultation. In particular, views are sought from ship owners; ship builders; classification societies; seafarers; regulators at international, national, regional and local level; and passenger representatives.

At the same time as this general public consultation, two parallel consultations are also being undertaken: with all Member State maritime administrations; and a targeted consultation of all stakeholders in six Member States: Denmark, France, Greece, Italy, Sweden and the United Kingdom.

The safety of passenger ships is regulated at three levels: through International Conventions to which Member States are party (e.g., SOLAS), EU acquit and national law. EU acquit is piecemeal and is found in several different legislative instruments (see the reference documents below).

The rationale behind the main passenger ship safety directive, Directive 2009/45/EC (the former Directive 98/18/EC, now consolidated and codified as Directive 2009/45/EC, recently amended by Directive 2010/36/EU), is that persons using passenger ships and high speed passenger craft throughout the EU should have the right to expect and rely on an appropriate level of safety on board.

The Directive thus aims to set out a common set of safety standards for domestic ships to maintain a common high level of safety and remove potential barriers to the transfer of ships between Member States and the operation of ships in Member State domestic waters.

International safety standards for most types of passenger vessels operating on international voyages are normally developed by the IMO under the Safety Of Life At Sea (SOLAS) Convention.

The 2011 White Paper for the future of transport – "Road map to a Single European Transport Area – Towards a competitive and resource efficient transport system" recognizes the need to modernize the existing EU passenger ship safety legislation.

In 2010 the Commission had already started the process by undertaking a review of the main Directive, 2009/45/EC, and initiated an ongoing consultation with the Member States competent authorities to identify problems and challenges in its implementation. Based on this process, the Commission examined the problems raised, to identify the main issues and underlying causes and from there to reconsider alternative policy options.

Currently Directive 2009/45/EC sets safety standards for all passenger ships made out of steel engaged in domestic voyages. While there are different levels of safety requirements dependent on the sea area within which the ship operates, the Directive's standards, derived from international standards, might not be suitable for smaller ships.

It is also a fact that the majority of ships operating in domestic waters are made out materials other than steel, such as Glass Reinforced Plastic. In addition, for certain categories of ship, there is no common regulatory framework: e.g., sailing ships, historic ships, vessels carrying offshore workers, cruise ship tenders.

The aim of this public consultation is to verify the accuracy of the problems identified, and to what extent stakeholders opinions are in line with and support the objectives and policy measures envisaged.

The consultation feeds into an ongoing impact assessment of alternative options for revised passenger safety regulation. It is planned to hold a stakeholder workshop at the end of the consultation to set out the results of the consultation process.

The safety of passenger has the purpose of increasing the interest and confidence of travelers in travelling by the sea, with low costs, good travelling conditions and high safety.

## 5. CONCLUSIONS

It is said that Maritime Transport is for economy what the artery is for the blood circulation system of the body. Without it, the world would be landlocked and its economy would not move forward, but remain stagnant in different areas. We can say that maritime transport is a key section in world's economy.

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# PRODUCTIVITY AND DURABILITY OF QUAY CRANES CABLES. NEXANS CASE STUDY

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**ABSTRACT**

Quay cranes are handling equipments used in ports with an important economic role in maritime transport. This paper presents theoretical elements of quay crane productivity and cable calculation along with a case study of improvements in the domain of quay crane cables durability.

**Keywords:** *quay cranes, productivity, durability, improvements*

## 1. INTRODUCTION

Quay cranes are means of production that allow replacement of hard and low-skilled work with easier and highly qualified work, mechanization and automation of production processes ensuring increased productivity, reducing costs and shortening the time of execution in all economic fields. They play an important role in the development of maritime transport.

## 2. PRODUCTIVITY

In terms of exploitation, productivity is the most important feature, being the one that defines the working possibilities of the quay crane.

Productivity can be expressed with the following common units:

- kN / hour
- kN / exchange;
- kN / day
- kN / year.

The annual productivity is the most representative and defines the real work possibilities of a quay crane. Productivity contains a number of elements related to the working parameters and on the port conditions in which it operates.

Wind pressure limits the equipment operation over a certain limit value, knowing that ports are located in open areas exposed to winds which have an important influence on the operation of cargo handling equipment. Statistical analysis show that duration of immobilization due to bad weather in our country is about 10% of calendar time.

Ship and wagons maneuvers at operative fronts (berths) also lead to parking equipment port.

Other causes which influence these machines are: power outages, changing shifts, changing the working machinery from one barn to another.

The general formula for calculating productivity that is currently used both in design and in practice is as follows:

$$P=Q\cdot n\cdot h\cdot T\cdot CUT\cdot CUC \quad [t/year] \qquad (1)$$

where:
Q is the amount of handled goods, in t / cycle;
n number of cycles per hour;
h the number of hours per day (24 hours / day);
T calendar time in days per year (365 days / year);
CUT - utilization of calendar time coefficient;
CUC - lift and transport utilization capacity coefficient.

## 3. CABLE CALCULATION

In quay cranes construction flexible bodies play an important role. They are used for binding, suspension or carrying loads vertically, horizontally or inclined, with help of the machinery and the lifting installations.

From the constructive point of view, flexible bodies are divided into the following groups:

- steel cables;
- chains;
- vegetal cables (ropes);
- rubber-bands.

These groups, themselves, are classified depending on construction, features and field of use.

Steel cables are the most used flexible bodies in the composition of quay cranes. They are made of several wires of high strength carbon steel, wrapped (braided) helicoidally and have in center a metal, vegetal or mineral heart.

Cables are classified depending on: section of steel wire comprising them, mode of wire winding, use, nature of central heart and wires quality.

Simple open design cables are made of one or more concentric layers of steel wires, without central heart. Each layer is wrapped in the opposite layer so that the surface layer of the last cable has always right winding.

Semi-open simple construction cables have outer layer made from round wires alternating with profiled wires and the closed ones have the outer layer consisting of profiled wires.

Double cables are commonly used. They are made of 6 or 8 strands wrapped around a helicoidally shaped heart.[1] Strand is a component of the cable, made from an assembly that consists of more helically wound wires and supported on a central heart in one or more overlapped layers. [2] Strands are, in fact, simple cables, but each in turn has one central heart.

For quay cranes cables are chosen according to structural characteristics and applications.

Some of the important characteristics of cables are: nominal diameter of the cable, cable construction, wire resistance, quality and condition of wire surface and direction of winding. Nominal diameter is the main size and is the circumscribed diameter of the cable section. Cable construction is expressed by the number of cable strands and the number of wires in the strand. [3]

### *3.1 Cable calculation based on breaking load*

In this case we determine the real minimum breaking load of the cable which is used to choose the appropriate cable from STAS. It is recommended to choose cables based on the real minimum breaking load calculation method because this method is simple and leads to good results, although bending effort is neglected. Real minimum breaking load of the cable is equal to the theoretical minimum breaking load of the cable multiplied by the coefficient of wire resistance decreased at twisting. Theoretical breaking load is calculated as the product of sectional area of cable and tensile strength. In reality, cable break is made under a lower effective load and that is why lifting load is multiplied by a safety factor that takes into account operating conditions. Calculation relation is:

$$\mathrm{F_r} = c \cdot F_{rd} = c_s \cdot F_{rt} = c_s A \sigma_r \tag{2}$$

where:

$F_r$ - real minimum breaking load, calculated in daN;

$F_{rd}$ - maximum effective lifting load for which cable is choose, in daN;

c - value between 4 and14 and represents the coefficient of effective safety. Since quay cranes are working light, medium, heavy and very heavy operating regimes, small values of the coefficient c is taken into account for the light operating regimes, and higher values are taken for very heavy operating regimes.

$c_s$ - value between 0.85 and 0.93 and represents the coefficient of decreasing wire resistance by wiring;

$F_{rt}$ - theoretical minimum breaking load in daN;

A - cross-section of cable which is the sum of nominal sectional areas of all active wire cable in mm2;

$\sigma_r$ - breaking strength of steel wire cable.

Based on the relation:

$$F_r = c\ F_{rd}\ [\text{daN}] \tag{3}$$

is chose the appropriate cable from STAS.

### *3.2 Cable calculation based on allowable resistance*

This method calculates the net area of the cable section, taking into account the allowable strength of steel of which are made cable wires and it is selected the cable depending on the diameter found. The calculation takes into account the complex effort of the cable at tension and bending.

## 4. IMPROVEMENTS IN QUAY CRANE CABLES DURABILITY

Today, technically advanced manufacturing process, combined with statistical process control, ensures conversion from raw material to improved integrity quay crane cables. For example, advances in micro-alloyed steels result in high carbon steel wire production facilities including substantial galvanizing and patenting heat treatment processes. Some cable manufacturers produce hybrid energy cables based on copper technologies. Others produce lighter and thinner than standard cables, thus reducing the total weight of the reel, and saving money for a complete handling system. Specialized modern cables offer higher tensile strength, ensures a long life cycle, add safety for goods and personnel, and maintaining freight flow continuity around the-clock.

Dynamic numerical analysis simulation software allows evaluating the mechanical performance of reeling cable designs and designers are able to accurately predict how stress will be distributed in the cross-section in terms of traction, torsion, bending, and crush load. Simulation tools are useful for creating a cable which could outlast conventional reeling cables by 10 times. For example, the French company Nexans, worldwide leader in the cable industry, developed a suite of machines in a handling cables application centre to subject cables to severe accelerated conditions. Sensors pick up all relevant data which is input into PCs to characterize cable performance as it would actually occur on a crane. These tests include:

- Reverse reeling machine to detect and analyze strain in real time;
- Torsion test bench to speed up cable ageing so as to improve cable design;
- Reverse bending test equipment to subject cables to 90°C bends around pulleys;
- Stiffness test equipment to calculate the force needed to bend a cable;
- Alternative roller bending to measure flexibility to avoid short circuits and breaks.

Tests include surviving a reeling speed up to 150m/min, bearing up under a traction force up to 7000N, and coping with a torsion couple of 600Nm [4]. The role of this tests is to improve production of cable performance and durability, without needing to increase its size as well as the performance and durability of cranes operating at high speeds of up to 150m/min. [5].

Thinner and lightweight polyurethane sheath from Buflex X'Prem enables similar performance to standard rubber sheathed reeling cables, but within a smaller overall diameter and enhanced abrasion resistance. The copper twisted pair cables or optical fibres can be integrated within the cable to combine advanced control solutions with the crane power supply [6].

## 5. CASE-STUDY: NEXANS CONTRIBUTION TO CRANE CABLES DURABILITY

Nexans is a worldwide leader in the cable industry, producing an extensive range of cables and cabling systems. Nexans cables are often thinner and lighter than those of the competition, and with a higher tensile strength (in terms of Newtons), thus ensuring a long life cycle for cranes, and an added safety factor for goods and personnel.

Nexans produces an entire range of cables to serve the four critical functions of various crane types: festoons, reels, spreaders and control for both small and large cranes.

*5.1 Festoon Applications*

Festoons are extendable all-energy or data/energy cables which permit the movement of a crane trolley back and forth along a horizontal beam supported by two towers that are often mounted on rubber tires or on tracks. Since they can easily serve a large rectangular area, bridge cranes are widely used in storage yards in ports and train hubs. Overhead traveling cranes are a smaller version of this technology, and are often found indoors on factory assembly lines. Nexans produces standard low-voltage (up to 750 V) PVC flat cables, both screened and non-screened, which provide flexibility and compactness for fast-moving, small overhead traveling cranes. Similar rubber flat cables are used in extremely abrasive environments, or for extremely low or high temperatures (-40°C to 80°C) both indoors and outdoors.

Rubber round cables combine both data and energy with an integrated database. These flexible, long-lasting cables are ideal for high-speed applications on large cranes, and are optimized to handle 200 MTM and more. This is definitely a high-end cable which is beginning to be much appreciated by leading large crane manufacturers.

For data transmission for bridge or gantry cranes, Nexans manufactures a rubber-sheathed optical fiber cable which is totally impervious to troublesome electro-magnetic interference. A smaller M cable was originally developed for mining equipment applications, but both it and the thicker R version perform excellently on ship-to-shore cranes in festoon and e-chain configurations. The R version even offers sufficient tensile strength for reeling.

*5.2 Reel Applications*

Spring cable reels are used for the automatic reeling of cables on various types of moving equipment, including most hoisting and material handling devices, e.g. portal cranes, grabs, magnets, lift and working platforms, transport systems, etc. Motorized cable reels use an electrical drive system for similar applications on many crane types and handling systems. Nexans manufactures both low-voltage and medium voltage polyurethane-sheathed standard reeling cables to feed and control motors on moving equipment. A multifunctional hybrid cable, they are rolled in mono or multi-spiral drums, providing maximum flexibility under high tension and traction.

Heavy duty rubber cables come in two versions for motor driven reels. A standard version can move at 120 meters per minute, while the thinner and lighter Reduced Torsional Stress (RTS) cable can deliver 200 MPM to significantly enhance crane operating speeds. A 3 to 30 kV high-voltage high-stress rubber cable provides energy and data for large STS cranes in versions with or without fiber optics. Standard operation speed is 190 MPM, but with an integrated steel strength member, it can handle up to 240 MPM.

A 3 to 30 kV high-voltage high-stress rubber cable provides energy and data for large STS cranes in versions with or without fiber optics. Standard operation speed is 190 MPM, but with an integrated steel strength member, it can handle up to 240 MPM.

Low-voltage and medium-voltage flat reeling cables are used mainly for container handling cranes, but also for special purposes requiring combined energy and data capability. Its flat form has a distinct advantage since a longer length of cable can be wound on one drum to accommodate long crane movements.

*5.3. Spreader applications*

Spreaders (or hoists) are devices used for lifting containers and unitized cargo. They are metal frames commensurate with container size and equipped with locking devices and aggregates to take over containers. The locking device is operated through a electrohydraulic facility located right on spreader, which in turn is powered by a cable from the electrical equipment [7].

Special cables are required to provide low-voltage for the reeling application, to allow them to move up and down safely and rapidly. Nexans spreader reeling cables provide control, often with rapid acceleration and at high operating and braking speeds. [8]

*5.4. Control applications*

Control cables allow an operator to command the three-dimensional movement of an individual object, package or container in close proximity via a hand-held control box. Nexans pendant cables are supported by a steel strength member for optimum ruggedness. They can contain from 3 to 54 cores for multiple shipping or handling operations.

Since Nexans' reduced outer cable diameters can deliver the same energy and data capacity in a smaller size, or increased capacity in the same size, this means important cost savings for systems suppliers. Durable lighter cables also greatly facilitate the construction of large cranes, allowing builders to serve the need for super-post-Panamax cranes in megaports and for large industrial operations. Reliability and ruggedness means fewer expensive breakdowns and work stoppages for the end-user. For example, new anti-torsion polyester braids greatly increase stability and minimize twisting. And a second sheath bonded with a third one gives the cables unsurpassed mechanical and chemical properties, including elongation at break, and resistance to abrasion, ultraviolet rays, and ozone.

## 6. CONCLUSIONS

Quay cranes play a very important role in the shipping industry and there is an increasing demand on faster, safer and reliable cranes. For proper quay crane exploitation, an important aspect is producing durable and improved cables. So far, researchers were able to make only empiric calculations obtained on the basis of results generalization. The results of calculations by different methods differ. Also, practical results differ and this demonstrates the need for further research in this area.

Technically advanced manufacturing process and statistical process control ensures improvement of quay crane cables durability. Nexans worldwide leader in the cable industry provides some good examples of such cable improvements in order to answer the actual demands.

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# INTERNATIONALIZATION IN TECHNOLOGIES AND INNOVATION SECTORS

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**ABSTRACT**

The level of R&D internationalization and innovation has been increasing in Europe since 1990. Growth in both external and internal activities indicate that the two of them complete each other and satisfy different needs, more than reciprocal substitution. The initiative of Innovation Union recently approached by the Commission, part of the European Strategy 2020 has consequently as a purpose increasing the attraction in the EU as an R&D location of the innovation investments and it has also as a purpose the promotion of international cooperation for research and innovation. On the EU level, there may be programmes relating partners in the EU with non-EU industrial partners in common R&D innovation projects. These would indirectly stimulate both the internal R&D investment of non-EU companies and the R&D internationalization of the EU companies.

**Keywords:** *internationalization technologies, innovation sectors, R&D*

## 1. INTRODUCTION

Technology, together with the companies' industrial sector, generally determines the internationalization level of R&D and innovation. Technologies and sectors differ when it comes to the accumulation, adequacy, space concentration level, or the degree in which it determines and makes reference to external knowledge from the company (Marsili 2001; Malerba 2005 a, b).

Technologies differ not only when it comes to the level of internationalization but also when it comes to the absolute level and growth rates. Figure 1 establishes the internationalization level in 30 different technologies based on the licensing data (licences created in EU were designated to one of the 30 technologies, according to the IPC code, and these 30 technologies have been grouped in six large technology categories – see Dachs et al. 2010 for details). The foreign licences quota in the total amount of licences approved in EU-27 on technology (horizontal axis) is related to the increase in the total number of licences in EU-27 between 1991-1995 and 2003-2007 (vertical axis). Plus, the circle dimension representing a certain technology illustrates the technology scale in an absolute number of licences approved in EU-27 between 2003 and 2007.

R&D and innovation activities still happen predominantly in the origin country, but there is a considerable variation in technologies.

Foreign licences quota is:

i) The lowest level (7%) for space technologies, weapons (with the corresponding industries in a few member States);

ii) the highest level (32%) for Telecommunications (a technology characterized by a rapid change, a decreased degree of accumulation and a leading role of a certain number of MNE with R&D and innovation activities distributed in a few countries);

iii) the majority of technologies are distributed in a medium interval with fixed limits by the two previously mentioned technologies.

With a high and increasing degree of internationalization and a large number of cross borders licences, Telecommunications Technology and Information Technology played important parts in the R&D and innovation internationalization in EU. This aspect may be observed also in the R&D data. Other technologies with an internationalization degree over average include chemical technologies and different technologies in the electrics' field. But the internationalization does not refer only to the "Advanced Technology". Agriculture and food, having a quarter of the foreign licences, is also among the most internationalized technologies. There is a technology with a certain degree of variety of the product and adaptability to different EU countries, which may necessitate a high degree of decentralization (Filippaios et al. 2009).

Generally speaking, there is no clear relation between the growth rate, absolute dimension and the level of internationalization of a certain technology. Increased and decreased internationalization is found in the Telecommunication and Information Technology, two key technologies in the centre of Europe 2020 initiative "Digital Agenda for Europe" (European Commission (2010 b)). Comparatively, technologies in the Chemical field, pharmaceutics, (coloured in green in Fig. 1) have high levels of internationalization, but they differ considerable when it comes to growth rates. Same happens with the technological domain. Mechanical engineering, machines (dark blue). Here, the decreased level of internationalization coincides both with low rates and growth rates.

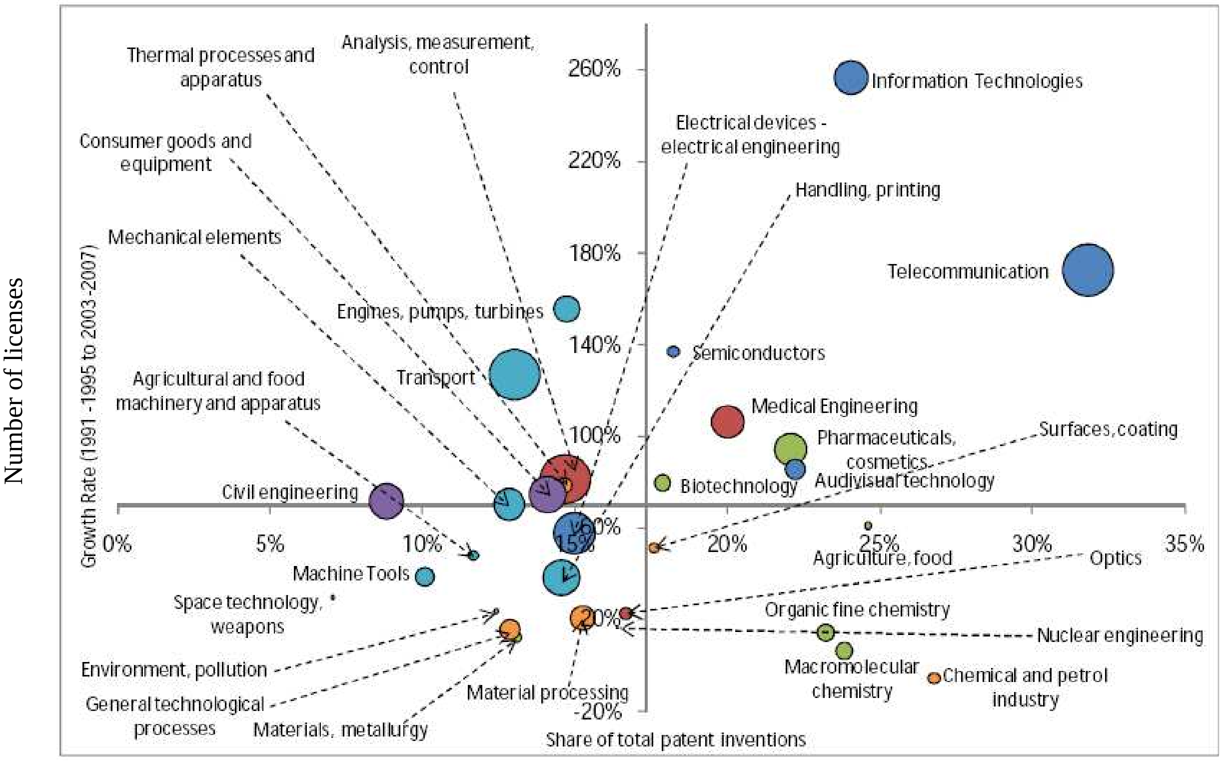


Figure 1 Foreign licences quota (2003-2007), increase (1991-1995 2003-2007) and number of licences (2003-2007) in EU-27 on technology (EPO)
Source: The Licences European Office, calculus ZEW/AIT

## 2. INTERNATIONALIZATION IN TECHNOLOGIES

Internationalization in technologies for regenerative energy is correlated with and increase in prices for fossil fuels and the threat of global warming bringing technologies for regenerative energy (REG) to the attention of the member States and EU levels. EU is the leader in developing REG technologies and this pattern reaches the R&D internationalization map and REG innovation technologies, focusing on the specific needs more than on the traditional technological or sectors classification.

In order to identify REG in the licences classification, this pattern follows the definition given by OECD (2009 b) and includes the following six technologies: wind energy, solar energy, geo-thermal energy, maritime energy, bio-mass energy and residues energy. It provides licences 2911 EPO for the period 2003-2007. REG technologies reveal high growth rates – the number of REG licences in EU increased with 422% from 1991-1995 up to 2003-2007. At the same time, REG represents a niche technology registering only 0,9% of the licences given by EU.

According to OECD (2009c, p.53), EU-27 registered the majority of applications for licences PCT (Licences Cooperation Treaty) worldwide in REG, with a level of approximately 37%, followed by USA (20%) and Japan (19%). In EU-27, research and innovation in REG is focussed in a small number of countries: only Germany, Denmark and Spain have a specialization above average in the period 2003-2007. Other five countries Austria, France, Italy, Holland and the United Kingdom – have a part to play in REG. Together, these eight countries, register 92,5% of all the REG licences in EU. Date related to the R&D expenses are incomplete, but it seems that they support the idea according to which EU-27 and the other member States previously mentioned are well positioned in the technologies' frame for regenerative energy (OECD 2009a).

Note: The bars indicate the total number of licences in REG in a country, divided between the internal applications in other EU countries (intra-EU), applications from European countries which are not EU members (OEC), and applications from outside Europe countries (extra-Europe).

The level of foreign licences in REG is significantly lower than for the other technologies: 89% of all the licences are internal, 6% belong to the organizations from other countries in EU, 1% of licences belong to other European countries and 5% belong to organizations from outside Europe. More than 90% of foreign licences in countries outside Europe belong to organizations in USA. Licences in REG both internal and foreign increased in a similar rhythm.

Above average specialization of Germany and Denmark in REG may be due to the fact that they are the only countries in EU with an appreciable quota of foreign licences in REG (see Figure 2 below). This fact indicates that whenever they decide R&D internationalization and innovation, companies go first of all to areas with a critical level of development and technology, although it is not necessary to have the lowest salaries and costs. REG example indicates that such factors as technological specialization, favourable market conditions and speciality technological knowledge are the main attractions for foreign and innovation R&D.

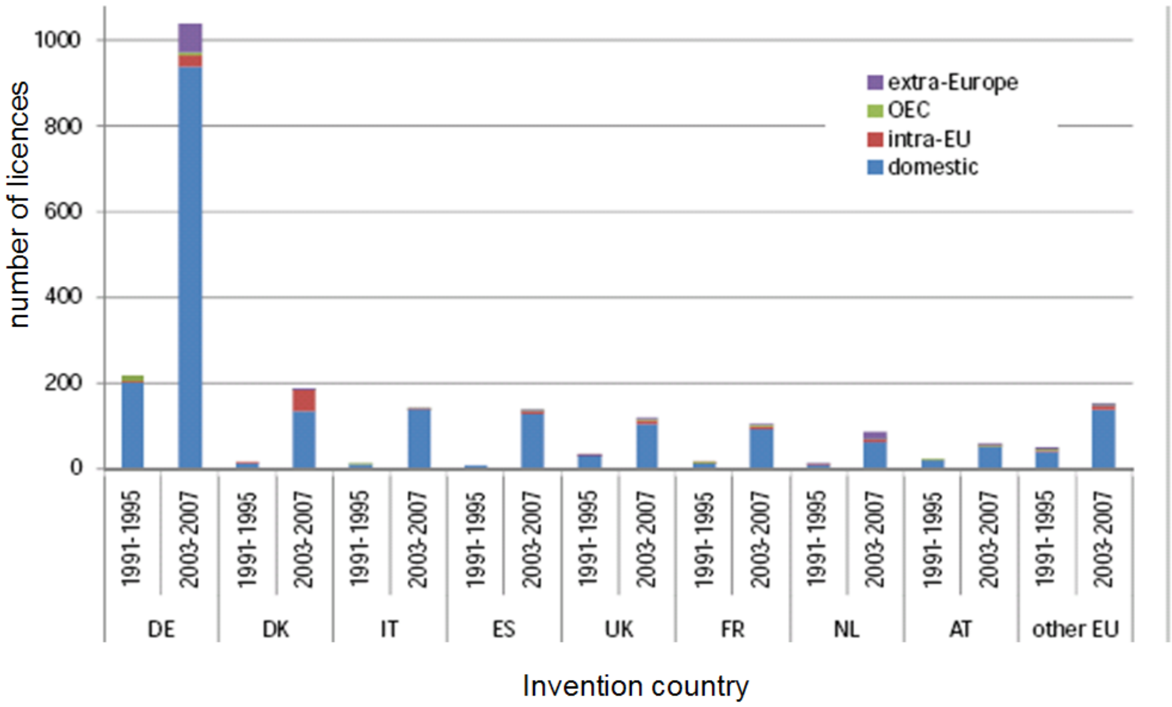


Figure 2 Number of REG licences according to the invention country and applicant's location (1991-1995 and 2003-2007, EPO)

Source: European Licences Office, calculus ZEW/ AIT.

Content of columns in figure 2:

1. nuclear engineering
2. audio-video technology
3. telecommunications
4. machines and thermal processes
5. materials, metallurgy
6. agriculture, food
7. semi-conductors
8. civil constructions, constructions, mining
9. organic chemistry
10. consumption goods and equipment
11. material processing
12. pharmaceutics, cosmetics
13. optics
14. electrical devices
15. information technology
16. macro-molecular chemistry
17. chemical and oil industry
18. transport
19. bio-technology
20. general technological processes
21. analysis, measuring, control
22. tool-machines
23. surfaces, coating
24. environment, pollution
25. engines, pumps, turbines
26. manipulation / treatment, printing
27. space technology, weapons
28. agriculture machines and food
29. medical engineering

Still, specialization above average and technological development create R&D and external innovation. Denmark predominantly hosts R&D and innovation from companies in Germany and Spain, while Germany hosts a considerable number of licences in REG from USA and also Denmark. REG registers approximately a quarter of the licences of Germany in Denmark, which represent a considerable quantity having in mind the REG quota in the total number of licences. Spain, the third country with a REG specialization above average in E|U, has only a few foreign licences in REG. Spanish companies, still, have been very active in Denmark in this field.

Figure 3 indicates the fact that on a technological level, R&D internationalization and innovation involves – in a considerable way – the European countries. The importance of the external property right of Europe (which is almost totally American) has a lower level in Agriculture and food and in Nuclear Engineering and the it has the highest level in Engines, pumps and turbines, Environment, pollution and Information Technology. It is also interesting to see the fact that the two technologies with the highest level and increase quota of internationalization – Telecommunications and Information Technology – have very different positions regarding the applicant's location. Internationalization in Telecommunications is predominantly intra-EU, while Information Technology registers 49% of the applications for licences outside Europe.

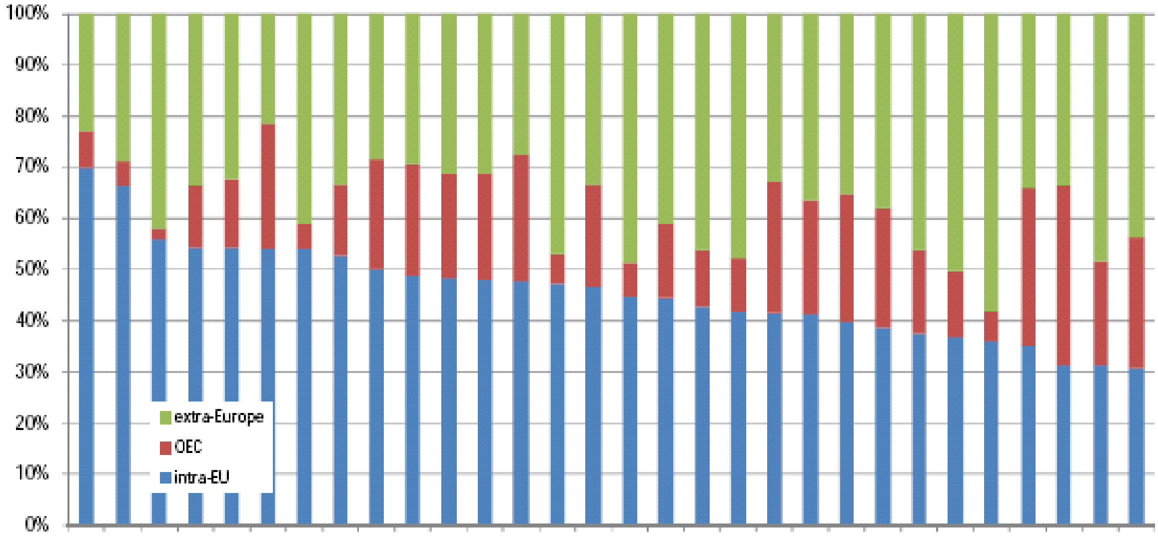


Figure 3 Applicants' location for foreign licences according to the technology.
(2003-2007, EPO)

Source: European Bureau for Certification, calculus ZEW/AIT
Note: intra-EU: applicants from other countries EU; OEC: applicants from European countries not part of EU; extra-Europe: applicants outside Europe

Telecommunications and Information Technology are in the centre of EU 2020 "A digital agenda for Europe". Both technologies offer a real illustration of the R&D power and importance and of the internationalized innovation. Telecommunications illustrate the importance of strengthening the internal market and fluxes intra-EU of R&D and innovation. Information Technology illustrates the importance of R&D fluxes and EU external innovation given that EU tries to win some advantage on these technologies field.

Applications from other European countries (which are not members of EU, especially Switzerland) have a tendency to be less important: almost non-existent in Telecommunications and Audio-video Technology (technologies for which cross-border licences intra-EU are predominant) but they are important in Space Technology, weapons, Manipulation, printing, Medical Engineering and Bio-technology (technologies in which cross-border licences intra-EU are not predominant).

Passing from technology to the sector perspective (see Figure 4 below), the internationalized sectors concerning R&D and innovation are producers of electronics (NACE Rev. 1.1 – including also producers of telecommunications equipments), electronic components (NACE 32.1), medical instruments, precision, optical and time measurement (NACE 33), computers and office equipments (NACE 30), food and drinks (NACE 15) and pharmaceuticals (NACE 24.4). Altogether these six sectors represent approximately two thirds of the certificates/foreign licences in EU-27. Comparatively, R&D internationalization and innovation have the lowest levels concerning the production of tobacco products (NACE 16), wood and wood products (NACE 20), and metal products (NACE 28) – the so called "inferior technology" sectors. This sector specialization corresponds to the observation that FDI concentrates on intensive technology industries (Barba Navaretti and Venables 2004).

A similar general image appears when taking a look on the expenses R&D with foreign capital affiliates. Foreign capital affiliates have a tendency of taking into account a high percentage of sector expenses R&D in chemical industries and electrical energy, while mechanical industries – including vehicles sector – have a tendency towards a lower percentage in the majority of countries. A recent study, European Commission (2010c), shows that for the TCI sector in Europe, over 40% of all the R&D centres belong to companies having their headquarters outside Europe. Variety among the internationalization levels in one sector in different countries, is still considerable. Sectors may have a higher percentage of affiliates with foreign capital in the total of R&D expenses in one country and a lower percentage in another.

From a sectors' point of view it must be emphasized that R&D internationalization and innovation does not stand only in production industries. Multi-national companies exist in a number of sectors of services also. Examples include software domains, finance, business services and transports. R&D internationalization and innovation in services is still more difficult to appreciate in production because companies from a number of sectors of services get involved in R&D less frequently and more innovation services cannot be protected by certificates.

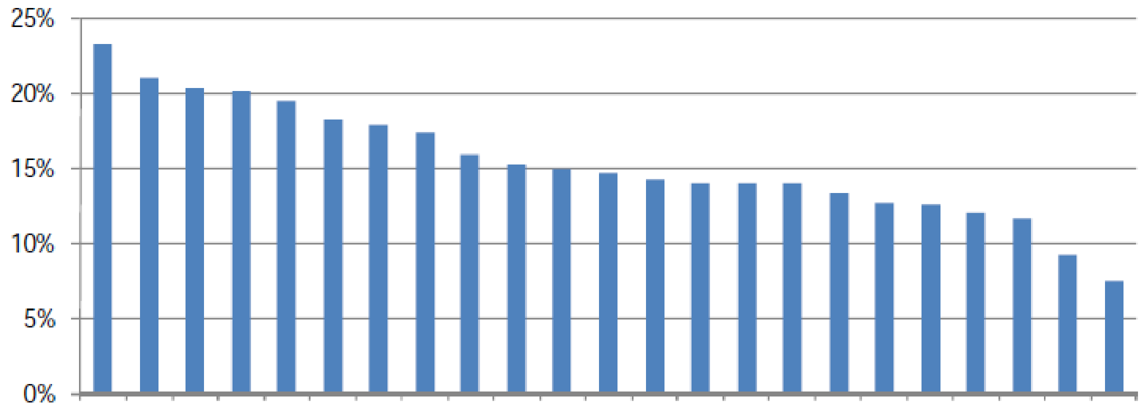


Figure 4 Certificates amount with a foreign capital on industrial sectors (2003 – 2007, OEB)
Source: Certification European Bureau, ZEW / AIT calculus.

Total Amount of certificated inventions

| | |
|---|---|
| Electronics | Basic materials |
| Food and drink | Clothing |
| Office equipments, computers | Other mineral non-metal products |
| Chemical products | Machines and equipments |
| Electronic components | Other transport equipments |
| Pharmaceutics instruments | Leather and footwear |
| Printing / publication | Metal products |
| Cellulose and paper | Other products |
| Electric equipment | Wood |
| Residues and plastic | Tobacc |
| Vehicles | Textiles |

OECD FATS data basis includes data from the R&D expenses supported by foreign affiliates in certain sectors of services. Numbers indicate the fact that in intensive acknowledgement 16% (Germany) and 60% (Ireland) from the total expenses of R&D. In commerce, repairs, hotels and restaurants, the quota is considerable higher. Altogether, the internationalization degree in services industries seems smaller than in production. This discovery is still an attempt due to weak coverage of data from the services sector.

## 3. CONCLUSIONS

The above analysis led to different perspectives of the R&D internationalization and innovation of the European Union.

The level of internationalization R&D and innovation have been increasing in Europe since 1990. Today, 7 % of all certificates awarded in EU-27 belong to foreign organization in and outside Europe. Growth in external and internal activities indicates the fact that the two of them complete each other more that substituting. The Innovation Union Initiative recently adopted by the Commission part of the European strategy 2020 has therefore the purpose of increasing attraction in EU as an R&D location and increasing innovation investments too, having also the purpose of promoting international cooperation for research and innovation (2010a,d)).

Small and medium EU member states indicate a higher degree of internationalization than large countries do. There are at least five countries in EU in which companies with foreign capital have at the present time more than 50% of the R&D expenses in production. Cultural and geographical closeness between countries explains the R&D internationalization and innovation. In spite of high levels of internationalization in EU-12, the highest part of foreign R&D and innovation activities take place between member states EU-15.

A high quota of foreign R&D and innovation activity may be found in sectors with intensive technology, such as electric, pharmaceuticals, office equipment and computers industry. Innovation in services is less affected by internationalization in R&D expenses than production.

External internationalization of companies in EU also increased along the last decade. Today, 10% of the EU certification applications are based on inventions outside EU. The favourite foreign location for R&D and innovation of companies in EU is USA.

An important observation is cooperation with internal partners, especially universities and research centres, which is frequent for companies with foreign capital. The analysis reveals that companies with foreign capital have at least the same tendency to cooperate with external organizations in the host country as internal companies do. Therefore, host economies may benefit from the knowledge that the foreign branch receives from his group of factories. Companies with a foreign capital, therefore, may act as agents of international diffusion of technology and as bridges between organizations from the host country and foreign knowledge sources.

A study of the internationalization of politics (see Dachs et al. 2010) indicated that one principle of non-discrimination is adopted by all member states EU. There is a little discrimination against companies with foreign capital regarding their access to funds or other restrictions of business activities as long as they don not have their headquarters in that country. There may be some preferences de facto in some member states for internal companies in innovation national programmes.

Empirical proof suggests that internationalization of companies will strengthen the whole business, meaning the economic activities in the residence country (see for example Europe's Economy (2010), Pfaffermyr (2004)).

It is not possible that through today's perspective to discover all the economic and financial crisis' effects on the R&D internationalization and innovation. Innovation and R&D, still, indicate a higher degree of consistency over the years (see Filippetti and Archibugi 2010), which suggest that the crisis will have minor consequences. Proof from the data panel described above indicates that R&D and other innovation expenses made by external and internal companies are affected in the same way by the economic cycle. In a decreasing cyclic trend, foreign companies have a tendency to maintain their high R&D investments for a larger period of time. A high percentage of the foreign R&D activity in a country may have therefore a stabilizing effect over the national R&D expenses during the crisis.

There are a few ways in which the European Commission may help companies to benefit from the R&D internationalization and innovation.

On the EU level, there may be programmes making the connection between EU partners and industrial non EU partners in R&D innovation common projects. These may indirectly stimulate both the R&D internal investment of non-EU companies and the R&D internationalization of EU companies. They could prove useful for non-affiliated companies, small and medium companies especially (see SBA, principle VIII), encouraging investment in research through SME and involving them in trans-national research activities – which may be partially obtained by involving them actively in the RTD no.7 Programme. The analysis indicated that this group cooperates considerably less with internal partners. There are specific obstacles in cooperating with SME, as well as lack of resources and long term financing of R&D, aspects less frequent in large companies.

Innovations' internationalization may increase the economical performance of SME in the residence country. Foreign R&D and innovations' exploitation on foreign market helps SME to increase their work force in internal locations (Rammer and Schimele 2008). Large internal multi-national companies do not need support from the public politics in order to intensify their international connections.

There are some aspects regarding R&D internationalization and innovation in which a pan-European discussion and further comparisons of nowadays politics in member state would be beneficial: one of the benefits is the integration of foreign companies with no domicile (having no branch in a member state) in the national financing schemes for R&D and innovation.

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# NAVAL OPERATIONS, IMPORTANT FACTOR OF THE CHANGES IN EFFICIENCY MANAGEMENT IN SHIPPING

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**ABSTRACT**

Currently the shipping companies have expanded managerial processes, and they began to be organized departments of logistics, marketing and information. They are based on management principles specific to their organization, but new concepts have emerged about time management and even that of chartering. But in terms of management most problems are with naval operations and crews. In this paper is an analysis of these naval operations. The question arises about what they are, how they influence the costs and efficiency of maritime management company. This information can be used by managers of shipping companies, ship-owners and masters of commercial vessels.

**Keywords:** *company, ship operation, management, efficiency.*

## 1. INTRODUCTION

At present management processes to a shipping company are divided as in Figure 1, Iordanoaia (2006):

- Human Resource Management.
- Management of Chartering.
- Management of Naval Operations.
- Logistics Management.
- Financial Management.
- Marketing Management.
- Management of Maintenance Ship (fleet).
- Time Management.
- Information Management.
- Management Directors (of head office).

The leadership of “top management” in the management processes undertaken at the premises of companies shipping their share is as follows, Figure 2:

- Management of naval operations (1): 35-40%.
- Logistics Management (2): 30-35%.
- Human Resource Management (3): 4-6%.
- Chartering Management (4): 4-5%.
- Maintenance-Management (5): 3-4%.
- Financial Management (6): 3-4%.
- Administrative Management (7): 1-2%.
- Marketing Management (8): 1-1.5%.
- Time Management (9): 1-1.5%.
- Information Management (10): 0.5-1%.

From company to company as share these values vary. Situations were observed studying managerial processes more shipping companies, which have different ships and by calculating the number of activities, using simple arithmetic average we obtained these results, TSM (2012). An important variable is time seasonal variations of activities, the period for making repairs to the ship, Beziris et. alt. (1988). They have great influence on the economic efficiency of the shipping company.

## 2. INFLUENCES INSPECTIONS AND MAINTENANCE SHIP SEA VESSEL

Ship inspection program is considered as an area “critical” for the fleet management, Branch (1988), where the main objective is to meet the requirements of the Management of vessel, with low cost effective and appropriate services at competitive capacity. This however requires attention mainly on the reliability and operability status of the ship, the correlation of market requirements in relation to its load capacity. In simple terms peak period traffic must “meet” with a full fleet, operational, meeting the demand of charterers.

Factors influencing the formulation of the inspection program include the following, Stan (2003):

- Requirements management plan that reflects: the volume of freight traffic in the port of call frequency transport service or ship out how many trips a year, the variety of goods transported. Research-based requirements during inspection and tolerance levels that allow flexibility research data. Working capacity of the terminal-operating costs, together with the storage location of goods, loading of the vessel reported during the ship's travel program.

- Extension to the inspection and maintenance work can be started the ship while the ship is in service or parking during the quay at the port.

- Age, classification and registration of the ship to the ship register.

-Size operating costs by type of terminal that is brewed during the call of the ship and every ship terminal part. In particular it is necessary to rent additional tonnage to take wastes from the ship for inspection.

- Terms of payment of freight, fully, partially or bank deposits. An increasing number of deposits allow a sharing of payment facilities, broken down over the year, affecting cash flow situation of the owner. But it also has negative influences on the company if payment is late.

- Requirements I.S.M. Code and I.S.P.F.S. Code

It was found that the best results from inspections are generally obtained through a well planned inspection program during the 12 months of the year, which are fully integrated company management plan requirements. Features computer programs play a key role in analysis and inspections system to monitors. Currently ships are climbed dry dock for load line inspections at intervals greater than two years.

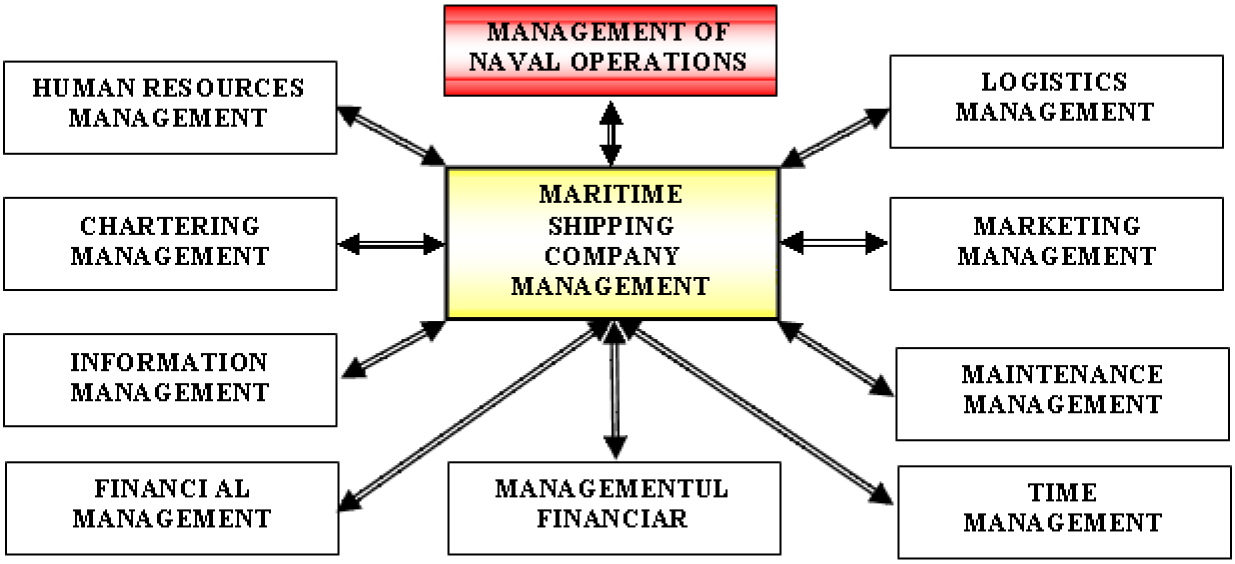


Figure 1 The maritime shipping company management.
Source: The author's study.

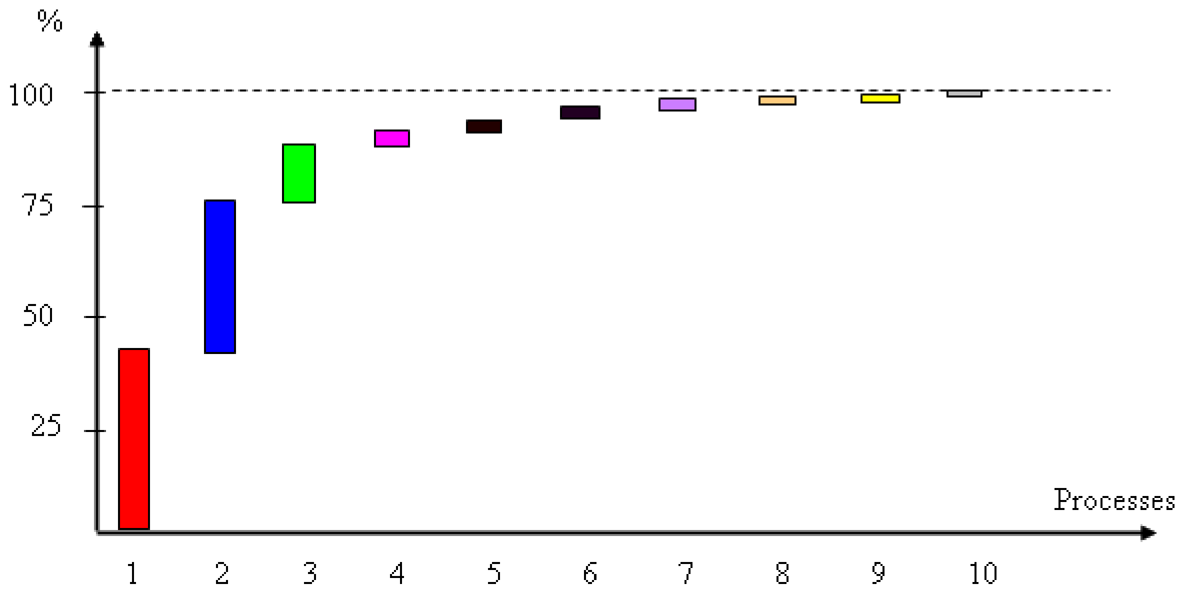


Figure 2 Weight management process.
Source: The author's study, original.

This was possible by adopting management techniques to control board, division of labor inspection across a number of years, we use the best paints, anti-fouling system, which lengthen the term of protection of the hull, etc. They have made significant contributions to extending the period of ascent ship on dry dock. The three primordial factors are considered: contractual costs, time of call, labor standards seamen. Traditional verification and research ship is to bring the dock, where parts to be inspected are disassembled, cleaned, inspected and reassembled. This method is both times consuming and expensive, but is still largely practiced for several reasons. But a number of alternative inspection methods are currently used and were developed with the classification made by the classification society. The most important checking and control board are:

A). Inspection voyage. Inspector is present during the voyage of the vessel and required inspections performed. If requested, prepare specifications in cooperation with the ship owner or manager on the parties or the facility to be repaired.

B). Notation B.I.S. (Built in Water Surveys for inspection). While ship repair is required after a certain period of time, yet for some reason, the interval between repairs has increased considerably. This extended period may conflict with the "normal" technical rules imposed by international regulations. To arrange minor changes on the body and plants, can be obtained BIS notation, which finally allows a range of repair at 5 years.

C). Inspection continues. Classification rules require inspections and car body to be held every four years. Alternative continuous systems occur even if inspections are divided by a cycle of five years. For engine inspection shows that the safety rules of this part of the ship, it is inspected by the chief engineer (chief engineer). More maintains the motor vessels, in accordance with established maintenance program, this system can replace the continuous inspection of main engine, so subtract one annual inspection class.

D). Planned maintenance system. It shall be a type of approval and may be used as a basis for special inspection arrangements for ships, individually, at the request of the owner. Most ship owners use advanced planning systems and maintenance procedures to increase the demand for cost effective operation. To avoid opening unnecessary equipment and to avoid duplication of work, many companies have introduced a classification alternative inspection arrangements and equipment. The arrangement is based on the planned maintenance system ready for operation ship-owner "on board". This program comprises the following controls:

Company-approved maintenance program classified the owner.

- Initial Inspection by inspector company board.
- Continuous inspection engine is operating.
- Name chief engineer to be approved by classification society.

Annual inspections are made by the chief engineer accepted as class inspections. However annual audit inspection must be made with AGS (Inspection Annual General Meeting). Audit inspection is done to check the arrangements are consistent with agreed procedures. Annual audit inspection report inspector points required by the ship-owner. Inspections were divided over the year and several visits to the board were required to be made by the supervisor. A number of companies have developed a classification system of harmonization of controls, as relevant inspections can be harmonized or synchronized with the requirements of Naval Authority (Maritime) in each country. Each inspection must be made with a tolerance for the link and there are three categories detailed below:

- Annual inspections for about one to three months before and after this date.
- Two inspections to be made six months before and after the date fixed.

Special inspection in four years, with a one year extension. To ensure total benefit from the harmonization of inspections of the ship owner has the following options:

- Inspection during the voyage, and the inspector takes into account the required inspections during the voyage of the ship. If requested and in cooperation with the ship owner, the inspector prepares specifications for the parts to be repaired.
- Annually, layout inspection equipment based on a planned maintenance system and approved.
- Construction Inspection of vessel at berth, obtained by arranging minor changes to the body and the machine, it increases the range of ship repair in five years.

## 3. PLANNING, ORGANIZATION AND FLEET MANAGEMENT COMPANY

Operational fleet planning is very important for company management and the ship. Its role is to use ships or fleet so as to bring the best results, in particular with reference to the market that is also a certain level of profitability that owners and want. This is a "zone" which is very well represented in the company's budget and shipping is usually scheduled for at least two years, but sometimes over 5 years. A number of factors significantly influence decision making in operational planning of the fleet as follows:

-Large ships tend to be more economical, but are generally constrained by the existence less deep water berths. This is a difficult situation for hiring heavy ships, such as oil tankers. A solution to this problem was found by building smaller ships with a draft, but with a greater width.

- Small Vessels greater operational flexibility, with easy access to port, maritime market can more easily accept a ship smaller than a larger, particularly at lower traffic in maritime trade during the economic crisis.
- Schedules should lead to best use the existing fleet as all ships costs are "out", even if the ships are working or not, go on tour or are pending.
- The company must decide if the navigation needs of fleet planning requirements peak, medium or low. You must understand that without the plan and make investments in ships, there is no benefit of high quality shipping services.
- Managers need to assess if they are planning for annual growth situation for a request or a drop in demand for ships. Method to consider the need for increased transport capacity should be well considered and thought of, before a decision because it can involve high-capacity ships, rental, new tonnage or fast programming.

The data required for fleet planning will vary depending on the situation, company or market, but also because of forecast revenues and costs, which will be dominant in the evaluation and formulation of fleet plan. Information and data that are required for this are:

- Year forecast traffic demand, which is given by the Marketing department.
- Looking for new business prospects, which are obtained for transport, such as those of perishable goods. Data provided by the marketing department may include maritime market research results.
- Details of seasonal peak demand and low months, together with an analysis of the goods contained, storage and revenue factors. They will determine the precise demand and income at different times of the year and will facilitate the choice of how best to provide economic carrying capacity, on the mix of goods and net income will be obtained.
- Specification acceptance ship ports and berths together with any fluctuations or other constraints.
- Port and the costs of their implementation.

Travel-time of each type of transport or shipping route. This is usually provided by the superintendent sea from a port or another.

Individual-capacity transport ship and its validity over the 12 months of the year, taking into account the demands inspections.

-Transshipments facilities on board and whether the port can be used to accelerate the download time and return the ship to reduce port costs.

-The cost of the voyage from a port and at berth, together with other relevant costs, including travel in port, fuel costs, which will vary depending on the port, the cost of the ballast voyage, the ship MF. For certain periods of time, the company may require driving the ship master and chief engineer to calculate and order the ship to a speed at which consumption is reduced or optimized, usually a half of maximum speed. This leads to increased time-to-sea voyage, but a fleet level, reducing fuel costs and lubricants will be significant.

- Alternative options such as the rental costs over the peak period.

- The cost of the crew.

Fleet planning must always be related to:

- Annual budgets and the total fleet of ships.
- Economic forecasts.
- Annual investment options.
- Maritime market-trends.
- Policy flag State or other states of the working area, the European Union or the World Wars Trade Organization.

This planning is facilitated by using specialized computer programs at the company, but those who use, general managers and logistics, must be familiar with market conditions and trends related to the use of the ship (or fleet of ships) on a profitable. Together with fleet planning, corporate business plan is an important task management and shipping company in its proper fleet management. This involves the use of the criteria, but can be influenced in particular the classification of the ship, the markets they operate ships and goods carried as follows:

-The first objective for the Steering Committee of the shipping company is to complete the business plan that will meet the fleet manager, working always within the framework of shipping, considering the safety of the ship (the ship) is the first principle from which begins designing a business plan. Business-plan should reflect the objectives of the company Board. It must be market driven, what is going on this, the annual budget is established based on agreement of all committee members. Fleet-capacity resources must be matched market forecasts sea and must be reflected in the annual budget and program of trips estimated shipping. Maximum resources to be available during peak activity. This is a very important task of logistics department Business-plan should be aimed at reducing costs and income are related to the mixture of freight transported on each trip to ensure that the income provided (estimated) annual budget will be achieved.

- The shipping or travel, arising from the business plan requires special attention on:

- Port costs,
- Purchasing, facilities and fuel costs,
- Area in which the port terminal,
- Port technology,
- Navigation-needed economic resources, MF-compatible with fuel costs used.
- Competition and obtain income from freight transported (of freight),
- Cost of transshipment cargo.
- Port infrastructure,
- Time return of the ship,
- Autonomy, in nautical miles, day sailing and stationary, and validity of food-storage on board, etc.
- Fuel, ship repair and inspection of the vessel shall be considered given the port and terminal arrangement reached by ship. In terms of planning they are considered the company's strategic goals of maritime navigation. To be cost effective, must involve the payment stage inspection programs and to cause minimum loss established travel program.
- Management of the ship, crew and vessel inspection program is an area of "critical", which generates costs. In fact this is the biggest source of problems for fleet management, the company, its owners or stockholders.
- Port costs, disbursements and insurance are all considered "areas" that require constant review to ensure that the ship owner is a profitable business that can make new investments.

## 4. FACTORS INFLUENCING SHIPPING SERVICE QUALITY

The current shipping is considered that there are five factors that influence the nature of such shipping service: speed, frequency, re-return, cost and quality of service. Fast and frequent services with re-return ship will be found generally in the liner trade, taking into account that usually can be found cheaper transport ships like "tramp". Speed and frequency of service are essential for safe cargo such as fruit and vegetables. Consumer goods manufacturers evaluate speed so as to reduce the risk of spoilage and cost of goods in transit. The need for high speed is required over the long-distance trade, which can be appreciably reduced during the voyage, and the sender shall benefit for quick deliveries.

Frequently service may be important where goods may be sold in small quantities at frequent intervals. Re-return is important for shippers who have deadlines to letters of credit and import licenses. It also means that goods must arrive in good condition and shipping companies must provide adequate facilities at the docks and their offices to complete the necessary documents and other port and customs formalities. These requirements are recognized and meet operators (charterers, major importers) liner, which require high speed vessels, which have additional capital and bear all operating costs involved, sharing the stage navigation (voyage), to match supply their customers with goods pace required. Price of transport rates for these services, are stable but somewhat higher than those of the ship "tramp". Vessel owners may maintain rates at a reasonable level to make a profit, although they must ally with shippers to ensure that rates are so high that it influences the final prices of goods transported, which would lead to decrease in market demand. There is some justification in arguing that "charterers of ships carrying goods line, you must pay high shipping costs for this service", in relation to navigation "tramp". Low-value goods, on the other hand, must be transported as cheaply as possible because the cost of transport is directly related to airworthiness. Many of these categories goods such as coal, ore, timber, grain and other bulk goods, are generally transported as scheduled arrangements, so that speed and frequency of service have a minor significance, i.e. no major influence final costs. But most important is the validity of space transportation vessels such as "tramp", where price rates vary by market supply and demand. If there is space available, rates will be only marginal cost of operating the ship. When the market is strong, rates will increase, but an upper limit will be determined by the prospective price of goods, the moment of sale. Prices remain a dominant factor in choosing service by the sender (charterer), despite the fact that governments and trade policy discrimination Flag exercise greater influence in international shipping. In broad terms the distribution costs are 8-15% of the total cost of production. It is also important for sea cargo price to be fixed at a reasonable level, but generate profits necessary to sustain a modern fleet. Service quality is now an issue of great importance in modern shipping and international trade today. Service provided should be customer-oriented, focusing on a safe and movements of goods in an effective way. Transshipments cargo must be effective and does not lead to destruction, partial or total. Wins if cargo carrier receives the deposit and sends it into production or sell, not compensation from the insurer. The management of shipping should be directed to the quality of service rendered to maintain customers, repetition and continuity to get transport.

## 5. COST-REDUCTION FACTOR OF ECONOMIC EFFICIENCY

Can be considered irrespective of the shipping company, the type of ship transport, sea transport way (line or "tramp"), the place where the head office of the company or Flag, nature and the costs are similar. In reality, major differences occur between shipping companies, which have a range of costs for office operation, costs of salaries of persons employed on the premises, pay taxes, etc., like all other shipping companies, but this is different through a series of specific costs, which are all quite large. Running a shipping company must take into account their level, their share in total business costs. For a company shipping costs are the following main groups:

- Administrative overheads or company.
- Vessel operating expenses.
- Vessel impairment.
- Travel expenses.
- The cost of loading / unloading of ships.

A number of specialist companies shipping expenses divided as follows:

-Operating expenses of the ship on which the share is:

-30-45% cost of crews,

-20-30% Technical expenses,

-10-15% cost of insurance,

-7-12% cost with shipping supplies and equipment,

-4-8% cost of lubricants.

- Financial costs are given by the fees and taxes paid.

There are also a number of external factors affecting the costs of:

- Type of ship,
- Area navigation.
- Degree of hazard of goods transported,
- Insurances for ship and crew, etc.

Reducing costs to the shipping company is a very important and is always very topical, given the competition in the maritime, economic and personal crises experienced in the last 20 years. But this is not a simple problem to be solved immediately, without consequences on the ship and its safety. For running a shipping company that is easier to reduce some administrative costs, overhead, staffing, but reducing costs is more difficult vessels. Over the past 10 years have seen a number of measures that were adopted by the management of shipping companies as:

- Changing the organizational structure.
- Reduce the staffing.
- Outsourcing of certain services to specialized companies (crewing, accounting).
- Change of flag-ship by registration in a country with tax cuts and tax (tax havens).
- Renting ship-management companies shipping.
- The introduction of computer performance.
- The introduction of modern communication technologies, etc.

But most problems are the vessels there have been, are and will be the most difficult problems in the future about costs, how to reduce theirs. In the past 20 years companies have adopted a series of measures, some drastic cost reduction and during this time period there were many conflicts in this case. The first measure was to reduce the number of crew members. Thus there were significant reductions of approx. 40-50 people in the early 80s, 15-20 today, their number varying by type of vessel. The second measure was the retrieve a greater number of tasks to persons on board boats, increase their risk even decrease of ship safety. Standing there was disputes between owners, authorities and trade unions the increasing number of tasks of the boat. A very important measure was the introduction of modern computers, reducing the time of writing official documents issued by the ship, sending information to the company, receiving messages with managers, etc.. Another milestone was the modernization of means of communication between parties as between ship and company management, ship agents, ship and brokers, ship and authority, company and third parties.

The highest costs are those crews. But companies have sought alternatives to crew "expensive", with more cheaply. That replaced the sailors and officers from European countries with those in India, the Philippines and in recent years in China. But after a short time ship-owners and ship managers have observed that the reduced quality of service provided on board, the increased number of accidents, incidents and remarks received checks authorities and auditors. Currently there are major distortions on the employment of seafarers, we can say that there is some confusion about future developments of seafarers. Technical costs are second in total cost share. Therefore reducing technical costs of the shipping company is a challenge for logisticians and managers for business professionals. Reduce technical costs, principle can be made by:

- Reduce the maintenance costs of the vessel by:
- Standardization of material consumption.
- Ship maintenance, planning and daily maintenance materials, weekly and monthly.
- Hiring a highly skilled staff that would have qualified to obtain a high yield of activities. But ask qualified personnel salaries!

Accurate planning of ship-repair.

- Evidence of the precise materials and spare parts.
- Provide means of work, tools and equipment performance, renewed stock of spare parts and consumables from suppliers that offer the best price-quality ratio.
- Avoid large stocks of parts.

You can use e-procurement through public bidding or negotiation to obtain discounts or discount sites. Reducing costs is a high boats, is directly related to naval operations management, at the logistics and marketing industry. In this type of role of logistics and marketing costs are very important purchase lifeboats, rescue equipment, fire fighting equipment and pyrotechnic materials that have high prices, are through electronic auctions. After replacing them at the end land use, the old can be sold to certain institutions or companies can use under certain conditions. Loading equipment, deck, mechanical installations, metal or rope ropes reduce purchase costs for new ones can be avoided by following the maintenance and repair measures on time, quality and especially the ongoing assessment of their status to avoid failures or worsening of these defects.

The motor vessel, its service facilities and electric equipment deck to avoid failure should be observed operating security features and their parameters, perform maintenance and repairs on time and quality. Another cost is related to consumption of drinking water, which must always be rationalized, even if this may cause dissatisfaction crew. It is recommended to use a program to limit water consumption on board. For reducing paint on board is recommended routine maintenance when dry weather conditions allow it, according to the technical characteristics of paint, use painting tools and instruments in performance, to avoid losses, to purchase from suppliers who can provide the quantity and quality needed . For chemicals used in strict compliance with the board recommends how to use them and avoid losses. To avoid additional consumption of fuel and lubricants is recommended the following activities: precise planning of the voyage from berth to berth, making precise navigational control of the position the ship for immediate correction of deviations from the road, their boarding providers that offer best price on the market.

For reducing administrative materials on board ships required the following measures: accurate calculation of daily consumption, weekly, monthly and annual maintenance materials, detergents, soap, etc. and supplies by public auction (electronic, online). For reducing office supplies necessary for the following measures: accurate calculation of consumption, use of standardized forms to reduce paper consumption, recharge printers on board, reducing the number of printed documents, use. To reduce costs to purchase clothing items are recommended only for areas and season where navigation is performed, for example for navigation during the winter will only purchase specific equipment, similar vessel in the shipping route in the tropical and equatorial will purchase equipment that may be faced by the crew considering the high temperatures, using a uniform means to reduce their costs by making a single supplier chosen by competition, cost reduction is significant especially for companies that have a large number of members and control for manufacturing is high, protective equipment can be purchased directly from producers auction.

## 6. NAVAL OPERATIONS MANAGEMENT IMPACT ON EFFICIENCY IN SHIPPING

For to determine this impact can use several methods of economic analysis. In the shipping can be used the method of the cost-effectiveness analysis based on the critical point method known as “threshold” of return. The critical point is actually an equilibrium that can be used to determine the size of company activity, following the statement of revenue derived from contracts of carriage (freight) and expenditure. Costs are fixed and variable and the dependent variable workload. In relation to the dynamic activities of the company and the ships, the company accounts are found grouped in fixed costs and variable, with the following evolution:

-Fixed costs per unit are variable (treated as one vessel or the entire fleet), with a total constant, and they decrease with increasing number of the transportation contracts.

-Variable costs are constant per unit in size, but their amount increases with increasing number of activities or transportation contracts.

The relationship between the sum of all operating expenses and total transport activities to be carried across a ship or fleet must be used to determine the minimum level of income to be obtained to cover these expenses. Meeting point of these is in fact break even. Above this threshold yield should obtain profit for the company. From here we actually observe management effectiveness and impact of management on naval operations as a whole. Methodology to perform calculations and then breakeven analysis is differentiated for a vessel for the entire fleet or all of the shipping company if it has in its scope and shipping related activities. Another important aspect that can be used to understand the impact and effectiveness of management decisions on naval operations, value chain analysis is the shipping company. In principle a shipping company has the following value chain analysis activities, Iordanoaia (2006):

- Decomposition transport process is relatively simple and entities contributing to the service are in a very small number as follows:
- Ship: runs the crew, approx. 15-20 people.

- General Manager: holding the “key” of the business.

- Deputy Directors, specifically those responsible for the ship, Logistics, Technical and

Marketing: approx. 4-6 people.

- Primary activity is the transport of goods, containing loading and unloading vessels.

- Support activities are only those related to:

- Quality-control and safety.

- Boats.

- Human Resources management.

The last two activities “support” can be outsourced to specialized companies, companies that take tasks and even if they contribute to the value of service activities not belonging to the company directly. Effectively use the value chain shipping company consists of the following steps:

- Decomposition process.

- Award costs.

- Identify critical activities.

- Identify valuable employees.

- Identifying value-links.

- Optimization links.

A) Decomposition process. Transport process is dependent on how ships are engaged on the line or “tramp”. Value generating activity is represented by loading the ship. When the contract is provided as loading and unloading operations to be performed with the help of the board, the service will increase, but the share of such additional activities is limited, basically just some type cargo ships and Ro-Ro is can make, and some ships have no such possibility because the way they have been built and that the board was abandoned facilities for these operations.

B) Award costs. Shipping company costs were already presented in this paper. Their effects on the company are very important and are not an easy task to reduce them.

C) Identification of critical activities. Implementation of the I.S.M. Code principles on board imposed the preparation of the lists of critical situations that may arise on board and that may have negative effects on it, the goods and the crew. Avoiding responsibility is so critical situations commander, crew, and the other factors of responsibility within the company. Avoid critical situations in a year means that brokers offer additional guarantees that the goods will reach their destination on time and keeping business characteristics of the goods. The procedures used on board and maintained at the company are kept strict to all these critical situations.

D) Identification of valuable employees. This step is easier to shipping companies “tramp”, where brokers are those who seek cargo charterers bring the owners to contracts of transport. Maintaining relationships with them is very important and their role in this type of navigation can not be underestimated.

E) Identifying value-links. In the maritime transport relations are among the most important practically very little chance that a shipping company manages to resist without realizing a system of relations with partners, to keep these relationships.

F) Optimization links. This stage is essentially “naval operations management”. Figure 2 shows the share of management processes within the shipping company. To be optimized link is needed primarily a classification of such activities:

- Direct-ship management. Activity commander is required.

- Supply ship. Liability is the company (the director of logistics, technical director or general director) and the vessel's agent, on orders from the master and the chief engineer.

- Searching charter contracts which is required by charter or marketing director.

- Searching for the best-trained officers and sailors, is the Director of Human Resources or crewing company, when the service is outsourced.

- Management's headquarters, the administrative director.

## 7. CONCLUSIONS

Change management activities in naval operations, involving direct cost variation. This link is established by those measures which they adopt maritime shipping companies to reduce costs. But as in any economic activity, especially in service provision, reducing investment costs by reducing or cutting spending, may have negative effects on medium and long term. Analysis of shipboard situations when reduced crew members, when they cut out parts lists, provide evidence on the downside quality service and lower yields on board facilities. Currently searching for new solutions to increase the role of logistics in naval operations, both in terms of the technical, maintenance, especially in the boats about.

Thus it is advisable to seek solutions to the global organization of the fleet of activities, effective use of information obtained from the maritime market, total involvement of human resources on board and at the company, determining the optimal level of shipping service for eliminate accidental costs, in order to avoid empty vessels traveling without cargo and reduce the time for current and capital repairs. All these aspects are very important for correct decision making by managers of shipping companies to achieve maximum business efficiency.

## 8. ACKNOWLEDGMENTS

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# THE INFLUENCES OF MARKETING PARTICULARITIES IN SHIPPING

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**ABSTRACT**

Among the most important aspects of the maritime company marketing is the life cycle of a ship. Managers should be aware of aspects of the operational period until the moment of the current and capital repairs, the degree of use of the ship and separately for each installation. These aspects are not easy to be calculate because there appear a series of aspects connected to the shipping zone, the type of the transported goods, the way of exploitation and maintenance performed by the crews, the number of the exploitation days and many more others. The life cycle of the service performed by the ship, in fact the type of the transported goods is very important taking into account the changes on the maritime market, the competition between shipping companies, the development of the international economy and the requests of the customers of the shipping companies. In this paper, there are analysed the two aspects which a ship represents, as ”product” and as a performed ”service” and it is presented a type of analyze for a maritime ship.

**Keywords:** *maritime, marketing, service, life cycle, ship.*

## 1. INTRODUCTION

Any product, during its presence on the market, evolves in a specific manner, this being known under the name of “life cycle”. The life cycle of the product can be defined as ”a process which is developed in time, starting with the launching and reaching the coming out of the product from the market”, Niculescu (2000) et al. The life cycle of the product is similar to the biological life cycle of the human being, including stages or phases as: the birth, the growing up, the maturity and the decline. Specifically to the marketing approach it is the fact that at each stage of the life cycle of the product, the company can use different kinds of strategies, being in concordance with the objectives which the company establishes, with the available resources, and according to other factors, Prutianu (2002) et al. The life cycle of an ordinary product is influenced by the general strategy of the productive company in a certain moment or in certain specific or circumstantial periods, Catoiu (2002) et al.

The study of the life cycle of the products has a great importance due to the following aspects: the possibility of explanation of the behavior of the product market, the identification of the actions performed by the competition, the influence of the commercial strategy of the company, etc, Kotler (1996) et al. The main aspects which characterized the life cycle of the product are given by the evolution of the sales, of the profits and the evolution of the orders and requests. The evolution of the product on the market can be described by a life cycle which the main stages are the launching, the growing up, the maturity and the decline. The launching or introduction stage of the product on the market or the birth stage of this supposes the expressing of the request for the product, its carriers being in this case the consumers of the ”innovative” or ”curious” type willing to try the product. The characteristics of this stage are the following: the low profits due mainly to the high costs of production and commercialization, the high prices, the selective distribution, the intense advertising pointed towards the innovators, etc. The growing up stage of the product supposes an evolution in a favorable way of the sales, the preponderantly used strategy being that of penetrating the market, respectively of convincing a larger and larger number of consumers to buy the product. This stage can be described by the following elements: the increase of the profits, the consequence of the high prices and the request found in increasing, the applied distribution is preponderantly intense, the advertising aims at the advantages of the brand, the product starts to differentiate itself etc. The maturity stage appears in the conditions of saturation of the market and of the stabilization of the sales, during this registering the maximum of sales, Sasu (1998). The defining elements of this stage are: the establishing of a relatively fixed structure of the company offer, which includes a reduced number of brands with a very-well defined position, the profits are reduced, the prices are maintained at a high level, the communication is that of a persuasive type and tries to differentiate and to maintain the brand image, the advertising is moderate, taking into account that the product is already known, it is applied the promotion of the sales towards the consumers and distributors, the channels of distribution are stable and the advantages offered to the distributors are high, with the purpose of maintenance the product on the market, they are considered offers much more complex which include the product, at which it is added a certain number of services, etc.

The decline stage appears in the conditions in which the product is morally worn out, it can’t respond anymore to the requests of the consumers. It is required, in this context, the redefinition of the product in the purpose of maintaining the request at an acceptable level. This stage can be characterized through: the decrease of the prices and of the profits (which are transformed in losses), the selective style distribution, the advertising in a minimum intensity, pointed towards the low price, etc. It is permanently shown a close connection between the life cycle of the product and the typology of the strategies used by the company. There can be considered from this perspective two levels of analyze, thus: on the one hand it is concretized the strategies which the company can adopt in theoretical stages of the life cycle of the product, and on the other hand the strategies which are adapted to the specific life cycle of each product. From the strategies perspectives which are adapted to the specific life cycle of each product, there are usually differentiated the following situations: The companies whose products cover a long maturity stage or which sales increase in a continued manner, act, with priority, in the following directions, Kotler (1999) et al: the use of some distributions channels as short as possible; the innovation of the products; the comparative advertising; the extensive distribution; the maintenance of some competitive prices. The companies whose products succeeded in penetrating fast on the market act for: maintaining a productive capacity which allows the survival on the market found in increase; keeping a good position on the market using the quality and the brand image. The companies whose products are in the stage of the decline and which could be abandoned have to: think and position again the product; appeal to the classical variables of marketing in order to increase the sales. The life cycle of the product is a concept which tries to describe the sales and the profits of the product, the consumers, the competition and the specific marketing actions performed from its appearance and until its removing from the market or more precisely, the period of time between the moment of the launching of a product on a given market and the period of its complete withdrawal from that market. The analyze of the life cycle of the product should have into consideration the following definitive elements, Boronad (2001) et al, too: The life cycle of the product is not identical with the period in which the product is in the use of the consumer: in certain situations, the withdrawal of the product from the market is not synonymous with its withdrawal from use/consume. The life cycle of the product is not identified with the life cycle of the group of the products from which this belongs to, respectively of the market of the product.

## 2. THE LIFE CYCLE OF AN ORDINARY SERVICE

The marketing of the services was considered as a distinct domain as a result of a long relative process characterized by a series of delimitations which happened on different plans which defined the concrete content of the marketing (Kotler et al, 1996). Although it was first applied in the material goods domain, the conception of the marketing happened gradually in other domains of the social life. The assertion period of the marketing in services coincided with the period in which in the international economy the services knew a strong development. Once with the development of the society it imposed the necessity of using the methods, the techniques and the instruments specific to the marketing in order to anticipate the market reactions, the knowledge of the changes inside the market and not the last thing to counteract the competition. No matter the way in which there are presented the features and the specific of this domain, it is sure that the marketing of the services is made up as a specialized domain, autonomous, clearly differentiated, found in consolidation and permanent development. The economical and social dynamism from the material production domain, the transformations made in the last years from the people mobility point of view reflected in the transport activities. The transport activities are based at the same time on equipments, infrastructure and human resources. As the other types of services, one of the main objectives in this domain is the synchronization of the offer with the request of transport services. In order to transform the offer of the services from potential into effective, it is implied the state, on the one hand, through macro economical decisions appropriate especially in the legislative and infrastructure domain, and, on the other hand, the economical agents who perform these services. The different kinds of transport, of people or of goods, which also can be: terrestrial transports, maritime or in the air, imposed the delimitation, the specification and the application of the methods and the techniques of marketing differentiated for each of these types. From here, it appears the necessity of determination of the elements specific to the shipping domain and to its characteristics.

## 3. THE LIFE CYCLE OF A MARITIME SHIP

The life cycle of a ship can be dealt with from two points of view, thus: the ship as a product and the service performed by the ship, Iordanoaia (2005). The builder shipyard is interested in the ship as a product, according to its type, because these can be asked for by ship owners according to the evolution of the market. The ship owner is interested in the life cycle of the service performed with the help of the ship, according to the type of the navigation and to the employment contract. Between the two situations there is a close connection because the existence of the transport service, the request of the market for ships of a certain type makes that a shipyard adapts, responds to the request of the ship owner. Sometimes the shipyard builds a ship of a certain type then it never has orders for this type and it re orientates its capacities of production towards other types of ships, so that it can say that it made a unique product.

A) PHASES OF THE LIFE CYCLE OF A SHIP AS PRODUCT. The life cycle of a ship is very important for the builder shipyard because the research of such a cycle supposes: the establishment of the general and the specific factors which act upon the life duration of a ship, the determination of the stage in which there is in a certain moment each of the main components of the category from which it takes part, the estimation of its future evolution on the maritime market. The research of the life cycle of the ships can lead to the obtaining of some ideas and solutions which concern the policy from the shipping building domain and from the maritime transports for the type of the ship submitted to the analyze, starting from its modernization in the opportune moment, the change of the initial destination (as it is in the case of the multi functional ships) or if it is the case even its taking out from the operational state, its selling at ”second hand” or at old iron, once with the launching in the sea of a new ship, Bauchet (1992). The life cycle of a ship is influenced from the moment of its launching in the sea and its entrance in the service due to the action of some factors: heterogeneous, general, specific, with a direct action, with an indirect action, controllable and uncontrollable. According to the way in which it is conjugated the action of such factors it will result a large variety of the trajectories of the life cycle of the ship. Starting from the general criterion accepted and mainly easier to be determined, the life cycle of a ship crosses more stages thus: the launching on the maritime market, the growing up or the development, the maturity, then the saturation of the market and the decline of the type of the ship. Most of the cases the concept of ”life cycle of the type of the ship” is presented under the form of a graphical profile. The volume of the sales of the ships of the same type will pass through more phases due to the appearance of other types of ships which will replace them on the market. In figure 1 it is presented the life cycle of an ordinary product, this graphic corresponds more to the situation of the small ships, those of the passengers type, sports boats and tourists’ ones because they are produced by the series shipyards, even on the basis of a potential request, then they are taken out for sale on the market and after a certain period of time, according to the graphic, these ”products” are replaced or withdrawn from the market. For the maritime ships of huge tonnage, built in series, the graphic has a special form, which differs from a ship type to another. Even in the situation of the building of some ships from the same series, these are not totally identical, due to the technical progress, to the appearance of some new machines and installations which are assembled on the same ”ship body”. Analyzing the factors which determine the duration and the structure of the life cycle of the type of the ship it is observed that these can be general and specific:

1).From the category of the general factors there can take part: the technical-scientific progress of the equipments of shipping, communications, deck installations, and naval engines; the increase of the income of the ship owners and their exigency; the income increase of the ”non-sailors” (amateurs) who wish to buy yachts and sport boats. These factors emphasize the moral use of the types of the maritime, river and tourists’ (of pleasure) ships or existed in a certain moment on the maritime market, Branch (1998).

2).From the category of the specific factors there can take part: the type of the maritime ship (its destination); the size of the order, it means a single ship or more ships; the capacity of the ships to be able to be used for the transport of other types of goods; the size of the order: unique, of small or big series; the regulations of the economical legislation, etc. Besides these factors, there must be added the ones directly connected to the builder shipyard, aspect which has a decisive influence upon the life duration of the ships. Corresponding to each stage from the life cycle of the ”products”, stages in which the sales reach different levels, there are necessary policies as different as the marketing, viewing the technical-functional characteristics of the ships, a certain price and distribution strategy, a different promotion policy. The duration of the life cycles of the products differ from a product to another, all being dominated by the correlation between the volume of the sales and the profit. In the conditions of the establishment of a connection between the life cycle and the curve ”of adopting the product by the consumers”, the passing from a phase to another of the life cycle will take place in accordance with the number of the ship owners or the amateurs who buy this type of ships. The entrance of the type of the ship in the decline phase supposes its abandonment gradually and in this way the restriction of the number of the customers. The shortness of the life cycle of the type of the product is a process which characterizes the majority of the modern industry branches. For each shipyard it shows a great importance both the total length of the life cycle of the ships, no matter their type, and the duration of each phase partly, the obtained benefit being found in a direct connection to the number of the ships made on the market. Even though there is a tendency of the request of the ship owners for building some unique ships, still the most advantageous for the shipyard is to build more ships of the same type or following the same project, McConville (1999). The ship owners, as a majority, are people who worked on the ship board, have sea experience and know the maritime market, but their training does not allow them the integral knowledge of the process of a ship building. Thus, these launch an order for the building of a ship, but the managers of the shipyard can make offers of building the same type of ship to other ship owners, too. If the project of building belongs to the shipyard, then this can sell it to other shipyards or ship owners. Another aspect of great importance is connected to the fact that an initial project can get to be changed in a proportion of 10-30%, due to the technical problems connected to the way of building the ship. This aspect is relevant because it helps us to understand why the ships from the same series do not look the same one with another.

B) “THE LIFE HOPE” OF THE SHIP. In theory and practice of the modern Marketing it is considered that when it is made the final decision of launching on the market of ”a new product” it is taken into consideration a certain ”life hope” of this, Niculescu (2000) et al. According to the prognosticated volume of the sales and of the benefits, the life hope of the product offers an economical justification for its propelling on the market. In real the conditions of the market, the companies can’t control, only in exceptional cases, the trajectory of the life cycle of the product, these are limited only to the surveillance of the evolution of the product on the market so that it can influence favorably its trajectory. Thus, through the permanent report of the pattern of the life cycle of the product to its real evolution on the market, the mix of the product will be adapted to the requests specific to the phases which the product practically passes through. In the shipping transport domain ”the life hope” of the ship is very important for the ship owners, because this has double meaning: technical and economical, Iordanoaia (2004). From the technical point of view, it is stated that a ship, after a few years of exploitation, gets to a certain technical use being necessary a series of partial or capital repairs. These must be planned and executed rigorously because they have direct influences upon the time in which the ship is not found in exploitation. From economical point of view it is stated a certain ”moral” use, it means new ships appear, with new installations and modern apparatus, with superior speed, with reduced consume of fuel and even with a reduced number of crew members. This type of use reduces the hope of life of the ship, that’s why it is important for the ship owner to be informed with the new evolutions and tendencies in the shipping transport, to anticipate and then to plan the modernization of the ships in order to prolong their life, both from the technical point of view and from the economical point of view. The withdrawal of the ship from the exploitation, selling it at ”the second hand” or at old iron must be anticipate in good time, and the choice of this moment must be chosen carefully, the establishments of the ways of avoiding the forced elimination of the ship from the market can lead even to the obtaining of some certain advantages. The problem of evaluation of the ”life hope” of the ship supposes a fair, realistic evaluation, but such a measure supposes the estimation of the probable life duration of the ship, still before its launching in the sea, and on the other hand after it was launched, the diagnosis of the phase from the life cycle which the ship reached, of its chances of ”survival”. In the case of the economical theories there is used a series of methods to find the respond for the two problems.

The first is represented by the possibility of evaluation of the life duration of the ship, right before the launching of the building order. This is a problem of anticipation, being able to use the method of the phenomenological extrapolation, Stopford (1997). Thus the ship can belong to a certain class, category or group, whose evolution determined by the life cycle and by the shape of its curve is known from the previous experiences. The second is the comparison method which starts from the premise that the ship evolution on the market can be the same with that which had the same type of ship on another market or even on the same market, in this case being about the transport routes, CIM (2007). There can be also used a series of intuitive methods of anticipation or simulations techniques, but the most used is the method of analyze the statistical data which regards the evolution of the sales and of the ships building from that type. In the table no.1 there are presented the main types of the maritime ships, with the anticipated duration of exploitation, the medium duration, the number of years until the first capital repair, the maximum number of years estimated in the active service (of exploitation) and the way of use after its taking out from the service, before its ship breaking.

Table 1.The life hope of the main types of ships

| TYPE OF SHIP | THE MEDIUM ANTICIPATED DURATION (YEARS) | THE MEDIUM DURATION IN SERVICE (YEARS) | THE NUMBER OF YEARS UNTIL THE FIRST CAPITAL REPAIR | THE MAXIMUM YEARS NUMBER IN SERVICE | THE POSSIBILITIES OF USE AFTER THE TAKING OUT FROM SERVICE, BEFORE THE SHIPBREAKING |
|---|---|---|---|---|---|
| OIL TANKER | 15 | 12-14 | 5 | 17-19 | CISTERN AT BERTH |
| CHEMICAL TANKER | 10 | 10-12 | 4-5 | 15-16 | CISTERN AT BERTH |
| LPG | 15 | 15 | 5 | 15 | - |
| PORT CONTAINER | 17 | 19 | 7 | 23 | - |
| BULK CARRIER | 25 | 30 | 7-10 | 35 | - |
| CARGO | 20 | 25 | 10 | 30 | FLOATING DEPOSIT |
| RO-RO | 15 | 15-17 | 7 | 20 | - |
| FERRY-BOAT | 15 | 15-16 | 10 | 25 | - |
| LINE PASSENGER | 20 | 20 | 7-10 | 25 | FLOATING HOTEL |
| CRUISE PASSENGER | 25 | 25 | 7 | 35 | FLOATING CASINO |
| TECHNICAL SHIPS (SPECIAL) | 25 | 25 | 10 | 35 | - |
| AUXILIARY SHIPS | 25 | 25 | 10 | 35 | - |

Source: The author’s study.

Table 2. The ship voyages, the operation, the repairs and the waiting

| YEAR | NUMBER OF VOYAGES | NUMBER OF DAYS OF OPERATION | NUMBER OF DAYS OF REPAIRS | NUMBER OF DAYS OF WAITING |
|---|---|---|---|---|
| 1995 | 36 | 298 | 48 | 19 |
| 1996 | 34 | 297 | 61 | 8 |
| 1997 | 28 | 224 | 116 | 25 |
| 1998 | 39 | 342 | 18 | 5 |
| 1999 | 35 | 314 | 36 | 14 |
| 2000 | 26 | 235 | 120 | 11 |
| 2001 | 37 | 341 | 20 | 4 |
| 2002 | 36 | 321 | 35 | 9 |
| 2003 | 28 | 226 | 110 | 29 |
| 2004 | 34 | 306 | 37 | 23 |
| 2005 | 33 | 305 | 42 | 18 |
| 2006 | 29 | 219 | 123 | 23 |
| 2007 | 33 | 318 | 31 | 16 |
| 2008 | 31 | 272 | 36 | 27 |
| 2009 | 27 | 262 | 40 | 36 |
| 2010 | 29 | 263 | 45 | 28 |

Source: “Dubai Shipping” Company.

The study of the author has at its basis: The situation of the ships built in the shipyards from: Constantza, Mangalia, Tulcea, Braila, Orsova and Galati from Romania, Varna from Bulgaria and others. The situation of the ships entered the capital repairs from The Maritime Fleet Exploitation Company ”Navrom” between the years 1970-1989, from the maritime shipping companies with state capital: ”Navrom” between the years 1990-1998, ”Petromin” between the years 1990-1999, ”Romline” between the years 1990-1997, National Company “CFR-Goods”, ferry-boat agency Constantza between the years 1996-2008. The situation of the ships of the Romanian maritime shipping companies with private capital: ”Mihei Shipping” between the years 1995-2008, ”Histria Shipmanagement” between the years 1994-2011, ”Idu Shipping” between the years 1995-2004, ”North Star Shipping” between the years 1994-2007, ”Cosena” between the years 1995-2006, “Coremar” between the years 1995-2011. The situation of some foreign maritime shipping companies: ”Zodiac” and “Tanker Pacific” between the years 1998-2011, “Dubai Shipping” between the years 1995-2011, “Santos” Bolivia between the years 1995-2007, “Neptun Orient Line” Barcelona between the years 2002-2010, “Maersk” between the years 1995-2011, “Thome Ship Management” between the years 2000-2011, but from other companies, too. The information was obtained through direct contacts with the general managers of the companies, with ship captains and the personnel hired at these companies headquarters or at their agencies from abroad. I took a number of 155 of maritime ships with tonnages between 5,000-165,000 tdw thus: 23 oil tankers, 14 chemical tankers, 10 LPG, 26 port-containers, 11 bulk carriers, 18 cargoes, 13 Ro-Ro-s, 7 ferry-boats, 8 line passengers, 4 cruise passengers for tourists, 9 special ships and 12 auxiliary ships. I consider that the study is estimated because margin of error is of 2,5-3 %, what at the total number of 155 of ships is quite much, also it is possible that from certain reasons the people who I asked the information wouldn’t give me all the necessary information. Thus in the margin of error enters certain wrong information and numbers, certain situations of the ships which were not taken into consideration by the ship owners, etc. But the results of the calculations can help us to understand the time period of exploitation of some types of ships.

## 4. THE LIFE CYCLE OF THE SERVICE PERFORMED BY THE SHIP

The life cycle of a service depends on its character, on the characteristics of the services which impose certain economical determinations. Starting from the characteristics of the services there can be made analyses and interpretations of their life cycle. The main characteristics and features of the services are the following:

A) The intangible nature of the result of the activity, meaning that the services can’t be appreciated qualitatively before of being bought or performed. Due to the fact that in the case of the shipping transports many contracts are obtained due to the previous relationships between the ship owners and charterers in the case of line shipping, it is possible that the charterers could anticipate the way of performing the service, meaning he could have trust in the ship owner, that the goods will reach well the destination.

B) The concomitant, the in-separation of the consume and the production, meaning the fact that the performance of the service takes place in the same time with the commercialization and the consume. In the case of the shipping transports the service means in fact loading, arranging the goods, making different activities for protecting the goods during the transport, unloading and the transfer of the commercial documents which accompany the goods.

C) The services can’t be measured in measurement units or counted, as in the case of the products. The use of some technical-economical indicators in order to measure the results of service performance refers in fact to the use of some objects (in our case ships) for their accomplishment, and the relationship with the customers (the charterers) is indispensable. Nowadays, there can be still measured the number of incidents at goods, the losses during the loading, during the transport or the unloading, which can thus be used by the charterers in order to measure and appreciate the performed service.

D) The proximity of the services, which supposes a certain participation of the customer at the service performance, what in the case of the shipping transports it is obvious through the fact that a charterer can send its representatives on the ship board in order to follow the way of loading, transport and unloading of the goods.

E) The social characteristic of the services which is given by the relationships between its participant groups or its beneficiary.

F) The perishability of the services is given by the fact that after their accomplishment they ”disappear”, they don’t remain as such. Once with the unloading of the goods in the port, the contract and the service are finished, not being able to exist, for example, a post-sales ”service”.

G) The heterogeneity of the services which means that these have a very different characteristic from a case to another, being great differences between two categories of services. This is found especially at the cargoes which transport general goods and which, in a very short time, after unloading some goods, can load totally different goods, which impose other technical solutions for the safe transport.

H) The variability of the services is determined by their complexity and by the basis factors which can’t repeat identically, from a situation to another.

I) The lower productivity comparing to the production of goods. This is one of the first problems of the ship owners, nowadays being searched solutions for the increase of this productivity through a series of methods and managerial techniques.

J) The diversity of the services imposes specific conditions of market for making the prices, different from those of the products. If in the line shipping the price is easy to be established, in that of ”tramp” the situation is different and implies bigger problems for the

ship owner.
K) The big ponderation of the personnel participant to the service performance, which influences the productivity and its quality. Besides the hired personnel at the company headquarters, which is in charge with the search for contracts of freight, with ship supplying, with the safety, with the accountancy, with the human resources, the ship crew, as an unit, has a special role in the service performance.

## 5. THE TYPE OF ANALYSE OF THE LIFE CYCLE

Further on, it will be presented the "life cycle" analyze of the performed service by the ship of the oil tanker type "Gulf Glory". This analyze has on its basis the real situation of this maritime ship, for a period between the year of its launching and a year predicted for the ship withdrawal from the market, having certain correlations with the indicators which refer to the prognosticated volume of the goods and of the benefit which the ship owner wishes to obtain. The shipping company can control the trajectory of the life cycle of the service of the ship, without limiting only to the surveillance of its evolution on the market, as in the cases of the production companies from the inland, so that it could influence its trajectory favorably. Through the permanent report at the "life cycle of the ship" type at its real evolution on the market, the operation and the functioning will be adapted to the requests specific to the phases which are crossed. This supposes a rigorous, detailed, in time training, thus the activities' programming, the current and capital repairs and the modernization of the equipments, of the installations and of the board systems which can contribute to the prolongation of the life cycle of the ship service. Following the activity of the ship in the period 1995-2010, with the help of the data from the table no.2 there can be made the graphics which represent the variation of the number of voyages of the ship, the variation of the number of the days of current and capital repairs. The waiting represents: waiting of setting free the berth for loading; unfavorable weather for the operation; dead times between the arrivals of the ships for unloading. In 1997 (Mangalia), 2000 (Piraeus), 2003 and 2006 (Dubai) there were made the capital repairs in the shipyards, with the climbing of the ship on a dry dock, Dubai Shipping (2006).

In figure no.1 it is presented the variation of the number of the voyages of the ship according to: the number of the voyages (Nv) made yearly and the period of 16 years taken into consideration. It is observed the direct correlation between the years in which the repairs were made and the following years, when the number of voyages increases every time comparing to the previous year. In figure no.2 it is presented the variation of the number of the repairs days of the ship according to the number of the repairs days (Nrd) made yearly and the period of 16 years taken into consideration. It is observed the fact that in the years following the years when the capital repairs were made, the number of the repairs days is very small comparing to the previous year. Comparing the two graphics it is observed each trend of being into a direct correlation. It means that the number of voyages is directly connected to the repairs days, so the increases and the decreases are observed on each graphic in those years. Such graphics are important for the company because the evolution on the maritime market implies risks, and the surveillance of the trajectory of the life cycle of the performed service must be permanent and cover the most critical periods.

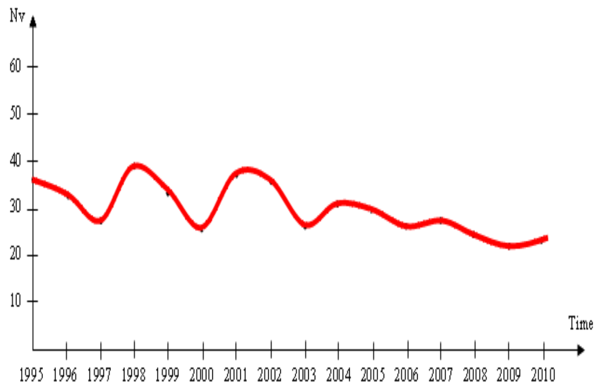


Figure 1 The variation of the number of the voyages.
Source: The author's study.

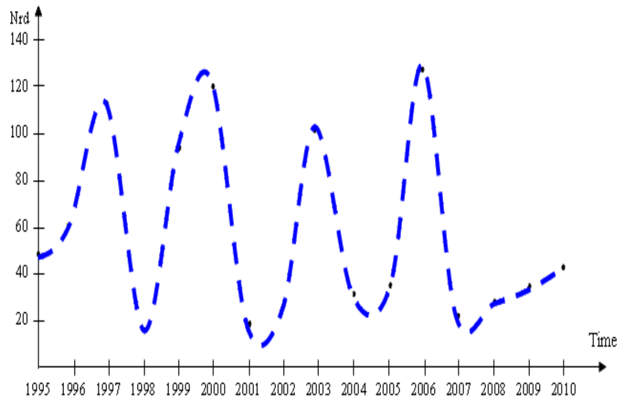


Figure 2 The variation of the number of the repairs days.
Source: The author's study.

In figure no. 3 there are presented the phases of the cycle of the service performed by the ship, for a period between 1981, the year of its launching in the sea and the year 2004, with a prediction of time for a period of activity between 25-30 years. The life cycle of the service can be also influenced by the international legislation, but following its shipping routes and knowing the fact that some states have a certain policy regarding the respect of the international regulations, it is considered that this ship will reach the "venerable" age of 30 years old through the yearly current and capital repairs at every 3-4 years what it will prolong the service of the oil transport and of its derived products. But, if the company's management has an offer of transforming this ship into a basis ship or into a deposit of the cistern type, with repairs at the body, structure and installations, without those at the main engine, it can prolong its life cycle as "a product", performing through this a service connected to the transport of the oil products, that of a floating deposit.

A series of authors use for the determination of the life cycle of the ship physical indicators, as the number of voyages, the number of days of operation and of stopping, Branch (1998), and the others use valuable indicators: the value of the freight, the selling price of the ship (nominal or on the market), the exploitation costs, etc, Stopford (1997). All these methods are significant for the company's management, but they must be made by the specialists in economical-financial analyze, by the specialized personnel in financial operations or by the experts-appraisers, otherwise they remain simple information and numbers, without relevance for managers, Iordanoaia (2004).

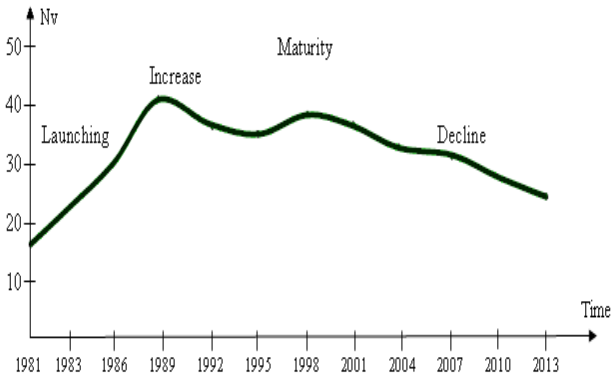


Figure 3 The phases of the life cycle of the service of the ”Gulf Glory” ship.
Source: The author's study.

## 6. CONCLUSIONS

The analyze of the marketing at a maritime shipping company must become an important component of its management due to the implications and the situations which can be solved. This analyze must be made at least once a year, but it can be made every semester, as well, due to the fluctuations which appear on the maritime market, both regarding the goods and the ships, the transport routes and the legislative limitations. The analyze of the marketing at a shipping company can point out a series of aspects which prove that inside it the management is a modern one, efficient and pointed towards the customers. Strictly from the marketing point of view, there are more aspects to be solved at the maritime shipping companies, there must be taken a series of measures for: the change of the organizational structure for the development of the marketing component, the selection and the employment of some specialists in marketing, perfecting the hired personnel with some marketing attributions. The companies which act in the maritime transport domain don't approach the marketing in the same way in which the products' companies do, and in the conditions of a high competition such as that from the complex market of the services of maritime transport, the things get complicated more. Due to the fast changes from the maritime market and with a future that can be uncertain many times, the maritime transport companies were put in the situation to adjust, to change the traditional strategies. The changes from the transport technology domain, the information and the connected branches, and the continual liberalization of the society, the shortness of the life cycle of the maritime ships and the change of the traditional relationships between the producers and the detail ones replaced the tendency of continual expansion, and the registered profits by the companies are bigger than the previous years.

During the years, some shipping companies adopted different strategies of differentiation, through the promotion of their brand associated with a high quality of the offered services, with the latest technology, equipments with a high rate of renewal, as for example the equipments which pass beyond a certain age and/or don't belong to the qualitative standards anymore, are withdrawn from circulation and sold, professionalism and experience. The successful companies tend to differentiate themselves especially through the elements which present an importance for their customers. Although apparently as in the case of the products, the price makes the difference, in the maritime transport the freight does it, the reality proves that there are taken into account much more aspects among which these which have a relevance in this paper: the oldness of the ships with which it is operated; the degree of technologizing the operations; the condition of the equipments on the board; the capacity of loading, speed, medium consume per nautical mile; the training of the captain, of the crew members and of the personnel inside the company which contribute to the maintenance and to the prolongation of the operational condition of the ship. These will mean for the shipping companies great investments of money and time for the acquisition of the latest technological equipments, capable to tolerate a bigger traffic of information, stocking some basis of data and confidential information, with limited rights for each user partly, organization of some training and perfecting courses for the company employees, these representing a ”key” resource in the prolongation of the life duration of the ship as ”a product”. Making the repairs in time and making the investments for the maintenance in functioning of the quality standards will help at the prolongation of the life cycle of the ship as ”a product” But the prolongation of the life cycle of the service performed by the ship takes part from a context connected to the transported goods, the shipping routes, the hardness of the legislation in this domain or other factors which contribute to the increase or decrease of the quantity, meaning the game of the request and offer from the maritime market.

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# IMPLEMENTING A SEA POLLUTION PREVENTION AND SAFETY MANAGEMENT SYSTEM IN THE NAVIGATION COMPANIES COMPETITIVNESS FACTORS

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**ABSTRACT**

The paper presents the main causes of the sea accidents and disasters, which call for the implementation of a sea pollution and safety management system (SMS) in the navigation companies, for certification purposes, in compliance with the International Management Code for the safe vessel operation and pollution prevention (ISM). For this purpose the objectives of the ISM codes are presented and which are to be found in the implemented Management System.

From the main causes of the safety deficiencies in vessel operation, by applying the cause-effect method, it was found necessary to implement a sea pollution and safety management system in the navigation companies able to provide more safety in ship operation, an implementation in the absence of which the international traffic would no longer be possible.

Thus the basic SMS implementation stages have been established taking into account the related international legislation.

**Keywords:** *sea pollution prevention, ISM code, sea pollution and safety prevention, SMS implementation*

## 1. INTRODUCTION

The world economic growth reported in the last decades has been accompanied by an increase in the foreign trade and implicitly in the world sea trade.

At the same time, the evolution of the world and European sea transport has been marked by more acute exigencies as regards safety, quality and sea-going vessels pollution prevention, the major cause being the large number of accidents and related high casualties along with heavy sea pollution (Bătrânca, 2004).

The maritime transport is an ample and complex economic activity both as amount of cargoes shipped annually and as material value. Its complexity also comes from its particular environmental conditions where it takes place - seas and oceans - which call for special safety measures (Bauchet, 1992).

The causes of sea accidents and their effects are constantly investigated by international organizations and institutions having authority in regulation, statistics, and insurance along with some sport associations. They are investigated, classified and the conclusions are further turned into rules norms or international conventions for the purpose of reducing or eliminating similar accidents in the future (Voicu et Al., 2000). Therefore, international organizations such as UNO, EC and specialized agencies such as IMO (International Maritime Organization), ILO (International Labour Organization) have elaborated a significant number of conventions, regulations, rules, norms, international standards that contain essential criteria for the sea safety and sea pollution prevention.

Due to the IMO member governments having accepted the constant modifications to the rules and conventions referring to ship safety at sea and sea and air pollution prevention, their evolution is constant.

Thus the IMO OILPOL 1954 convention was first modified in 1969, and in 1973 a much sever convention was adopted, "the Convention for Prevention of Sea Pollution by Ships". The latter's ratification was initially slow, but a number of accidents that occurred in the period 1976-1977, determined the call for the Conference on Oil tankers safety and Pollution Prevention in 1978, the Convention of 1973 being amended under the form known today as MARPOL 73/78 (MARPOL73/78, 1997).

In 1967-1977, a series of accidents of some oil tankers have result in new modifications to the SOLAS Conventions (International Convention for the Safety of Life at Sea) adopted in 1974 and MARPOL (Convention for the Prevention of Pollution from Ships). SOLAS, the most important convention, has been repeatedly modified as a response to major disasters (SOLAS, 1974).

In 1989 IMO adopted the International Convention for Saving (SALVAGE, 89) and the International Convention on Oil Pollution Preparedness and Cooperation (OPRC, 1990), for the purpose of introducing a global system of response to the major oil discharges (International Convention on Oil Pollution Preparedness and Cooperation, 1995).

The navigation disasters resulting in casualties and severe contamination of the marine environment made it that in 1993 the IMO General Assembly elaborate and adopt the International Code of Safety Management (ISM, 1993). This is integral part of the International Convention SOLAS and it became compulsory for all vessels over 500 GRT (Gross Tons), since July 1, 2002. The ISM Code was elaborated to make from safety a major priority in the shipping companies' management (ISM, 2002).

Navigation accidents have had a considerably strong impact on the national economies, on companies and civil society as a whole. That why all over the worlds the new norms and regulations have had a major impact on the management of both navigation and shipping companies.

Within this world-wide strive for a safety and unpolluted marine transport with the slogan “Safer Shipping and Cleaner Oceans” a large number of programs are focused on two fundamental objectives: maritime safety and sea pollution protection.

The concern for achieving these two objectives covers international organizations, governments, navigation companies, ship owners, crews. It can be assessed that these objectives are the objectives of a World Management of Sea Safety Assurance.

The paper intends to present the main causes of a poor safety in ship operation and the need for implementing the Safety Management System and sea pollution prevention in the navigation companies.

## 2. CASE-STUDY

### *2.1. Applying the cause -effect method to establish the main causes resulting in poor safety at sea*

Elimination or reducing naval accidents is only possible if there is full knowledge of their causes. Statistics reveal that the most frequent causes resulting in naval accidents are: complex technology, improper operation and maintenance of equipment, fittings, featuring old service life, improper spare parts, ships ‘ age, the company itself, the management and last but not least the human factor .

An item on which all studies on naval accident coincide is that most of them are based on human error.

The human element is a multidimensional complex source which affects sea safety and sea environment protection. It is involved in the entire range of human activities performed by the ship crew, the on -shore management, regulating organisms, recognized organizations, shipyards and other relevant institutions, being necessary the cooperation of these factors for an efficient and safety orientation of the human element.

The proportion of the human error influence is variable but, in general, it is very high. Thus, a study carried out by the Institute of Shipping Economics of Bremen, Germany revealed that 75% of the accidents have been caused by two factors: the too heavy work the crew had to performed, especially in the harbour, and their unsuitable training (Alexiu, 2002).

An analysis carried out by United Kingdom Protection & Indemnity Club, shows that 60% of the accidents are caused by human error. The human error is also responsible for 50% in the case of pollution, 65% in case of staff injury, and 90% in case of collisions. The supervising by the Advisory Committee on Pollution of the Sea of numerous cases of oil discharges in the Great Britain waters in 1990, has found out that the human error is the cause of 66% of the cases (MEPC, 1999).

The Australian Ministry of Transports and Communications reported in 1992 that approx. 75% of the accidents investigated were caused by human errors.

A report published by the American Bureau of Shipping Marine Service in 1994 revealed that, statistically 65% of the major damages reported are due to human operating errors, out of which 27% are due to uncertain practices (IMO, 1994). Although percentages may vary, all studies on the subject show that most maritime accidents take place due to an error which might have been avoided.

Consequently, any attempt to reduce accidents at sea should focus on the elimination of the human error, the human factor being considered almost unanimously to be the cause of 80% of the naval accidents (Branch, 1996). An evaluation of the possible causes resulting in poor safety is made by the cause-effect method (Ishikawa diagram). Evaluation is based on the data from the literature and the main causes of maritime accidents are investigated. Major causes can be thus revealed along with sub-caused which effect is poor safety in ship operation.

In conformity with the statistic data published, the rate of accidents which further led to marine disasters is as follows: complex technology 5%, improper equipment operation/handling 8%, old equipment 3%, ship aging 4%, human error 80%. Taking into account the percentages, the cause-effect diagram (Fig. 1) highlights the major causes which are based on human factor.

The diagram highlights that the major causes for human factor error are: no plans for emergency situations, no planned actions, lack of information, lack of standards, unclear instructions, no proper knowledge and experience and, last but not least, no motivation.

Implementing a sea pollution and safety management system in the navigation companies

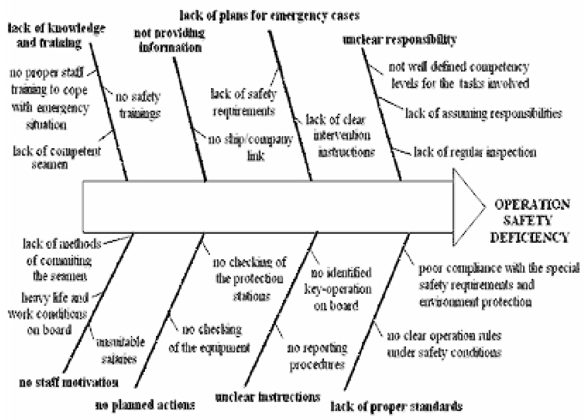


Figure1 The cause-effect diagram

All such causes can be eliminated and human errors avoided or reduced by implementing a Safety Management System.

Management and human resources is the key for success in a company nowadays. Maintaining a navigation company in the sea traffic implies to accept the idea that improving sea safety depends on the human factor.

### *2.2. Necessity of implementing a Safety Management System in the navigation companies*

The new requirements and rules of the international maritime organisations bring in front of the navigation companies a number of problems such as (Iordanoaia, 2003):

- Pollution protection and prevention of the environment and especially the marine environment;
- Safer marine operation procedures;
- Methods of response to emergency situations, identified or likely to occur;
- Development of integrated management systems of quality -environment - safety;
- Training of the on board staff so as to be able to work safely on board, to know and observe the international norms and rules on safety and environment protection.

Taking into account all this, as well as the causes affecting safety at sea, the ISM code require each navigation company to implement and maintain its own Safety Management System (SMS). Thus, this becomes not only the condition to take part in the international traffic but also a compulsory condition to insure the ship (starting with July 1998).

The Safety Management System, which as a result of the evolutions in the international maritime world, becomes compulsory for the entire world sea fleet, stands for the national dimension of the ISM code, this being the most important dimension, the system efficiency and results depend on.

The ISM code is considered by the literature as the norm document having the heaviest impact on the world commercial fleet. It is an international standard for the operation and management of ship safety and pollution prevention (ISM, 2005).

The main objective of this code has been the increase in ship safety and keeps the marine environment uncontaminated. The ISM code is a unitary set of rules and requirements applicable to both ships and navigation/shipping companies, starting from the pre-requisite that the most important modality of preventing maritime accidents and sea pollution by ships is to design, manufacture, equip and maintain vessels and further having them operated by properly trained crew, in compliance with the international conventions and standards about maritime safety and prevention of marine pollution (ISM, 2005).

Applying the ISM code is expected to encourage the development of a true culture for shipping safety.

The success factors for developing such a safety culture may include confidence, values and conviction.

The motivation of the Safety Management System is to keep ship in the international maritime traffic under safety and environment protection conditions, reducing the number of accidents, damages and disasters. Its general objectives are the ship safety, life and work conditions on board and prevention of the contamination of the sea where the ship is operating (Iordanoaia, 2006).

A model of Safety Management System is given in Fig. 2. The Safety Management System makes specific provisions for suitable steps likely to ensure that the company, due to its organisation capabilities, be able to cope any time with the dangers, accidents and emergency situations which might occur.

## 3. RESULTS AND DISCUSSION

Highlighting the main causes and sub-causes that affect ship operation safety at sea revealed the need for implementing a Safety Management System in each shipping company.

The SMS proposed model (Fig. 2) provides for the major stages of its implementation for the purpose of obtaining the safety management Certificate for each ship and the Certificate of conformity of the shipping company.

They are the proof that both the ship and the company meet the requirements of the ISM code issued in 1993.

The stages provided are: evaluation of the existing state of the company in terms of ISM code, establishing a Safety Management System implementation program, and the certification audit as per ISM code.

The company objectives with respect to safety management and pollution prevention as defined by ISM code are to be found in the company‘s SMS (ISM, 1993).

They are the followings: assuring safe practices in ship operation and a danger- free working environment, establishing safety measures against the identified risks, permanent improving of the on shore and on board staff competences as regards the safety management, including staff training for emergency cases.

In order to achieve these objectives, the shipping company establishes whether it applies and maintains a safety and marine pollution prevention policy. This policy shows how objectives are out into practice at all organization levels on shore and on board equally.

To guarantee safety operation of each vessel and to make the proper link between shipping company and the staff on board, the company appoint one or more persons on-shore which have direct access to the highest management level. Among their responsibilities is the surveying the ship operation, pollution safety and prevention, assign the suitable resources and their related support on shore.

A good safety and pollution prevention management both off- and on- shore implies that the operational responsibility is the ship captain’s but the overall responsibility asks for a deeper commitment of the on-shore management.

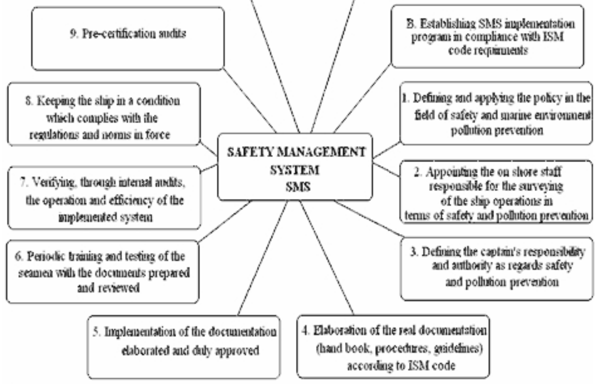


Figure 2 Safety Management System

The company clearly defines the captain’s responsibility as regards: implementing the policy, motivating the crew, making up the orders and guidelines very clear, checking the compliance with the specific exigencies, analysing the safety Management system and informing about lack of compliance with the on-shore management. Within the system the supreme authority belongs to the ship's captain since it is up to him to take decisions on safety and pollution prevention.

Within the System, the company establishes a set of procedures for: training the staff for the system implementation, making the schedules and instructions for the major operations on board, identify and describe the emergency situations and measures to take, identify the equipment and installations whose sudden damage may create dangerous situations. The system provides for specific measures to increase reliability of such equipment.

The procedures included in the Safety Management System must ensure that potentially dangerous accidents are reported to the company, as they are investigated so as to improve ship safety and pollution prevention (Willingale, 1998).

The company performs internal audits to check if the activities related to safety and pollution prevention are in compliance with the implemented system, making periodical evaluations of its efficiency.

The safety management certificate is issued to a ship after the initial verification of the compliance with the ISM code requirements. This includes verification if the company conformity document is applicable to the specific type of ship and the implemented system is in accordance with the ISM code and is properly applied.

## 4. CONCLUSIONS

The cause-effect analysis as regards the causes and sub causes that determine the human errors accompanied by accidents and marine disasters resulting in casualties and sea contamination has shown that such causes may be eliminated by introducing a SMS in the shipping companies.

The safety Management system means a structured and documented unit which enables the implementation of the company policy of safety and marine pollution prevention. It should ensure that compulsory rules and regulations are strictly observed, along with the applicable codes, standards recommended by the organization, administration, classification societies and marine organizations.

The fundamental condition of a good safety management is the highest commitment. In the issues of safety and pollution prevention the final result is determined by the commitment, competence, attitude and motivation of individuals at all levels.

The Safety Management System provides for adequate measures so as to ensure that the company organization is able to face, any time, the accident dangers and emergency situations its ship may found itself into.

Implementation of such a system is a condition to maintain each ship in the international traffic circuit.

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# COMPETITIVENESS FACTORS

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**ABSTRACT**

Porter's theory supports the idea that, despite the globalization of production and trade, the competitive advantage is created in a national framework, nations, through their institutional, natural, cultural, economic characteristics ultimately determining the development of certain economic activities. The factors considered by Porter as determinants for the competitive advantage are grouped in four categories, the linkages between them being important as well.

**Keywords:** *Competitiveness, microeconomic, macroeconomic*.

## 1. INTRODUCTION

Competitiveness is in the most general sense a complex phenomenon related to the capacity of a country compared to others, to form and to ensure an economic, social, political way, to support the rapid creation of added value.

## 2. CASE-STUDY

Therefore we present a range of definitions available for the notion of competitiveness:

- Uri (1971): "the ability to create preconditions for high income".

- Orlowski (1982): "the ability to sell".

- Scott and Lodge (1985): "the ability of countries to produce, distribute and sell goods and services in the global economy, and doing so gains to increase the standard of living".

- Porter (1990): "the only indicator that completely defines the concept of competitiveness at the national level is national productivity";

- OECD / TEP (1992): "to produce goods and services able to cope with international competition while maintaining and amplifying real domestic income";

- Management Forum (1994): "Competitiveness world country or company is able to generate proportionally more wealth than its competitors on the international market".

The notion of competitiveness has uses in various ways, on multiple levels. When referring to the development of a country heading into the world economy, the concept of competitiveness allows comparison performances, but also growth potential in the future.

Studies on competitiveness of nations began in the 40s. The most representative work is the theory of the commercial trade flows which is rooted in the classical Ricardian theory of comparative advantage. The theory of comparative advantage argues that the factor endowment of a nation determines its competitivity, the theory was exceeded due to the economic realities that have denied it. This does not explain a present situation: there are many resource-rich countries, but with poor economy around. Today raw materials, capital and even labor force are mobile, a phenomenon called globalization, that inheritance factors are not sufficient to determine the increased competitiveness of a nation.

Main drivers of national competitiveness are:

I. national economic factors:

- Local resources (endowment with natural resources, labor, existing infrastructure, technology and financial resources, etc.)
- Size and structure of domestic demand;
- The art and industry efficiency and sub-suppliers parts;
- Industrial structure and competition.

These four national economic factors create an economic environment, a national context in which firms are born, compete and gain competitive advantage using it internationally. In the local resources are taken into consideration human resources, physical resources, scientific and technological resources, financial resources and national infrastructure. National competitive advantage is that companies can use the necessary combination of factors at low cost or whether the factors used are of a higher quality level.

The companies gain competitive advantage if domestic demand creates enough pressure to influence innovation accelerated. Also high standard of domestic customers can contribute to competitive advantage and it obliges companies to use high standards in quality, facilities, services and more.

The presence of efficient sub-suppliers and sub-branches of industry related to potential other sectors is very important in gaining competitive advantage. The last component of national economic factors relate to the existing industrial structure. Oligopolistic competition type structures facilitate the conquest of new markets for the following reasons:

- National rivalries create pressure for innovation that enhances competitive advantage;
- Oligopolistic structure creates competitive advantages for all industries with competitive prices, quality, reliability in long term relationships;
- This structure creates a competitive environment that is difficult to recreate by competition with foreign rivals.

II. Action by government is crucial to creating competitive advantage outside the company. The role of government is to influence and enhance the national economic factors mentioned above. This influence can be direct subsidies, industrial policy and other domestic demand indirectly by shaping the standards and regulations. A crucial role of the government market is the fact that is a major buyer of goods and technologies such as telecommunications equipment, weaponry, computers, vehicles etc..

III. Mondo-economic factors are constituted of three main elements:

- Deregulation of the U.S. had four important consequences:
  - eradication of strong inflation (inflation down below 4%);
  - loss of state control over interest rates and exchange rate term by strengthening financial markets;
  - directing the market economy at the expense of government;
  - Consolidation involves globalization economies to cope with increased competition.
- Collapse of communist systems of economic management - a phenomenon with many economic and political implications.

-Internet explosion - as soon the whole world will be "a global network" and everyone can receive and deliver messages for any purpose including buying or selling.

Globalization of markets has led globalization marketing. Global marketing refers to encouraging research initiatives to find new market segments or niches around the globe, harnessing the opportunity of buying and selling products and services internationally.

Globalization of markets has triggered a phenomenon that at first sight seems paradoxical to say individualization consumer needs. Gradually the company's trade policy is going from national markets to absorption of the transnational consumer segmentation with identical behaviour in several countries. Product-market couple move from a national even international European dimension.

The production is not standardized, but flexible and the company is no longer considered an isolated entity, it maintains itself with suppliers, distributors a set of relationships which give a high degree of flexibility in operation.

IV. Other factors affecting competitiveness are:

- Structure favouring foreign investment and domestic demand helps to modernize the economy. The most widespread foreign investment may have adverse effects located mainly in the industrial specialization (in many areas indigenous firms are unable to defend their market positions in the foreign companies).
- Demands ever higher that environmental protection requires.
- Evolution phenomena and processes in the global economy.

According to Michael Porter, the main factor of profitability of firms is given by the industrial sector for economic attractiveness. In any industry, there are five forces that determine the profitability and structure: the entry of new competitors, the existence of substitutes, bargaining power of buyers, bargaining power of producers and economic rivalry. The importance of the five forces varies from one industry to another depending on economic and technical characteristics change over time (M. Porter, 1980).

Michael Porter distinguishes three types of strategies that can be applied by companies to create competitive advantage: cost leadership through differentiation and focus. Appropriate strategy allows the company to capitalize on strengths and to protect the adverse effects of the five forces. Each of the three strategies involves choosing different ways to ensure competitive advantage.

Porter defines four stages of competitive development at national level:

- The development stage due to factors of production;
- Develop specific investment stage;
- The development stage due to innovation;
- Stage of development determined by wealth.

## 3. RESULTS AND DISCUSSION

The transition from one stage to another involves a metamorphosis in the industrial infrastructure, financial system, technological standards and attitudes. A great importance id also constituted by cultural values behind the forces creating and distributing wealth. To explain the success of similar systems adopted by different countries is necessary deep understanding of cultural ethics and social values of these nations.

The first three stages of economic development, national competitiveness is increasing, and in the fourth economy may decline. Following the four stages of developing the competitiveness of a nation defined by Porter, Romania could be between the first and second stage, and between that determined by factors that determine production and investment. The competitiveness notion has various uses in multiple ways. The term is used in national competitiveness, but sequentially, for narrow areas such as international trade, commodity market and others.

## 4. CONCLUSIONS

To obtain an advantageous position on the reference market, the companies are determined to discover the factors of competitiveness that will put in such a position and will enable competitive advantage. Moreover, a trader with a marketing vision focuses its strategy towards the market in order to create a product or a service more competitive, that the consumer needs and is adapted to the exigencies.

The most important factors that may contribute decisively to the competitiveness of an organization, are considered next:

- price of the product / service. If a product or service satisfies a consumer need, be it especially if price is lower than that of competitors. As a result, price competition becomes a factor eliminator.
- quality product / service. If the product or service to consumers the same price is better quality than the competitors, then be preferred by consumers, quality becomes a factor eliminator.
- value for money. This factor captures the best way to purchase a product or service to most consumers, while highlighting the competitiveness of enterprises. If at a

certain quality of a product or service required a higher price than the prevailing market respect, the value for money becomes a factor eliminator for the entity in question, because it fails to obtain profit than by increasing the price of a product (service) the same quality to that provided by its direct competitors. Or the selling price is the same with that of competitors, but quality product (service) is lower.

Using these three factors determining competitiveness quantitative always a balancing market as a price reduction or quality improvement of products / services will determine the reaction the other competitors, so that consumers will be permanently put in the position to choose the product or service with the best quality / price ratio.

- cost of the product / service. To be efficient and competitive businesses are looking to produce a lower cost as consumer products or services.
- profit. The difference between price and cost of production becomes the profit gained through work performed by the entity. Profit, the competitive factor is both a function and objective pursued by it.
- the cost / profit. Even if profit maximization is the goal of any trader, this does not allow obtaining competitive if profit is made with high costs. In the long run, the operator be removed from the market by a competitor who registers the same income but with a cost / profit efficiency. There are situations, especially for small businesses, when a company can ACTi a small market and a profit based on production costs very low. in time, the lack of possibility to allocate a portion of profit for development, investment, etc., is precisely its lack of competitiveness will lead to removal from the market.
- volume of sales made. This factor determines the size of the economic competitiveness in the market concerned, especially when they can be calculated and a series of indicators of capacity market (market share, relative market share). As the market share held by a company be greater, the more we can say that it occupies much of the market, so it holds a competitive position.
- economies of scale. The quality factor contributes significantly to the competitiveness of an economic agent. As it achieve a higher yield lower cost experience curve occur that cause economies of scale.
- technology used. May become an important asset of an undertaking which uses modern production capacity, has a high capacity to integrate Cloudy and technological progress in a particular field.
- time. As the decisive factor to obtain competitive advantage time is the speed of providing a product / service, but also the reaction speed of competitors in certain situations. To these we can add the speed "with which consumers can choose the product / service, providing a great source of variety information sources.
- management. It is a decisive competitive factor especially when used by managers who fail to harmonize their objectives with available resources and market demands. In other words the entire management system should be market oriented, so that now manage to hold a competitive position. But this can not be achieved without applying the next competitive edge:
- marketing. Regarded as a function of enterprise marketing is one of the most significant competitive factors existing at present. As consumers are turning to these products / services that best meet their needs, they will choose those who have significant advantages. As stated Philip Kotler.

Most prosperous companies are those that manage to offer their customers the expected satisfaction, understanding marketing cape not a separate function but as the learned philosophy of the entire organization. What is needed is to identify marketing compartment categories of consumers and the needs that a company can meet in a profitable way, and the ways in which this can be achieved with high efficiency in comparison with other competitors.

The first stages of economic development, national competitiveness is increasing, and in the fourth economy may decline. Following the four stages of developing the competitiveness of a nation defined by Porter, Romania could be between the first and second stage, and between that determined by factors that determine production and investment. The competitiveness notion has various uses in multiple ways. The term is used in national competitiveness, but sequentially, for narrow areas such as international trade, commodity market and others.

If we consider equality between prosperity and competitiveness, then rightly marketing vision, so necessary a company acting in a competitive market, requires that it be market oriented, taking into account customers, and competitors.

It is possible that in the future to shape a new factor of competitiveness, management, marketing, because it embodies the best all processes, relationships and practical actions necessary to carry out an effective activities designed to ensure a position in a competitive field. Understood and used effectively, marketing management can be turned into an advantage major competitiveness of enterprises (organizations) modern market oriented.

The level that is generated is the microeconomic competitiveness. A country becomes competitive when you manage to build that environment that allows each company to become effective added value, to be able to survive or develop in any domestic economic environment, especially internationally.

The level that supports and reinforces competitiveness is macroeconomic. Country maintains or improves their profitability internationally when deciding to apply the set of economic policies to stimulate the achieving optimal micro-level required expansion.

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# BUSINESS CYCLES AND ECONOMIC DISTORTIONS

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**ABSTRACT**

Business cycles are – as in definition of Burns and Mitchell -a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle; in duration, business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar characteristics with amplitudes approximating their own. On the other hand, Julius Shiskin suggested several rules of thumb to identify a recession, which included two successive quarterly declines in gross domestic product (GDP), a measure of the nation's output. What about the present situation - a real, major and global recession or a different kind of business cycle particularity?

**Keywords:** *Business cycles, GDP, global crisis, Keynesian economy, global market, Eurozone, mortgage, recession*

## 1. INTRODUCTION

The first systematic exposition of periodic economic crises, in opposition to the existing theory of economic equilibrium, was the 1819 *Nouveaux Principes d'économie politique* by Jean Charles Léonard de Sismondi. [2] Prior to that point classical economics had either denied the existence [3] of business cycles, blamed them on external factors, notably war,[4] or only studied the long term. Sismondi found vindication in the Panic of 1825, which was the first unarguably international economic crisis, occurring in peacetime. Sismondi and his contemporary Robert Owen, who expressed similar but less systematic thoughts in 1817 *Report to the Committee of the Association for the Relief of the Manufacturing Poor*, both identified the cause of economic cycles as overproduction and under consumption, caused in particular by wealth inequality. They advocated government intervention and socialism, respectively, as the solution. This work did not generate interest among classical economists, though underconsumption theory developed as a heterodox branch in economics until being systematized in Keynesian economics in the 1930s.

Sismondi's theory of periodic crises was developed into a theory of alternating *cycles* by Charles Dunoyer,[5] and similar theories, showing signs of influence by Sismondi, were developed by Johann Karl Rodbertus. Periodic crises in capitalism formed the basis of the theory of Karl Marx, who further claimed that these crises were increasing in severity and, on the basis of which, he predicted a communist revolution. He devoted hundreds of pages of *Das Kapital* to crises.

There were frequent crises in Europe and America in the 19th and first half of the 20th century, specifically the period 1815–1939, starting from the end of the Napoleonic wars in 1815, which was immediately followed by the Post-Napoleonic depression in the United Kingdom (1815–30), and culminating in the Great Depression of 1929–39, which led into World War II. See Financial crisis: 19th century for listing and details. The first of these crises not associated with a war was the Panic of 1825.

Business cycles in the OECD after World War II were generally more restrained than the earlier business cycles, particularly during the Golden Age of Capitalism (1945/50–1970s), and the period 1945–2008 did not experience a global downturn until the Late-2000s recession. Economic stabilization policy using fiscal policy and monetary policy appeared to have dampened the worst excesses of business cycles, and automatic stabilization due to the aspects of the government's budget also helped mitigate the cycle even without conscious action by policy-makers.

In this period the economic cycle – at least the problem of depressions – was twice declared dead; first in the late 1960s, when Phillips curve was seen as being able to steer the economy – which was followed by stagflation in the 1970s, which discredited the theory, secondly in the early 2000s, following the stability and growth in the 1980s and 1990s in what came to be known as The Great Moderation – which was followed by the Late-2000s recession. Notably, in 2003, Robert Lucas, in his presidential address to the American Economic Association, declared that the "central problem of depression-prevention [has] been solved, for all practical purposes."[11]

## 2. EVOLUTION OF CYCLES THEORIES

In 1860, French economist Clement Juglar identified the presence of economic cycles 8 to 11 years long, although he was cautious not to claim any rigid regularity.[6] Later, Austrian economist Joseph Schumpeter argued that a Juglar cycle has four stages: (i) expansion (increase in production and prices, low interests rates); (ii) crisis (stock exchanges crash and multiple bankruptcies of firms occur); (iii) recession (drops in prices and in output, high interests rates); (iv) recovery (stocks recover because of the fall in prices and incomes). In this model, recovery and prosperity are associated with increases in productivity, consumer confidence, aggregate demand, and prices.

In the mid-20th century, Schumpeter and others proposed a typology of business cycles according to their periodicity, so that a number of particular cycles were named after their discoverers or proposers: [7]
the Kitchin inventory cycle of 3–5 years (after Joseph Kitchin); [8]

- the Juglar fixed investment cycle of 7–11 years (often identified as 'the' business cycle);
- the Kuznets infrastructural investment cycle of 15–25 years (after Simon Kuznets also called building cycle]);
- the Kondratiev wave or long technological cycle of 45–60 years (after Nikolai Kondratiev) [9]

Interest in these different typologies of cycles has waned since the development of modern macroeconomics, which gives little support to the idea of regular periodic cycles.[10]

## 3. ECONOMIC DISTORTIONS AND CRISIS EVOLUTION

The original version of the crisis had its origins in the collapse of the US subprime mortgage derivative deck of cards in 2007 before morphing into a broad-based financial crisis in the fall of 2008. It gradually spread to most other first-world advanced economies, but did not wreck havoc on emerging markets and second and third world nations. Most such economies were insulated from the folly of first-world finance - credit, borrowing, overwhelming debt and onerous interest payments – simply because they did not qualify for the intoxicating elixir of credit [13].

Furthermore, other weaknesses in the global financial system have surfaced. Some financial products and instruments have become so complex and twisted, that as things start to unravel, trust in the whole system started to fail [12].

Securitization was an attempt at managing risk. There have been a number of attempts to mitigate risk, or insure against problems. While these are legitimate things to do, the instruments that allowed this to happen helped cause the current problems, too. In essence, what had happened was that banks, hedge funds and others had become over-confident as they all thought they had figured out how to take on risk and make money more effectively. As they initially made more money taking more risks, they reinforced their own view that they had it figured out. They thought they had spread all their risks effectively and yet when it really went wrong, it all went wrong.

Derivatives, financial futures, credit default swaps, and related instruments came out of the turmoil from the 1970s. The oil shock, the double-digit inflation in the US, and a drop of 50% in the US stock market made businesses look harder for ways to manage risk and insure themselves more effectively [12].

The finance industry flourished as more people started looking into how to insure against the downsides when investing in something. To find out how to price this insurance, economists came up with options, a derivative that gives you the right to buy something in the future at a price agreed now. Mathematical and economic geniuses believed they had come up with a formula of how to price an option, the Black-Scholes model.

In the absence of enough foreign or private sector purchasers, the US central bank, the Federal Reserve Board, has been ‘monetizing’ federal government debt through its purchases of Treasury bonds. The process dubbed Quantitative Easing, by which the FED creates money out of thin air, allows the FED to become the purchaser of last resort of government debt. At the present rate it is expected that the FED will purchase a full 50 percent of all new and maturing Treasury bonds in the current fiscal year [13]. This is necessary simply because there are not enough foreign or domestic, private sector or government buyers to be found at current rates of interest and levels of risk.

Nouriel Roubini [14], famous for his early call on the global financial crisis, has recently pointed to the danger China faces of an economic "hard landing" after 2013. Beijing added massive stimulus to China's economy in 2008 to head off damage to the Chinese economy from the global financial crisis. The government has been relatively unsuccessful in slowing the growth of the money supply, bank credit and fixed investment that helped boost growth - even though the global crisis is clearly in the rearview mirror of a Chinese economy growing 10% a year.

That has led to a major distortion in the Chinese economy, [14] because economic growth in China increasingly depends on investment in fixed assets that may not be economically productive in themselves but produce massive profits for well-connected Chinese officials and businesspeople. That has led to a serious bad-loan problem in China, he says, and has produced massive amounts of excess industrial capacity.

No one will challenge current policies [14] during the leadership transition, but once leaders are in place, China will have to confront these problems. That will mean, I'd say, not only further attempts to dampen bank lending and raise reserve requirements but serious escalation of the battles on these fronts. It will mean new steps to fight inflation. And it might even mean willingness on the part of the new leadership to sacrifice some economic growth to achieve these ends.

One possible alternative to slower growth would be a shift from growth based on exports and investment in fixed assets to one based on domestic consumption. But that would require shifts in the economy - and challenges to powerful interests in that economy - that could be even more disruptive than a slowdown in growth.The bad news, of course, is that the actions of the politicians that support growth now will have to be paid for in 2013.

## 4. GLOBAL MEASURES

Until September 2008, European policy measures were limited to a small number of countries (Spain and Italy). In both countries, the measures were dedicated to households (tax rebates) reform of the taxation system to support specific sectors such as housing. The European Commission proposed a €200 billion stimulus plan to be implemented at the European level by the countries. The plan combines short-term measures to stimulate demand

and maintain jobs and longer-term measures to invest in strategical sectors, including research and innovation. The aim is to promote growth and ensure sustainable prosperity. The plan includes targeted and temporary measures amounting to 200 billion euros, or 1.5% of EU GDP, using both the national budgets of the national governments, the budget of the EU and that of the European Investment Bank. The plan is scheduled on a period of two years.

At the beginning of 2009, the UK and Spain completed their initial plans, while Germany announced a new plan.

On September 29, 2008 the Belgian, Luxembourg and Dutch authorities partially nationalized Fortis, a former company active in insurance, banking and investment management. The German government bailed out Hypo Real Estate. On 8 October 2008 the British Government announced a bank rescue package of around £500 billion [15] ($850 billion at the time). The plan comprises three parts. The first £200 billion would be made in regard to the banks in liquidity stack. The second part will consist of the state government increasing the capital market within the banks. Along with this, £50 billion will be made available if the banks needed it, finally the government will write away any eligible lending between the British banks with a limit to £250 billion.

In early December German Finance Minister Peer Steinbrück indicated a lack of belief in a "Great Rescue Plan" and reluctance to spend more money addressing the crisis.[16] In March 2009, The European Union Presidency confirmed that the EU was at the time strongly resisting the US pressure to increase European budget deficits. [17]

On September 15, 2008 China cut its interest rate for the first time since 2002. Indonesia reduced its overnight repo rate, at which commercial banks can borrow overnight funds from the central bank, by two percentage points to 10.25 percent. The Reserve Bank of Australia injected nearly $1.5 billion into the banking system, nearly three times as much as the market's estimated requirement. The Reserve Bank of India added almost $1.32 billion, through a refinance operation, its biggest in at least a month. [18] On November 9, 2008 the 2008 Chinese economic stimulus plan is a RMB¥ 4 trillion ($586 billion) stimulus package announced by the central government of the People's Republic of China in its biggest move to stop the global financial crisis from hitting the world's second largest economy. A statement on the government's website said the State Council had approved a plan to invest 4 trillion yuan ($586 billion) in infrastructure and social welfare by the end of 2010. The stimulus package will be invested in key areas such as housing, rural infrastructure, transportation, health and education, environment, industry, disaster rebuilding, income-building, tax cuts, and finance.

China's export driven economy is starting to feel the impact of the economic slowdown in the United States and Europe, and the government has already cut key interest rates three times in less than two months in a bid to spur economic expansion. On November 28, 2008, the Ministry of Finance of the People's Republic of China and the State Administration of Taxation jointly announced a rise in export tax rebate rates on some labor-intensive goods. These additional tax rebates will take place on December 1, 2008.[18]

The Federal Reserve, Treasury, and Securities and Exchange Commission took several steps on September 19 to intervene in the crisis. To stop the potential run on money market mutual funds, the Treasury also announced on September 19 a new $50 billion program to insure the investments, similar to the Federal Deposit Insurance Corporation (FDIC) program. [20], [21] Part of the announcements included temporary exceptions to section 23A and 23B (Regulation W), allowing financial groups to more easily share funds within their group. The exceptions would expire on January 30, 2009, unless extended by the Federal Reserve Board.[22] The Securities and Exchange Commission announced termination of short-selling of 799 financial stocks, as well as action against naked short selling, as part of its reaction to the mortgage crisis.[23]

The interconnectedness of global activity will serve to further destabilize the global financial system in 2012. Although the federal government debt to GDP ratio is surging past 100%, if private indebtedness is included our debt to GDP ratio exceeds 350%. The same calculation reveals a debt ratio of 490% in Japan, 443% in Euro currency countries, and 459% in the United Kingdom. Similar to the U.S., their growth rates are also falling rapidly. In fact, there is compelling evidence that Europe and Japan have already entered recessions. In addition, manufacturing recessions have emerged in China and India, and growth in the Brazilian economy came to a standstill in the third quarter. These contracting growth rates suggest that U.S. exports will contribute to slower growth in 2012.

Exports have been critical [24] to the expansion of the U.S. economy since the end of the last recession. Compared with the tepid rates of expansion in consumer expenditures of 2.1% and overall real GDP of 2.4%, real exports have surged at a 9.7% rate. Thus, the fast rising gain in exports equals slightly more than 48% of the increase in real GDP from the recession low. Considering that exports spur the need for increased non-residential fixed investment, as well as higher inventories, it is clear that without a booming export sector our expansion since 2009 would have been truly dismal. Unfortunately, the negative feedback of a global recession will not only impair the U.S. exports sector, but also will cause a steeper downturn overseas.

For instance, in Germany, the United Kingdom, and Japan exports accounted for 51%, 30%, and 16% respectively of their GDPs in 2011. In France, Italy and Spain exports averaged about 29% of GDP. The loss of exports to the United States will be most detrimental to the European economies, feeding back to a slower export sector in the United States. [24] Thus, the main driver of growth (exports) for this expansion will be sharply diminished in 2012. The economic slowdown in the US, the eurozone, and China already implies a massive drag on growth in other emerging markets, owing to their trade and financial links with the US and the European Union (that is, no “decoupling” has occurred). At the same time, the lack of structural reforms in emerging markets, together with their move towards greater state capitalism, is hampering growth and will reduce their resiliency.

Finally, long-simmering tensions in the Middle East between Israel and the US on one side and Iran on the other on the issue of nuclear proliferation could reach a boil by 2013. The current negotiations are likely to fail, and even tightened sanctions may not stop Iran from trying to build nuclear weapons. With the US and Israel unwilling to accept containment of a nuclear Iran by deterrence, a military confrontation in 2013 would lead to a massive oil price spike and global recession.

These risks are already exacerbating the economic slowdown: equity markets are falling everywhere, leading to negative wealth effects on consumption and capital spending. Borrowing costs are rising for highly indebted sovereigns, credit rationing is undermining small and medium-size companies, and falling commodity prices are reducing exporting countries' income. Increasing risk aversion is leading economic agents to adopt a wait-and-see stance that makes the slowdown partly self-fulfilling.

## 6. CONCLUSIONS

The political philosopher John Gray, who recently retired as a professor at the London School of Economics, wrote in the London paper The Observer: “Here is a historic geopolitical shift, in which the balance of power in the world is being altered irrevocably.” [25]

Since in the Keynesian view, recessions are caused by inadequate aggregate demand, when a recession occurs the government should increase the amount of aggregate demand and bring the economy back into equilibrium. This the government can do in two ways, firstly by increasing the money supply (expansionary monetary policy) and secondly by increasing government spending or cutting taxes (expansionary fiscal policy). [26]

By contrast, some economists, notably New classical economist Robert Lucas, argue that the welfare cost of business cycles are very small to negligible, and that governments should focus on long-term growth instead of stabilization. All of this seems to be more provocative in the future.

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# CONSUMERS' IDENTITY- THE ROLE OF THE 'SELF' CONCEPT IN THE CONSUMER BEHAVIOR

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**ABSTRACT**

As Kotler (2008) suggested, the marketplace is the location where goods and services are exchanged, so traders set up the product and buyers browse the merchandise. Consumer attitudes can be influenced by many factors outside the product attributes. Social and cultural environment as well as demographic, psychographic, and geographic conditions can sometimes shape consumer behavior. Consumer attitude, if positive, is an advantage to a marketer. The reaction of buying or refusing a certain product might be influenced by various factors, but marketers have acknowledged the role of personality and how this might influence consumers' behaviors toward a product.

**Keywords**: *Marketplace, Consumer Behavior, Consumers' Identity*

## 1. INTRODUCTION

Knowing an individuals' way of thinking, his tastes and what causes him pleasure is the best way to understand his behavior as a consumer within the marketplace, fact that have determined marketers to develop a highly interest within this area.

Consumer behavior is the study of how a consumer thinks, feels, and selects between competing products. Moreover, the study of attitudes is critical to understanding the motivation and decision strategies employed by consumers. The combination of beliefs, attitudes, and behaviors influence how a consumer reacts to a product or service. Marketers develop relative, compelling marketing messages using the same combination of information, and ultimately influence consumer behavior.

## 2. BODY

Consumer attitudes are both an obstacle and an advantage to a marketer. Choosing to discount or ignore consumers' attitudes of a particular product or service — while developing a marketing strategy — guarantees limited success of a campaign. In contrast, perceptive marketers leverage their understanding of attitudes to predict the behavior of consumers. These savvy marketers know exactly how to distinguish the differences between beliefs, attitudes, and behaviors while leveraging all three in the development of marketing strategies [1].

Because of the inner characteristics that constitute an individual's personality are a unique combination of factors, no two individuals are exactly alike. Nevertheless, many individuals may be similar in terms of a single personality characteristic, but not in terms of others. One must keep in mind that most decisions are made unconsciously. Jim Nightingale, states that "we simply decide without thinking much about the decision process". In a controlled environment, such as a classroom, instructors encourage students to weigh pros and cons before making a decision. However in the real world, most of our decisions are made unconsciously in our mind because it would take too much time to sit down and list the pros and cons of each decision we must make on a daily basis.

Logical decision making is an important part of all science-based professions, where specialists apply their knowledge in a given area to making informed decisions.

When talking about consumers and their personal values, the matter might be approached from various points of view, especially regarding marketers and how they tend to approach consumers' individual characteristics within the market- place in order to take advantage of and increasing their awareness and as a result, sales.

For example, when taking into consideration one's action of purchasing a powerful car, instead of relying on why that person had bought that type of product instead of buying an ordinary car, his motivation should not be treated individually, but combined with information of the person's interests, past experience and knowledge gained related to the automobile area, his lifestyle, income and of course, his expectations from the product. A person with a similar background and knowledge might probably make the same decision while other individuals might judge his choice and find it extravagant or dangerous.

Consumer behavior is an integral part of daily life and this matter has been a subject of great interest for business psychologists and for other professionals concerned by the market environment and consumers' attitudes toward services and products. Competition within the market place is extremely high between suppliers, so marketers are continuously making use of various marketing strategies in order to manipulate the masses.

There have been used four personality theories to describe consumers' behaviors: psychoanalytic theory, social- cultural theory, self- concept theory, and trait theory.

Self - concept theory holds that individuals have a concept of self- based on who they think they are (the actual self) and a concept of who they think they would like to be (the ideal self) [2].

As presented within a research study concerning individuals' personality undertaken by Dolich, it highlighted that over 70 per cent of consumers buy products and access services related to their self- concept [3]. In the same research, analyzing the relationship between consumers and products such as beer, cigarettes and tooth- paste, it was found that respondents tend to prefer brands that they perceive as similar to themselves.

On the other hand, the research undertaken has shown that consumers who buy in accordance with their actual self- concept may be achieving consistency, but may not be enhancing self esteem. Although theories vary on the development of a self- concept, psychologists agree that a person's conception of self displays a high degree of consistency, especially in the short - run.

Being relatively a fixed structure, the one's conception of his self tends to resist change, but ideas formed from a new experience are easily absorbed into the existing organization of the self, particularly the experiences perceived as consistent with the existing structure. In contrast, ideas perceived inconsistent with the present self are either rejected or altered fit into the self, since they pose a threat to the individual [4].

The approach related to the level of self- esteem increased by purchasing products was also supported by Furnham [5], who stated that although consumers buy products that conform to their actual self- image, if they are lower in self- esteem, they are more likely to buy products based on what they would like to be rather than on what they are.

Furthermore, the self- concept theory is thought to be governed by two principles, such as the desire to attain self- consistency and the desire to enhance one's self- esteem. Attaining self-consistency means that individuals act in accordance with their concept of actual self.

As a matter of fact, a consumer may see himself as a self- controlled individual and decides that for his health and wellbeing he must consume just organic food. In the same time, the individual acknowledged the threat the modern world is facing regarding energy usage and pollution and buys an eco- friendly car. But deep inside, sometimes he might feel that he would like to be more carefree and drive a powerful small sport car after he enjoyed a delicious meat meal with his friends. The second assumption regarding how the individual would act in order to achieve self- esteem might be related to social comparison and to the fact that individuals understand themselves in comparison with the others. Individuals consume to distinguish themselves from the others or to show their membership within a group, establishing their group belonging and identity in this way. So, it might be stated that individuals decide who they are and who they would like to be by the process of "compare and contrast within the social environment" [6].

Considering an article posted on Brand Republic related to women and the usage of make- up, especially the usage of lipstick and mascara, it was highlighted that despite the tough times the economy is facing, cosmetics have kept their position as the fastest growing beauty categories. More than that, according to Mintel, in the United Kingdom this market has been growing in value by 35 per cent between 2003 and 2007 [7]. Considering gender differences, gender have also been shown to be an important factor in the formation of self-concept. Early research inspired by the differences in self-concept across culture suggested that men tend to be more independent while women tend to be more interdependent.

However, more recent research has shown that, while men and women do not differ between independence and interdependence generally, they do differ in the distinction between relational and collective interdependence. Men tend to conceive of themselves in terms of collective interdependence while women conceive of themselves in terms of relational interdependence. In other words, women identify more with dyadic (one-on-one) relationships or small cliques whereas men define themselves more often within the context of larger groups.

Relating these facts with women' desire to enhance their beauty and to increase self- esteem, it might be a reliable proof that perceiving cosmetics as helping themselves having a good appearance, cosmetics can boost women's confidence and self- esteem for relatively little outlay. To conclude, the more satisfied women are, the more their self- esteem increases and they continue to purchase. Taking into consideration the results highlighted in the article, it might be considered that self- esteem is related to various personality characteristics and to gender, gender being a powerful factors in influencing consumers' behavior. But historically, self- esteem derives from a series of self-estimates and the evaluation of the self linked to the reflected appraisals of others [7]. "Self-esteem" as depicted by the word itself, refers to one's views about himself and his place in the whole scheme that is life. The concept is closely related to the concepts of self-worth and competence, so self-worth is all about seeing oneself in the whole context of reality, keeping in mind the basic human values.

A number of studies have shown that consumers' attitudes toward products vary depending on the situation, and differences in attitudes by situation might indicate strengths and weaknesses of brands. On the other hand, consumers' psychological condition and willingness to purchase is essential, so it might be stated that there is a two - way interdependence between products and consumers, each influencing and being influenced by the other. People view themselves in a particular and subjective manner, fact that might ease individuals to be able to have multiple identities in accordance to the situations they are facing in certain moments [8].

There is no one actual identity [10]. Taking into consideration this theory which states that consumers have various 'role identities', it might be added that each identity may be accessing different products, fact that marketers have acknowledged and seek to take advantage of it.

In term of consumer behavior, this idea that an individual embodies a number of different 'selves' suggests that marketers should target their products to consumers within the context of a particular 'self' and in certain cases, a choice of different products for different selves [11].

Considering the various ‘role identities’ someone is taking on, such as the role as a daughter, working woman or as a member of a charity, one of the roles is dominant in a specific situation, affecting the style of dress and behavior of the individual. In different contexts, the working woman might select a different self- image to guide her attitudes toward a product. For instance, going to a party thrown by their work colleagues, she might access a more expensive wine to use as a gift, instead of an ordinary one she might use to drink at lunch within her privacy.

## 3. CONCLUSIONS

People communicate with other people through what they buy and make use of, in this way consumption being a powerful tool to establish who you are in front of the others and products being most likely to be viewed as symbols [12]. In the market-environment, this trend has been noticed and was carefully looked into especially in the recent years, in the way that companies and brands started more and more to make use of the consumers’ ideal self. Also, research has shown that consumers who buy in accordance with their actual self- concept may be achieving consistency, but may not be enhancing self - esteem.

Worldviews about the self in relation to others differs across and within cultures show that in Western cultures "the normative imperative is to become independent from others and to discover and express one's attributes. Relationships, memberships, groups, and their needs and goals, tend to be secondary to the self.

When assessing self-concept, one’s positioning among peers is important because of the competitive nature of society, where people view themselves as better or worse than peers. On the other hand, in Asian cultures, an interdependent view of the self is more prevalent. Interpersonal relationships are more central than one’s individual accomplishments [13]. Great emphasis is placed on these relationships, and the self is seen primarily as an integral part of society.

To conclude, part of the philosophy of a competitive, free market system is that efficiency is gained when individual participants act in their own self interest. Milton Friedman called this cooperation without coercion [14]. So, by advancing one's own good, one advances the good of society as a whole.

In The Wealth of Nations, Adam Smith said, "By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it." This is sometimes referred to as the "Invisible Hand," which theoretically assets with the efficient allocation of resources in a free market system [15].

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# LEADERSHIP AND CRISIS MANAGEMENT DURING CRISIS SITUATIONS

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**ABSTRACT**

The business environment is regarded as a dynamic system that is in a continuous change. As a result, there is an imperative need within organizations to have trained people managing the various situations that might occur. Years before this approach was acknowledged, it stated that one effective solution in order to overcome problems is by identifying the real cause, recognizing which leadership is appropriate and 'encouraging' employees to examine critically the leadership method in concrete situations, in this manner to better fit their 'style' to the situational demands. Nowadays, the research shows that leadership is still recognized as the way of focusing and motivating a group to enable them to achieve their aims.

**Keywords**: *Crisis, Leadership, Management*

## 1. INTRODUCTION

There have been given plenty of definitions for a crisis. Important to note is that all definitions emerged had in commune the three related threats a crisis can create, such as the public safety, financial loss and reputation loss [1].

Leadership and management represent two distinct and complementary systems, each system having its own functions and specific actions [2]. Taking into consideration this approach, added that leadership and management are two concepts that work together, but none of them is superior to the other.

Furthermore, it was suggested that leadership is a facet of management and that the best way to differentiate them is by illustrating what happens when there is one without the other. The importance of leadership within the organization increased as the environment became more volatile and competitive and people better prepared and informed. It was also stated that the remedy for this situation is the recruitment and selection of employees with leadership potential who are then trained and exposed to experiences that contribute to its development. Within the literature, it was suggested that there are various steps that might help leaders to encourage innovation and to create a new strategic direction, in order to overcome a crisis situation within an organization.

Firstly, it was suggested that developing new perspectives on the meaning of control was essential to encourage innovation. Linking this approach with a democratic leadership, allowing organizing processes and learning groups, might result in encouraging employees to take part actively in finding solutions to overcome problems.

Analyzing the relationship between crisis management and leadership and how the two concepts are influencing each other, it might be stated that there are clear differences between followers and leaders and between effective leaders from less effective leaders, theories supported and reinforced by specific literature.

## 2. BODY

Crises are products of "either a threat or opportunity that arises from internal or external issues that may have a major impact on an organization". Analyzing other theories on the matter, most of the authors favored crises definitions that emphasize business impacts due to environmental accidents, employee shootings and bankruptcy [4]. Moreover, a similar approach was theorized by Gold [5] who organized crises around four different types: technological, societal, natural disaster and managerial or systematic.

Taking into account the approach of understanding crisis as opportunity, it should be highlighted the fact that many authors have supported this theory. In addition, Brockner and James (2008). Analyzed the way executives see crisis [6]. The aim of the research was to investigate the conditions under which executives come to perceive crisis as opportunity. Within the journal article called "Toward an Understanding of When Executives See Crisis as Opportunity" there have been highlighted the behavioral manifestations of perceiving crisis as opportunity and the importance of seeking the views of multiple and diverse stakeholders, in order to emphasize both short and long term outcomes, not merely short term outcomes [7].

Crisis management is a critical function and failure can result in serious harm to an organization's stakeholders, losses for the organization, or even might end its very existence. Considering crisis situations, the matter was regarded that organizations prepare contingency plans in recognition of the fact that things sometimes go wrong. This approach targets managers to prepare plans for predictable and quantifiable crises as well as for unexpected events. On the other hand, leadership is seen as essential when such situations happen, being seen as an attribute of a hierarchical position in the organization, a characteristic of a person, a process of mobilization and training of staff in a particular direction, a capacity of mobilization or a category of behavior. Leader's contribution to the process of leadership is given by his personality, motivation, skills and legitimacy. The followers, in their turn, will bring their contribution of personality, motivation, skills and expectations to the situation,

situation which has certain resources, types of tasks, social structures and specific rules.

Looking at leadership, there were identified various styles of leadership correlated with leadership functions. Dividing the styles into two separate categories, autocratic and democratic, it was highlighted the idea that participative leadership, also known as democratic leadership was thought to be the most effective leadership style, matching the employees' needs. Some of the primary characteristics of democratic leadership include:

Group members are encouraged to share ideas and opinions, even though the leader retains the final say over decisions.

Members of the group feel more engaged in the process.

Creativity is encouraged and rewarded.

Emphasis was also placed on various leadership behaviors, which are thought to improve the relationships between managers and employees and that, were suggested to ease the process of overcoming the crisis. Researchers have acknowledged the importance of employees' perception concerning their own role in the organization and stated that as long as employees felt that they belonged to that organization, a crisis situation might be overcome easily. Referring to this approach, it might be highlighted that consideration and targeting were thought to be effective instruments to improve the relationship between the leader and followers. Analyzing these concepts, consideration was defined as the extent to which a leader is approachable and concerned about the fate of the subordinates [8].

Furthermore, targeting was the concern to achieve the objectives related to a strong relationship between employees and managers. When referring to targeting, accent is placed on the division of tasks, setting deadlines, correcting poor performance. The aim is to correlate all these activities with the fulfillment of the mission. As a result, the most effective leader was defined as able to harmoniously combine strategies, in order to activate the socio- emotional function between managers and employees [9].

By analyzing the relationships between leaders and employees and linking the moral claims of an organization's employees to corporate responsibility strategy, the findings have shown that the corporate responsibility strategy would succeed only if the employees recognize that this strategy created value for them as well. The main idea of the research was to demonstrate that an organization could strengthen emotional bonds with its key stakeholders through an effective participative leadership. Considering the limitations of the research, it was suggested that various potential problems might appear in participative leadership such as the waste of time and energy when there was a situation that required a quick decision. In addition, it was suggested that the leader' roles in an organization were to build a shared vision and testing mental models, in order to attract new and innovative ideas, attitudes that might be attained only by applying a participative leadership.

Leadership is regarded as a social influence. By highlighting that leadership means 'leaving a mark', it was also suggested that leadership is about initiating and guiding, the result being the change. Considering this theory, the change may consist in a product that sets a new direction of an organization.

Another similar approach highlights that leadership is seen as a social process of exchange in which the leader gives something to those who follow him. This process has three variables: the leader, the followers and the situation.

Considering all the presented theories regarding leadership, a general statement widely accepted and supported by theorists is that leadership sets the strategic direction of the organization; using the vision it has on its future and then develops and implements the strategy. Essential to underline is the importance of leadership especially during crisis situations. In an attempt to provide strategic insights and practical thinking regarding crisis situations in organizations, Emerald Group Publishing Limited (2006) posted an independent article highlighting that successful companies rapidly admit responsibility, apologize to those harmed and take bold steps to limit and repair damage.

Crisis management might be understood as "a process of strategic planning for a crisis or negative turning point" that is linked to crisis communication as "the dialog between the organization and its public prior to, during, and after the negative occurrence". Furthermore, crises are usually thought to focus on communication issues and accent is placed on the communication between the organization and its stakeholders. Moreover, it was suggested that the media has a crucial role in a crisis situation. Summing up the previous theories, it should be highlighted the fact that the media has the power to potentially damage the reputation of an organization and to cause a variety of employees relations, consumer relations, and community relations problems.

Regarding crisis management, within the journal article on 'Crisis communication- Managing the Media', Toft [10] argued that there is a need to develop a crisis communication program, as part of the crisis management plan, well in advance of any problem that might occur. More than that, it was suggested that an organization must have planned procedures to be followed in case of a crisis. In the research undertaken, Zerman (1995) showed that within organizations, there is a need to react immediately against the media and that managers should learn how to handle public relations in a crisis situation.

Lerbinger [11] reinforced this theory by adding that because every crisis created an information gap, an organization had a better chance to be affected if managers do not step up and activate the leadership role as spokesperson. Silence by an affected organization is though to work against it because the media and the public might believe it has something to hide. Moreover, in "quick moving crisis", the first moments after the event has been released are of critical, in order that managers are able to take control of the situation and report the event in a diplomatic way, and save the reputation of the organization.

Seeing an organization as part of a dynamic system, it was assumed that the changes that happen over time might affect the smooth development of the organization. More than that, it was also assumed that when all these changes happen, experts want to detect if these patterns display properties that are stable or unstable, predictable or unpredictable. Going in more depth, research highlighted that when systems move form their equilibrium state are prone to small changes in their environment which might cause major changes in the behavior of the system itself. As a result, under conditions of major change, the long- term future of an organization might be threatened, due to the fact that its development is assumed to be unknowable.

This approach was the point of interest of other researchers, stating that all the major and sudden changes are the roots of a crisis situation within an organization. However, in the academic papers, crisis was sometimes replaced with the concept of ‘chaos’. Looking at the concept of ‘chaos’, which is similar in many respects and depending on the context, with the concept of ‘crisis’, Vroom [12] defined the chaos as being an irregular pattern of behavior generated by well defined non linear feedback rules commonly found in nature and human society. In an attempt to apply this approach to a business organization, a chaos might be understood as the result of any sudden event that affcted the smooth development of the organization.

Looking at Cole’s [13] theory concerning post – crises best practices, three main steps should be followed, such as: delivering the information to stakeholders as soon as the information is know, keeping them up to dated, integrating the lessons learnt within the new crisis management systems

Regarding crisis situations, it might be said that no matter the size of an organization, effective leadership and crisis management are essential for the smooth development of the organization. Leaders who are expected to perform as crisis managers need to be trained and experienced in crisis management, and should not be placed into such positions without applicable training and assessment.

## 3. CONCLUSIONS

Regarding leadership and leader’s roles within organizations, it was concluded that leadership skills might be acquired through study, practice and perseverance, therefore communication was essential within the process. Furthermore, it was suggested that the most important activities of the leaders were activities related to the achievement of objectives that interested subordinates, and in the same time, improved the organizations’ development. Thus, an effective leader corelates subordinate’s objectives to the objectives of the organization.

Considering the two approaches, it might be said that only through an appropriate organizational culture, able to provide strong networking and extended interpersonal relations, conflicts can be avoided and problems within an organization overcome. Through organizational culture, a communion of values and interests, mutual trust and communication can be reached.

To conclude this section, it might be stated that the leadership development process within the organization is extremely important arguing that if leadership is strong, but there is inadequate management, the situation is more dangerous than the reverse. Moreover, leadership is seen as essential when such situations happen, being seen as an attribute of a hierarchical position in the organization, a characteristic of a person, a process of mobilization and training of staff in a particular direction, a capacity of mobilization or a category of behavior. Leader's contribution to the process of leadership is given by his personality, motivation, skills and legitimacy.

It might be added that two facts stand out about organizational leaders. Leaders are appointed and they direct a group with an assigned task. Leadership often goes beyond the organization, involving communicating with stakeholders, so as stated by Eliott [14], both the qualities of the individual and environmental factors are important elements in the leadership equation. Finally, leaders who are expected to perform as crisis managers need to be trained and experienced in crisis management, and should not be placed into such positions without applicable training and assessment.

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# TRANSFORMATIONAL LEADERSHIP AND THE ECONOMIC COMPETITIVENESS IN SHIPPING INDUSTRY TODAY

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**ABSTRACT**

An important analysis of the parameters of global competitiveness, in shipping industry, shows that there is a series of issues that can be reviewed and interpreted on the basis of new models. One of the models based on which we could analyze economic competitiveness is the transformational leadership in this industry. Attributes of a competitive economy can be found in the selection of methods which determines the performance in a company and in a nation, as in training employers in a framework of cooperation. Through this study we intend to analyze the manner in which the global economic competitiveness in shipping industry is influenced by transformational leadership in this industry. We will try to make a comparison between different ways of analyzing economic competitiveness to what extent the transformational leadership is involved here.

**Keywords:** *shipping industry, competitiveness, leadership, transformational, training employers.*

## 1. INTRODUCTION

Economic meanings derive from different economic models, and development derives from the transformation of existing technologies based on knowledge of the relationship to new methods of analysis and practice, that can be applied after 2012.

Institutions create environments in which people can develop self respect, enthusiastically participate in company life and society in general. Transformational leadership intervenes where one or more people share their levels of motivation and morality very elevated.

Considering that each step is due to the successful interaction and collaboration, we try to shape a framework of economic competitiveness in relation to transformational leadership in shipping industry.

We try to find some descriptions of transformational leadership and to describe the relation between transformational leadership and economic competitiveness in this industry.

We also considered what authors in management and marketing studies had to say about transformational leadership, the transformational leadership examples of start-ups and young firms, and big companies, and big states, the processes of competitiveness creation and competitiveness sharing, and competitiveness different analyzes in general. This tip of leadership must manage:

- Safety,
- Commercial activity,
- Efficiency,
- Running costs,
- Managing people on board,
- Managing shipboard maintenance,
- Managing information,
- Managing risk,
- Managing social relationships with multi-cultural crews

In commercial fleets, economics, efficiency and competition are a dominant influence. A transformation leadership can answer proper at all demands claim by this factors. Only this tip of leadership can assure good condition for a good profit.

## 2. TRANSFORMATIONAL LEADERSHIP IN SHIPPING INDUSTRY- DEFINITION AND IMPORTANCE

Maslow estimated that the process of becoming a leader is analogous to that of a musical conductor (Abraham H. Maslow, Deborah C. Stephens, p. 165).

MacGREGOR Burns in 1978 (David M. Boje, 2005) presented the analysis which was earlier researched by Max Weber and showed the differences between the Leadership of the transactional and the transformational Leadership. If the transactional leadership is the bureaucracy and work for money, in contrast, the transformational leadership is based on charismatic leaders convinced by their attitude toward cooperation. He gives the example of A.H., suggesting that sometimes such cooperation can be fatal. Burns has proposed another form of leadership less frequently, what he calls transformational leadership, a leadership that is founded on the human need to have a reason to manifest and create a goal for the enterprise.

In contrast to Burns, Bernard Bass presents the key to success in the transformational leadership, which is accompanied by the charisma and character, not by the desire to have power, but the ambition to succeed. This is well highlighted by the finding that people are enticed to follow leaders who inspire, people who have not only a vision of what they do, but do things with passion but who really do things with passion, the path to being successful "by injecting enthusiasm and energy (Bass, 1990). Transformational leadership is correlated with high values, the choice based on ethical and inspirational motivation. Today this tip of leadership must be compulsory for shipping industry.

The transformational leadership is a new way to analyze the results of collaboration between managers and other employees. "The concept of transformational leadership is used to highlight the stronger result while practicing a style of management effective on people who are guided" (Nistoreanu Puiu, Pericle Uidumac, p.12).

In the context of a transformational leadership, relations between manager and employee are based on cooperation and willingness of self overcome, supreme interest of carrying out activities to determine success in the company.

Name of transformational leadership is due to the transformation that has a certain style of management and employees on the set of values necessary for success. Transformational leaders have in minded the objectives and training to achieve those objectives. According to Waren Benis leaders who are part of the transformational leadership have four significant components that are "management attention, meaning management, trust management, self management (Puiu Nistoreanu, Pericle Uidumac, p.13).We emphasize that management attention is focuses on the elements that are truly important to the company and employees, management presents examples of what should be interpreted as data management, trust is based on relationships of trust between managers and other employees, management is seen as self a detailed analysis of the limits, but also skills and personal resources. Abraham Zalesnick specifies the difference between managers and leaders: "Managers prefer to work with people, leaders causing emotions" (Tom Peters, Robert Waterman, p. 101).

Kamal Dean Parhizgar considers that the motivation factors are achievement, recognition, the work itself, responsibility, advancement and growth (p. 137).

By the analysis of the four styles of management, it results that each of them is a step in achieving effective collaboration between manager and employees. Transformational leadership is based on developing collaborative relationships between leaders and employees, and the impact it has on their features and development company and its competitiveness. This collaboration is based on teamwork without distinction to be made between hierarchical relationships. Also this is the key of success in this tip of business.

## 3. FROM TRANSFORMATIONAL LEADERSHIP TO ECONOMIC COMPETITIVENESS IN SHIPPING INDUSTRY

Transformational leadership is an appropriate training of competitive economy; it is like a picture frame of competitiveness.

To understand which is the ratio between transformational leadership and economic competitiveness, we will try to determine first the foundation for economic competitiveness.

It is important to use such an approach because the "meaning of meaning is the relationship between things," (Eric McLuhan, 2006, p.530). Economic competitiveness is formed in a framework in which market economy conditions are conducive to development of new products or services, thus strengthening the foundations of international affirmation and harnessing existing benefits.

Research, the volume of knowledge and technological development contributes largely to the preparation conditions for the development and stimulate economy nationally and internationally.

Economic competitiveness can be analyzed at the micro and macro levels. At the micro level, it can be analyzed within the company and at the macro level in the country. Michael Porter proposes an analysis of economic competitiveness, explaining how some countries can be leaders in the production of certain products. Porter explains how some nations are competitive in certain industries (John J. Wild, etc., 2006, p.168).

Porter presents national diamond as composed of national policy, national application, related industries, and business strategies that companies adopt.

Primary factors are represented by the resources available to business or economy, the factors and qualities of the various advanced segments of labour, technology infrastructure of the country or firm.

Advanced factors are the result of investment in education and innovation due to different training sessions and research, technological development, and various modern methods of management and incentive systems.

Factors that a firm has, are based according to Porter primarily on human resources, then the capital resources, physical infrastructure, administrative, informational, scientific and technological.

Company should consider the context in which it develops, how to protect intellectual property, competition in the growing, and demand conditions, which can be analyzed nationally and globally.

In contrast to Porter, Paul Krugman (Paul Krugman, 1994) presents an analysis of competitiveness in relation to its limits. Thus he suggests that the possibility that calculus the assumption that economic competitiveness is deducted from the success that we are a nation in international marketing, not to justify the practice.

Krugman believes that this happens because there is an obsession of growth especially in developed countries, economic growth, which should not be seen as a well-founded business, but as a record known. He believes that the competitiveness level of the nation is much more problematic than determining competitiveness at the firm. In this sense if a firm is not competitive and goes bankrupt, ceases to operate, a nation can not leave under any circumstances the scope of business.

Based on this analysis of economic competitiveness, we can distinguish the presence of transformational leadership in value creation and human resources while training support required in the performance of the company and an entire nation.

Economic competitiveness by developing economic growth based on resource efficient and managed on a process of collaboration both within companies and between them and between different governments or institutions specialized in the research. A good growth plan captures the vision for expanding the company (Michael A. Cusumano, Georg Von Krogh, p. 270).

The seven keys are the organization's structure, strategy, systems, shared values, savoir-faire of the staff, style. (Tom Peters, Robert Waterman, p.32).

Investing in leadership is the transformational powers of creating cumulative lead to economic competitiveness of the company. A manager or employee must know how to adapt to any situation, he has to "to consider if any changes that are proposed or imposed, which will track the decision for his career" (Peter Noll, Hans Rudolf Bachmann, p.65).

Tom Peters and Robert Waterman (p. 35) consider that the best innovative companies are the following: those who share responsibility and make first practice, they are always learning from their customers, listen carefully to their suggestions, they encourage autonomy and innovative spirit, these innovative enterprises preserve many leaders and innovators in all levels of organization, thus companies respect what Fletcher Byrom said: "Make sure to generate a reasonable number of errors". For these companies, productivity is associated with staff motivation and the best companies treat the base as the source for quality and productivity gains, they are mobilized around the key values, these companies know how to do, they keep the structures simple and casual, structures and systems of the best enterprises have an elegant simplicity, they are centralized or decentralized depends of the context.

Michael Best presents productivity triad in business model, skill formation, production system (Michael H. Best, p. 10).

The transformational leadership is to develop human capabilities to achieve performance, open new opportunities for employees and the working team, encourage open dialogue and ideas new results, however to have both short term and the long terms contributing in order to increase economic competitiveness.

Analyzing practice, this it means choosing the most appropriate ways of leadership, representation and participation in decision-making and implementation. Michael Porter (Porter, 2003) presents three sources that lead to economic competitiveness, that is innovation, productivity, prosperity.

Innovation is based on the transformational leadership, which leads to productivity, creating a healthy economic environment for a competitive business and for development of new products.

## 4. CONCLUSIONS

It can be noticed in the presentation of the characteristics of transformational leadership its footprint in the conduct of firms in which such a stand. We could find a basic definition and analysis based on its economic competitiveness in shipping industry.

People are the most important resource in this industry; the manner we use it depends on the manner we understand it and the style of leadership existing and being accepted.

Economic competitiveness in this industry exists as a form of progress for certain people and for others only as a form of indoctrination to certain values. An alternative training in economic competitiveness is a detailed analysis of the transformational leadership and taken as a reference in dealing with economic competitiveness.

If one looks at the changes that occurred in management through the transformational leadership, one could say that it is a tool to cause economic competitiveness and to develop new areas of its analysis. Since there are several views on the concept of competitiveness, evaluation may be done by reference to modern reference bases.

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