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CONTENTS

STRUCTURAL ANALYSIS ON SPARKING SUPERFICIAL LAYERS WITH TUNGSTEN AND TITANIUM CARBIDES ELECTRODES

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The paper shows some theoretical and experimental aspects with reference to the superficial processing using electrical sparking.
The tests objective was the superficial processing through sparking process on alloy and non alloy steel samples using a sinter carbide W and Ti electrodes type WCo8, Ti15Co6.
The paper shows metallographic analysis on sparking superficial layers. The analysis was made on NEOPHOT 32 (special microscope) and MC-2 and MC-6 (metallographic microscope).
Optic metallographic analyses of sparking superficial layers obtained using “hard” carbide electrodes W and Ti sinterysed had as a result a white layer resistant at normal chemical reactive attack on sample surface. Under this layer a transition zone will form which is obvions at hardened proofs and under “hard” working condition.

***Keywords**: superficial layers, analysis of phases*

1. INTRODUCTION

Science and technology of superficial layers is subject to many research projects during the last decade for a most efficient use of metallic materials.

Obviously the continue our improvement of superficial layers can not be done without a detailed knowledge of these layers structure, the structure modifications, during manufacturing, the factors and the directions of these modifications.

The structural analysis methods will be developed after performing the technology of superficial layers, irrespective of the type of process. The most important issue is to optimize the economic process.

The protecting film obtained through superficial deposition on alloy and non alloy steel increases the properties of these pieces.

In this paper the optic metallographic method was used to elucidate the structural aspects

2. EXPERIMENTAL WORK

Spark micro alloying is based on the material transfer effect from electrode to the surface of the treated piece during the electrical discharge in the gaseous environment between electrode and piece. The basic requirement is the electrical conductivity of the piece and electrode.

During the process of electrical sparking the electrode is in vibrating motion.

In case of compact materials used as anode, the most known method of sparking process is when the commutation of the anode with cathode is realized through vibrations.

The electrical sparking process was done between 15 to 220 V, the frequency of vibrations is 50-300 Hz, and the amplitude during sparking process is no more than 0,2 -0,5 mm.

The tests objective was the superficial processing through sparking process on alloy and non alloy steel samples. In this sense, the following steel samples have been used: OLC 45, 165MoCr120, 45VSiCrW20, and 155VMoCr115, 51Si17A, 34MoCrNi15.

Sparking was performed on clean and degreased plane surfaces witch belonging to parallelepiped samples (20x20x10) from alloy and non alloy steel. The processing with electrical discharge was performed manually by using an electrode bent at 60^o. Any sample surfaces to be processed ware finished at roughness R_a = 5-10 μm, beforehand.

At processing with electrical discharge a special importance in superficial layers forming and its qualities has the electrode section; this influence manifests at chosen working conditions temperature variation and at current density that crosses the electrode.

The tests followed the superficial processing with vibrating electrode using a sinter carbide W and Ti electrodes type WCo8, Ti15Co6.

Metallographic analysis was made in vertical section on sparking superficial layers. The analysis was done on NEOPHOT 32 (special microscope) and MC-2 and MC-6 (metallographic microscope).

The sample was polished, planished extra bright and attacked. The reactive used for attack was NITAL 3% and MURAKAMI.

3. RESULTS AND DISCUSSIONS

After the sparking process, the piece surface will be covered with a layer made of electrode material, named “white layer”, which is not attacked by the reactive used for sample basic structure. Under the white layer especially in “hard” sparking regimes a darker layer formed, as a transition zone formed by the basic material in which the electrode materials has diffused.

We can mention that at low values of discharging energy on sample surface only a white layer with thickness between 2:10 μm is formed, the transition zone does not appear or is very hard to be observed because it is very thin.

Consequently we must observe that the superficial white layers obtained in hard conditions are thicker than the other layers obtained under “weak” conditions and have a transition zone between the layer and sample materials, more porose, many fissures and the surface is rougher.

In Figures 3.1, 3.2, 3.3, 3.4 sample structures from different steel types processed through electric sparking under different working condition are presented.

The basis structure of steel proofs, presented in Figure 3.1 is pearlitic-ferrite for annealed samples and martensite plus residual austenite for hardened samples.

The superficial layer obtained after the sparking process on samples of type 3 working condition is uneven, white, resistant at chemical attack. The superficial layer structure is non-uniform, cracks in layer appear, it is fine-pored and inclusion. On hardened and non hardened samples, a transition or diffusion zone could be observed under the white layer.

In both cases, under the white layer obtained after electrical sparking discharge, there is a material a thermic affected where zone phase transformations in solid state are produced.

The heat is transferred from discharging zone in the base structure, in the first phase, the material under the white layer is very highly heated and the next phase is quench.

For the annealed sample in the transition zone hardened constituents could be form, and for hardened sample tempering constituents will appear.


a


b

Fig.3. 1. OLC45 steel sample sparking with WCo8 electrode
a. annealed sample; b. quenching and tempering sample

Appearance of cracks in the white layer shows the pronounced structural tensions existing (figure 3.3). As we can observe from figure 3.2 in "weak" working conditions such as small energies for impulses discharged in the white layer do not appear efforts, or there are low tensions.

The thickness of the superficial layer, sparking processed depends on the discharging energy value this means the machine working conditions.

In Figure 3.2 we can observe that the white layer thickness and the diffusion zone grow in the same time with the grow the working conditions.

The samples in figure 3.2 which are alloy steel present a typical bases hardened structure formed from martensite plus residual austenite plus primare carbide (white and big) and secondary carbides (white, fine and elongated). Over the bases structure after electrical sparking process, a more compact white layer will form in weak working conditions.

The tests objective was the superficial processing through sparking discharge on alloy and non alloy steel samples using both sinter carbide W electrodes and sinter carbide Ti. In figure 3.3 are shown structures of steel which were sparking with Ti15Co6 and WCo8 electrodes at the same working conditions. Over the martensite structure it observe very clear the white layer formed. Under this layer it observe the diffusion zone. The layer obtained through sparking process with titanium carbide electrode is more uneven and more homogeneous (highly porous) due to decomposition titanium carbide, during electrical discharge and release titanium in layer immediately followed by its oxidation.

The layer obtained with Tungsten carbide electrode is uniformly, do not has pore, but at the working conditions 4 is observed cracks in layer. Better compactness of the layer obtained with the WCo8 electrode is observed in 34MoCrNi15 steel samples presented in Figure 3.4. At an average working regime even at high magnification (Figure 3.4,b) is not observed pores and cracks in the layer, it is uniform and very compact. In both structures presented we observe a fine structure under the white layer due to changing initial structure under the influence of thermal gradient formed during electrical discharge. Traces of hardness determinations highlight that the newly formed layer is much tougher than the basic structure.

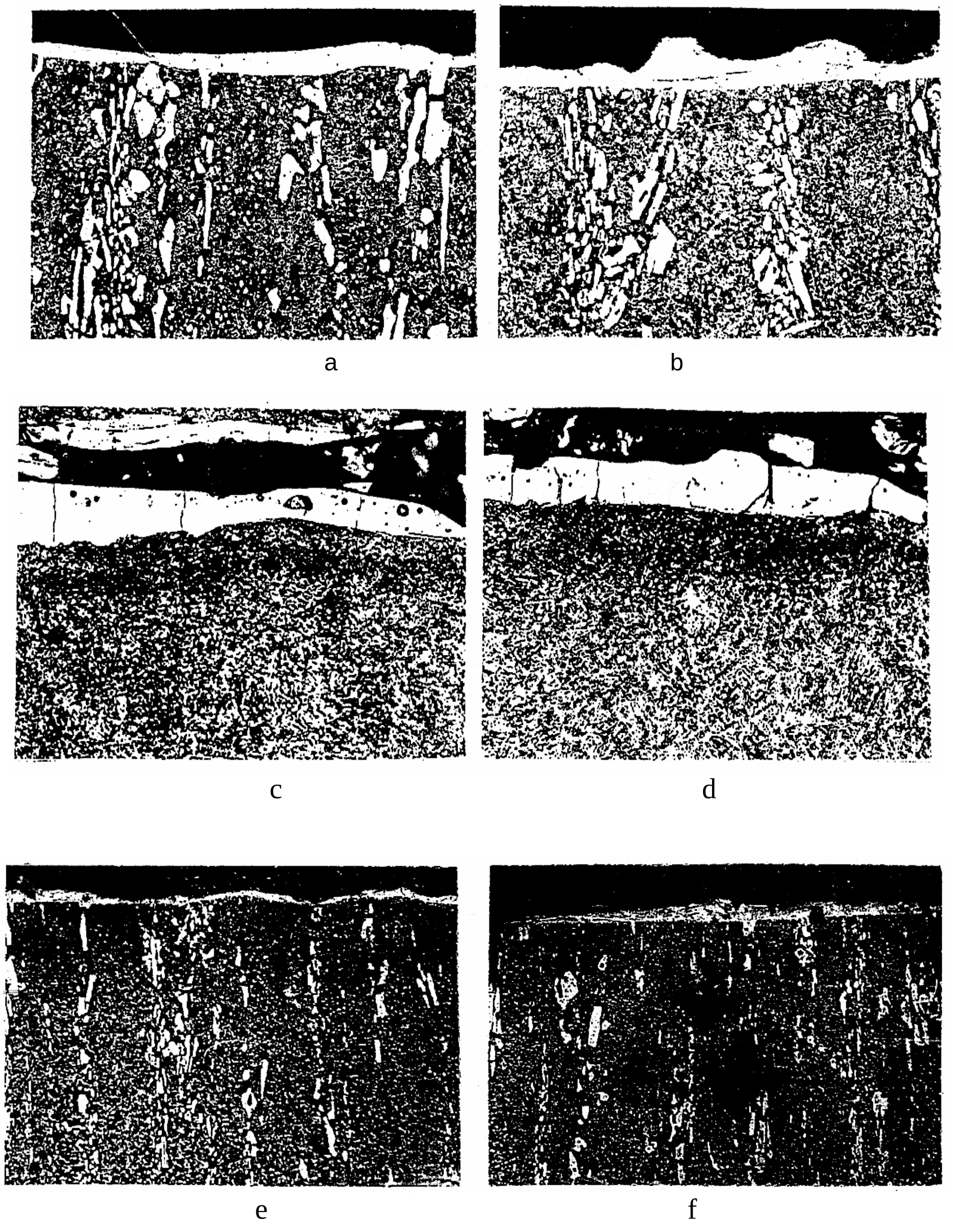


Figure 3.2. Alloy steel structure sparking with WCo8 electrode

a. 165VMocR1200- 2 working condition; b. 165VMoCr120-4 working condition c. 45VSiCrW20-3 working condition; d.45VSiCrW20 – 4 working condition e. 155VMoCr115- 1 working condition; f. 155VMoCr115 – 2 working condition – 400:1

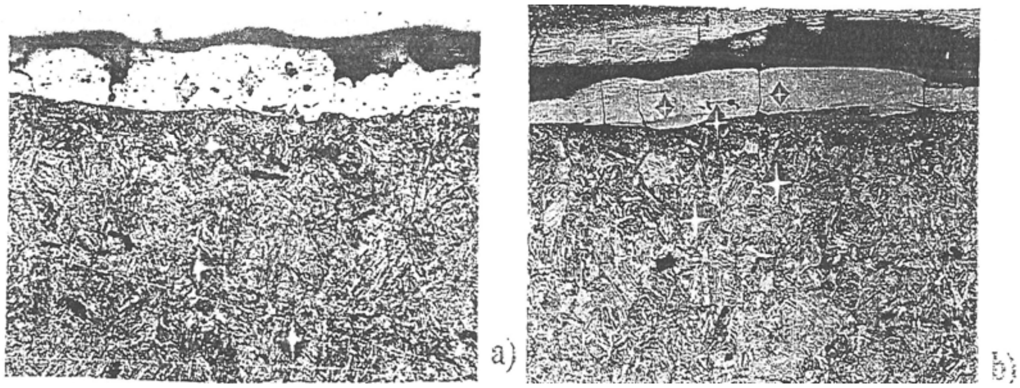
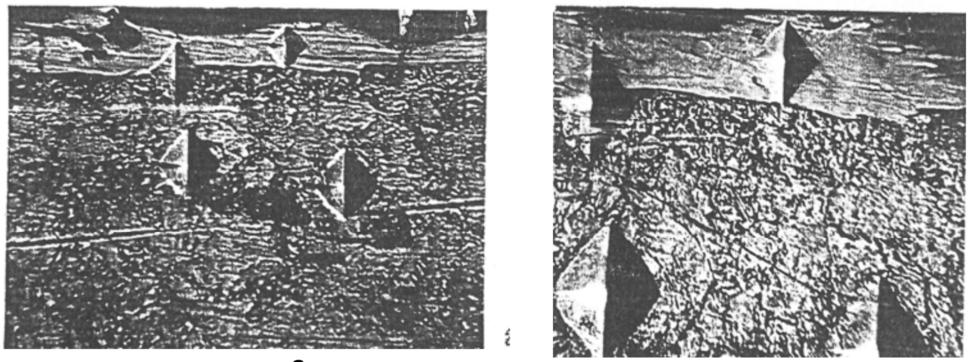


Figure 3.4. 51Si17A steel sample sparking on ELITRON – 22 at 4 working conditions (500:1)

a. steel sample sparking with Ti15Co6 electrode

b. steel sample sparking with WCo8 electrode



a ***b***

Figure 3.4. 34MoCrNi15 steel sample without heat treatment sparking on ELITRON – 22 at 3 working conditions

a. layer microstructure 400:1

b. layer microstructure 800:1

4. CONCLUSIONS

Superficial processing using electrical sparking is a typical discharging through multiple impulses and during a very short time. In essence, during the time of discharging a cathode erosion is produced and there is a material transfer on the processed surface.

A bigger distance between the electrodes leads to a high quantity of energy in the discharging channel, and to a decease of the energy transmitted to electrodes. As a consequence, there is a decrease of erosion, so the material transfer between the electrodes is decreased.

The working processing time can influence the thickness of new formed layer. For a long processing time an erosion process will appear which has as a result a decrease of the layer thickness.

The used working condition will determine the layer geometry and quality. By using "hard" working condition we will obtain thicker layers but their structure will be defective with pores and cracks.

Optic metallographic analyses of sparking superficial layers obtained by using "hard" carbide electrodes W sinterysed have as a result on the sample surface a white layer resistant at normal chemical reactive attack. Under this layer a transition zone will form which is evident for hardened samples and in "hard" working condition.

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TECHNOLOGICAL ASPECTS OF THE INDUCTION HARDENING OF INTERNAL ROTARY SURFACES OF SHIP JOINTS

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The surface hardening by induction heating has many advantages over other methods of conventional thermal processing. It is known that this method is applied to achieve high hardness in the surface layer maintaining a resilient core. The implementation of the required thermal cycle depends both on the characteristics of the material undergoing processing and of the parameters of the system of induction impact. Some difficulties arise in high-frequency hardening of internal cylindrical surfaces of ferromagnetic joints with relatively small diameters, as there is a pronounced the Ring effect, leading to displacement of the eddy currents in the detail and to reduce the efficiency, and hence the quality of the products. The purpose of this work is to study the technological aspects of the induction hardening of internal rotary surfaces.

***Keywords**:* induction, modeling, metallographic analysis

1. INTRODUCTION

Constant velocity joints are located on both ends of the drive shaft in the flexibly mounted drive arrangement for ships – Figure 1 [10].

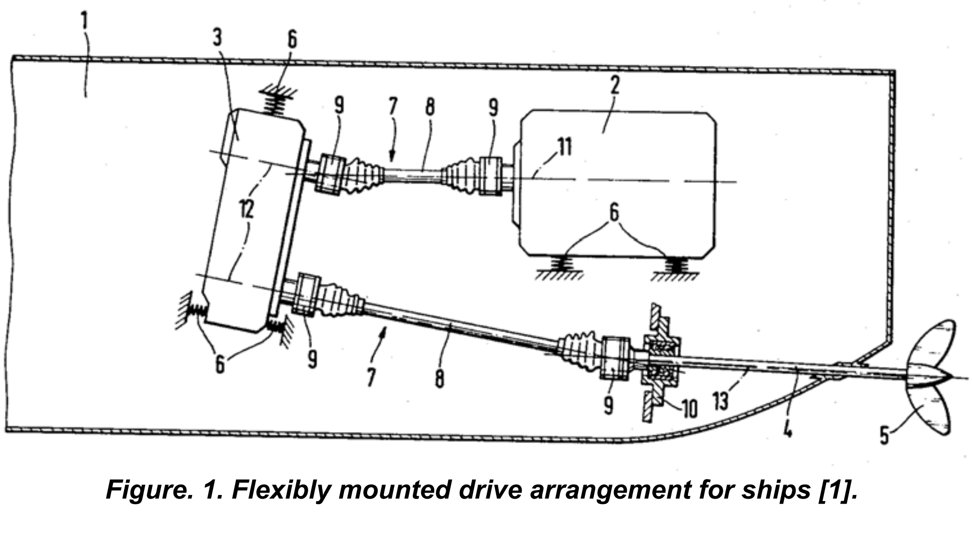

Figure. 1. Flexibly mounted drive arrangement for ships [1].

In a drive arrangement for a ship, a flexibly mounted drive unit provides the torque for a propeller shaft. The propeller shaft can be supported in a flexibly mounted thrust bearing.
A drive shaft interconnecting the drive unit and the propeller shaft includes a single length rigid shaft with a constant velocity universal joint at each end – position 9 in Figure 1.

The high-frequency induction heating may be used to harden the inner ball track inside the outer ring of the constant velocity joint, because the inner ball track is directly in contact with the steal ball and the roller on the side of the inner ring – Figure 2 [4].

It is important to take account of temperature rise and the timing of it inside of the heated object for designing of induction heat system such as high-frequency hardening.

The loss distribution obtained from magnetic field analysis can be used as a heat source for thermal analysis to obtain the temperature distribution and the temperature variation caused by high-frequency induction heating.

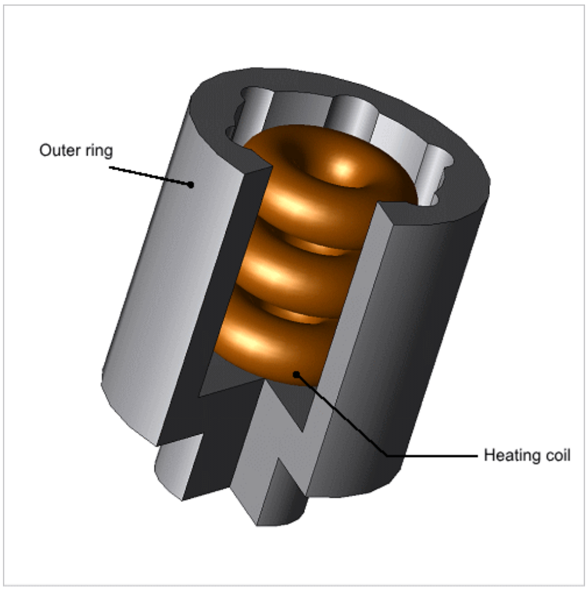

Figure 2. Constant velocity joint with an inductor [2].

The eddy current is produced on the outer ring by the time-varying magnetic field generated by the coil. In the induction heating, this eddy current is used as the heat source. When the high frequency is used, eddy currents are induced on the surface of the outer ring due to the skin effect. The outer ring is heated by the eddy current, and the temperature rises over time. After many seconds, most part of the inner surface of the outer ring reaches the Curie point, but the temperature distribution is not uniform. Some improvements, including the modification of the coil geometry, are required to heat the inner surface of the outer ring uniformly.

The surface hardening by induction heating has many advantages over other methods of conventional thermal processing. Using this method allows to improve the quality of the products such as reducing distortions and complete removal of oxidation and decarbonisation and significantly increase the productivity of the process. As is known the surface hardening with induction heating is applied to obtaining high hardness in the surface layer of the detail retaining the resilient core [2,3].

The implementation of the required thermal cycle (speed and temperature of heating, depth of the impact, cooling rate), providing an opportunity for surface hardening, depends on characteristics of the material itself, and the parameters of the mode of induction impact -

frequency of current fluctuations in the loop, time of the process, and type of the power supply source [7,9].

In induction heating eddy current distribution is never uniform throughout the processed area, and therefore it is impossible to create a uniform closed shell in the entire heated area. Only rolling details with simple geometric shapes (cylinder, sphere), can be heated uniformly over its entire surface, which is a relevant internal or external for the inductor.

When comparing the active resistance of inductors for heating internal or external surfaces, in internal inductors it is less, due to the Circular effect and Proximity effect, so the wire conductive area is used better. But this did not offset the negative impact of the Circular effect. To have such inductors sufficiently high electrical efficiency, it is necessary to choose the air gaps no larger than 2 ÷ 3 mm, and with a detail diameter less than 50 mm, the gap should be approximately 1 mm [1].

Heating of holes smaller than 100 mm, should be realized with radio frequencies, which provide better magnetic connection between the inductor and the heated detail, and hence higher efficiency of the inductor. For diameters larger than 100 mm, can be used frequencies of 2500 ÷ 8000 Hz. In all cases the electrical conversion efficiency appears to be lower than inductors for external surfaces hardening. For small diameters of the holes (<30mm) an inductor with a simple design has efficiency 20-30% which practically precludes its use.

The purpose of this work is to study some of the technological aspects of hardening of internal rotary surfaces with induction heating for processing details with diameters, which provide relatively low value of the electrical efficiency.

2. METHODOLOGY

For achieving the objective of hardening with induction heating are used sample joints, made of steel type C50 EN 10083-2, chemical composition of which is presented in Table 1.

Table 1. Chemical composition of the used steel, wt%*

Steel	C	Si	Mn	Cr	Cu	Ni
C50	0.47-0.55	0.17-0.37	0.5-0.8	0.25	0.25	0.25

** S,P < 0.03%*

The geometry of the details is presented in Figure 3.

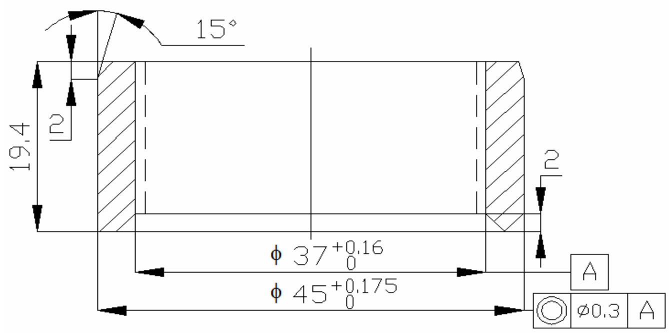

Figure 3. Geometry of the samples.

The technological requirements to the details are:

- Surface hardness 55.7 +7 HRC

- Depth of hardened layer 1-1.5 mm
- Hardness of the semi-martensite zone 450-500 $HV_{0.1}$

The Figure 4 presents the type and geometry of the inductor used for hardening, and in Table 2. the parameters measured on one phase of the primary coil during the process are presented.

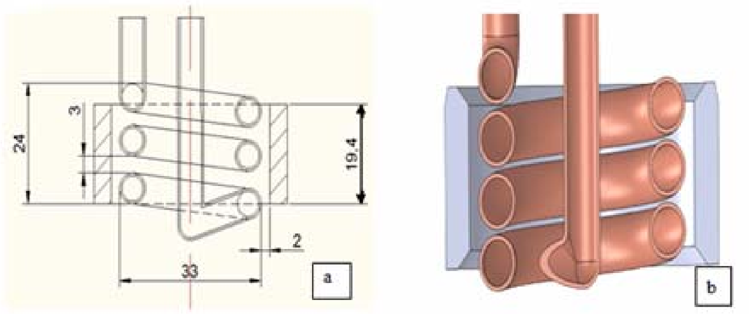

Figure 4. Scheme (a) and general view (b) of the heating zone of the inductor.

Table 2. Input parameters.

Sample №	**1**	**2**	**3**	**4**	**5**
t,s	2.5	3.0	3.5	4.0	4.5
P^* =19 kW; I^*=92A; U^*=223 V					

* P, I, U – measured parameters of one phase of the primary winding.

To further study of the realized regimes of induction impact multiphysics simulation experiments were made using the Heat Transfer Module of the COMSOL MULTIPHYSICS software [5,6].

For this purpose, the following data is used: f = 440 кHz – operating frequency; t = 0÷4,5 s – heating duration; w = 3 – number of windings of the inductor; a = 24 mm – width of the inductor.

The necessary to perform the simulation analysis thermodynamic properties of the used steel C50 EN 10083-2 are taken from [6].

To assess the degree of impact and its applicability for hardening of the details a metallographic analysis was performed. Polished cuts are used, parallel to the axis of the details, hence their length. For the development of the microstructure is used 3% solution of HNO_3 in ethyl alcohol. The microhardness was measured on a microscope *PMT-3* with 0.98 N load by the method of Vickers. The microstructure was investigated using a light microscope *Neophot 32*.

3. RESULTS AND ANALYSIS

Numerical analysis using the Finite Elements Method

On the presented in Figure 5 preliminary simulation analysis of the proposed experiment is observed inequality in the distribution of the magnetic potential with application of the presented in the methodological part of this paper methodological parameters of impact and duration of 2.5 seconds, although the presented in Figure 4 inductor is fully geometrically consistent of the processed details. This determines a shortage of power leading to insufficient for phase changes of the material temperature of heating, both in depth and the surface, where the magnetic field lines are concentrated.

According these results on the distribution of the temperature for duration of the impact of 2.5 seconds - Figure 5, this applies to almost the entire volume of the detail. Concentration of heat, respectively, the presence of the required temperature is likely to have the necessary values only at the ends of the detail, on the surface in proximity to the inductor. Uniformity in the distribution of the magnetic potential in the detail surface was observed in duration of impact of 3.5 seconds - Figure 5.

This defines a similar distribution regarding to the temperature of heating. That is evenly distributed on the heating surfaces and has a required value over 802°C in layer depth 1-1,5 mm, as are the technological requirements to the details. It is expected to be achieved hardness of over 544 $HV_{0.1}$ in this area of the detail.

In duration of 4,5 s – Figure 4, the observed temperature is over 800°C in a large volume of the detail, subjected to high-frequency induction effects.

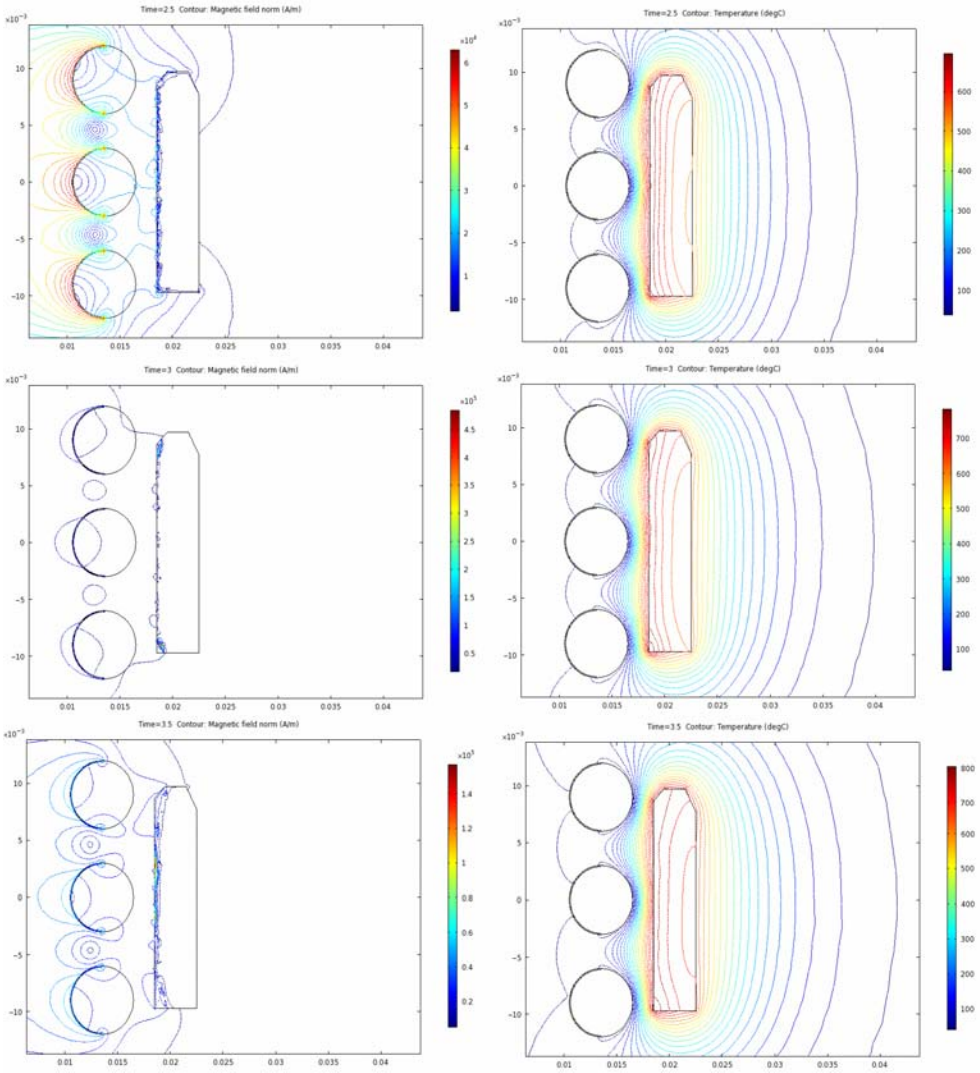

Figure 5. Distribution of the intensity of the magnetic field and the temperature during the heating process for times 2,5; 3,0; 3,5 s

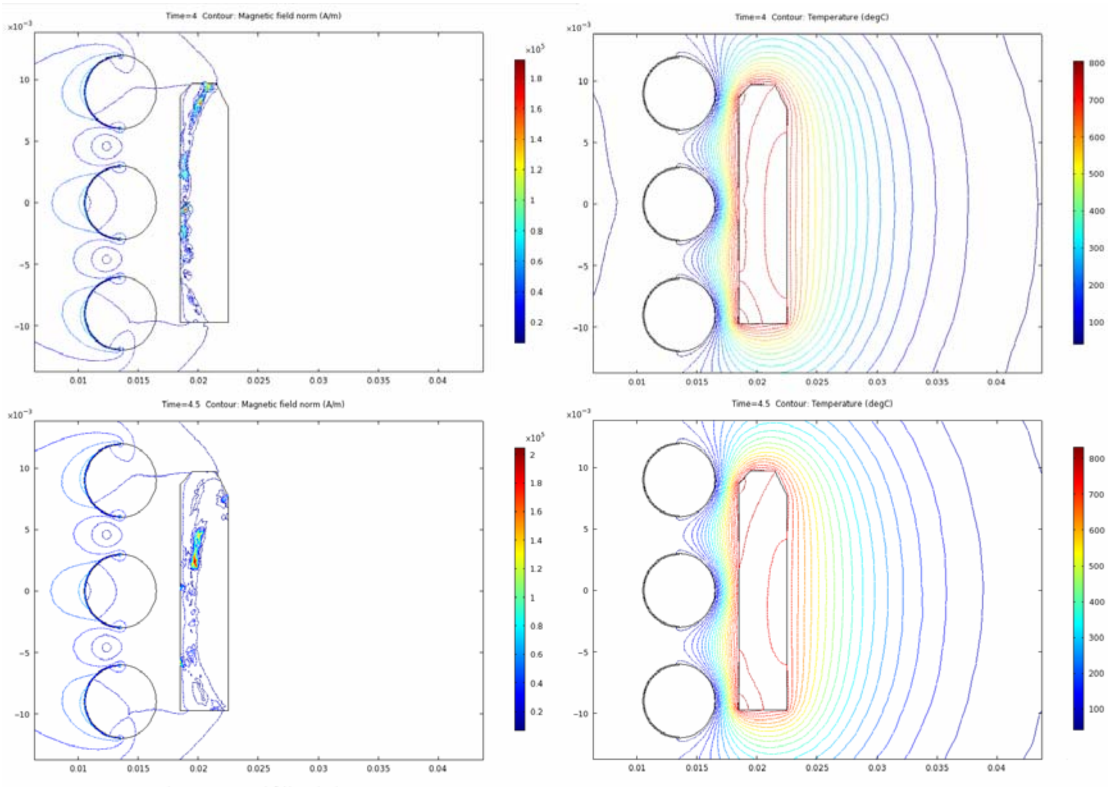

Figure 6. Distribution of the intensity of the magnetic field and the temperature during the heating process for times 4,0; 4,5 s

Metallographic analysis

The results of the preliminary numerical simulation analysis using the finite elements method is fully confirmed by a metallographic analysis carried out on details subjected to induction impact with the presented in the methodological part of this paper operating parameters.

At the time of impact 2.5 s the hardness is about 250 $HV_{0.1}$, in the entire depth of the detail – Figure 7. This indicates a lack of phase changes in the volume of the detail even for locations near the surface, due to lack of necessary for the implementation of phase changes temperature of heat.

This is evidenced by the characteristic of the entire volume structural condition of the detail, presented in Figure 8. The structure consists of ferrite and pearlite, with no trace of polymorphic transformation proceeded as for heating and cooling.

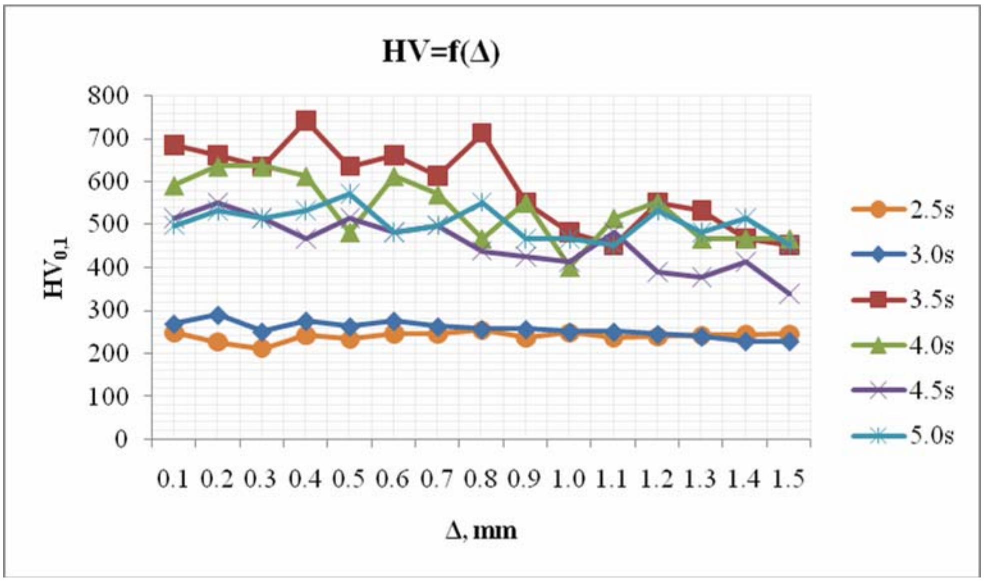

Figure 7. Change of the microhardness in depth of the material depending on the duration of the induction impact.

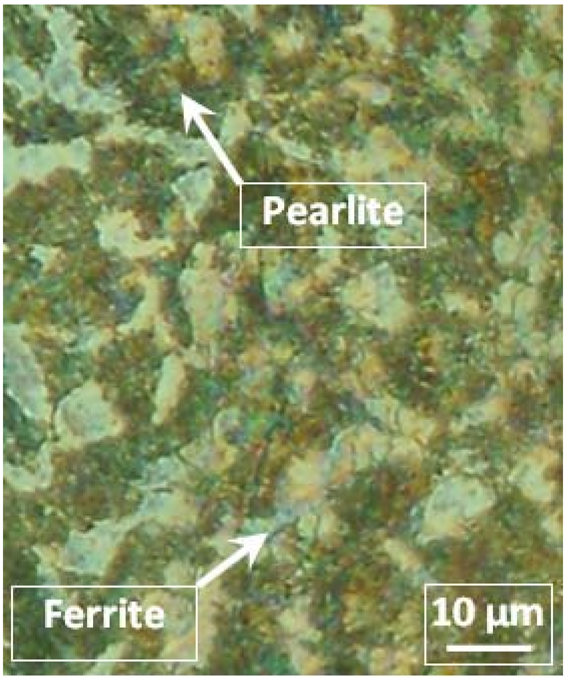

Figure 8. Microstructure in the area of the induction impact of sample № 1 (no phase changes). Exposure time 2.5 s.

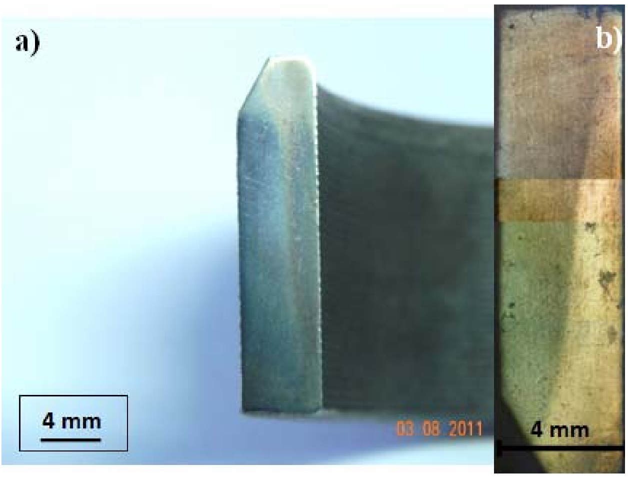

Figure 9. General view (a) and geometry (b) of the area of induction heating. Exposure time 3.5 s.

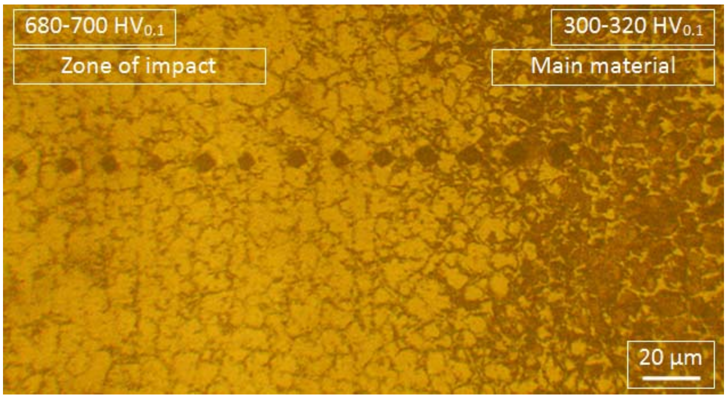

Figure 10. Microstructure consisting of martensite residual austenite in the zone of impact and ferrite and pearlite in the main material. Exposure time 3.5 s.

This situation obviously is amended at the time of impact 3.5 seconds. The microhardness measured in the depth of the material is within 550-680 $HV_{0.1}$, to a distance of 1 mm from the surface of the detail. This is entirely consistent to the set technological requirements, presented in the methodological part of this paper. The hardened zone is unevenly distributed along the specimen (Figure 9 a, b) due to the characteristic geometry of the real detail and the presence of technological inclinations in the ends, and by not quite fit of the geometry of the detail and the inductor during the treatment process. This does not alter the general conclusion that the applied mode of impact is appropriate and meets the process requirements. This is confirmed by the presented in Figure 10 structural condition, consisting of martensite and residual austenite in the zone near the surface of the detail and the ferrite and pearlite in depth.

In durations of impact 4 and 4.5 seconds the hardness is within the 450-500 $HV_{0.1}$ and is distributed in such amounts and at a distance greater than 1-1,5 mm from the surface of the detail (Figure 7). This does not meet the technological requirements, as the observed heating of the detail leads to hardening of almost the entire volume of the sample (Figure 10). The structure consists of martensite and much residual austenite (Figure 11) as the increase in the volume of the latter structural component is due to the lower hardness that the hardened layer obtained during the impact of 3.5 seconds (Figure 7).

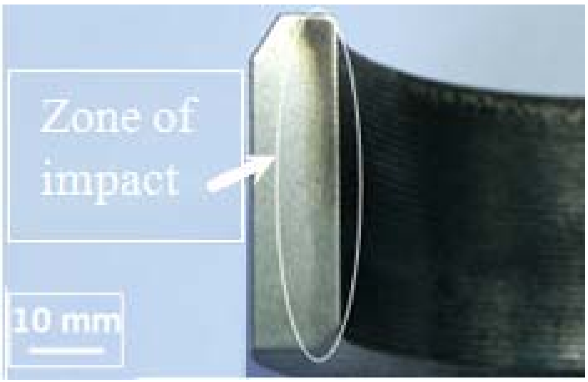

Figure 11. General view and geometry of the zone of induction impact of sample № 4. Exposure time 4,0 s.

Figure 12. Geometry of the hardened layer. Exposure time 4.5 s.

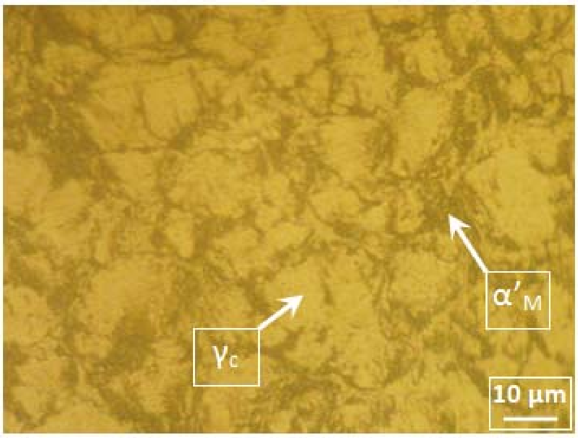

Figure 13. Microstructure in the hardened layer. Morphology of martensite and residual austenite. Exposure time 4.5 s.

4. CONCLUSIONS

The most - favorable impact, providing the technical requirements to the joint is obtained by heating at 3.5 sec.

The maximum surface hardness is 680 $HV_{0.1}$, reaching 400-450 $HV_{0.1}$ in a depth of 1,5 mm.

The layer is with suitable microstructure and geometry.

From the available results the following conclusions can be wrought:

- To achieve uniform distribution of the temperature field along the axis of the joint and reduce overheating in his ends is necessary to use a shorter inductor to compensate the Boundary effects and to reduce the full impendence of the system achieving higher values of the power in the circuit.
- The methodology used for the simulation provides sufficient accuracy and applicability of the software COMSOL MULTIPHYSICS use in the design of inductors for high frequencies.

ACKNOWLEDGEMENT

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A NEW INNOVATIVE HIGHLY EFFICIENT TWO COMPRESSION STAGES TURBOCHARGER-INVENTION PATENT PRESENTATION

[1]CALIMANESCU IOAN, [2]GRIGORESCU LUCIAN

[1]Saipem SpA Italy, [2]Constanta Maritime University, Romania

The present paperwork is meant to present a new innovative and highly efficient solution for a two compression stages which is the object of a brand new invention Patent. This paperwork is proving that the proposed high efficiency turbocharger is a viable solution to be adopted when the engine manufacturer is looking for extra-power from any existing type of combustion engine. The solution is simple, elegant and compact, which can be realized with the existing technology. By analyzing the numerical simulation we may pull the conclusion that the existence of the second compression stage rotor is greatly improving the output pressure of the device and is consistently shortening the reaction time.

Keywords*:* Turbocharger, Two compression Stages, Simulation

1. INTRODUCTION/HISTORY

A turbocharger, or turbo (colloquialism), from the Greek "τύρβη" (mixing/spinning) is a centrifugal compressor powered by a high speed turbine that is driven by an engine's exhaust gases. Its benefit lies with the compressor increasing the mass of air entering the engine (forced induction), thereby resulting in greater performance (for either, or both, power and efficiency). They are popularly used with internal combustion engines (e.g., four-stroke engines like Otto cycles and Diesel cycles). Turbochargers have also been found useful compounding external combustion engines such as automotive fuel cells.

The term turbocharger is a modern one, derived by shortening the turbosupercharger, which was widely used during the World War II era and earlier. This term refers to the fact that turbochargers are a specific type of supercharger, one that is driven by a turbine. The most common form of supercharger at the time, which was often referred to as a "geared supercharger", was mechanically driven by the engine, whereas turbochargers are always driven by a turbine that gets its power from the engine's exhaust stream. Twinchargers combine a supercharger and turbocharger.

Turbochargers are also employed in certain two-stroke cycle diesel engines, which would normally require a Roots blower for aspiration. In this specific application, mainly Electro-Motive Diesel (EMD) 567, 645, and 710 Series engines, the turbocharger is initially driven by the engine's crankshaft through a gear train and an overriding clutch, thereby providing aspiration for combustion. After the engine achieves combustion, and after the exhaust gases reach sufficient temperature, the overriding clutch disengages the turbo-compressor from the gear train and the turbo-compressor is thereafter driven exclusively by the turbine, which, in turn, is driven by the exhaust gases. In the EMD application, the turbocharger is used for normal aspiration during starting and low power output settings and is used for true turbocharging during medium and high power output settings. This is particularly beneficial at high altitudes, as are often encountered on western U.S. railroads. One EMD engine model was fitted with a "locked" turbocharger; it was used in normal aspiration mode during starting and all power output settings.

Forced induction dates from the late 19th century, when Gottlieb Daimler patented the technique of using a gear-driven pump to force air into an internal combustion engine in 1885. The turbocharger was invented by Swiss engineer Alfred Büchi, who received a patent in 1905 for using a compressor driven by exhaust gasses to force air into a piston engine. During the First World War French engineer Auguste Rateau fitted turbochargers to Renault engines powering various French fighters with some success. In 1918, General Electric engineer Sanford Alexander Moss attached a turbo to a V12 Liberty aircraft engine. The engine was tested at Pikes Peak in Colorado at 14,000 feet (4,300 m) to demonstrate that it could eliminate the power loss usually experienced in internal combustion engines as a result of reduced air pressure and density at high altitude. General Electric called the system turbosupercharging.

Turbochargers were first used in production aircraft engines such as the Napier Lioness in the 1920s, although they were less common than engine-driven centrifugal superchargers. Ships and locomotives equipped with turbocharged Diesel engines began appearing in the 1920s. Turbochargers were also used in aviation, most widely used by the United States, which led the world in the technology due to General Electric's early start. During World War II, notable examples of US aircraft with turbochargers include the B-17 Flying Fortress, B-24 Liberator, P-38 Lightning and P-47 Thunderbolt. The technology was also used in experimental fittings by a number of other manufacturers, notably a variety of Focke-Wulf Fw 190 models, but the need for advanced high-temperature metals in the turbine kept them out of widespread use.

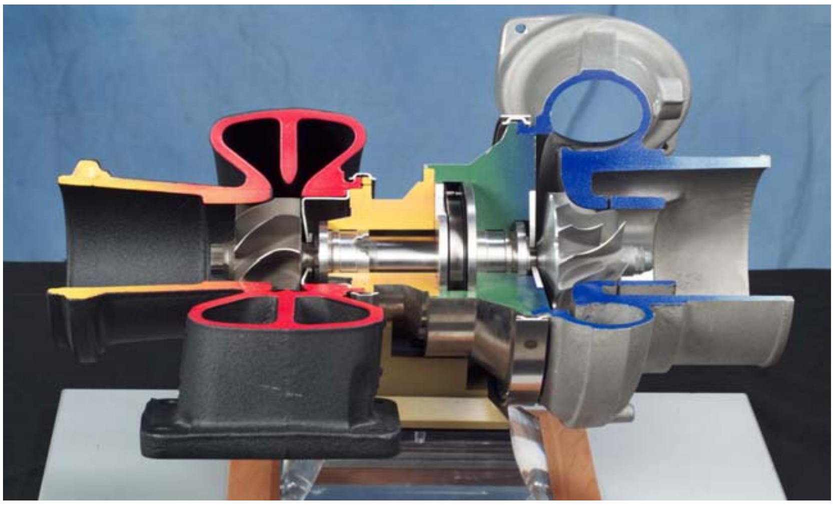


Fig.1. Cut-away view of an air foils bearing-supported turbocharger

All naturally aspirated Otto and diesel cycle engines rely on the downward stroke of a piston to create a low-pressure area (less than atmospheric pressure) above the piston in order to draw air through the intake system. With the rare exception of tuned-induction systems, most engines cannot inhale their full displacement of atmospheric-density air. The measure of this loss or inefficiency in four-stroke engines is called volumetric efficiency. If the density of the intake air above the piston is equal to atmospheric, then the engine would have 100% volumetric efficiency. However, most engines fail to achieve this level of performance.

This loss of potential power is often compounded by the loss of density seen with elevated altitudes. Thus, a natural use of the turbocharger is with aircraft engines. As an aircraft climbs to higher altitudes, the pressure of the surrounding air quickly falls off. At 5,486 m (18,000 ft), the air is at half the pressure of sea level, which means that the engine will produce less than half-power at this altitude.

The objective of a turbocharger, just as that of a supercharger, is to improve an engine's volumetric efficiency by increasing the intake density. The compressor draws in ambient air and compresses it before it enters into the intake manifold at increased pressure. This results in a greater mass of air entering the cylinders on each intake stroke. The power needed to spin the centrifugal compressor is derived from the high pressure and temperature of the engine's exhaust gases. The turbine converts the engine exhaust's potential pressure energy and kinetic velocity energy into rotational power, which is in turn used to drive the compressor.

A turbocharger may also be used to increase fuel efficiency without any attempt to increase power. It does this by recovering waste energy in the exhaust and feeding it back into the engine intake. By using this otherwise wasted energy to increase the mass of air, it becomes easier to ensure that all fuel is burned before being vented at the start of the exhaust stage. The increased temperature from the higher pressure gives a higher Carnot efficiency.

The control of turbochargers is very complex and has changed dramatically over the 100-plus years of its use. A great deal of this complexity stems directly from the control and performance requirements of various engines with which it is used. In general, the turbocharger will accelerate in speed when the turbine generates excess power and decelerate when the turbine generates deficient power. Aircraft, industrial diesels, fuel cells, and motor-sports are examples of the wide range of performance requirements.

In all turbocharger applications, boost pressure is limited to keep the entire engine system, including the turbo, inside its thermal and mechanical design operating range. Over-boosting an engine frequently causes damage to the engine in a variety of ways including pre-ignition, overheating, and over-stressing the engine's internal hardware.

For example, to avoid engine knocking (pre-ignition or detonation) and the related physical damage to the engine, the intake manifold pressure must not get too high, thus the pressure at the intake manifold of the engine must be controlled by some means. Opening the waste-gate allows the energy for the turbine to bypass it and pass directly to the exhaust pipe. The turbocharger is forced to slow as the turbine is starved of its source of power, the exhaust gas. Slowing the turbine/compressor rotor begets less compressor pressure.

In modern installations, an actuator controlled manually (frequently seen in aircraft) or an actuator controlled by the car's Engine Control Unit, forces the wastegate to open or close as necessary. Again, the reduction in turbine speed results in the slowing of the compressor, and in less air pressure at the intake manifold.

In the automotive engines, boost refers to the intake manifold pressure that exceeds normal atmospheric pressure. This is representative of the extra air pressure that is achieved over what would be achieved without the forced induction. The level of boost may be shown on a pressure gauge, usually in bar, psi or possibly kPa. Anything above normal atmospheric level is considered to be boost.

In most aircraft engines the main benefit of turbochargers is to maintain manifold pressure as altitude increases. Since atmospheric pressure reduces as the aircraft climbs, power drops as a function of altitude in normally aspirated engines. Aircraft manifold pressure in western-built aircraft is expressed in inches of mercury, where 29.92 inches is the standard sea-level pressure.

In high-performance aircraft, turbochargers will provide takeoff manifold pressures in the 30- to 42-inchHg (1- to 1.4 bar) range. This varies according to aircraft and engine types. In contrast, the takeoff manifold pressure of a normally aspirated engine is about 27 in. Hg, even at sea level, due to losses in the induction system (air filter, ducting, throttle body, etc.).

As the turbocharged aircraft climbs, however, the pilot (or automated system) can close the wastegate, forcing more exhaust gas through the turbocharger turbine, thereby maintaining manifold pressure during the climb, at least until the critical pressure altitude is reached (when the wastegate is fully closed), after which manifold pressure will fall. With such systems, modern high-performance piston engine aircraft can cruise at altitudes above 20,000 feet, where low air density results in lower drag and higher true airspeeds. This allows flying "above the weather". In manually controlled wastegate systems, the pilot must take care not to overboost the engine, which will cause pre-ignition, leading to engine damage. Further, since most aircraft turbocharger systems do not include an intercooler, the engine is typically operated on the rich side of peak exhaust temperature in order to avoid overheating the turbocharger.

In non-high-performance turbocharged aircraft, the turbocharger is solely used to maintain sea-level manifold pressure during the climb (this is called turbo-normalizing).

All turbocharger applications can be roughly divided into 2 categories, those requiring rapid throttle response and those that do not. This is the rough division between automotive applications and all others (marine, aircraft, commercial automotive, industrial, locomotives). While important to varying degrees, turbo lag is most problematic when rapid changes in engine performance are required.

Turbo lag is the time required to change speed and function effectively in response to a throttle change. For example, this is noticed as a hesitation in throttle response when accelerating from idle as compared to a naturally aspirated engine. Throttle lag may be noticeable under any driving condition, yet becomes a significant issue under acceleration. This is symptomatic of the time needed for the exhaust system working in concert with the turbine to generate enough extra power to accelerate rapidly. A combination of inertia, friction, and compressor load are the primary contributors to turbo lag. By eliminating the turbine, the directly driven compressor in a supercharger does not suffer from this problem.

Lag can be reduced in a number of ways:

1. by lowering the rotational inertia of the turbocharger; for example by using lighter, lower radius parts to allow the spool-up to happen more quickly. Ceramic turbines are of benefit in this regard and or billet compressor wheel.
2. by changing the aspect ratio of the turbine.
3. by increasing the upper-deck air pressure (compressor discharge) and improving the wastegate response; this improves performance but cost increases and reliability decreases.
4. by reducing bearing frictional losses; by using a foil bearing rather than a conventional oil bearing. This reduces friction and contributes to faster acceleration of the turbo's rotating assembly.
5. Variable-nozzle turbochargers greatly reduce lag.
6. by decreasing the volume of the upper-deck piping.
7. by using multiple turbos sequentially or in parallel.
8. by utilizing an Antilag system.

Lag is not to be confused with the boost threshold. The boost threshold of a turbo system describes the lower bound of the region within which the compressor will operate. Below a certain rate of flow at any given pressure multiplier, a given compressor will not produce significant boost. This has the effect of limiting boost at particular rpm regardless of exhaust gas pressure. Newer turbocharger and engine developments have caused boost thresholds to steadily decline.

Electrical boosting ("E-boosting") is a new technology under development; it uses a high-speed electrical motor to drive the turbocharger to speed before exhaust gases are available, e.g., from a stop-light. An alternative to e-boosting is to completely separate the turbine and compressor into a turbine-generator and electric-compressor as in the hybrid turbocharger. This allows the compressor speed to become independent to that of the turbine. A similar system utilising a hydraulic drive system and overspeed clutch arrangement was fitted in 1981 to accelerate the turbocharger of the MV Canadian Pioneer (Doxford 76J4CR engine).

Turbochargers start producing boost only above a certain exhaust mass flow rate. The boost threshold is determined by the engine displacement, engine rpm, throttle opening, and the size of the turbo. Without adequate exhaust gas flow to spin the turbine blades, the turbo cannot produce the necessary force needed to compress the air going into the engine. The point at full throttle in which the mass flow in the exhaust is strong enough to force air into the engine is known as the boost threshold rpm. Engineers have, in some cases, been able to reduce the boost threshold rpm to idle speed to allow for instant response. Both Lag and Threshold characteristics can be acquired through the use of a compressor map and a mathematical equation.

Some engines, such as V-type engines, utilize two identically sized but smaller turbos, each fed by a separate set of exhaust streams from the engine. The two smaller turbos produce the same (or more) aggregate amount of boost as a larger single turbo, but since they are smaller they reach their optimal RPM, and thus optimal boost delivery, more quickly. Such an arrangement of turbos is typically referred to as a parallel twin-turbo system. The first production automobile with parallel twin turbochargers was the Maserati Biturbo of the early 1980s. Later such installations include Porsche 911 TT, Nissan GT-R, Mitsubishi 3000GT VR-4, Nissan 300ZXTT, Audi RS6, and BMW E90.

Fig.2. A pair of turbochargers mounted to an Inline 6 engine (2JZ-GTE from a MkIV Toyota Supra) in a dragster.

Some car makers combat lag by using two small turbos. A typical arrangement for this is to have one turbo active across the entire rev range of the engine and one activates at higher RPM. Below this RPM, both exhaust and air inlet of the secondary turbo are closed. Being individually smaller they do not suffer from excessive lag and having the second turbo operating at a higher RPM range allows it to get to full rotational speed before it is required.

Such combinations are referred to as a sequential twin-turbo. Porsche first used this technology in 1985 in the Porsche 959. Sequential twin-turbos are usually much more complicated than a single or parallel twin-turbo systems because they require what amounts to three sets of intake and waste gate pipes for the two turbochargers as well as valves to control the direction of the exhaust gases. Many new diesel engines use this technology not only to eliminate lag but also to reduce fuel consumption and reduce emissions.

2. TWO COMPRESSION STAGES TURBOCHARGER-INVENTION PATENT PRESENTATION

The Authors are proposing a new concept of Two Compression Stages Turbocharger with compressor rotors placed in opposition installed inside a common housing, solution which is simplifying the construction and making it in the same time more compact. The construction solution itself is solving the problem of the reaction time (Lag) for the High Pressure compression stage when the engine demand for extra pressure is sudden. Some of the main elements are to be seen in the figures below as follows: 3-Turbine rotor for the Low pressure stage (LP); 4-Turbine Housing; 5-Exhaust gases Low Pressure turbine duct; 9-Exhaust gases High Pressure (HP) turbine duct ; 10- Turbine rotor for the High pressure stage; 14-Compressor housing; 15- High pressure compressor rotor; 18-Low pressure compressor rotor; 22-Inlet for exhaust gases for Low Pressure turbine; 23-Inlet for exhaust gases for high Pressure turbine.

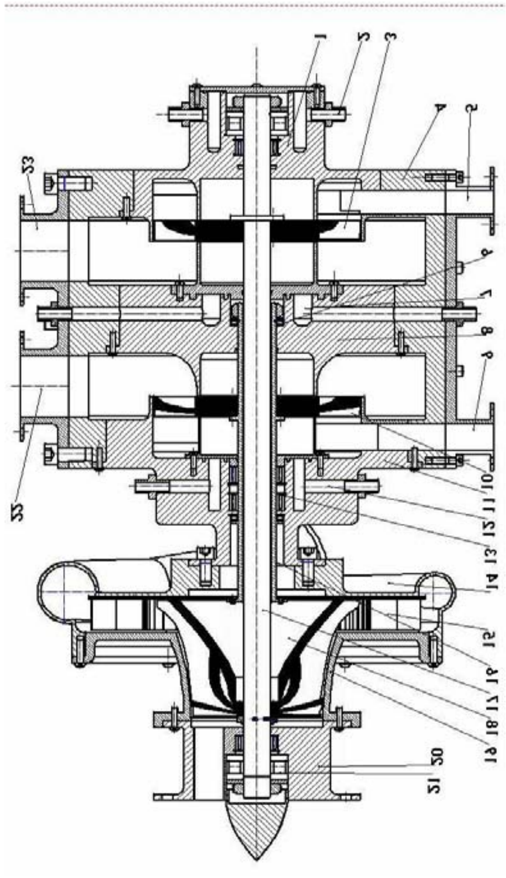


Fig.3. Cross-section of Turbocharger

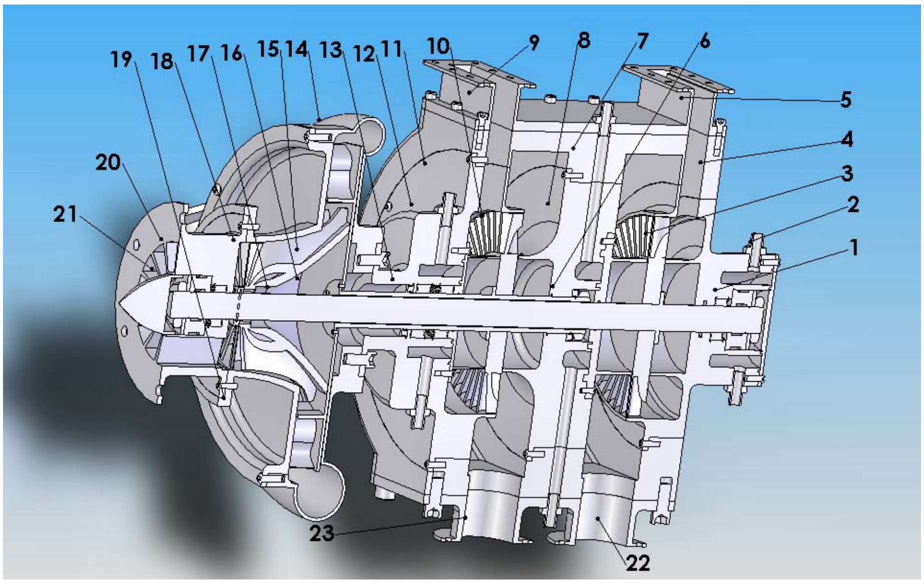


Fig.4.3D View of Turbocharger

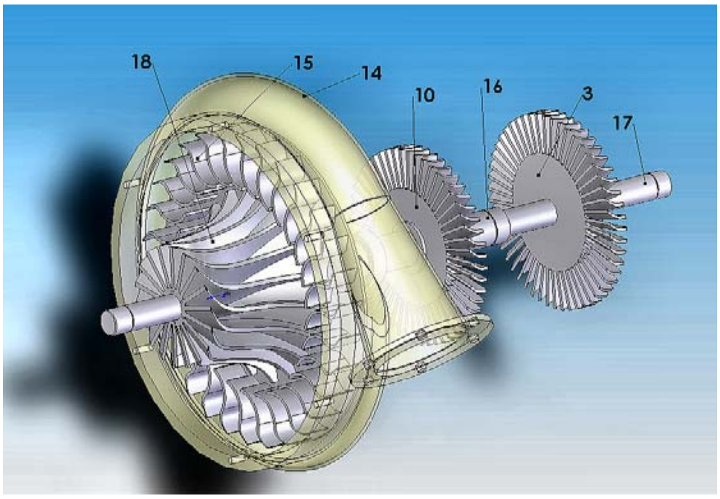


Fig.5. Turbines rotors and compressor rotors

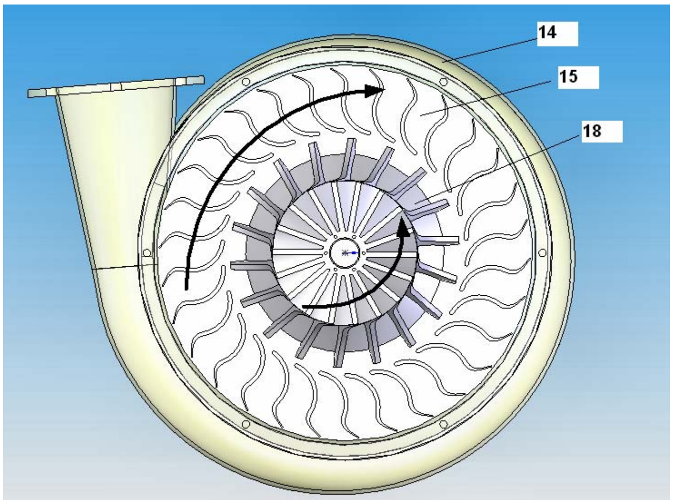


Fig.6. Compressor housing and compressor's HP and LP stages rotors

How it works?

The exhaust burned gases coming from the engine are directed to the 22-Inlet for exhaust gases for Low Pressure turbine and 23-Inlet for exhaust gases for high Pressure turbine. They are putting in motion 3-Turbine rotor for the Low pressure stage (LP) and 10-Turbine rotor for the High pressure stage. 3 and 10 are placed on the same shafts with 15-High pressure compressor rotor; and 18-Low pressure compressor rotor which are delivering compressed air to the engine.

For normal functioning of the engine the HP compression stage is not working, and that is via a throttling valve for instance, the exhaust gases coming from the engine is feeding only 22-Inlet for exhaust gases for Low Pressure turbine and only 18-Low pressure compressor rotor is working whereas the 15- High pressure compressor rotor is still playing just a role of guiding and transforming the kinetic energy of the air in static pressure.

Once the engine demand for air is increasing the 23-Inlet for exhaust gases for high Pressure turbine receives exhaust gases and 10- Turbine rotor for the High pressure stage is delivering extra kinetic energy to the air and thus increasing the pressure of the air to feed the engine. Since the constructive solution is very compact and between compression stages the distance/gap is extremely small, the reaction time is almost instantaneous and depends entirely only of the reaction time of the throttling valve.

3. NUMERICAL SIMULATION

Several numerical simulations (with finite volumes) were performed for various scenarios. The scenarios are covering the functioning of the device for 8000, 12000 and 16000 rpm and for delivered pressures from 0 bar (r) corresponding to atmosphere releasing to 0.5, 1, 1.5, 2, 2.5, and 3 bar pressure to the exit of the second stage of the compressor and which is supposed to be delivered inside the engine.

We'll present in the followings only the simulation results for the rotors speed of 16000 rpm and 3 bar pressure to the exit of the second stage. The rationale for this simulation scenario is that 16000 rpm is somehow a mild value for a turbocharger to function whereas 3 bar output pressure is 50-70% higher than any existing commercial highly efficient turbochargers in which 2 bar is considered as being a value reached by the most competitive ones in the market. To these limit functioning values the behavior of the proposed turbocharger is numerically studied and analyzed.

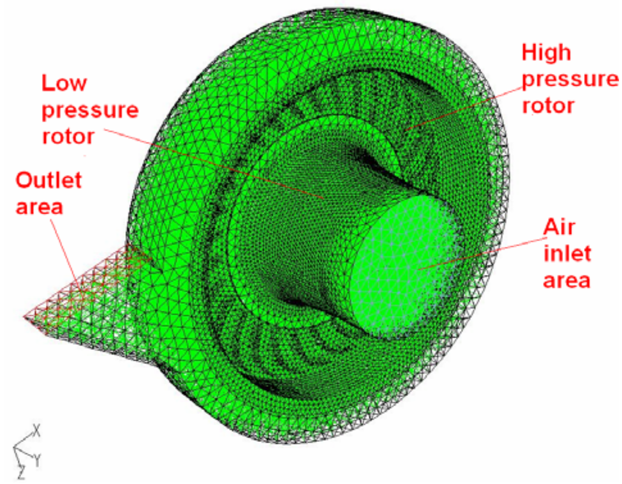


Fig.7. Finite volumes grid

The fluid domain geometry and the finite volumes elements grid are defined as in figure above. We used 214,168 finite volume cells with 52,192 nodes with 6 cell zones and 21 face zones in order to simulate the rotation of the rotors. In the figure are defined the inlet air area where the air is accessing the low pressure rotor (here the boundary condition is 0 bar (r) corresponding to atmosphere), the outlet air area from which the compressed air is leaving the turbocharger and where the boundary condition is 3 bar output pressure to feed the engine.

The air properties were defined as constant density 1.225 kg/m^3 and constant viscosity of 1.7893 kg/m-s.

After several thousand iterations in which the stability of solutions was reached, the results are as follows:

3.1 Computed Static Pressure

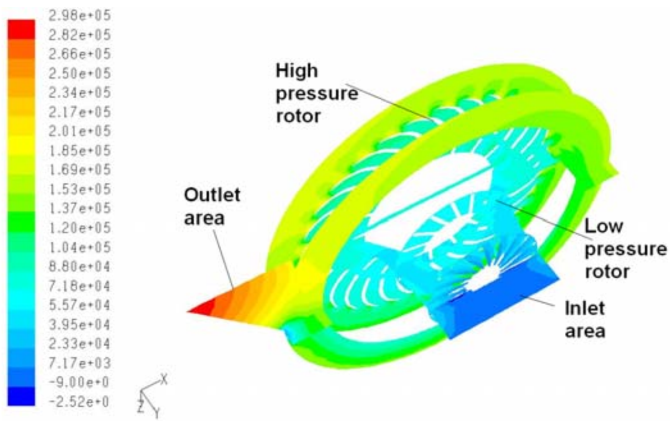


Fig.8. Computed static pressure

In order to make explicit the results some sectioning planes were defined to capture the results for the inlet-outlet areas and the results profiles along the rotors as one can see in the figure above.

By analyzing the results one may see that the first stage compressor rotor is increasing the static pressure from 0 bar (r) existing to the inlet area to 7.18e04 Pa whereas the second stage is boosting the pressure from 7.18e04 Pa to 2.34e05 Pa. To the outlet area the static pressure is near 3 bars so that if the load of the proposed turbocharger is 3 bars then the device is working properly.

3.2. Computed Dynamic Pressure

As seen in the following figure the dynamic pressure developed by the device is steadily increasing from 6.85 Pa at the inlet area to a peak of 2.06e05 Pa near to the outlet area. The second stage rotor is the most effective in increasing the values.

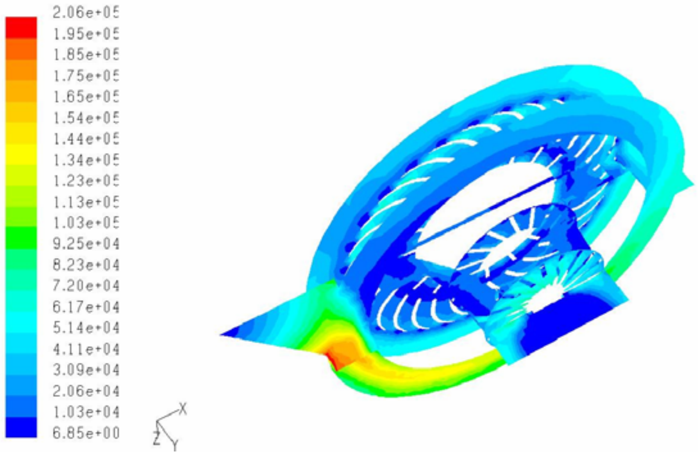


Fig.9.Computed dynamic pressure

3.3 Computed Absolute Pressure

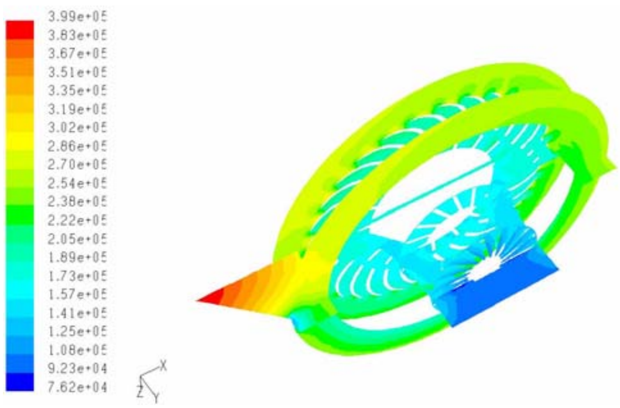


Fig.10.Computed absolute pressure

As seen in the above figure the computed absolute pressure developed by the device is steadily increasing from 7.62e04 Pa at the inlet area level to a peak of 3.99e05 Pa to the outlet area. The second stage rotor again is the most effective in increasing the values of the parameter.

3.4 Computed Total Pressure

As seen in the figure below, the computed total pressure developed by the device is steadily increasing from 1.35e04 Pa at the inlet area to a peak of 3.07e05 Pa to the outlet area. The second stage rotor again is the most effective in increasing the values of the parameter.

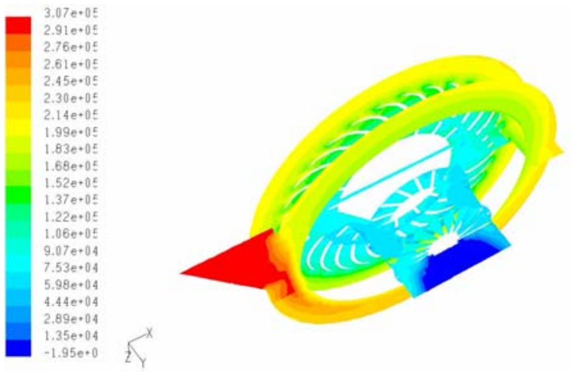
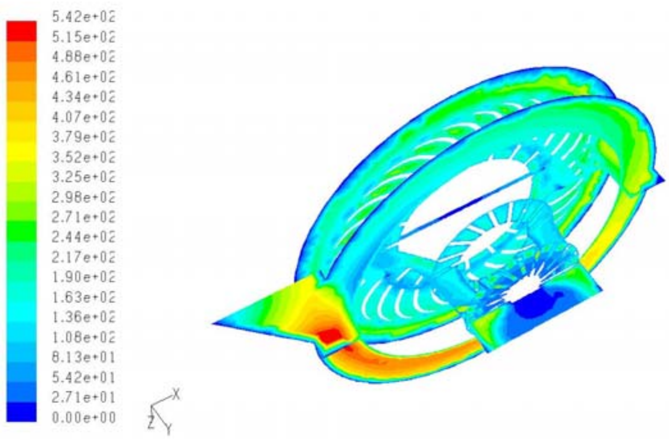


Fig.11.Computed total pressure

3.5 Computed Total Velocity fields



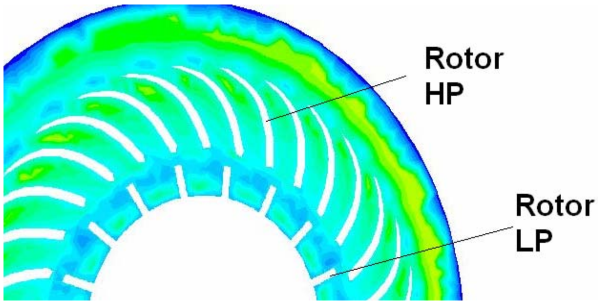


Fig.12. Computed total velocity

The total velocity of the fluid is defining the kinetic energy developed inside the device. As to be seen in the above figure the total velocity is increasing from 0 m/s in the inlet area to a maximum of 542 m/s right near the outlet area. By comparing the velocity profiles computed in the first stage rotor and the second stage rotor, we may pull the conclusion that the second compression stage is the most effective in terms of imposed kinetic energy to the fluid.

4. CONCLUSIONS

This paperwork is proving that the proposed high efficiency turbocharger is a viable solution to be adopted when the engine manufacturer is looking for extra-power from any existing type of combustion engine. The solution is as obvious is simple, elegant and compact, which can be realized with the existing technology.

By analyzing the numerical simulation we may pull the conclusion that the existence of the second compression stage rotor is greatly improving the output pressure of the device and is consistently shortening the reaction time.

This new turbocharger should be a must in the next generation of combustion engines.

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LINGUISTIC ANALYSIS AS A SOURCE OF TEACHING/LEARNING MATERIALS DESIGN

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The paper focuses on the methods and techniques of composing teaching/learning materials for marine engineers who are trained to receive Bachelor Degree. Maritime English language materials meant for communicative activities are linguistically oriented, authentic and highly motivating from the professional point of view. These materials are based on the arrangement principles of English-Russian Dictionary of Maritime Terms developed at ESP department of the Academy. The paper suggests terminographic essays for the language classroom activities as a means of practical work with engineering terms.

***Keywords**:* teaching/learning materials*,* marine engineers, a terminographic essay

1. INTRODUCTION

The English-Russian Dictionary of Maritime Terms contains 10 000 terms and expressions used in texts covering multiple themes, namely: Introducing Oneself. Personal documents. Types of documents. Preparing for an Interview. Letters, numbers, colours. Maritime code words. Times at sea and at shore. Languages, nationalities, flags. Maritime jobs and professions. Functions and duties. Daily routine. Places and locations. Countries, water bodies. Various geographical names. Maps and charts. Longitude, latitude. A ship’s dimensions particulars, parts, structure, functional zones. Types of vessels. Motion and directions: navigation, propulsion. Types of a vessel’s equipment. Engines. Auxiliary equipment. Running the vessel. The bridge. The engine room. Watches and watch keeping. SMCP: on-board, external. VHF radio. Weather. Weather forecast. Natural disasters. Emergency situations. Safety equipment and its location. Berthing, mooring, anchoring. Piloting. Port and port infrastructure. Port’s administration, customs, sanitary inspection. Navigational aids. Cargoes: types, loading/discharging operations. Cargo handling equipment. Deck equipment. Bunkering operations. Oils and fuels. Checking supplies. Incidents and accidents. Injuries. First aid.

The Dictionary of Maritime Terms has been designed on communicative principles introducing the terms and expressions in real situations and context thus making the entries description almost ready, prefabricated terminological materials. If necessary, they are expanded and converted into a kind of terminographic descriptions, or terminographic essays. Some of them are presented in this paper.

2. TERMINOGRAPHIC ESSAYS FOR MARINE ENGINEERS

1. Essay 1 MARITIME JOBS: Wiper. TEXT 1: ***The wiper*** is not a qualified member of the engine room in the true sense of the position. He is an all-around worker in the Engine Department of an oil-fired vessel. His is the only position open in that department for beginners and others not qualified in the more responsible ratings. The wiper washes paintwork, chips, scrapes, paints, and performs all those various duties tending to maintain the machinery spaces in a clean condition. Where overhauling and repair work of boilers and machinery is carried on, the wiper helps in various ways, and it is through the knowledge that he gains while doing this work that he prepares himself for advancement. He should be familiar with nautical terms. He should realize the importance of emergency drills, know his stations in each, and be able to fulfill his part should the necessity arise to combat fire or abandon ship. As an engine department worker he should have an interest in mechanics, and be familiar with the names and the purposes of all the units in the power plant of the vessel. Generally he is a day worker, and is not assigned to a watch. He should, as quickly as possible, familiarize himself with the hazards of using oil fuels, and operating pressure vessels.

INTRODUCTION OF TERMS RELATED TO THE TOPIC: **To wipe – a wiper**

A paint – to paint – painting – paintwork. To clean – a cleaner – cleaning . To work – a work – a worker – a workman - working – works (pl). Day worker = Day labourer Day-labourer (One who works by the day; - usually applied to a workman who does not work at any particular trade.) **To scrape – a scrape** [Old English *scrapian;* related to Old Norse *skrapa,* Middle Dutch *schrapen,* Middle High German *schraffen*] - To remove (an outer layer, for example) from a surface by forceful strokes of an edged or rough instrument: scraped the wallpaper off before painting the wall. The act of scraping; a scraped place.

Trash *Synonyms*: **rubbish, scrap, chip (**мусор; то, что нужно убрать**)**

Paintwork - a surface, such as wood or a car body, that is painted; the painted surface of something, for example the body of a car or the wooden surfaces in a building. (Similar word formation: *Needlework* - Work, such as sewing or embroidery, that is done with a needle.

Woodwork - Objects made of or work done in wood, especially wooden interior fittings in a house, as moldings, doors, staircases, or windowsills; *knitwork* - needlework created by interlacing yarn in a series of connected loops using straight eyeless needles or by machine.

ENGLISH-RUSSIAN VOCABULARY:

-*Nouns:* **not a qualified member**(неквалифицированный член команды) **an all-around worker** (разнорабочий) **engine room** (машинное отделение) **machinery spaces** (машинный отсек) **a day worker** (неквалифицированный рабочий) **not assigned to a watch** (не назначается вахтенным) **paint** (краска) **surface** (поверхность) **trash** (мусор) **overhauling and repair work** (ремонтные работы) **emergency drills** (учебная тревога) **power plant** (силовая, энергетическая установка) **oil fuels** (топливо) **hazards** (опасность, риск) **importance** (важность, значение);

-*Verbs*: **to wash paintwork** (мыть окрашенные поверхности) **to chip** (состругать) **to scrape** (соскребать) **to paint** (красить) **to maintain the machinery spaces in a clean condition** (поддерживать машинный отсек в чистоте) **to know stations in drills** (знать свои функции на учениях) **to use oil fuels** (использовать масла и горючее) **to handle jobs on deck** (проводить работу на палубе) **to combat fire** (бороться с пожаром) **to abandon ship** (покидать судно) **to have an interest in mechanics** (интересоваться механикой) **to keep in order** (содержать в порядке) **to pick up trash** (собирать мусор) **to pick up tools** (собирать, убирать инструменты) **to familiarize** (знакомиться с …) **to prepare for advancement** (готовиться к самообразованию) **to understand** (понимать) **to realize** (осознавать) **to carry on** (проводить, осуществлять).

TEXT 2: **Wiper's responsibilities** revolve around keeping the engine room and rest of the vessel well maintained. This is no easy task though. But if a marine career is what you are interested in, wiper marine job would be the best way to get a firsthand experience of life on ships. Unlike most jobs on ships, a wiper gets to learn a lot more. A person's time as a wiper on a ship can be regarded as the time of apprenticeship for preparing for a maritime job later in the future. **How to become a wiper on ship?** Since a wiper's job is basically the beginning point of a marine career, good news is that qualification requirement for this position isn't too much. All you need is a Merchant Mariners Document or a certificate as a wiper (Equivalent certificate for people in other countries). The MMD is a basic requirement to qualify you as a certified person to handle jobs on deck, including handling some marine equipment and acquainting you with basic terms and definitions of marine world. A medical test including background test, drug test and physical fitness test. To obtain a maritime job of wiper, the best way would be to get information from various jobsites. With experience, a person can expect to get higher rank, more responsibilities and better pay. **Wiper** is in the engine room, emergency engine room out, plus the inert gas plant on the rear side outside; plus an experienced Oiler is the senior crew again in the engine room in duty with the Engine officer in-duty. *Engine fitter* is generally in the engine=as per 2nd engineer or Chief Engineer. **Wiper:** Trash pick up in engine room, tool pick up, general cleaning and painting of engine room. The Wiper's duties include general engine department maintenance, cleaning, painting, preservation of the ship and assisting unlicensed and licensed engineering department personnel with machinery repairs. Entry level position, basic English Language skills required.

VOCABULARY BOX TO DESCRIBE ONE'S PROFESSIONAL DUTIES:

- to be responsible for (отвечать за…) **to be in charge of** (руководить) **to carry out** (осуществлять) **to report to** (подчиняться) **to run** (управлять) **to maintain** (обслуживать, поддерживать) **to repair** (ремонтировать) **to play a role** (играть роль) **to participate in** (участвовать в…) **to take part in** (принимать участие в…) **to stand watch** (нести вахту)

to operate (действовать; работать; производить операции; эксплуатировать; обслуживать) **to keep** (держать) **to upkeep** (поддерживать) **to clean** (чистить, делать чистым) **to wipe** (вытирать, обтирать) **to oil** (смазывать) **to lubricate** (смазывать) **to direct** (направлять)

to oversee (контролировать) **to supervise** (направлять) **to instruct** (инструктировать) **to inspect** (инспектировать) **to execute** (исполнять) **to store** (хранить) **to inventory** (проверять наличие) **to serve** (служить) **to receive** (получать) **to issue** (давать, выдавать) **to cook** (готовить /пищу/)

-**on board ship** (на борту судна) **a deck** (палуба) **a superstructure** (надстройка) **an engine room** (машинное отделение)

-**equipment** (оборудование) **machinery** (механизмы, машины) **mechanisms** (механизмы) **engines** (двигатели) **auxiliary equipment** (вспомогательное оборудование)

-**a rank** (чин, ранг) **a position** (должность) **a profession** (профессия) **a crew** (экипаж) **a member of the crew** (член экипажа) **a junior member of the crew** (младший член экипажа) **a senior member of the crew** (старший член экипажа) **a chief** (начальник) **a subordinate** (подчиненный) **a chief officer** (старший офицер) **an assistant** (помощник) **officers** (офицеры) **ratings** (рядовые) **a graduate** (выпускник)

- a duty –duties (обязанность-обязанности) **a responsibility** (ответственность) **a task** (задание) **an assignment** (задание) **a role** (роль) **a daily routine** (распорядок дня) **a schedule** (график)

Manual tools used by a wiper: *a bucket, a brush, a scraper, a mop, a paint brush, a paint roller (Pictures)*

2. Essay 2 MEASURING TOOLS: METERS. DEFINITION: **me·ter** (mē'tər) *n.* Any of various devices designed to measure time, distance, speed, or intensity or indicate and record or regulate the amount or volume, as of the flow of a gas or an electric current. Any of various measuring instruments for measuring a quantity. An instrument for measuring, especially one that automatically measures and records the quantity of something, as of gas, water, miles, or time, when it is activated. –meter, **suffix.** Measuring device: *anemometer.* –meter: a combining form meaning "measure," used in the names of instruments measuring

quantity, extent, degree, etc.: *altimeter; barometer.* Etymology: [French **-mètre,** from Greek **metron,** measure] **Synonyms:** gauge, gage, device, tool, instrument.
Airmeter, n = air *meter (*A device that measures the flow of air, or gas, expressed in volumetric or weight units per unit time. Also known as *airometer*.)
Barometer, n (A scientific instrument used in meteorology to measure atmospheric pressure.)
Calorimeter, n (from Latin *calor*, meaning heat) is an object used for calorimetry, or the process of measuring the heat of chemical reactions or physical changes as well as heat capacity. An adiabatic calorimeter is a calorimeter used to examine a runaway reaction. Since the calorimeter runs in an adiabatic environment, any heat generated by the material sample under test causes the sample to increase in temperature, thus fuelling the reaction. The world's first **ice-calorimeter**, used in the winter of 1782-83, by Antoine Lavoisier and Pierre-Simon Laplace.
Chronometer, n (An exceptionally precise timepiece. Chronometers are used in scientific experiments, navigation, and astronomical observations. It was the invention of a chronometer capable of being used aboard ship, in 1762, that allowed navigators for the first time to accurately determine their longitude at sea.)
Echometer, n (A graduated scale for measuring the duration of sounds, and determining their different, and the relation of their intervals.)
Multimeter, n (An instrument designed to measure electrical quantities. A typical multimeter can measure alternating- and direct-current potential differences (voltages), current, and resistance, with several full-scale ranges provided for each quantity. Sometimes referred to as a volt-ohm meter (VOM), it is a logical development of the electrical meter, providing a general-purpose instrument. Many kinds of special-purpose multimeters are manufactured to meet the needs of such specialists as telephone engineers and automobile mechanics testing ignition circuits.)
Ondometer, n (An electric wave meter. An instrument for measuring the wavelengths of radio waves.)
Pluviometer- Etymology: [Probably from French pluviomètre : Latin pluvia, *rain*; see *pluvious* + -mètre, *-meter*.] Gauge consisting of an instrument to measure the quantity of precipitation. An instrument for measuring the amount of precipitation at a given location over a specified period of time. Also called *udometer*. Synonyms: rain gage, rain gauge, udometer.
Pitometer, n (Pitometer log is a type of navigation tool used in the ships for measuring the ship's speed relative to water. An integral part of dead reckoning system, pitometer log is used for both ships and submarines.**)**
Radiogoniometer, n (A **goniometer** is an instrument that either measures an angle or allows an object to be rotated to a precise angular position. The term **goniometry** is derived from two Greek words, *gōnia*, meaning angle, and *metron*, meaning measure. A miniature electro-mechanical goniometer stage. This type of stage is used primarily in the field of lasers and optics. *A positioning goniometer or goniometric stage is a device used to rotate an object precisely about a fixed axis in space.)*
Psychrometer, n (An instrument for measuring the tension of the aqueous vapor in the atmosphere, being essentially a wet and dry bulb hygrometer. A hygrometer consisting of a dry-bulb thermometer and a wet-bulb thermometer; their difference indicates the dryness of the surrounding air**)**
Ratiometer, n (A meter that measures the quotient of two electrical quantities; the deflection of the meter pointer is proportional to the ratio of the currents flowing through two coils.)
Salinometer, n- any device for measuring the amount of dissolved salts in a solution, esp. one that measures the electrical conductivity of a water sample.

Sillometer, n - applies to the area of general science can be defined as 'instrument measuring speed of ship'. An instrument for determining the speed of a ship without the aid of a log-line. The various forms include the indication of speed at any time or for any given length of time, as well as the total distance passed over.
Stadiometer, n - stadia, n (pl) [Italian, probably from Latin, pl. of stadium, *a unit of length*; see stadium.] Stadia is a telescopic instrument having two parallel lines through which intervals on a calibrated rod are observed, used to measure distances. The parallel lines in this instrument. The calibrated rod so used. The technique of measuring distances with this instrument.
Stadimeter, n (A stadimeter is an optical device for estimating the range to an object of known height by measuring the angle between the top and bottom of the object as observed at the device.)
Tachometer, n (An instrument indicating instantaneous rotary speed of a shaft in rpm. An instrument used to measure the rotations per minute of a rotating shaft. [Greek takhos, *speed* + -meter.])
Voltmeter, n -An instrument used for measuring the difference in voltage between two points in an electric circuit. Voltmeters typically make use of an ammeter that measures current flow across a known resistance inside the voltmeter; direct-current voltages can then be determined by Ohm's law. Digital voltmeters employ A/D converters to provide the numerical value of the voltage displayed.
Thrustmeter, n (An instrument for measuring static thrust)
Udometer, n (an archaic term for rain gauge) Gauge consisting of an instrument to measure the quantity of precipitation. [Latin ūdus, *wet* (contraction of ūvidus) + -meter.] **Syn.:** pluviometer, rain gage, rain gauge
Vibrometer, n (Any of several engineering devices that measure the characteristics of a vibrating structure.**)** A **laser Doppler vibrometer (LDV)** is a scientific instrument that is used to make non-contact vibration measurements of a surface. The laser beam from the LDV is directed at the surface of interest, and the vibration amplitude and frequency are extracted from the Doppler shift of the laser beam frequency due to the motion of the surface. The output of an LDV is generally a continuous analog voltage that is directly proportional to the target velocity component along the direction of the laser beam.

Essay 3 Different Types of Mechanical Measuring Tools and Gauges Used on Ships

TEXT: Machinery onboard ships require regular care and maintenance so that their working life and efficiency can be increased, and the cost of operation, which includes unnecessary breakdowns and spares, can be reduced. For different types of machinery and systems, different measuring tools, instruments and gauges are used on ship. Measuring instruments and gauges are used to measure various parameters such as clearance, diameter, depth, ovality, trueness etc. These are important engineering parameters which describes the condition of the working machinery.

INTRODUCTION OF TERMS: **Ruler and scales**: They are used to measure lengths and other geometrical parameters. They can be single steel plate or flexible tape type tool. **Calipers**: They are normally of two types- inside and outside caliper. They are used to measure internal and external size (for e.g. diameter) of an object. It requires external scale to compare the measured value. Some calipers are provided with measuring scale. Other types are odd leg and divider calliper. **Vernier caliper**: It is a precision tool used to measure a small distance with high accuracy. It has got two different jaws to measure outside and inside dimension of an object. It can be a scale, dial or digital type venire caliper. **Micrometer**: It is a fine precision tool which is used to measure small distances and is more accurate than the venire caliper. Another type is a large micrometer caliper which is used to measure large outside diameter or distance. **Feeler gauge**: Feelers gauges are a bunch of fine thickened steel strips with marked thickness which are used to measure gap width or clearance between surface and bearings. **Telescopic feeler gauge**: It is also known as tongue gauge and it consists of long feeler gauge inside a cover with tongue or curved edge. The long feeler strips protrude out of the cover so that it can be inserted in to remote places where feeler gauge access is not possible. **Poker gauge**: This gauge is used to measure propeller stern shaft clearance, also known as propeller wear down. **Bridge gauge**: Bridge gauges are used to measure the amount of wear of Main engine bearing. Normally the upper bearing keep is removed and clearance is measured with respect to journal. Feeler gauge can be used to complete the process. **Liner measurement tool**: Liner measurement tool is a set of straight assembled rod with marked length in each set. It is used to measure the wear down or increase in the diameter of the engine liner. **American Wire Gauge**: American wire gauge or AWG is a standard tool which is circular in shape and has various slots of different diameter in its circumference. It is used to measure cross section of an electric cable or wire. **Bore Gauge:** A tool to accurately measure size of any hole is known as bore gauge, It can be a scale, dial or digital type instrument**. Depth gauge:** A depth gauge is used to measure the depth of a slot, hole or any other surface of an object. It can be of scale, dial or digital type. **Angle plate or tool**: It is a right angle plate or tool used to measure the true right angle of two objects joined together. **Flat plate**: Flat plate is a précised flat surface used to measure flatness of an object when it is kept over the flat plate. **Dial Gauge**: Dial gauge is utilised in different tools as stated above and can be separately used to measure the trueness of the circular object, jumping of an object etc. **Lead Wire**: It is a conventional method to used soft lead wire or lead balls to measure the wear down or clearance between two mating surfaces. The lead wire or balls of fixed dimension is kept between two surfaces and both are tightened against each just as in normal condition. The increase in the width of the lead wire or ball will shoe the clearance or wear down.

3. CONCLUSIONS

Terminographic essays serve as guidelines for the language classroom activities in practical work with maritime terms. Developed on the basis of terminographic database, this type of teaching/learning materials for marine engineers appears to be efficient both as a linguistic source and a professional reference. Supplemented with ME language information (translation, definitions, etymology, synonyms, structural elements, etc.) each essay on a professional subject (represented by an individual term) helps to arrange a ME classroom activity on a linguistic base which is essential for ME training. According to researchers there are four components of an effective vocabulary programme: wide or extensive independent reading to expand word knowledge; instruction in specific words to enhance comprehension of texts containing those words; instruction in independent word-learning strategies; word consciousness and word-play activities to motivate and enhance learning (Graves, 2000). These ideas are extremely helpful in case of interdisciplinary communication arrangements (Thomas, 1993) for marine engineers.

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WELDING ALUMINUM ALLOY INVESTIGATIONS WITH EDDY-CURRENT DEFECTOSCOPY METHOD

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The purpose of this paper is to make investigations at aluminum alloy welded structures in condition of normal welding (TIG-tungsten inert gas welding), and the same procedure but arc-weld is disrupting and makes void spaces into the weld bead. It is very known that aluminum reacts with oxygen despite of using protective argon atmosphere and will cause porosity which decrease strength and ductility.

Keywords: mushy zone, brittle temperature range

1. INTRODUCTION

The combination of light weight and relatively high strength makes aluminum most popular metal that is welded. Aluminum is not difficult to join but aluminum welding is different from welding steels. Aluminum possesses properties that make welding it different than the welding of steels:

- High thermal conductivity;
- Low melting temperature;
- High thermal expansion coefficient;
- Aluminum oxide surface coating;
- The absence of color change as temperature approaches the melting point.

The normal metallurgical factors that apply to other metals, apply to aluminum as well. Aluminum is an active metal and it reacts with oxygen in the air to produce a thin hard film of aluminum oxide on the surface.

The melting point of aluminum oxide is approximately 1926^{o}C, which is almost three times the melting point of pure aluminum, 660^{o}C. In addition, this aluminum oxide film, particularly as it becomes thicker, will absorb moisture from the air

Moisture is a source of hydrogen which is the cause of porosity in aluminum welds. Hydrogen may also come from oil, paint, and dirt in the weld area. It also comes from the oxide and foreign materials on the electrode or filler wire, as well as from the base metal. Hydrogen will enter the weld pool and is soluble in molten aluminum. As the aluminum solidifies it will retain much less hydrogen and the hydrogen is rejected during solidification. With a rapid cooling rate free hydrogen is retained within the weld and will cause porosity. Porosity will decrease weld strength and ductility depending on the amount.

The aluminum oxide film must be removed prior to welding. If it is not all removed small particles of un-melted oxide will be entrapped in the weld pool and will cause a reduction in ductility, lack of fusion, and may cause weld cracking.

Aluminum conducts heat from three to five times as fast as steel depending on the specific alloy. This means that more heat must be put into the aluminum even though the melting temperature of aluminum is less than half that of steel.

Because of the high thermal conductivity, preheat is often used for welding thicker sections. If the temperature is too high or the period of time is too long it can be detrimental to weld joint strength in both heat-treated and work-hardened alloys. The preheat for aluminum should not exceed 204^{o}C, and the parts should not be held at that temperature longer than necessary. Because of the high heat conductivity procedures should utilize higher speed welding processes using high heat input. Both the gas tungsten arc and the gas metal arc processes supply this requirement.

The high heat conductivity of aluminum can also be helpful since if heat is conducted away from the weld extremely fast the weld will solidify very quickly. This with surface tension helps hold the weld metal in position and makes all-position welding with gas tungsten arc and gas metal arc welding practical.

The thermal expansion of aluminum is twice that of steel. In addition, aluminum welds decrease about 6% in volume when solidifying from the molten state. This change in dimension or attempt to change in dimension may cause distortion and cracking.

The final reason why aluminum is different to weld from steels is that it does not exhibit color as it approaches its melting temperature [1].

2. EXPERIMENTAL DATA

Table 1 Composition of base metal

Aluminum alloy sheet		
Chemical composition [%]	Al	99,4
	Si	0,216
	Fe	0,240
	Cu	0,0058
	Mn	0,0011
	Mg	0,0019
	Zn	0,0206
	Cr	0,0064
	Ni	0,0104
	Ti	0,0176
	Sn	0,0266
	Ga	0,0184

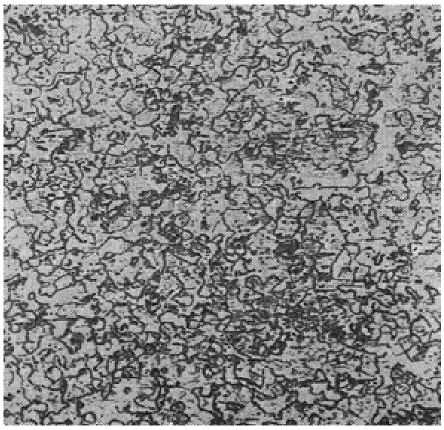

Fig. 1. Microstructure of MB (x300)

In the present study, aluminum alloy sheet 5 mm thickness is used as the base metal (MB). The chemical composition of base metal is presented in table 1 and welding wire has almost same chemical composition.

The microstructures of the welds and the base material were examined after conventional polishing and etching with 1 % fluorhidric acid solution.

The base metal is obtained through cold rolled process. Microstructural examination of this base metal showed the softly hardened grain structures (Fig. 1), oriented to yields way of the metal.

Aluminium alloys are highly sensitive to hot cracking phenomenon. It appears during solidification of the alloy, so it can be observed during welding, as well as during casting or other processes involving solidification.

During welding, components are subjected to high thermal gradients around the melting zone due to localized heat input. Solidification area, located at the rear of the melting zone, corresponds to a "mushy zone" where liquid and solid phases coexist. When solidification speed is not too high, the mushy zone is ranged between two isotherm surfaces corresponding to liquidus and solidus temperatures. However, for high solidification speed, the temperature range of the mushy zone is moved due to undercooling [2].

Hot tearing phenomenon is generally associated to a lack of ductility of the mushy zone when liquid fraction becomes too low. The material sensitivity to hot tearing can then be characterized by the ductility into a "Brittle Temperature Range" (BTR) corresponding to the interval between the "coherency temperature", where the liquid does not easily circulate because of the low permeability of the solid skeleton, and the "coalescence temperature", where the solid opposes mechanical resistance (Fig. 2). The solidification range width depends on the thermal gradient. The alloy studied in the article [3] has a wide range of fragility, the BTR is between 570-600°C. The heat load imposed by welding parameters, induced in this interval fragility microstructure and mechanical loading overall facilitating crack initiation.

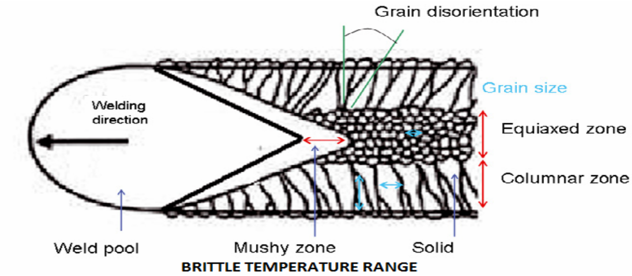

Fig. 2. Microstructural characteristics of welded joint [2]

3. INVESTIGATIONS WITH DEFECTOSCOPY METHOD

Eddy current examination is a process that may be used for determining the defects and consists in passing of the electric low current. A coil carrying an alternating current is placed close to the welded zone to be examined, inducing an eddy current in the specimen. Defects in the specimen will interrupt this eddy current flow and these perturbations can be detected by a second, search coil. The coils can be placed either side of a thin plate-like sample or can be wound to give side-by-side coils in a single probe. The equipment is calibrated using a defect-free specimen. The accuracy can be affected by metallurgical condition, and coil dimensions. These defects could be solidification cracking, impurities, or porosity zones [2].

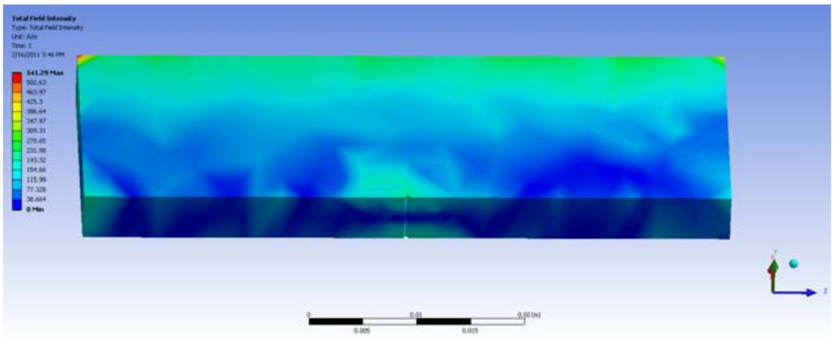

Fig. 3. The measurements of field current intensity near the solidification area with 0,5 mm defect diameter

Our study makes the defects aproximation with through and blind holes with different diameters and presents measurements of field intensity current in vicinity of them.

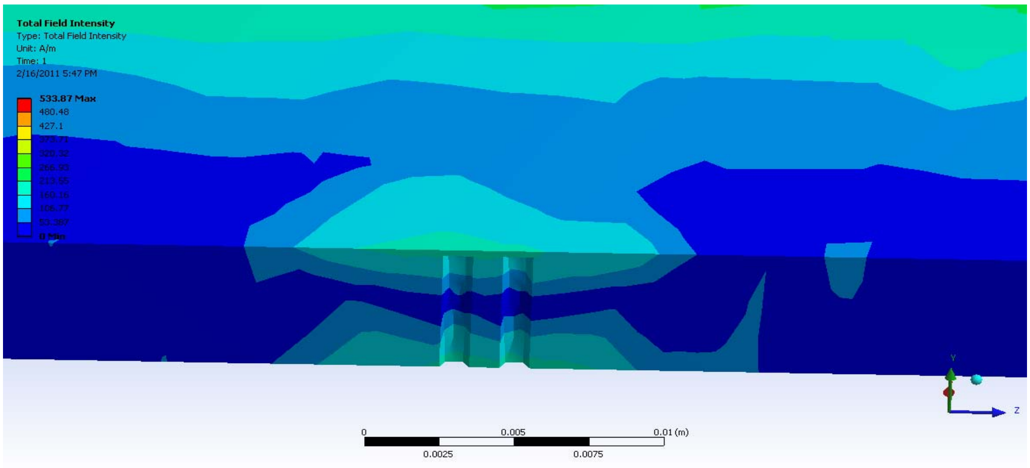

Fig.4. The measurements of field current intensity near the welded zone with 1 mm two blind defect diameter

3. CONCLUSIONS

Our study demonstrates that solidification cracking is a many faceted problem, with many influencing parameters including relationship between mechanical aspect induced by process and microstructure.

Alloying elements like iron and silica improve the mechanical properties of aluminum but they have high influences on welding aspects. Above concentration of 0,3-0,4% the iron occurs fragility and solidification cracking process.

It is known that columnar dendrite morphology, with dendrites growing in the thermal gradient direction, generally observed for low solidification speed and/or high thermal gradient, is more sensitive than equiaxe dendrite morphology (Fig. 2). Hot tearing appears when the mushy zone is subjected to critical strain and stress fields [2].

In welding, the mechanical loading is primarily produced by thermal strains due to temperature evolution in the mushy zone. High speed cooling after welding implies a solidification and thermal contraction of the solid skeleton (which depends on the expansion coefficient of the solid already formed).

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GREEN SHIP-THE FUTURE CONCEPT OF MARITIME TRANSPORT

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At the beginning of the 20th Century, as humanity entered the age of industrialism there was not a soul asking the question what the effects on the environment would be. However, the negative impacts that have gripped the entire planet are now undisputable, although at that time, because the human activity was negligible so was its impact.
This paper focuses on how maritime transport acts as a pollution source, and what can be done to reduce the quantities of pollutants, looking both at the existing technologies and at latest research programs.
The Green Ship idea refers to ideal ships that are environment friendly. We will detail this looking from two points of view:
The first one is the Green Ship being a vessel that uses alternative means of propulsion, where the internal combustion engine is replaced with electrical engines that use sun charged voltaic batteries, or rotary sails, or sails that are raised to high altitudes.
The second idea refers to what can be practically done on board ships to reduce pollution. This includes, improving the quality of fuel or lowering its sulphur content, improving the construction process or methods for ship hulls or engines.

Keywords: Environment pollution, Green Ships, MARPOL

1. INTRODUCTION

The continuous degradation of the marine environment should have been easily foreseen particularly when referring to the last 30 years period. It is a side effect of the heavy industrialization and development that is still found in the maritime transport and the world economy as a whole. There is no excuse for the way humanity has so badly managed pollution prevention and degradation of both the marine environment and other planet ecosystems.

Natural occurring pollution of the marine environment is almost completely inexistent when compared with man made ones.

The World Ocean, which covers almost three quarters of the world's surface, which is about 95% of the hydrosphere's volume, contains a variety of biological, mineral and energetic resources, most of which are not adequately studied or not even discovered.

The marine environment deterioration has become obvious throughout the world. Human activity has already caused damage to flora and fauna, the extinction of some fish species, altered the topography and caused the corrosion of the coastlines, and water's colour and density. Further damage is caused by excessive and uncontrolled fishing, the release of pollutants into the waters from both ships and land installations, the disposal of toxic waste, exhaust gases, invasive foreign species carried either in the ballast water or on the ships hull, the toxic paints and primers used for painting the ship, phonic pollution caused by ships, marine transport infrastructure and different nuclear experiments which take place in the maritime area.

Rivers which flow into oceans amplify sea water pollution. Inland waters are the perfect means of transportation for toxic waste and residues, as well as for many chemical substances like phosphates and nitrates. They also help carry harmful substances, like the ones used for pest control such as insecticides and herbicides, plastic materials and domestic waste. A large part of these polluting agents are a permanent source of pollution due to their non-degradable characteristic.

Initially, air pollution was not regarded as important as the one cause by oil spills, and toxic substances and garbage dumping. Latest reports concerning Earth's atmosphere show that nowadays ocean going vessels generate pollutant agents such as sulphur dioxide (SO_x) more than all the cars, trucks and buses combined. Ships represent one of the most important and most difficult to control pollution sources.

In the last 15 years, there was a drop in the level of pollution caused by cars and other means of transport which are powered by Diesel engines.

Heavy fuels used by ship engines have a higher concentration of sulphur than Diesel oil used by land means of transport.

Throughout time, a series of international conferences and conventions, of various importances, proved that humanity wishes to protect the marine environment and reap its benefits of many years to come.

The most important convention regarding marine pollution prevention is the 1973 MARPOL Convention. By it, certain standards were imposed to shipbuilders, ship owners and to all parties involved in maritime commerce. Over time the Convention was amended because of the ever-changing situations within the maritime transport industry. Such is the case with the 1978 Protocol, and the more recent adoption of the sixth annex to the Convention that refers to maritime ships generating exhaust and other gases in 2007.

However, because of the increasing number of treaties regarding pollution prevention between world states, initially only at ministerial level and later at presidential one, the European Parliament together with the European Council were able to develop long term policies and plans for the marine environment protection. This is why the "new community strategy" for preservation of the marine environment was established and Strasbourg.

This document states that by 2020 UE member states will have taken positive actions for a god ecological state of the marine environment. Such strategies will be implemented as to prevent any deterioration of ecological nature as well as to restore ecosystems that have already been affected by external factors.

The Strasbourg agreement establishes for the first time an integrated policy for the protection of the marine environment. This policy has the following guidelines: the conservation and protection of the marine environment, the elaboration of rules for the protection of such an environment which would guarantee that there will not ever be no impact or significant risk for marine biodiversity marine ecosystems human health or lawful.

The Strasbourg approved direction states for the first time an integrated strategy for the environment. This particular policy ensures the protection and the conservation of the marine environment, the progressive reduction of pollution, and getting guarantees that no further impact will ever take place that would impact or pose a serious risk for the marine biodiversity, marine ecosystems human health. Another line of strategy for the Strasbourg Convention is the limitation posed on the activities that can take pace in the marine environment. Such activities must not compromise either the use of the activities of future generation, or the capacity of the marine ecosystems to react to either man made or natural changes.

Efforts will have to be made both logistical and pecuniary so that these objectives are met and this convention is to serve its purpose. Member states have to take clear action in order for their territorial waters to be safe by the end of 2020.

2. SHIP AS A SOURCE OF MARINE POLLUTION AND MEANS OF REDUCING THEIR POLLUTION EFFECT

Environment pollution, especially the one caused by ships both sea going and those that are fond in the coastal areas is as follows: the pollution of the marine environment, atmospheric pollution and sonic pollution of a microhabitat.

There can not be any clear quantification of the risk posed by pollution and this would be beyond the purpose of combating ship pollution. However sonic pollution does not have the same impact as oil spills or garbage dumping. The impact of noxious gases on life in general can be visible enough, but it generally takes time to fully develop. Such is the case with the disappearance of entire fish species or plants.

The pollution of the atmosphere: develops when one or several substances is released in the atmosphere, with negative effect on the environment. Air polluters are the following: carbon dioxide, carbon monoxide, sulphur dioxide and other chemicals, exhaust gases from ships' engines or auxiliary diesel generators.

The pollution of the aquatic environment: develops as a result of the release of individual toxic substances (solid, liquid, gases or radioactive) into this environment. As a result the waters suffer chemical, physical or biological changes that make them improper for sustaining marine life. Furthermore it is dangerous for fishing or tourism activities to take place in the vicinity of such waters. Pollutant agents for the marine environment can be the following: ship diesel oil or oils, garbage dumps, toxic wastes, drained water, ballast water, and dumped paints.

The sonic pollution of a microclimate is produced by the propagation of sound and vibrations. However, for these sounds and vibrations to become dangerous they need to have much higher values than the normal ones. Sound is defined as a kind of a mechanical vibration of an elastic medium liquid or solid or even gaseous through witch energy is transmitted in the form of progressive sound waves. Noise is emitted either naturally, as it is the case with sound generated by waves or underwater volcanic eruptions or earthquakes, or they can be generated from man made devices such as echo sounders or propeller generated vibrations or other ship born heavy duty machinery.

The three pollution sources can manifest in several ways, although the same pollution source can have several pollutant agents that pose a threat to the environment.

Regarding air pollution, the latest reports regarding the atmospheric environment of Earth show that today's seagoing vessels generate more pollutants such as the sulphur dioxide (SO_x) than all the land vehicles combined.

In the last 15 years it has been achieved through several means a reduction in the pollution generated by vehicles and other diesel powered transportation means. However in the maritime transport industry the same polluting factor has not only increased but it is also proving difficult to control. The fuel used to power ship engines has a much higher concentration of sulphur than the one used by the diesel engines used on cars and trucks.

Ship engines usually use fuel that is a mix of semi-processed oil with diesel oil that has a sulphur concentration of roughly 27 ppm to the only 10 ppm that vehicle fuel has. As a consequence vessels also generate at least 15% to 17% of the nitrogen oxide (NO_x) emissions into the atmosphere, in some areas of the globe this value going as high as 25%. Furthermore carbon dioxide emissions (CO_2) from the exhaust gases generated in the main engines have values that are causing concerns. This is coupled with the fact that carbon dioxide is one of the leading elements that are causing global warming due to the green house effect.

A measurement of just how much air pollutants are released in the European space by ships has been attempted. This research has been conducted in the following areas: The

Baltic Sea, in the Mediterranean, Black Sea, North Sea and the NE Atlantic. It is estimated that 2.6 million tons of SO_x and another 3.6 million tons of NO_x are released every year.

This research has forced the European states into taking sound actions. Amongst them the more noticeable is the impounding and the detention of the ships that use fuel that has higher sulphur concentration than it is legally permitted.

Table 1. Estimated figures regarding SOx and NOx emissions into the atmosphere generated from ships navigating European waters. (Source : Entec 2002)

Year	Sulphur dioxide (ktons)	Nitrogen Oxide (ktons)
2000	2.578	3.617
2010 (increasing by 1.5% / year)	2.845	4.015
2010 (increasing by 3 % / year)	3.294	4.649

After the burning process of fuel is complete the SO_x and NO_x are transformed in very fine sulphur and nitrate particles that combine with other substances in the air. Inhalation of air that contains such particles can increase the chances of cardiovascular disease, heart and lung diseases, and can cause a general increase in the mortality rate amongst the general population.

Furthermore nitrogen oxides when exposed directly to sunlight are known to generate a thin layer of ozone that sins to ground level, with devastating effects on both vegetation and human health. In the areas where high concentration of such substances can be found it has been observed a fast developing corrosion of metallic objects.

One way for reducing NO_x emissions into the atmosphere is a direct approach to the very process that produces them. This approach is called a primary method and is done by augmenting the mechanical process. This can be coupled with additional industrial processes such as the chemical or mechanical treatment of the exhaust gases in the evacuation chamber of the engine.

Reducing the SO_x emissions can be achieved by introducing additives in the fuel, or by further refining it in the first place thus eliminating the sulphur content.

On the other hand the release of CO_2 can not be diminished by controlling the fuel burning process. As an alternative we propose either reducing the consumption rate of the engine, or the use of fuels with low carbon to hydrogen ratio. The most popular methods for reduction carbon dioxide emission are the ones based on the idea of separating the mix of substances while in their gaseous state. This requires a rather complex process: absorption and low temperature distillation, polymeric membrane separation and cryogenic techniques.

The sixth 73/78 MARPOL Convention Annex now in force makes it mandatory for all ships to have a ship noxious gases pollution prevention certificate.

3. THE POLLUTION CAUSED BY OILS AND OTHER TOXIC LIQUIDS, SHIP GENERATED GARBAGE AND ANTI-FOULING PAINTS

Oils Pollution: Although lately the number of incidents due to oil spills in European waters has dropped, from time to time, they do occur. Accidental spills of disastrous proportions represent approximately 10 to 15 % of the total number of spills globally each year. These hydrocarbons have a huge impact on the marine life and on the ecosystem; their chemical structure and the fact that oils stay on the surface of the water mean that they can cause toxic build-ups over long periods of time. An essential heavy oil component is the aromatic polycyclic hydrocarbon, which unfortunately is rather difficult to be dispelled especially after being added to marine sediments.

The Alaskan Exxon Valdez disaster has killed 30000 marine birds and 1000 of the marine wildlife but also there is a staggering amount of fish that has been literally buried in oil.

Exactly how the oil spills occur varies. Out of a total of 100 incidents, 75% were accidental, most of them happening during loading operations.

13% were caused with malicious intent and the last 12% have an undetermined nature.

The means of combating oil pollution depend greatly on the type of pollution.

If confronted with accidental oil pollution we must bear in mind that ships designed to carry oil cargo have their own equipment designed to limit or even combat pollution. Such solution may include chemical dispersants or mechanical aids such as floating dams, oil collector ships.

Each oil tanker must have an *Oil Record Book* that contains all cargo operations when taking on fuel or cargo oil, tank to tank ship cargo transfer, bunkering plans etc.

There are methods for reducing operational pollution. Thy include waste management for the engine compartment as well as for the bilge, oil separators, slop tanks and waste transfer to shore.

All ships must have an International Oil Pollution Prevention Certificate that complies with Annex I of MARPOL 73 / 78.

Table 2. Major incidents that involve oil tankers in European waters

Ship's name	**Year**	**Location**	**Oil spills in tons**	**Cause**
Amoco Cadiz	1978	Brittany, France	223 000	Grounding
Haven	1991	Genova, Italy	144 000	Explosion
Torrey Canyon	1967	Scilly Islands, UK	119 000	Grounding
Urquiola	1976	La Coruña, Spain	100 000	Grounding
Jakob Maersk	1975	Oporto, Portugalia	88 000	Grounding
Braer	1993	Shetlandl UK	84 000	Grounding
Aegean Sea	1992	La Coruña, Spain	73 500	Grounding
Sea Empress	1996	Milford Haven, UK	72 360	Grounding
Prestige	2002	Finistere, Spain	62 657	Structure failure
Nassia	1994	Black Sea Turkey	33 000	Collision
Erika	1999	Brittany , France	19 800	Structure failure

Pollution caused by ballast water: for a long period of time this method of pollution was not considered to be dangerous for the environment. Instead it was considered as a simple transfer of water between different port areas. However after a closer analysis this common custom was actually a means of transportation for foreign/alien marine organisms or micro organisms. The introduction of exotic invasive species in unwary habitats can lead to negative changes that are also irreversible and can damage the dynamics of a marine ecosystem. Algae that are introduced in areas with warm waters thrive and block the sun light from reaching the underwater flora thus causing it to disappear with dire consequences for the fauna.

Nevertheless ballast water is very important for a ship's safety and it is estimated that up to 10 billion tons of water is transferred each year. In 2004 the World International Maritime Organization (IMO) adopts the "International Convention for ballast and sewage water management "(*Ballast Water Management Convention*) in an attempt to prevent and reduce as much as possible the ballast effect on the marine environment. Under the Convention all maritime ships have a "Ballast management plan" implemented on board, and no ship is allowed to enter a port until a loading and discharging plan for ballast water is sent to the port authorities. Moreover in 2007 a project called *Global Ballast Water Management Project (GloBallast)* was started with ONU collaboration focussing on the environment.

The methods for reducing ballast water pollution are many. They vary from the constructive design of the ship, to the treatment of water in the ballast tank. Other methods include filtering, heating up the water up to boiling point, reducing the oxygen level in the water, centrifugal separators or electrolysis

Pollution caused by ballast waste and garbage dumping from commercial ships and passenger type ships is still a common occurrence.

Every day huge quantities of garbage are washed on ocean shores. This garbage is usually generated from day to day activities or leftovers from past cargoes. The fifth MARPOL Annexes states under what conditions garbage can be thrown overboard with strict specification for special zones and with strict rules for plastic materials.

Every day one person generates about 3.25 kilograms of garbage. Thus on board a ship for every 125 tons of loaded material about 1 ton of garbage and waste is generated. It is estimated that over the entire Planetary Ocean in one single day, about 8 million articles are dumped. They include metal boxes, bottles and plastics. Other wastes include, paper, rags, metals, nets, lashing materials and cargo materials.

Garbage and other solid wastes can be dangerous due to their high content of hydrocarbons and/or other chemicals. The most dangerous ones are the plastic products that float and take years to decompose. Even small plastic objects like plastic caps and plastic bottle rings can produce disasters.

This is why ships have a *Garbage Management Plan* that includes precise indications on how garbage is to be treated on board or disposed of. Any action taken on board regarding wastes is to be logged into the *Garbage Record Book.* The *Garbage Record Book* is subject to Port State Control investigations.

Minimizing pollution caused by garbage or other wastes can be done with the following actions: The correct management of on board garbage, collecting and depositing it with the purpose of surrendering it to on shore facilities. In order to encourage such activities mandatory taxes for garbage delivery have been imposed on ships entering ports all over the world, regardless of whether garbage is delivered or not. This encourages ship owners to deliver the garbage to the shore based specialized companies instead of dumping it into the sea, because they pay for these services regardless.

Pollution caused by sewage waters is one of the malicious methods of introducing harmful substances in the marine environment. These waters come from the ship's galleys, cabins, cargo washing tanks operations etc. It has been calculated that almost 80% from the sewage waters dumped in the Mediterranean Sea was not treated or filtered in any way.

As a rule sewage water is divided into two categories: black water and grey water

Black water is made up of water and other residues that come from toilets, medical offices. It contains bacteria, parasites, and other pathogens. Uncontrolled dumping of such liquids can lead to contamination of marine life.

Grey water has it's origins in showers, kitchens, laundries and other washing areas on board ships. These liquids contain detergents, oils, fats, organic components, food residues. Analysis shows that grey water may contain the e-coli bacteria.

Methods of dealing with sewage water pollution are among others: chemical treatment of used water, or collecting it in special tanks for shore disposal, recycling for on board use after treatment.
The sixth MARPOL 73 / 78 Annex has specific rules for dumping sewage water, as well as for the required installation for on board water treatment, storage and shore disposal. All ships regardless of type or class must have an International Sewage Pollution Prevention Certificate

Pollution that originates form paints used for ships hull has been long considered as minor and ignored as a result. Nevertheless paints are applied in multiple layers and they contain among other substances tributyltin (TBT) and trifenyltin(TPT), [Tributyltin hydride, tributyltin fluoride, tributyltin chloride] substances that were discovered in the 60`s and that have revolutionized the paints chemical industry.

These substances are extremely toxic for marine life (larvae, shells and fish). They have extremely high endurance in the water and are noxious. Studies show that they are dangerous even in small concentrations. As they are accumulated in the bodies of whales and other mammals they interrupt blood flow, produce sterility and death.
As this information became apparent, 159 International Maritime Organization member states adopted the “International Convention on the Control of Harmful Anti-fouling System on Ships” which starting from 1st of January 2008 bans the use of organotin based paints.
Furthermore, ships are required to have an International Anti-fouling System Certificate.
Pollution from chemicals can only be effectively prevented by not using such chemicals on board ships.

4. POLLUTION MADE BY NOISE

This is a problem that can be addressed depending on how noise is being generated, the environment where the noise is emitted and what kind of receivers are in the area.

There are quite a few activities that generate such pollution: an ever increasing number of motor boats, commercial shipping, underwater exploitation utilities, all these generate noise.

The underwater propagation speed of sound is 4 times greater than in the air, and the distance travelled by it is even greater. This is because water has a higher density than air, and thus the sound waves travel more efficiently.

Sound pollution is neither apparent nor visible when compared with other pollution types, but nonetheless it has an irrefutable impact on the environment.

Studies have shown that one sound by itself has a negligible effect. But when dealing with pleurae of emitting sounds, and over a long period of time, the effects are apparent and lasting.

In conclusion what can be done on board ships are the following: We can install *active devices*: systems that ensure a smooth movement of any pistons or moving parts thereby reducing resonance and vibrations. Also we can install passive devices: sound isolating screens that also buffer vibrations.

5. THE GREEN SHIP CONCEPT- THE IDEAL SHIP FOR POLLUTION PREVENTION

Studies’ regarding the perfect ship from the pollution prevention point of view begun long before the concept of Green Ship was even thought of. Problems such as: reducing engine fuel consumption, with low or no afterburning resulted particles, or resolving the *sewage and oily water* problem by releasing it only to land based facilities among other things were thought of in the past.

The first thing about a Green Ship is upgrading the existing ships. This can be easily done, using existing and easily available technologies. To begin with, we can start our analysis by looking how ships are being built.

Their engines, for the most of the existing ships, are not as efficient as they could be. Indeed a constructor would look for the cheapest he can buy, but in order to produce low atmospheric pollution it would be necessary to have an efficient internal combustion in the engine, along with biodegradable oiling agents and a system of washing and treatment of exhaust gasses.

There is an intrinsic connection between how a propulsion engine is built and the type of fuel it is designed to function with. The upgrading of such engines could make them so efficient that they could perform just as well using low sulphur fuel.

Existing projects for such types of engines have shown that it is possible to cut back on CO2 emissions with up to 30% and a 90% decrease in SO_x and NO_x emissions as compared with similar systems in 2007.

Project developments for Green Ship requires a close collaboration between ship engine builders, oil producers and ship manufacturers.

Currently, world wide there are a series of initiatives for Green Ships such as:

1. Technological investments and initiatives: Those focus on the reduction of noxious gas release into the atmosphere, and new hull design.

- *Green ships research programme (Norway):* program started in 1991, was based on the idea that pollution can be reduced by re-engineering ship engines, and fuels, and by processing exhaust gasses.
- *Ecoship* (Sweden) started in 1995, focused on ship hull design, preventing the corrosion effect, and improving the propeller design.
- *TRESHIP (Technologies for Reduced Environmental Impact from Ships) (Norway)* focused on ship hull design, and improving oil spill reduction in case of collision.
- *Super Ecoship* (Japan) : still in prototype phase but includes existing technologies such as gas turbines and electrical motors
- *Evergreen Post-Panamax Ships* (Taiwan): involves the actual building project of several Green Ship type container vessels with double hull.
- *Green ship of the future (Denmark) focuses on the reduction of gas pollution.*Project developed by Force Technology.

2. Economical investments that can also be regarded as a social acknowledgement of how environment issues can be managed: these initiatives consider human life on board ships as well as the money issue regarding shipping.

- *Green Shipping Award* (Rotterdam): started in 1994 it is aimed at promoting the environment and the way to preserve it. It was very important for the U.S. *Qualship 21* program
- *Blue Angel 2002*. This program is the reason why a series of legislations regarding shipping pollution have taken effect.
- *Qualship 21* (USA) initiated by the Coast Guard, proposes that all ships which are under standard should be eliminated. Things like the hull of the ship, the on board equipment, and the requirements of the ISM Code are considered.
- *Voluntary class notation and certification*: a program by which classification societies such as Det Norske Veritas and Lloyd's certify that pollution prevention systems are installed on board ships and meet the requirements of the classification society for the respective class of ship
- *Green Passport* (IMO, MEPC): this initiative proposes that all substances that may have a negative impact on the environment and are to be found on board a ship should be

documented. These include but are not limited to: the documents that accompany the ships through their construction process and then are passed on to the Owner, and then to the scrap shipyard where the ship is laid to rest.
- *Keep it Blue* (France): is a program that is looking on how much garbage is generated on board ships. Currently is an undergoing project with the cooperation of over 250 European ports.

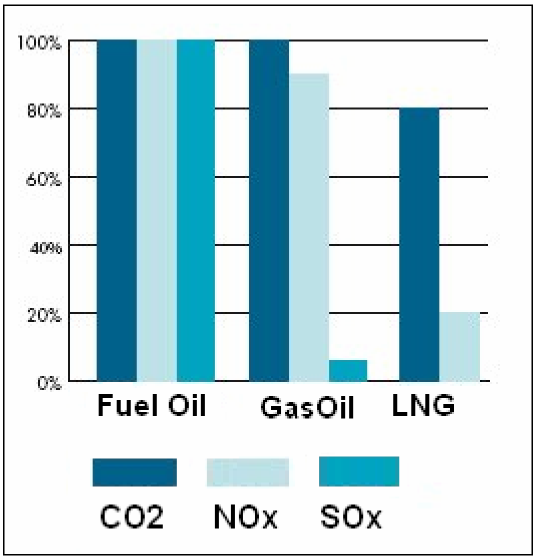

Fig.1 Exhaust emissions generated by LNG driven engines are generally lower than the ones produced by Heavy Fuel Oil (HFO) engines or Motor Gas Oil (MGO) engines

The second most important aspect of a Green Ship is related to the new ways (that are in fact almost traditional) of seamanship, but through unconventional means. They are called unconventional because of the propulsion methods. Such methods involve the use of air power, and thus are different from the propulsion methods used by most seagoing vessels. Another unconventional means of propulsion is the one that involves electrically driven engines that are powered by solar panels.

These are not new ideas, but when they were proposed, not so long ago, there was no need for them and as such they were discarded as bold tries and technical feats that lacked practical applications and economical sense.

Today the environment issue is a global one, and thus we have to go back to what were once considered “futuristic ships”

There are quite a few systems for ship propulsions, starting with sailing ships. Taking this a step forward a series of kite like systems were developed.

The ship that is towed by a sail situated at a certain height (kite type).

The “Beluga SkySails” ship (Beluga Shipping Company Germany) is using this type of propulsion with good results. The sail has a 160 m² surface that has a dramatic effect on efficiency and generated exhaust gasses. Future sails for such projects are estimated to have surfaces of up to 5000 m².

The kite has the great advantage of reducing the annual bunker costs with 10-35%, which has a secondary advantage of reducing atmospheric pollution.

The shape of the sail and the ability to command its orientation with the aid of computers means that it can catch the wind with different orientation relative to the position of the ship. Also the kite operates at high altitudes (100-300 meters) and haws an increased efficiency in maritime areas where the winds are constant and with high speeds (between 12 and 74 kph). What is important is that the wind does not necessarily have to blow directly from behind the ship.

There are other projects that use the same principle however the main differences are only in the shape of the kite and its elevation relative to the sea surface.

- ***Ships that use solar charged batteries and sails***

The first ship to have ever used this concept was “Orcelle”. The reduction of atmosphere and maritime pollution is almost complete. Her hull has a dolphin like shape and the main idea behind her is close to the Green Ship concept.

Solar energy and wind power is collected by 3 rigid sails which can rotate for increased efficiency.

The wave energy is being used by the 12 floaters that transform this dynamic energy into electricity. These “fins“ can also double as propulsion motors and use electric energy as well. The main propulsion method is the azipod system, which also provides steering.

Half of the required energy for all these systems is provided by the fuel cells. The fuel cells extract the hydrogen through an exothermal process from the water. The resulting energy is either stored or used for powering up the ship.

The entire ship is build using light weight materials such as aluminium and composite materials that eliminate the need for ballast tanks and has the benefit of eliminating problems such as corrosion.

Although such a ship can be produced right now, we predict that it would take some time before such an enterprise is undertaken

- ***The electric propulsion for ships***

Generally ships that use this kind of propulsion operate close to shore conducting research activities. The sound produced in the engine compartment and the vibrations generated there are negligible. The methods for the protection of the environment on such ships are very effective, and the quantity of CO2 released into the atmosphere is low.

Classical means of propulsion (internal combustion) require an alignment between the main engine and the propeller through and their connection through an engine shaft. An electric engine does not require such a strict disposition, and thus does not require a large engine compartment. Moreover, electrical engines are not affected as internal combustion ones when the propeller operates in different depths in the water.

Furthermore, an electric propulsion system has approximate 3 to 4 sets of electric generators that have the same capacity and are easy to maintain and repair. This means a cut in the annual maintenance program time.

Electrical motors were easy to adopt, and their use as ship engines is still considered a revolutionary step forward.

Nowadays we can find a great number of ships that use hybrid means of propulsion, especially ships that do not require high speeds.

6. CONCLUSIONS

It can be stated that shipping around the world is interested in reducing pollution in the marine environment. However, for reasons that vary from case to case, many of the projects and initiatives that are put into practice fail, or are abandoned, or are considered to have a lower than predicted efficiency. At present it is considered among ship owners that the Green Ship concept is difficult to grasp and fathom.

In the authors' opinion, the Green Ship is almost a reality that exists in a factionary way, because there are many projects, practical and technical initiatives, but all of them are not efficiently implemented.

Also, there are quite a lot of researches being made at this moment on these topics, but these too are separate, like a jigsaw puzzle that require unity in order to provide a clear picture.

It is difficult for the shipping community to fathom and be satisfied with what a Green Ship concept is at this moment, while each and every one is having a different perspective of this topic and its implications.

To begin with, we as an academic community have to make these people understand that although the pollution problem is analysed very thoroughly, too little is done about it. And even then, ship owners will not give up on their standard vessels or existing ones easily because of the high costs that Green Ships imply.

Moreover, the ship building industry will have to modify or completely change their production line, and use new kinds of materials.

This new concept of "Green Ship" seems to be at the forefront of the practical methods for reducing pollution. However this advantage is only theoretical, and exists only on paper and in the minds of few enlighten people, through research and design, and we are a long way away from mass producing them.

We believe that it would take a clear stand form the International Maritime Organization and other international organizations, along with clear legislation passed and imposed world wide from every major state in order for such ships to become a reality.

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MEASURES FOR IMPROVEMENT OF ENERGY EFFICIENCY OF SHIPS

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The purpose of this paper is to show a vast range of potential areas for energy efficiency improvement and examine different technologies and possibilities for reduction of energy consumption in ships. A combination of energy efficiency measures is considered as an integrated solution for achieving effective ship operation.

Keywords: ship,energy efficiency,improvement

1. INTRODUCTION

Climate change and limited reserves of fossil fuels became a global problem and the issues of energy efficiency are extremely important both for the scientific community and for the development of global economy. Scientific researches are focused on the development of different energy saving technologies for low emissions and significant reduction of energy consumption while maintaining the required quality and quantity.

Maritime transport is the most efficient way for freight transport, carrying more than 70% of the global freights, it facilitates trade and reduces greenhouse gas emissions from international transport. [12]. This requires constant researches of opportunities for improving efficiency in shipping and also actively promote innovative ideas for reduction of fuel consumption. Environment and efficiency are key topics in global researches. More efficient energy use and power generation from renewable sources like sun and wind are the main priorities for achieving energy efficiency.

2. POTENTIAL AREAS FOR EFFICIENCY IMPROVEMENT

Energy efficiency improvement measures cover many different operational and technological areas. A combination of this areas could give us solution for improvement of ship's energy efficiency.

The main fields for improvement are: optimization of the ship's construction, propulsion, ship's energy system, use of renewable energy sources, optimization of operation of the ship.

Technical measures:

- Optimization of size and design of ships;
- Optimization of power and propulsion system of ships;
- Use of alternative sources of energy (LNG; Hydrogen; Wind; Solar; Wave energy);

- Waste heat recovery ;
- New technologies for exhaust gas cleaning systems.

Operational measures:
- Optimization of port activities;
- Voyage planning and weather routing;
- Speed reduction ;
- Ship maintenance (hull cleaning, propeller polishing);
- Shore-power.

All this measures could be applied in many different combinations , depending on ship's type and operation mode. The ship must be concidered as an integrated system and optimization of different parts of this system could provide overall efficiency improvement.

Fig. 1. Interaction of different optimization areas

3. DESCRIPTION AND ANALYSIS

Technical measures:

For energy efficiency improvement and reduction of greenhouse gas emissions is required better power quality and technological development.

Opportunities for reduction of fuel consumption and emissions of CO_2, through a variety of technical measures represent 5-30% for new ships and 40-20% for old [6.].

3.1 Optimization of size and design of ships

Main dimensions and hull shape are very important to reduce drag and provide the necessary capacity of the powerplant.

Increasing size of the ship is one of the main technological measures that improves the efficiency of transport activity, and saves fuel per ton-kilometer. Analysis of the new built ships shows that a 10% larger vessel will give 4-5% greater efficiency. [14]. The selection of optimal hull shape depends on the operation mode and characteristics of the ship. High-speed passenger and naval vessels are built with larger values of the ratio of length to width. Small values of this ratio provides good maneuverability and stability, they are characteristic of icebreakers.

Steel constructuction of the ship, should provide sufficient longitudinal strength, but also need to be lightweight, to minimize required propulsion power.

Optimization of hull design. A bulbous bow is a hull change of the ship just below the waterline. With proper selection of its shape and size can be obtained favorable interference when wave systems of the hull and the bulbous bow are in the contrary phase. The bulb modifies the way of water flows around the hull, reducing drag and thus increasing speed range, stability and fuel efficiency.

For reduction of kinetic energy losses from the hull friction, scientists from Australia and Saudi Arabia (University of Science and Technology "King Abdullah"), offer interesting technology, whereby the hot hull reduces the resistance of water. [15]. This technology could be applied for significant reduction of fuel consumption and emissions of ship, but it requires further studies.

Improvements of construction and design for acheiving less drag on a hull would provide energy savings and optimization of ship's efficiency. Scientists at the University of Michigan are experimenting with ballast tanks that allow seawater flow through them instead of being stored. Potential savings from the new design will be up to 7.3% of the required propulsion power for ship. [22] The Hydrodynamics could be improved by optimization of size, shape and positioning in water of the ship and that would provide better efficiency.

3.2 Optimization of power and propulsion system of ships .

Conventional power plants in ships utilize diesel engines as prime movers, due to its operating simplicity. For this mechanical system is difficult usually to maintain optimal operation mode as the engine speed is related to the speed of the propeller, and this requires use of electric propulsion.

An integrated electric system combines the vessels power-generation and propulsion system. Variable speed drives ensure that fixed pitch propellers operate at their optimum conditions and with by 30% better efficiency. [4].

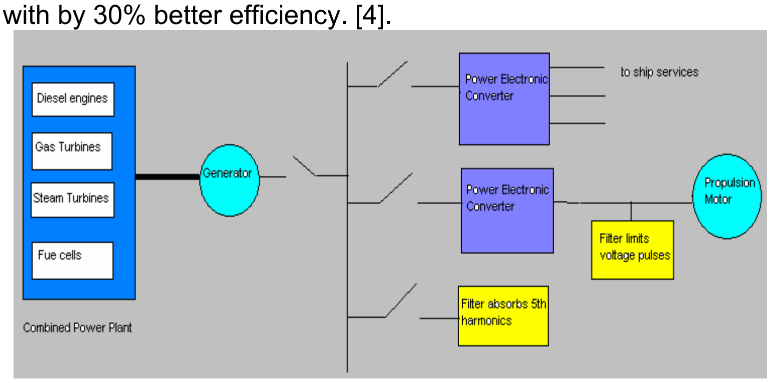

Fig. 2. Structure of an integrated electric system

Compared with conventional power plants, electrical solutions provide a wide range of benefits for acheiving efficiency and cost savings. Electric propulsion, allows power generation by a combination of diesel engines, gas turbines, steam turbines or fuel cells.

This power plant ensures optimal performance, reduction of total installed power of ship and increase of reliability. Offers flexibility and compactness in design of the ship, optimum load of engines at all ship speeds and optimization of energy control system. [2]. Integration of the vessel's power and propulsion system provides benefits like high maneuverability and safer operation, reduced maintenance, reduced fuel consumption and greenhouse gas emissions. Electric power managing system ensures optimal load conditions and improves efficiency of the generators. All these advantages lead to greater savings for the owner.For optimization of propulsion system in many vessels is applied the Azipod ® propulsion unit, composed of electric motor with variable speed drives and fixed propeller. This concept ensures better hydrodynamic efficiency by recovery of the kinetic energy of the flow behind the ship, Azipod® improves maneuverability and saves space inside the vessel. The most important advantage of the system is reduction of fuel consumption and CO2 emissions.

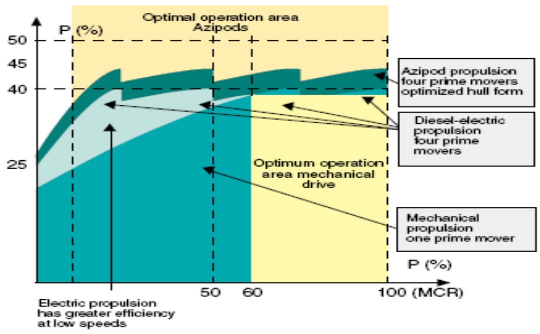

Fig. 3. Diesel engine efficiencies for different loads [5].

If the speed is lower, electric propulsion improves the total propulsion efficiency.

CRP Azipod concept of pod-propulsion innovator ABB, includes a system of contra-rotating propellers, located on the same axis, but without any physical connection. The forward propeller rotation energy is utilized in the aft propeller. As a result of hydrodynamic propulsion system efficiency is increased by about 10%.[1].

This concept provides high performance at a good price and a lower total installed engine power. It enhances maneuverability in ports, provides greater safety in emergency situations, and bad weather.

Other innovative concept offers the use of an integrated electric system, composed of electrical machines with hightemperature superconducting coils (HTSC), which substantially improve maneuverability of vessels. Superconductors have zero resistance at superconducting temperature and achieve denser magnetic fields than those of conventional machines. As a result, weight and size are significantly reduced and potential for greater payloads is increased. Compared to conventional engines, superconduction machines at the same energy are 70% smaller and lighter. HTSC used for improvement of efficiency of engines, gives significant energy savings for continuous operation. This technology makes new ships more fuel-efficient and free up additional space.

American Superconductor Corporation(AMSC) successfully completed the testing of the world’s first 36.5 megawatt HTS ship propulsion motor. HTS Utility Generators of AMSC's, bringing power to the grid more efficiently, less expensively, can offer significant advantages:reduced size and weight,longer life,lower up-front costs,improved reactive power compensation. At full load, conventional 100 MVA generators run at approximately 98.5% efficiency. HTS generators can improve net efficiency by 0.3% to 0.5%.[3].

3.3 Alternative fuels and sources of energy

Significant change in use of alternative fuels and energy sources is difficult in the short term as most promising alternative technologies are still unable to compete with diesel engines. The innovative ideas and technologies for use of solar panels, sails, and alternative fuels are possible in the long term but need public support for wider application.

- Liquefied natural gas (LNG)

Due to emission control and low prices , LNG is considered as a promising alternative fuel for all type of vessels. Shipping industry should consider issues related to switching from traditional fuels to LNG in order to reduce operating costs and ensure protection of the vessels and the environment. By using of LNG all of sulfur oxides (SOx) emissions are eliminated and the nitrogen oxides (NOx) and carbon dioxide (CO2) emissions are reduced by about 80% and 20% respectively. Ships could be fuelled solely with LNG or with diesel and LNG.

Dual fuel diesel engines use natural gas as the main fuel source with a small amount of diesel fuel injected to initiate the combustion. They can run with 80% to 99% of fuel energy from gas. [12]. Wärtsilä Corporation has developed a coastal cruise ferry using LNG as fuel.The ferry features a machinery of the hybrid dual fuel (H-DF) type, which consists of two Wärtsilä 6R32DF propulsion engines and two 9R32DF generating sets. These give a total installed power of 10.5MW. The engines use LNG as primary fuel and marine diesel oil as pilot and back-up fuel. [17]. The use of LNG is truly environmentally-friendly solution, all major emissions can be significantly reduced, which is difficult to achieve with conventional fuels, lowered fuel costs for the owner and improves efficiency are the main benefits of LNG.

- Hydrogen

Hydrogen is a powerful source of energy obtained in fuel cells and from combustion in internal combustion engines. Hydrogen fuel cell produces electricity by combining hydrogen and oxygen. In transport vehicles is used fuel cells with proton-exchange membrane, which has the ability to pass protons in one direction only. Hydrogen enters on the anode , and oxygen on the cathode of the cell. By a catalyst , hydrogen atom splits of electrons and protons. The flow of electrons on the way to the cathode is used as electricity.This fuel cells produce energy with 25-40% efficiency. [9]. Fuel cell with energy storage systems is called reverse fuel cell. By using electrolysis, powered by solar energy, water splits into hydrogen and oxygen, generates electricity, heat and water. Then the received water is returned for further splitting and the circle closes. This technology could be applied in ships , but high cost of the process is a major disadvantage.

The hydrogen systems can be more efficient than engines, and reduces greenhouse gas emissions, but the higher costs still limits the use of hydrogen.

- Solar energy

This energy is clean, renewable and has great potential. Every square meter of the earth's surface, when exposed to direct sunlight, receives about 1000 watts of energy from the sun's light. Solar power is the conversion of sunlight into electricity, either directly using photovoltaics , or indirectly using concentrated solar power. In shipping are used panels with photovoltaic cells, they directly convert solar energy into electricity. This technology has many benefits - reduce pollution, significant lifetime of photovoltaic cells and lower costs for maintenance. Solar panels could be installed on the deck of ships in order to reduce fuel consumption and CO2 emissions. This technology is applied by more and more companies. Japan's largest shipping company Nippon Yusen KK develope the first cargo ship propelled with solar power. Planet Solar build the world's largest solar-powered boat – TÛRANOR- powered entirely by up to 500 square metres of photovoltaic solar panels.The solar panels on PlanetSolar power two electric motors, which can reach 15 miles per hour. [19].

According to experts, however, is difficult large cargo ships to be propelled only by solar energy. There is option to combine solar energy with other renewable sources (wind). In this context, the Japanese company Power Eco Marine, develop innovative technology Aquarius System, which will allow ships to utilise wind power and solar energy in order to reduce fuel consumption and lower noxious gas emissions. In addition ship owners and operators will be able to reduce the carbon footprint of their fleet and employ the system on a variety of ships and vessels. The concept consists in placing on the deck of mobile, rigid solar panels which can be used both as sails, and as portable power plants. This combination of technologies is expected to deliver annual fuel savings of 40% or more and significantly reduce the ships emission of harmful gases. [15]. This technology represents a hybrid system - combines wind and solar energy and provide constant electricity source.

- Wind energy

Wind energy is unconventional energy source, clean and renewable. In the past years wind energy has become the fastest developing energy source in the world. Energy could be generated by using wind turbines , windmills , or sails to propel ships. Offshore wind power is used due to greater wind speeds available offshore compared to on land. Capacity of this energy is expected to reach a total of 75 GW worldwide by 2020. [16].

German company "SkySails" developed "Kite technology", this technology ensures by 10 -35% lower fuel costs, depending on course and weather conditions. It consists of the use of additional sails, which rises high above the ocean where the wind is constant and has a great power. The SkySails system tows the ship using large, dynamically flying towing kites, which generate up to 25 times more energy per square meter than conventional sails propulsion systems. This equals up to 2,000 kW of propulsion power in good wind conditions. [10]. This kites provides additional propulsion energy and fuel economy. "Kite technology" could be combined with conventional power sources and contributes for a hybrid propulsions. This technology provides higher fuel efficiency and reduce greenhouse gas emissions.

- Biomass

Biomass is a renewable energy source .

This energy source, can be used directly or from biomass conversion into other energy products such as biofuel. In shipping, biomass is used for the first time in warship of the U.S.- “Spruance”. The ship is powered by a mixture of equal proportions of conventional fuel and special biofuel from algae. The US Navy has set a goal of deploying a “Great Green Fleet” powered entirely by alternative fuels by 2016, and of reaching 50 percent alternative energy use overall by 2020. [8].

- Energy of sea and ocean waves

As ocean waves are created by the interaction of wind with the surface of the sea, waves have an unlimited energy potential of up to three times the current world energy consumption. Wave energy could be extracted and converted into electricity by wave power machines. They could be placed either on the shoreline or in deeper waters offshore.

Wave power formula per unit area [kW / m], of gravity waves on the water surface is:

$$J = \frac{\rho . g . H_S^2}{16} . \frac{g}{4\pi} . T_E$$

where ρ is the density of sea water $\left[kg / m^3 \right]$, g = 9.81 m/s2 is the gravity acceleration, Hs - significant wave height in meters, Te [s] - energy or time period of the group wave that carries energy. Average value of the wave power is 5,23 kW / m. [13].

Ships could be propel through wave energy. The first wave-powered ship is built by the Japanese company Tsuneisi Shipbuilding Company. Unusual propulsion system of ship, consists of two fins, which absorb wave energy. The fins move up and down with the incoming waves and propel the boat forward. [19].This innovative wave propulsion system could be applied in other ships, but has one disadvantage - low-speed. A similar concept was proposed by researchers from Boston University and scientists from the Fraunhofer Center. The 50-metre-long ships would harvest wave energy via buoys attached to their sides by pivoting arms. The plan could produce electricity at $0.15 per kilowatt hour (kWh), which is far cheaper than energy produced from existing wave technology, which costs between $0.30 and $0.65 per kWh.[11]. The wave energy is prospective and clean energy source and must be considered as efficient way to generate electricity.

4. Technologies for reduction of greenhouse gases and cleaning systems

For reducing emissions of sulfur oxides, nitrogen oxides, particulate matter and emissions CO2, some companies developed different technologies, which offered cost-effective and environmentally friendly solutions:

- Optimization of the combustion process.- provide reduction of fuel costs and emissions. By using fuel-water emulsion or a water injection directly into the combustion chambers, could be acheived more complete combustion and reduction of nitrogen oxides (NOx) by 20% to 50%.
- The exhaust gases recirculation (EGR), can achieve 70% NOx reduction with less fuel consumption by about 2%.
- Selective catalytic reduction (SCR) can achieve up to 95% reduction in NOx and allows engine to be adjusted to maximum fuel economy. [2].

Exhaust gas scrubbing technology- water scrubbers removes by 90% or more, of sulphur and over 80% of particulates from exhaust gas. [7]. Some of companies which have developed technologies for exhaust gas cleaning are - Aalborg - Denmark, Clean Marine AS, Krystallon - England, Marine Exhaust Solutions Inc, Wärtsilä – Finland , and concepts offered are not very popular yet.

5. Waste heat recovery

The waste heat recovery system generates electrical energy from a ship's exhaust gases.This reduce the ship's fuel consumption and CO2 emissions. Energy costs are lowered ,and the ship runs economically.

Operational measures :

1. Speed reduction

Significant reduction of energy consumption and CO2 emissions could be achieved by reducing optimal speed of the ship. 10% reduction in speed leads to a 20% reduction in fuel consumption for the same distance. [12]. This measure provides lowered fuel costs and optimization of energy efficiency of the ship

2. Optimization of port activities - changing the configuration of the terminals, improving loading and unloading of the ships.

Ports and terminals are integral parts of supply chains and offer better logistics services. A combination of different transport modes improves transport services, that provides certain advantages such as low cost, high speed, or high capacity. Intermodal transportation, may help a carrier reduce its operating costs .

3. Power the ship from the shore-side power grid.

For energy conservation and clean air, when vessels berth at port, more and more ports are offering vessels the opportunity to plug into the city grid and turn off their engines while at port, which is called "cold ironing." By shutting down the vessel's engines and using the power from the port, it can cut CO2 emissions by 29% annually and will financially save up to 26% per call.[21]. For example the state of California has mandated that by 2014, half of container-ship, passenger-ship and refrigerated-cargo-ship fleets must plug into the shore-side power grid while docked on the California coast.

In order to reduce costs and emissions, some ports has turned to renewable energy.(The Jaffa in Tel Aviv, The port of California), and supplying ships with alternative energy,(Italian port Civitavecchia).

4. Voyage planning and weather routing.

For efficient ship operation is very important to reduce significant additional resistances caused by wind, seaway and fouling of the hull. The strong head wind can increase the total resistance up to 10%. The fair wind does not always lead to a gain in speed because of the unfavorable influence of тhe seaway. Disturbance of the propeller work, caused by waves and changes in load also affects on the speed and fuel consumption. [18].

5. Maintenance

Maintenance is performed to keep equipment end system running efficiently.

Maintanance include reducing or delaying the impact of corrosion until the ship is dry-docked (hull cleaning, propeller polishing, rudder, propeller and plating repairs), limiting liability issues for safety concerns and to maintain all equipment in optimal working order.

4. CONCLUSIONS

The implementation of new, environmentally friendly technologies provide low fuel consumption and cut operational costs.

Specified approaches and technological solutions could be applied for improvement of energy efficiency of the vessel, but they need to be combined in the most efficient way and considered together as an integrated solution.

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THE DEAD STATE CHOICE IN EXERGY CALCULATIONS FOR MARINE AND NAVAL APPLICATIONS

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In this work the double choice for the dead state in exergy calculations is considered. Energy systems for marine and naval applications cover a wide range of possibilities and the exergetic analysis have proven to be a very useful tool at the previous design stages. Exergetic efficiency calculations of power generating systems allocated on board require a dead state definition as well as the knowledge of ambient conditions at any location defined by latitude and longitude. Temperature, pressure and relative humidity values at sea level all over the world have been estimated by using EdGMC software. Total exergy of ambient air and a methanol/water liquid mixture has been calculated at every latitude and longitude by using a unique dead state and a local dead state. The results obtained with both dead states are compared.

***Keywords**: dead state, exergy, ,ambient conditions*

1. INTRODUCTION

Since the property exergy is related with the maximum/minimum work obtainable/deliverable from/to a given energy conversion device, the definition of a dead state is a topic of interest in exergy calculations. Ships can travel all over the water world and ambient conditions vary with latitude and longitude. The exergy of possible fuels and oxidants used to power generation on board can be different depending on the dead state choice, and those values can vary clearly if a unique or a local dead state is used in calculations. The aim of this work is to determine the influence of the dead state choice in exergy calculations of substances at sea level all over the world. For this, a liquid mixture of methanol and water has been chosen as a possible fuel and ambient air has been devised as the oxidant in a chemical reaction involved in a process giving rise to power delivery.

2. AMBIENT PARAMETERS' ESTIMATION ALL OVER THE WORLD

It is quite difficult to know the temperature, pressure and relative humidity values all over the world. Therefore, software is used to make estimations instead of performing overhelming manual calculations. In this study, EdGCM software [1] has been used to make the parameters' estimations. EdGCM program is developed by the Columbia University and can make a parameters' estimation using ambient data collected by N.A.S.A. from 1956 until nowadays. The parameters estimation has been made using ambient data from 2006 until 2010 in the EdGCM to produce an actual data series of annual parameters. Approximated curves have been made by adjusting to polynomial functions. The results as a function of latitude and longitude are shown in Figs. 1 to 3 for temperature, pressure and relative humidity, respectively.

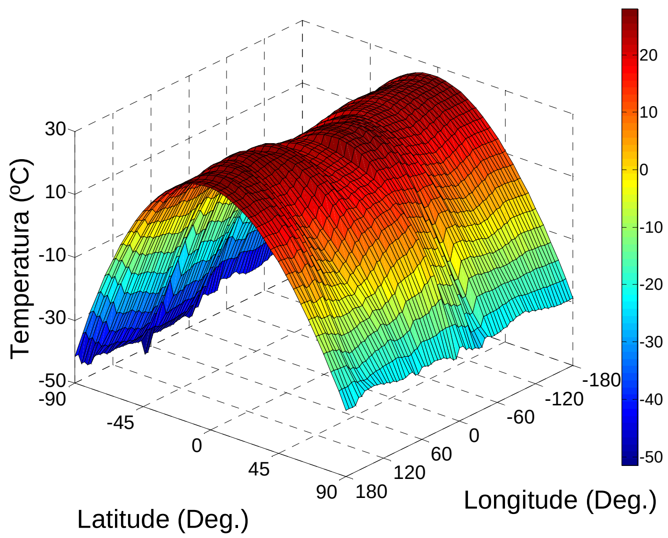

Fig. 1. Temperature estimated values at sea level as a function of latitude and longitude

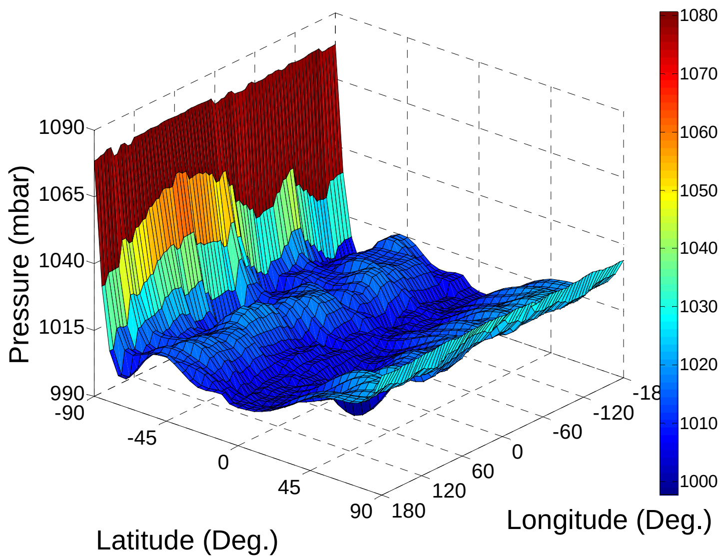

Fig. 2. Pressure estimated values at sea level as a function of latitude and longitude

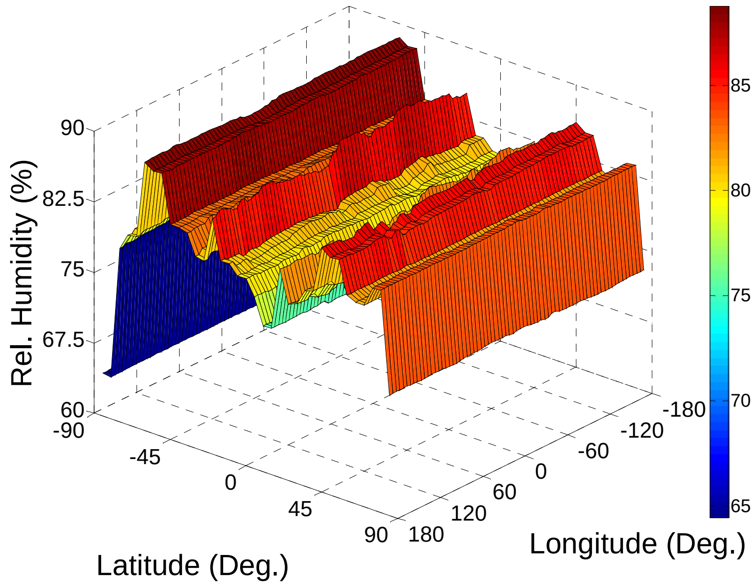

Fig. 3. Relative humidity estimated values at sea level as a function of latitude and longitude

3. THE EXERGY OF BINARY LIQUID MIXTURES AND OF AMBIENT AIR CALCULATED BY USING TWO DEAD STATE APPROACHES

The general expressions used to calculate the total exergy of a stream [1] as the sum of chemical exergy e_x^{ch} and thermomechanical exergy e_x^{tm} are summarized as:

$$e_x = e_x^{ch} + e_x^{tm} \tag{1}$$

with

$$e_x^{tm} = h - h_0 + \frac{\omega^2}{2} + gz - T_0\left(s - s_0\right) \tag{2}$$

where the subscript "*0*" stands for the dead state, and

$$e_x^{ch}\Big|_{humidair} = RT_0\left(x_{N_2}\ln\left(\frac{x_{N_2}}{x_{0N_2}}\right) + x_{CO_2}\ln\left(\frac{x_{CO_2}}{x_{0CO_2}}\right) + x_{O_2}\ln\left(\frac{x_{O_2}}{x_{0O_2}}\right) + x_{H_2O}\ln\left(\frac{x_{H_2O}}{x_{0H_2O}}\right)\right) \tag{3}$$

$$\left.e_x^{ch}\right|_{CH_3OH(l)} = \mu^0_{T_0CH_3OH} + \frac{3}{2}\mu^0_{T_0CO_2} - \mu^0_{T_0CO_2} - 2\mu^0_{T_0H_2O} + \frac{p_0 - p^0}{\rho_{CH_3OH(l)}} + RT_0 \ln\left(\frac{p_0}{p^0}\right)^{-\frac{3}{2}} + RT_0 \ln\left(\frac{x_{0O_2}^{3/2}}{x_{0H_2O}^2\, x_{0CO_2}}\right) \tag{4}$$

$$\left.e_x^{ch}\right|_{H_2O(l)} = M_{H_2O}\frac{p_0 - \left(10^3 \exp\left(16.54 - \frac{3985}{T_0 - 39}\right)\right)}{\rho_{H_2O(l)}} - RT_0 \ln\left(\phi_0\right) \tag{5}$$

and

$$\left.e_x^{ch}\right|_{CH_3OH/H_2O,l} = x_{CH_3OH}\left.e_x^{ch}\right|_{CH_3OH} + x_{H_2O}\left.e_x^{ch}\right|_{H_2O} + RT_0\left(x_{CH_3OH}\ln\left(x_{CH_3OH}\right) + x_{H_2O}\ln\left(x_{H_2O}\right)\right) \tag{6}$$

The composition of humid air is calculated form the dry air composition and relative humidity of air as

$$x_{H_2O} = \frac{\varpi}{1+\varpi} \qquad \varpi = \frac{\omega}{0.622} \tag{7}$$

$$x_{dryair} = 1 - x_{H_2O} \tag{8}$$

Therefore

$$x_i = x_{0i} \cdot x_{dryair} \tag{9}$$

Table 1: Unique Environmental reference state composition to calculate the exergy of the compounds involved in this study. ($T_0 = 298.15\,\mathrm{K}$; $p_0 = 101.325\,\mathrm{kPa}$; $\phi_0 = 0.69$). Based on [3,4].

Species	Dry composition x_{0i}^{dry}	Dead state mole fraction
N_2 (g)	0.7896	0.77251
O_2 (g)	0.2101	0.20555
CO_2 (g)	0.0003	0.00029
H_2O (g)	-	0.02165

Table 2: Local Environmental reference state composition to calculate the exergy, at sea level, of the compounds involved in this study. ($T_0 = T_{amb,local}$; $p_0 = p_{amb,local}$; $\phi_0 = \phi_{amb,local}$). Based on [3,4].

Species	Dry composition x_{0i}^{dry}	Dead state mole fraction
N_2 (g)	0.7896	Calculated with eqs. (7) to (9) for each $\phi_{amb,local}$
O_2 (g)	0.2101	
CO_2 (g)	0.003	
H_2O (g)	-	

4. RESULTS AND DISCUSSION

Figures 4 and 5 show the total exergy values of ambient air and liquid methanol/water mixture, respectively, as a function of latitude and longitude, when a unique dead state is used for exergy calculations. A typical composition of the liquid methanol-water mixture has been selected x_{CH_3OH} =0.567 and x_{H_2O} =0.433.

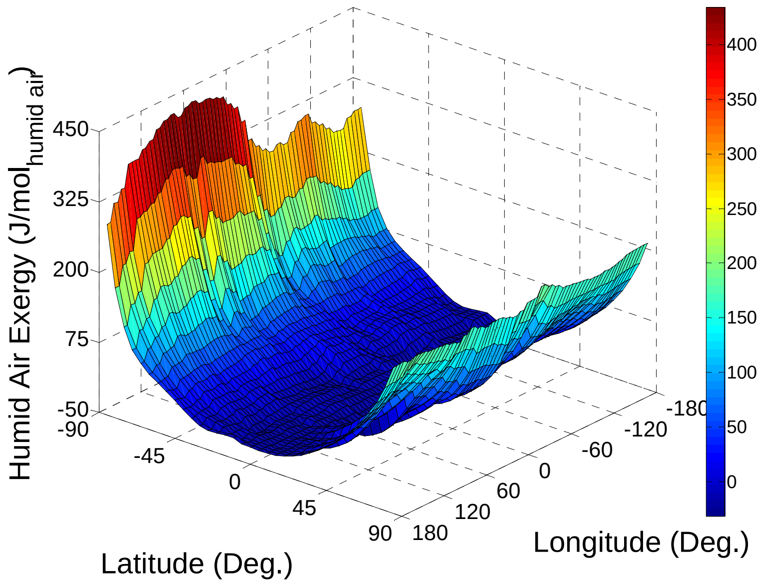

Fig. 4. Humid air exergy (unique dead state)

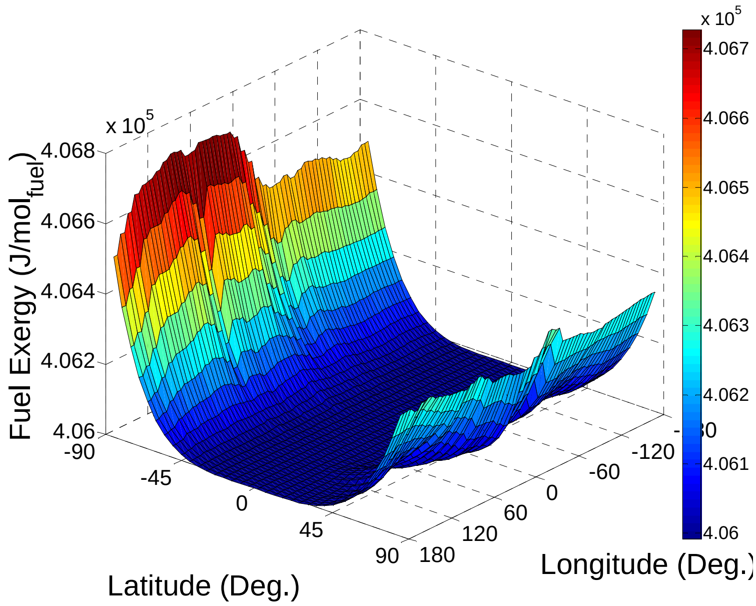

Fig. 5. Liquid methanol/water mixture (x_{CH_3OH} =0.567 and x_{H_2O} =0.433) exergy (unique dead state)

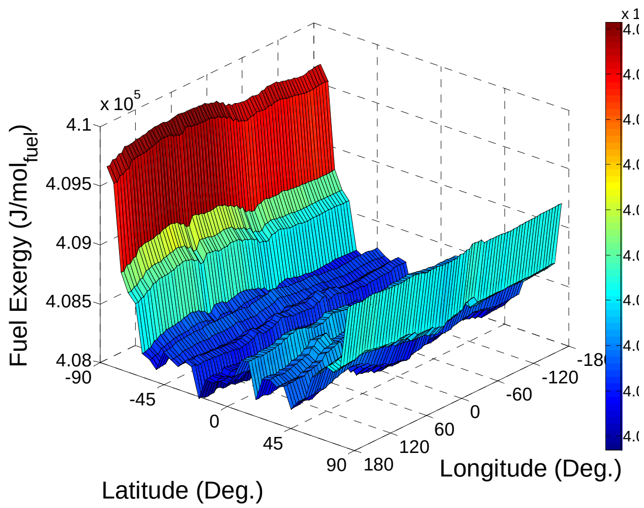

Fig. 6. Liquid methanol/water mixture exergy (x_{CH_3OH} =0.567 and x_{H_2O} =0.433) (local dead state)

Fig. 6 shows the total exergy values of liquid methanol/water mixture as a function of latitude and longitude, when a local dead state is used for exergy calculations. In this case, the total exergy of ambient air is zero in all locatations.

In Fig. 7 comparison between the total exergy of ambient air calculated from a unique and a from local dead state is made. Fig. 8 shows the same topic for the liquid methanol/water mixture.

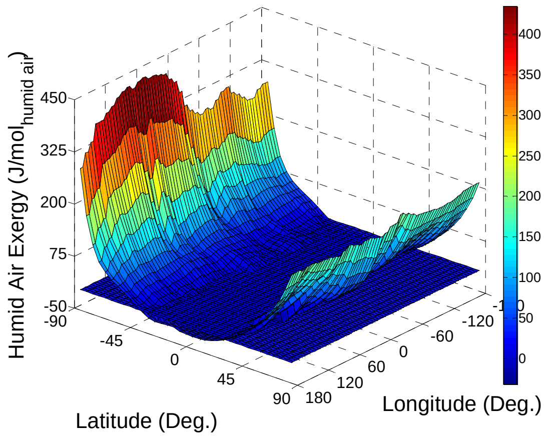

Fig. 7. Humid air exergy comparison (unique dead state and local dead state)

When the exergy entering the energy conversion system (ambient air+liquid methanol/water mixture)is to be taken into account, the ambient air exergy difference becomes insignificant representing less than $1^0/_{00}$ of the total value. In the case of the liquid mixture, a 1% difference is found between the exergy calculated based on one or other dead state. Nevertheless, as can be observed in Fig. 8, more information is obtained when a local dead state is used, as variation against latitude and longitude is more clearly appreciated.

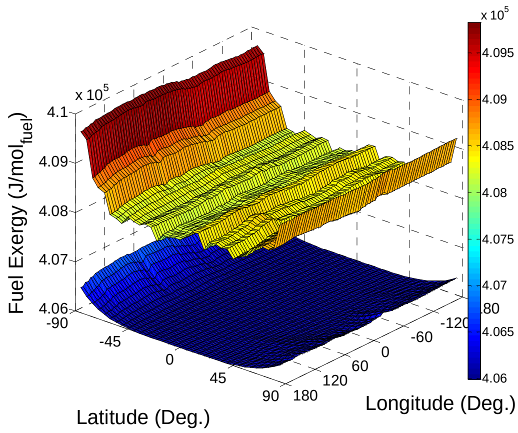

Fig. 8. Liquid methanol/water mixture exergy comparison (x_{CH_3OH} =0.567 and x_{H_2O} =0.433) (unique dead state and local dead state)

5. CONCLUSIONS

Total exergy calculation for marine and naval applications of an ambient air stream and a stream of a binary liquid methanol/water mixture at sea level and at any latitude and longitude, is made in two cases: using a unique dead state and using a local dead state. The results are compared and the main conclusions from this work can be summarized as follows:

- The dead state choice is not decisive when the total exergy of a stream of ambient air and a stream of liquid alcohol/water mixture is calculated.
- The local dead state choice allows appreciating the influence of local ambient conditions in exergy calculations.
- The choice of a local dead state is advisable for exergy calculations in order to obtain realistic values and to establish comparisons for different locations of energy conversion devices.

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ASPECTS REGARDING SHIP MAGNETISM GENERATED BY CORROSION CURRENTS AND STRAY FIELDS

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In order to determine the ship's vulnerability to magnetic detection all sources generating static and alternative magnetic fields must be considered. Besides ship ferromagnetism and induced eddy currents, major sources of magnetic signatures are corrosion related magnetism - giving both static and variable magnetic fields through various mechanisms, and the stray fiels generated by electric circuits onboard. This paper discusses the last two sources, their characteristics, the various processes of generating magnetic fields and the particular methods of reducing the resulting signatures.

Keywords*:* cathode protection system, corrosion currents, stray fields, ship magnetic signature

1. INTRODUCTION

The magnetic signature of a ship is the result of several magnetic fields generated by various sources. Due to the absorption phenomenon of electromagnetic waves in seawater, only two frequency bandwidths are relevant to electromagnetism – the ultra low frequency band (≤ 3 Hz), and the extremely low frequency band between 3 Hz and 3 kHz. Regarding the former bandwidth, there are four major magnetic field sources (Holmes, 2006):

- The ferromagnetic materials in the ship's hull subjected to the earth's magnetic field;
- The eddy currents induced by ship motion in the conducting materials onboard;
- The electric currents generated within the corrosion phenomenon;
- The electric currents circulating in distribution systems onboard.

The first two sources have been intensively treated (Barbu - 1990, Holmes - 2008) and there are several means of reducing the magnetic fields thus generated. These methods range from using materials with low magnetic permeability and electric conductivity in the construction of the ship's hull and internal structure, to active cancellation of the generated fields, by applying an identical field in magnitude and pattern, but of opposite polarity.

The final two sources are gaining interest in the past decades, with the use of non-magnetic and poorly conducting materials in naval constructions. In this paper the magnetic signatures produced by corrosion phenomenon and stray fields are discussed.

2. MAGNETIC FIELDS RELATED TO CORROSION

The corrosion currents that circulate through the ship's hull and around it represent a major source contributing to the ship magnetic signature and generating both static and variable magnetic fields (Daya et al., 2005). The electric field associated to corrosion currents constitutes the Underwater Electric Potential (UEP), whereas the Corrosion Related Magnetism (CRM) represents the magnetic field associated to the UEP field (Jeffrey et al., 2006). Due to its non-ferromagnetic nature, the CRM signature cannot be controlled nor reduced through standard degaussing methods, employed in the ferromagnetic signature reduction process. The main source of corrosion currents is the difference in electrochemical potential between the hull and propeller, constituted of a nickel, aluminum and bronze alloy (Daya et al., 2005). Thus are generated the galvanic currents passing through the hull and the surrounding seawater, determining the ship to act as an electric dipole. Without the aid of a cathode protection system, the steel in the ship's hull acts as the anode and sends an electric current through the seawater, towards the propeller - the cathode, and back to the anode through the connection point (Susanu, 1995).

The cathode protection system supplies the hull with a negative electrochemical potential in order to determine its cathode behavior, thus preventing corrosion. There are two types of cathode protection currently employed: the passive system, with zinc bars, and the active one, with impressed currents – the Impressed Current Cathode Protection (ICCP). The passive system consists of several zinc bars, having an electrochemical potential of -1000mV and acting as the anode, which are welded on the ship's hull, turning it into a cathode. The Impressed Current Cathode Protection system employs platinum coated cables that inject electric currents into the seawater and determine the hull to play the role of the cathode. The voltage is continuously monitored through the reference electrodes mounted on the hull and thus adjusted so that a pre-determined value of the potential difference is measured (Susanu, 1995).

The propeller position is in the aft part of the ship, therefore the main corrosion currents flow in the bow – stern direction, meaning from the fore part of the ship to the back. The simplest representation of the corrosion current source, as illustrated in Fig.1, is the electric dipole, oriented on the ship longitudinal axis which coincides with the z axis of the cylindrical coordinate system bounded to the ship (Holmes, 2008).

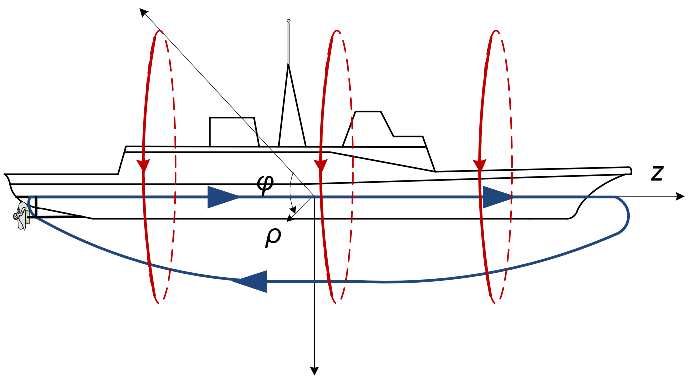

Fig. 1 Field lines of the static magnetic field produced by corrosion currents

Assuming that the propeller is located in the *z=-L/2* position and that the corrosion currents flow from it through the propeller shaft and hull, to a point in the *z=+L/2* position along the ship's hull, the B_φ component of the magnetic field is (Fogiel, 1995):

$$B_\varphi = \frac{\mu_0 I}{4\pi\rho}\left(\frac{z+\frac{L}{2}}{r_1} - \frac{z-\frac{L}{2}}{r_2}\right), \tag{1}$$

where:

$$r_1 = \sqrt{\left(z+\frac{L}{2}\right)^2 + \rho^2}\ , \tag{2}$$

$$r_2 = \sqrt{\left(z-\frac{L}{2}\right)^2 + \rho^2}\ , \tag{3}$$

where I represents the source current intensity, L – the dipole length and ρ – the radial coordinate. The maximum value is attained for z=0 :

$$B_{\max} = \frac{\mu_0 I}{4\pi\rho\sqrt{\left(\frac{L}{2}\right)^2 + \rho^2}}\ . \tag{4}$$

The magnetic field is proportional to the magnitude of the electric current, therefore through the selection of appropriate materials for the hull, the cathode protection system current magnitude is decreased and the CRM signature is reduced accordingly. The signature is also reduced if the distance between the anode current source and the propeller is decreased. The static magnetic fields due to corrosion have a smaller rate of decrease in range compared to the ferromagnetic signature and the one produced by eddy currents, because they are generated by an electric dipole. Therefore, starting from a certain range, the only detectable magnetic signature is the one produced by corrosion currents.

The corrosion currents are also an important source of alternative magnetic fields of extremely low frequency (Extremely Low Frequency Electromagnetic - ELFE), based on the modulation of corrosion currents through two separate mechanisms: the variation of the contact resistance between the propeller shaft and bearing (Daya et al., 2005) and the improper filtering of the seawater injected currents by the active corrosion protection system (ICCP). The corrosion currents flow from the propeller towards the ship's hull, through the shaft and bearing. On this path, any variation in the contact resistance between the propeller shaft and bearing determines the current modulation, generating an alternative electromagnetic field with the frequency equal to the propeller fundamental rotation frequency plus the harmonics. The ELFE signatures are easier to detect because the underwater magnetic sensors present a higher sensitivity at lower frequencies and the environmental noise is lower in the respective frequency band. They can be used as independent means of detection, but also as confirmation of an acoustic contact.

3. STRAY FIELDS

Stray fields are generated by any electric circuit on the ship, but the most intense are produced by the electromechanical and electric distribution systems. The ferromagnetic steel hull acts as a screen for most stray fields, mainly for the ones of higher frequencies, but the screen efficiency considerably decreases for the static fields and the ELFE fields. The geometrical aspects of magnetic screening were treated by Hasselgren and Luomi, and also presented by Holmes (Holmes, 2008). There is considered the case of an extremely long cylindrical shell with a distribution cable placed inside it, passed by the current I, and placed in position (0,-c) to the center of the shell. The other part of the cable, in position (0,+c) to the center, is passed by the electric current –I. The screen efficiency is expressed through:

$$S_H = 20\log\left(\frac{|\nabla X_0|}{|\nabla X_S|}\right) \tag{5}$$

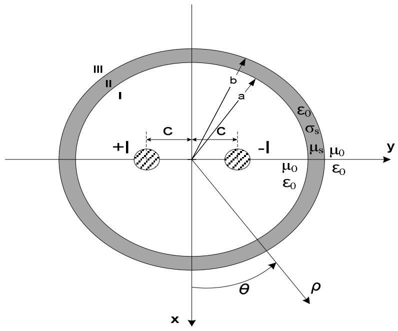

Fig. 2 Plane representation of the cylindrical shell screen

where:

$$X_S = -\frac{1}{\pi}\sum_{n=1,3,5,...}^{\infty}\frac{1}{n}\left(\frac{c}{\rho}\right)^n Q_n \sin(n\varphi) \tag{6}$$

$$Q_n = \frac{1}{\cosh(h_n(b-a)) + \frac{1}{2}\left(K_n + \frac{1}{K_n}\right)\sinh(h_n(b-a))} \tag{7}$$

$$K_n = \frac{h_n b}{\mu_r n} \tag{8}$$

$$h_n = \sqrt{\frac{n^2}{b^2} + \gamma_S^2} \tag{9}$$

$$\gamma_S = \sqrt{j\omega\mu_S\sigma_S} \tag{10}$$

$$\mu_r = \frac{\mu_S}{\mu_0}\ . \tag{11}$$

If the screen is absent, the parameter values are: X_0=X_S, and Q=1. Because the ferromagnetic hull screens most of the internal sources of stray fields, the magnetic signatures generated by stray fields are minimal compared to the other sources. But in the case of ships with non-magnetic hull, the screening efficiency is dramatically decreased. Furthermore, the all electric ships, with large electric motors for propulsion, the electrical networks onboard are passed by extremely high electric currents determining major stray fields.

4. REDUCTION OF CORROSION RELATED SIGNATURES

Regarding the static magnetic fields generated by corrosion currents, the method of reduction consists in covering the propeller by several layers of highly corrosion resistant paint. But the process of applying the paint is intensive, requiring special temperature and humidity conditions. Another disadvantage of using this particular type of paint is the necessity of removing the paint during structural inspections of the propeller.

The reduction of current modulation by propeller shaft is accomplished through passive and active shaft grounding systems - Passive Grounding System (PSG) and Active Grounding System (ASG), respectively (Jeffrey et al., 2006). The Passive Grounding System has the role of supplying a low impedance path to the ship's hull in order to avoid modulation mechanisms of the shaft's bearing, but its efficiency is lower compared to the Active Grounding System's. The latter, illustrated below, consists of two sets of sliding rings and brushes attached to the shaft. The first brush measures the electric potential of the shaft and hull, through a high impedance electronic amplifier, meant to reduce the impact of ring-brush impedance variations on the measurements. The system supplies electric current to the shaft through the second ring-brush set, so that the voltage between the shaft and hull is reduced to minimum. This condition effectively shortens the bearing and its modulation mechanisms.

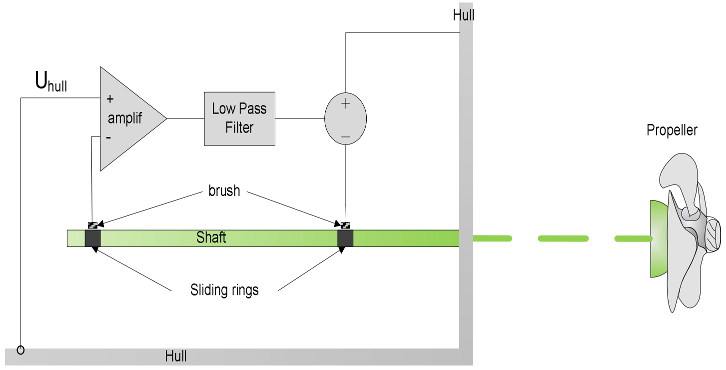

Fig. 3 The Shaft Active Grounding System scheme

The magnetic field produced by an electric dipole fades much slowly with distance compared to the one produced by a magnetic dipole. Due to the source nature of the Corrosion Related Magnetism (CRM), the standard degaussing procedures used in cancellation of magnetic signatures prove inefficient in the reduction of the CRM signature.
Reduction of both electric and magnetic fields produced by electric sources of the ship, including the corrosion currents and the impressed currents in the active cathode protection system, is based on a set of positive sources of electric current placed on the ship's hull, for the purpose of actively compensating the CRM signature, as well as anti-corrosion protection of the hull. By optimizing the number and positions of the ICCP system anodes, the corresponding signature can be reduced (Susanu, 1995). Both UEP and CRM signatures can be reduced through proper design of the ICCP system. These signatures may vary in time, due to several factors; therefore they need to be regularly measured in special ranges and the ICCP system accordingly adjusted.

5. REDUCTION OF STRAY FIELDS SIGNATURE

Through optimum design of the electric system and the distribution cables, the stray fields can be considerably reduced, with low costs and minimum impact on the ship, if this is performed before the ship construction. In order to demonstrate this, the previous case of a conducting cable is considered. The expression of the magnetic field for an infinitely long cable passed by an electric current is (Fogiel, 1995):

$$B_\varphi = \frac{\mu_0 I}{2\pi\sqrt{(x-x_0)^2+(y-y_0)^2}} \tag{12}$$

where (x_0, y_0) are the cable coordinates, (x, y) – the measurement point coordinates, and the other measures are known. If this configuration of two cables in the aforementioned example is replaced by a larger number of cables, and the passing current is equally divided between the cables, a considerable decrease in the stray fields is noticed.

The significance of stray fields is probably increasing, due to the use of non-magnetic materials. Moreover, by introducing the all electric ships, equipped with electric motors for propulsion and extremely high power consumption, the ship's electrical system is passed by large currents, generating high stray fields. The magnetic compensation system is capable of actively compensating the magnetic signature generated by stray fields. All stray field sources basically consist of current coils composed by closed electric circuits and they all form a magnetic dipole, which can be cancelled by another dipole created by degaussing coils. On the other hand, the current magnitude and path can modify abruptly, thus changing the data entered in the calibration system, rendering it inefficient. Therefore, the optimal method of reducing the magnetic signatures created by stray fields is the efficient design of the components of the ship's electrical system. If it renders necessary, small coils may be installed around major sources, and controlled by monitoring the source local field or current flux at its terminals (Daya et al., 2005).

6. CONCLUSIONS

The necessity of reducing the ship magnetic signatures relies mostly on the danger posed by magnetic mines. In order to determine the ship's vulnerability to magnetic detection all sources generating static and alternative magnetic fields must be assessed, removed, if possible, and then actively cancelled. Besides ship ferromagnetism and induced eddy currents, major sources of magnetic signatures are represented by corrosion currents, corrosion currents modulation, the injected currents by the ICCP system and the stray fiels generated by electric circuits onboard. The techniques of reduction are adjusted to each source characteristics, in order to attain a minimal magnetic signature.

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A FIRST AND SECOND LAW ANALYSIS DEVELOPED ON A TWO STAGE VAPOR COMPRESSION REFRIGERATION SYSTEM

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The Coefficient of Performance is a standard criteria for performance analysis of refrigeration cycle. Even if the first law analysis method is widely used to evaluate thermodynamic systems, it deals only with energy conservation. Instead, exergy analysis offers useful indications when the performance improvement is aimed.
In this paper it is developed a first and second law analysis. It is studied the influence of different parameters on the Coeficient of Performance and on the exergy efficiency of a two stage vapor compression refrigeration cycle working with ammonia frequently used in fishing industry.

Keywords: vapor compression, performance, exergy

1. INTRODUCTION

The spoilage of fish results from the protein denaturation, fat chages and dehydration, but it can be delayed by deposition at low temperatures. It is recommended that frozen fish products to be stored at temperatures specific to each species, type of product and intended time of storage.

In Europe, the storage temperature for all fishery products is –30^{o}C, for which spoilage because of bacterial action is definitely stoped and the rate at which other unfavourable changes continue is considerably diminished. Some products might be stored at higher temperatures without risk, but only for a short period. Appealing to freezing and frozen storage of fish it is possible to obtain a storage life of more than one year. Due to this technology, fishing vessels are able to stay at sea for long time, allowed the stockpiling of fish during periods of good fishing and important catching rates, but also was allowed the expansion of high quality fish products market.

A single stage vapour compression refrigeration system has one low side pressure (evaporator pressure) and one high side pressure (condenser pressure). The performance of single stage systems shows that these systems are adequate as long as the temperature difference between evaporator and condenser (*temperature lift*) is small. However, there are many applications where the temperature lift can be quite high. The temperature lift can become large either due to the requirement of very low evaporator temperatures and/or due to the requirement of very high condensing temperatures.

Most large cold stores are equipped with two stage vapor compression refrigeration systems working with ammonia.

Even if ammonia is considered to be toxic, its irritating odor will give early warning to personnel to evacuate the area. Yet, although modern ammonia refrigeration systems are designed to avoid the accidental release of ammonia, leaks and spills continue to occur each year. To avoid an accident, adequate staff training is needfull.

Besides the request for substances without ozone depletion potential (ODP=0), refrigeration technology must accomplish the task related to the direct ozone depletion potential (GWP) due to refrigerant emission. Natural refrigerants have no or very low GWP and zero ODP being able to meet prerequisites of the Montreal Protocol. These refrigerants also fulfil the aims of the Kyoto Protocol in terms of reduction of CO_2 equivalent emissions. Ammonia is an environmentally compatible refrigerant because it has zero ODP and GWP.

In the following, it is analysed from thermodynamic point of view a two stage vapor compression refrigeration cycle working with ammonia, frequently used in fishing industry.

In Figure 1 it is shown the refrigeration cycle in the log p – h diagram.

The main parts of the system are: a low and high pressure compressors, condenser, expansion valves and evaporators.

In one of the evaporators it is revealed the refrigeration capacity $\dot{Q}_{E_1}$ at the low evaporation temperature, t_{E_1}. In the second evaporator it is obtained additionaly an other refrigeration effect, $\dot{Q}_{E_2}$ but for a higher evaporation temperature $\left(t_{E_2}\right)$.

This temperature will determine the value of the inter–stage pressure.

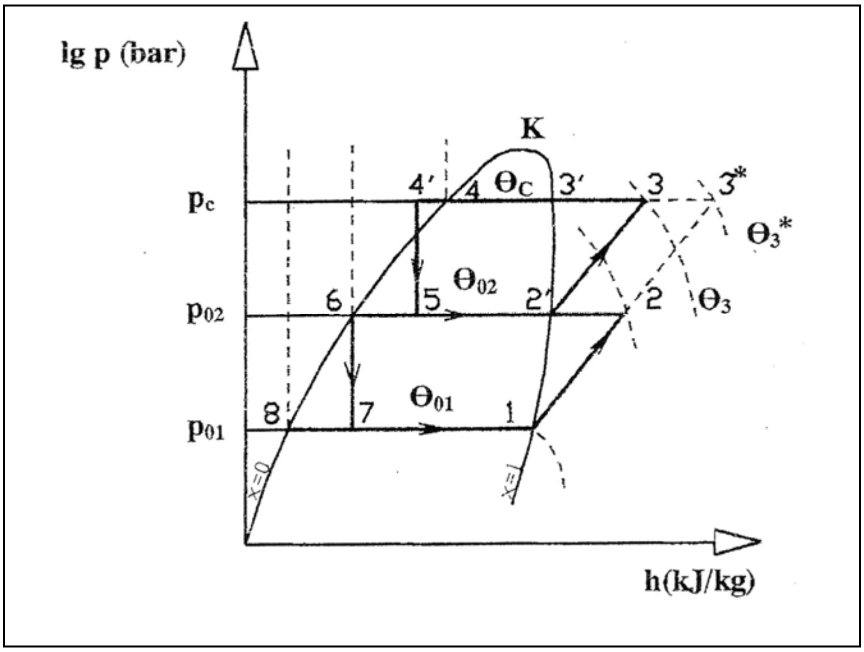

Fig. 1. log p–h diagram for a two stage vapor compression cycle working with ammonia.

2. ENERGETIC AND EXERGETIC EQUATIONS

The measure of the efficiency of a refrigerator is expressed by the Coefficient of Performance, COP. It is given by the ratio of the useful effect or desired energy transfer accomplished by the evaporator to the energy cost to achieve the effect (work of compression) in equivalent units.

$$COP = \frac{\textit{Heat extracted at low temperature}}{\textit{Work supplied}}$$

The COP of the studied system is given by:

$$COP = \frac{\dot{Q}_{E1} + \dot{Q}_{E2}}{\dot{W}_1 + \dot{W}_2} \tag{1}$$

Where:

$$\dot{Q}_{E1} = Q_{m1}\left(h_1 - h_7\right) \tag{2}$$

$$\dot{Q}_{E2} = Q_{m2}\left(h_{2'} - h_5\right) \tag{3}$$

$$\dot{W}_1 = Q_{m1}\left(h_2 - h_1\right) \tag{4}$$

$$\dot{W}_2 = Q_m\left(h_3 - h_{2'}\right) \tag{5}$$

$$Q_m = Q_{m1} + Q_{m2} \tag{6}$$

In the above equations, Q_m is the mass flow rate and h is the enthalpy.

The mass flow rates "Q_{m1}" and "Q_m" can be determined from relations (4) and (5) since the mechanic power for the two compressors (low pressure and high pressure) are get from the manufacturer's specifications.

The traditional analysis method based on the first law of thermodynamics consists in writing the equation of energy balance, but doing so, no information is available on the degradation of energy occurring in the process.

The exergy method of analysis overcomes the limitations of the first law of thermodynamics.

The first law of thermodynamics only deals with the magnitude of energy and does not refer to its quality, while the second law of thermodynamics states that energy is featured both by quantity and quality. Exergy analysis is performed when it is aimed the maximum performance of a system

Exergy analysis combines the first and second laws of thermodynamics, being considered lately the more powerful method for assessment of both quantity and quality of energy utilization.

The exergy method is seen as a powerful tool in improving the performance of the systems due to its benefits:

- more strict efficiencies are assessed by the use of the exergy analysis since exergy efficiencies are an indicator of the approach to the ideal;
- inefficiencies encountered during a process are assessed with exergy analysis because the kind, causes and places of losses are identified and evaluated.

The maximum work obtainable from a system using the environmental parameters as reference state is called "exergy" and it is given by its four component parts: physical exergy, kinetic exergy, potential exergy and chemical exergy. Normally, the kinetic and potential exergies are neglected. The exergy of the enthalpy of a process fluid (the refrigerant in this case) is calculated according to the first and second laws of thermodynamics:

$$ex = (h - h_0) - T_0(s - s_0) \tag{7}$$

where h and s are the enthalpy and entropy respectively and T_0 is the reference environmental temperature; h and s of the substance have to be evaluated at temperature and pressure conditions (T, p) and h_0 and s_0 are assessed at temperature and pressure of the environment (T_0, p_0).

As the refrigerant changes from state (1) to state (2), the exergy variation of the enthalpy is determined by:

$$ex_2 - ex_1 = (h_2 - h_1) - T_0(s_2 - s_1) \tag{8}$$

Exergy efficiency (ε) is a strong parameter used in the evaluation of an actual thermodynamic process and performance of the refrigeration system.

In our case:

$$\varepsilon = \frac{(\dot{E}x_1 - \dot{E}x_8) + (\dot{E}x_{2'} - \dot{E}x_5)}{\dot{W}_{1e} + \dot{W}_{2e}} \tag{9}$$

In the first evaporator:

$$\dot{E}x_1 - \dot{E}x_8 = Q_{m1}(ex_1 - ex_8) \tag{10}$$

In the second evaporator:

$$\dot{E}x_{2'} - \dot{E}x_5 = Q_{m2}(ex_{2'} - ex_5) \tag{11}$$

$\dot{W}_{1e}$ and $\dot{W}_{2e}$ are the electric powers supplied to the low pressure and high pressure compressors.

$$\dot{W}_{1e} = \frac{Q_{m1}(h_2 - h_1)}{\eta_c} \tag{12}$$

$$\dot{W}_{2e} = \frac{Q_m\left(h_3 - h_{2'}\right)}{\eta_c} \tag{13}$$

In the last two relations, η_c is the mean average performance; $\eta_c = 0{,}5$.

3. RESULTS OF THE THERMODYNAMIC ANALYSIS

In Table 1 are given values of the Coeficient of Performance and exergy efficiency for specified evaporation temperatures ($T_{E_1} = -40^oC$ and $T_{E_2} = -10^oC$), while the condensation temperature (T_c) varies.

Table 1: COP and ε values related to T_c values, when T_{E_1} and T_{E_2} are specified

T_c (°C)	32	36	40	44	48
COP (-)	3,45	3,17	2,81	2,6	2,5
ε (-)	0,8	0,75	0,5	0,27	0,25

In Table 2 are given values of the Coeficient of Performance and exergy efficiency for the same values of the evaporation temperature as above ($T_{E_1} = -40^oC$ and $T_{E_2} = -10^oC$) and for a given condensation temperature ($T_c = 35^oC$) when the vapor temperature before the high pressure compressor ($T_{2'}$) is varying.

Table 2: COP and ε values depending on $T_{2'}$, **when** T_{E_1}, T_{E_2} and T_c are specified

$T_{2'}$ (°C)	3	3,5	5	5,5	7	7,5	9	9,5
COP (-)	3,2	3,2	3,18	3,18	3,11	3,11	3	3
ε (-)	0,75	0,75	0,7	0,7	0,68	0,68	0,65	0,65

Next, in Table 3 are presented values of the Coeficient of Performance and exergy efficiency for different values of the evaporation temperature in the first evaporator (T_{E_1}) for the fixed T_{E_2} and T_c, respectively $T_{E_2} = -10^oC$ and $T_c = 35^oC$.

Table 3: COP and ε values depending on T_{E_1}, for given T_{E_2} and T_c

T_{E_1} (°C)	–43	–41	–40	–39	–37
COP (-)	3,23	3,17	3,12	3	3
ε (-)	0,55	0,7	0,73	0,75	0,92

In the last table (Table 4) are shown resulted values of the Coeficient of Performance and exergy efficiency for different values of the evaporation temperature, for the given evaporation temperature $T_{E_1} = -40^oC$ and condensation temperature ($T_c = 35^oC$).

Table 4: COP and ε values depending on T_{E_2} , for fixed values of T_{E_1} and $\boldsymbol{T_c}$

T_{E_2} (°C)	–13	–11	–10	–9	–7
COP (-)	2,8	3	3,17	3,25	3,48
ε (-)	0,47	0,66	0,7	0,75	0,8

4. CONCLUSIONS

In this paper it was investigated the way in which different parameters of a two stage vapor compression refrigeration system influence the Coeficient of Performance and the exergy efficiency. These parameters were: condensation temperature, temperature at the admission in the high pressure compressor, evaporation temperature.

It is seen that COP values are always higher than ε values. These results are absolutely normal because the occurred ireversibilities destroy a part of the input energy.

Developing an analysis on plant sections or processes with the lowest exergy efficiencies it is certain that the result is the efficiency improvement, while working only with energy efficiencies might not lead to accurate results.

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THE IMPACT OF THE GLOBAL CRISIS ON THE MARITIME TRANSPORT IN UE

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That through a period of global economic crisis is a topic on the agenda, but we have to analyze what impact it has on shipping and what measures we take to maintain or why not develop maritime activity in this period. The structural changes that occur in international trade and maritime development have a direct impact on growth and expansion port.

***Keywords**:* crisis, maritime transport, globalization, risks

1. INTRODUCTION

Maritime transport is the main means of transport for imports and exports of Europe.

Maritime trade increased four times in the last 40 years. Approximately 40% of EU's internal trade and 70% of external trade is transported by sea. This sector represents an important source of jobs and revenue for Europe. Each year, through its ports get over 400 million passengers and approximately 3.5 billion tons of cargo are loaded or unloaded.

Taking advantage of the rapid growth of international trade, shipping goods from Europe has grown considerably in recent years, with companies investing heavily in fleet renewal and expansion.

The global economic crisis affecting the world's strongest traffic of goods, the latter falling dramatically as the reduction of global economic activities. The downward trend has made its presence felt in EU ports in 2009, when the first three quarters of goods loaded and unloaded volume was reduced by about 30% over the same period of 2008.

According to Eurostat estimates for the first quarter of 2009 economic crisis in the shipping of goods to deepen in the first quarter. Quarterly growth rate calculated against the corresponding quarter of previous year was also negative by -12.9%. By default, there is a negative annual rate in the amount of cargo handled in major ports EU27 (excluding Italy), calculated for the first quarter 2009 and last three quarters of 2008, down from 2.5% to -3.7 %.

2. FACTORS INFLUENCING DEMAND FOR SHIPPING

Complexity of the global maritime industry is due, among others, the factors influencing supply and demand decisive shipping market. Demand is significantly influenced by several factors, such as: global economy; specific consumption; average distance; unforeseen events; shipping cost; speed of delivery and transport safety.

The world economy has the greatest influence on the demand for shipping, generating most of the goods that are transported by sea, be it raw materials or semi-finished or finished products.

Specific consumption is the second variable affecting the demand for shipping. An important question is short term seasonality. Maritime trade in agricultural products is subject to significant seasonal variations due to sampling periods, especially for cereals, sugar, and citrus. Fluctuations are observed at the shipping demand for oil and oil products, due to seasonality recorded in the energy consumption (high energy consumption in the northern hemisphere will determine the demand for shipping higher in autumn and winter than in spring and summer).

The average distance significantly influences the demand for shipping. To consider the average distance, shipping demand is expressed in tons / mile, a unit representing tonnage carried multiplied by the average distance at which goods are transported. For example, closing the Suez Canal led to a change in the average transport distance by sea from the Arabian Gulf to Central Europe, this distance increased from 6000 miles to 11,000 miles. Increasing the average distance driven increased demand for shipping which in turn increased the price.

Unforeseen events - such as economic events, political, changes of climate, price crashes - have always had a significant influence on the demand for shipping.

Economic shocks are most important influence on demand. For example economic shocks caused by the two oil crises in the years '73 and '79 have had dramatic effects on the demand for shipping. Had the same effect on stock market crash in 2000, but current global financial crisis. Policy shocks are also very strong even if their impact is rather indirect.

The cost of transport has always been an important element, the focus of this item the buyer goods intensifying with the growing share of the total cost of goods purchased. Thus, raw materials will be transported by seas and oceans, from great distances, if the final shipping cost will be an acceptable percentage of the total cost of goods.

Shipping cost significantly influences demand, especially long term rather than short term. In general, demand for shipping services is relatively inelastic, a sharp drop in tariffs for the transportation of such oil barrel remains without impact or having little impact on volumes of oil transported by seas and oceans, at least, the short term.

Speed of delivery and transport safety. Special attention is given how fast shipping, especially for goods with high value are. In their case, beneficiaries prefer a quick delivery to exempt them from possible devaluation of goods purchased or unpleasant situation, until the arrival of goods, assembly lines, for example, would be to suspend the activity causing losses. In such situations, sea transport air transport competed strongly, that the merit of being much faster, but at the same time, much more expensive.

3. SHIPPING COST

Throughout its existence, merit global shipping industry is that the shipping costs kept low, so it does not represent much of the value of goods transported. Low cost of shipping has encouraged individual beneficiaries to source goods from long distances desired, almost anywhere in the world.

Global shipping industry has managed to keep the cost of this service at a low level in a time when prices of goods increased by 10-20 times. In these conditions, for many goods, shipping cost is now a much smaller proportion of the value of goods transported only represents the past. For example, in 1960, cost of shipping a barrel of oil represents 30% of the oil transported, because, until 2004, the cost to drop to 5% of the oil transported.

Performance was obtained by combining economies of scale, new technologies, modern ports, operating systems and efficient use of international flags in order to reduce costs of different taxes and obtain economic benefits.

Unit cost for transporting a large amount of freight ton capital cost (CC), operating cost (EC) and the cost of handling goods (CM), divided by the PS indicator (parcel size), the bulk of goods is tonnage represented by.

$$\text{Unit cost} = CC + EC + MC$$

Shipping cost decreases as the ship carrying capacity increases as capital cost, operating cost and handling of goods do not increase proportionally with the carrying capacity of the vessel. For example, an oil tanker 300,000 dwt only costs two times more than 100,000 dwt each, but can carry three times more cargo. Hence, shipping cost of oil Lots 100,000 tons are much greater than the cost of shipping 300,000 tons of Lots.

There is a clear tendency to carry goods in Lots bigger. Aggressive curve of cost per unit transported (to transport bulk goods is the cost per tone cargo transported) created pressure led to increased freight Lots in the last century. This explains the great success including the shipping container, a container 20 feet can be loaded 15 tons of general cargo, one containership can carry up to 8,000 TEU (twenty foot equivalent units).

The decision to choose the shipping way is influenced by the following situations encountered in practice: distance to be traveled cannot be met otherwise than by sea (the two points can be connected only by sea, transoceanic transport Europe - South America); when the volumes are large enough and allows a conventional type irregular shipping or shipping container, resulting in a lower cost of transport; transit time increased when the client does not mind.

Whenever the distance you have to travel a commodity may be covered by another mode of transport, maritime transport will be chosen only through the much lower cost.

4. CONCLUSIONS

Shipping community at particular importance, are the main mode of transport by which the EU imports and exports approximately 40% of EU's internal trade and 70% of external trade is transported by sea.

Each year the Member States ports are loaded, unloaded about 3.5 billion tons of goods and over 400 million registered passenger terminals are specialized.

The importance of maritime transport is recognized at Community level and through the many jobs created both directly and indirectly in related economic sectors, but also because of significant revenue from this sector to the national budgets of Member States.

Given the important role, U.E. encourages development through actions shipping for modernizing infrastructure, harmonization of specific laws and procedures in the field. Exploiting the potential of shipping a Community level would result in a relaxation of freight traffic, especially road and rail infrastructure.

U.E. committed to pay particular attention to shipping and to take appropriate measures to stimulate the development sector. The document is known as the Community Strategy in sea transport 2018. The main objective of this strategy is to maximize the use of maritime transport, encouraging the development of competitiveness and its security.

It is known that in conditions of crisis, the recession, industrial and public consumption are reduced. Following the collapse diminishes the production and investment, which affects the volume of international trade

Shipping feels most strongly this development, since 90% of global trade in goods is carried by sea.

In conditions of crisis, many remain unused transmission capacity, and many new ship orders are canceled. Here, already, the three largest container transport companies folded, each, to construction contracts of over 50 ships.

In the world trade, China acts as a major exporter. Share his supplies owned by intensive products (rolled, pipes, reinforced concrete, cement, construction steel) and quantities of equipment and facilities. Most ships of the world touching the shores of China. Here, however, that this country in full economic assertion, aims to become a great naval power and transport their own goods. Under its shipping, China launched several new ship orders, and to ensure the necessary crews, urged seafarers serving in foreign shipping companies to return home, the national fleet.

In conclusion, global economic crisis because, there is a reduction in the freight to be transported, on the other hand, the Chinese fleet increased its market share, forcing the other fleets to shrink more and, once with it, to reduce crew requirements.

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THE INFLUENCE OF TUNGSTEN INERT GAS WELDING CURRENT ON MECHANICAL PROPERTIES OF AA5083 JOINTS

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The aluminium and its alloys are widely used in marine applications such as ship hull and its components due to its lightweight and corrosion resistance. The aluminium alloys require special tool and skill to weld due to high thermal conductivity. A research vessel "RV Discovery" is currently being constructed exclusively using 5083-aluminium alloy for University Malaysia Terengganu and the welding properties were investigated. The aluminium welded joint specimens were prepared using the Tungsten Inert Gas (TIG) welding process by certified welders at different current settings. The mechanical characteristics of the welded alloys were carried out for tensile, impact and hardness tests. Further, metallographic examination was conducted to identify and observe the various fusion zones. The results of these tests are presented in this paper. This study revealed that, the different welding current settings in which specimens were prepared remarkably affect the mechanical properties of 5083-aluminium alloy joints.

Keywords*:* 5083-Aluminium Alloy, Mechanical Properties, Tungsten Inert Gas

1. INTRODUCTION

Aluminium and its alloys are widely used in marine applications such as ship hull, its structural members and wheel house due to its lightweight and corrosion resistance. The aluminium alloys require special tool and skill to weld due to high thermal conductivity.. Aluminium is not just a single material, but a family of a variety of alloys grouped according to the alloy elements added and that provide the best combination of properties for a particular application. The end-user requirement to use alloy in ship construction may include strength, corrosion resistance enhancement and ductility, ease of welding, formability or combinations of some of these properties. A 5xxx series which contains up to 5% magnesium are widely used for engineering components, pressure vessels and transport equipment either in road, rail or shipping applications. The common alloys are 5083, 5454 and 5251.

Aluminium and its alloys are routinely welded and brazed in industry by a variety of methods. As expected they present their own requirements for the welded joint to be a success. Welding aluminium alloys are not more difficult or complicated than welding steel as it is just different and requires specific training. Aluminium and its alloys are easy to weld, but their welding characteristics need to be understood and the proper procedures employed. Aluminum is an excellent conductor of heat, thus it requires large heat inputs when welding starts, since much heat is lost in heating the surrounding base metal.

A variety of welding processes can be used to join aluminium, including the fusion methods MIG (Metal Inert Gas) and TIG (Tungsten Inert Gas) either mechanised or fully automatic. Furthermore, resistance welding MMA (Manual Metal Arc) and advanced processes such as solid state and friction stir welding also are used. Choice of the process is based on technical and economic reasons. For the most structural, selection of economic and quality welds such as TIG and MIG are recommended for aluminium alloys.

TIG welding is widely used for aluminium alloys welding because it produces of good welds appearance and quality. A constant AC (Alternating Current) power source with a continuous high frequency is used with water or air-cooled TIG torch and an externally supplied inert shielding gas. The AC process is used to provide a degree of cleaning of the aluminium surface during the electrode positive cycle though this is not a substitute for proper cleaning of the base material. The tungsten electrode diameter is usually about 2 - 4 mm. The filler material is fed into the weld bead from outside (see Fig. 1). TIG welding gives the welder very good control, but welding speed is normally slower than MIG because it requires higher welder competence.

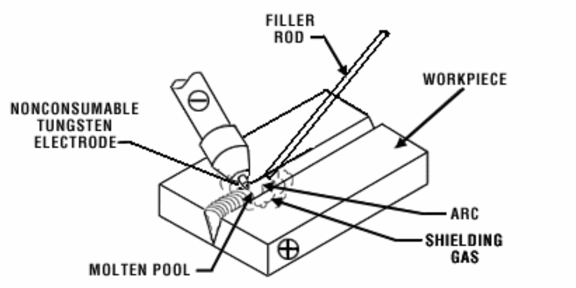


Fig. 1. TIG welding process

In arc welding, voltage and current are voltage of the welding machine which can be controlled. The length of the arc is directly related to the voltage and the amount of heat input is related to the current [1]. The variation of welding voltage and welding current can affect the strength and mechanical properties of 5083 aluminium alloy joints. Higher strength aluminum alloys are more susceptible to hot cracking in the Fusion Zone and the Partially Melted Zone and losses of strength or ductility in the Heat Affected Zone [6]. Thus, the aims of this paper were to study the influence of TIG welding current on mechanical properties and microstructure of AA5083 joints. This material is currently being used for hull construction of University Malaysia Terengganu research vessel namely “RV Discovery”. The results from the research can be used as a guideline in order to produce good quality of AA5083 joints during fabrication process.

2. MATERIALS AND METHODS

2.1 Parent material

The material used in this study was marine wrought aluminium 5083-H116 alloy. Wrought aluminium alloy is the term used for the alloy that is suitable for shaping by a working process such as forging, rolling and extrusion. Al-Mg-Si alloy is a typical example of wrought aluminium alloy widely used for structural applications with medium strength [2]. Aluminium 5083-H116 alloy are normally used as a hull structure in vessel fabrication. The material chemical composition analysis as revealed by mill certificate is shown in Table 1.

Table 1. Chemical Composition of the 5083 Aluminum Alloy (in wt %).

Al	94.747
Mg	4.300
Si	0.080
Fe	0.190
Cu	0.026
Mn	0.560
Zn	0.004
Cr	0.077
Ti	0.015
Pb	0.001
Bi	0.000

2.2 Welding procedure

Three sets of plates were used which each plate has a dimension of 300 mm x 150 mm x 8 mm. These sets of plates were welded together with different current settings at a constant voltage. One set of plates was used as a standard reference sample. All specimen thickness was 8 mm. After welding process, each plate was cut into 8 samples; 3 samples for tensile test and charpy impact test, 2 samples for hardness test and metallographic examination. The details of welding parameters are as follows:

Welding process : Tungsten Inert Gas (TIG)
Welding position : Downhand (1G)

At constant voltage =13.5 V; the welding current are varied as:
Sample A: 179 A, Sample B: 185 A, Control Sample: 182 A
The plate edge and welding joint preparation are shown in the figure 2

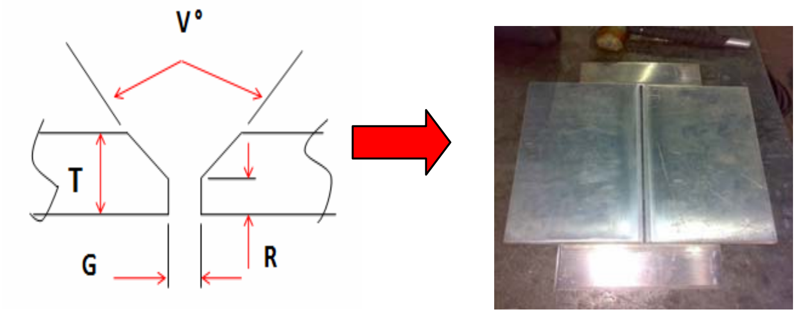


Fig. 2. Plate Edge and Welding Joint Preparation

The joint type used is Single V butt joint with the following particulars:
Thickness (T) = 8 mm
Root Gap (G) = 3 – 4 mm
Root Face (R) = 2 – 3 mm
Bevel Angle (V) = 60°

3. MECHANICAL TESTS

3.1 Tensile test

The welded samples were tested for tensile strength using the Instron tensile machine. The edges of the test samples were fitted into the jaws of the testing machine and subjected to tensile stress until the sample fractured. During the test, the various stress-strain diagrams were drawn for each of the samples from where the tensile load is determined. This is used in determining the strength and stiffness of the materials.

3.2 Impact test

The impact test was carried out using the Charpy impact machine. The charpy impact test used a 10 mm square bar notched in the centre of one face. A standard length of 55 mm ($\pm$ 0. 1 mm) samples was used. The V-notch was 2 mm deep and of angle 45°. The energy absorbed in breaking the test piece is measured in joules. The ability of the material to withstand the applied load is referred to as toughness.

3.3 Hardness test

Hardness test was carried out using Rockwell and Vickers hardness testing machine. The surface was first polished, and diamond indentor was used to make a dent on the polished surface and the diameter of the dent measured.

3.4 Metallographic examination

The microstructure details of the welded and the control samples were studied. The samples were cut to small pieces using metallographic cutter and put in a furnace at about 500°C for heat treatment. The base was made by using a hydro-press mounting machine and ground with emery paper of finer grade (180, 320, 600, 800 and 1000), then polished using the 6µ, 3µ and 1µ of diamond particles. The samples were etched with chemical solution that contained 190 ml distilled water, 5ml nitric acid, 3ml hydrochloric acid and 2ml hydrofluoric acid for about 80 seconds before being observed under the microscope (20x, 50x and 100x magnification).

4. RESULTS AND DISCUSSIONS

4.1 Effect of Variation Welding Current on Tensile Properties

Figure 3 shows the ultimate tensile results. It was revealed that the samples serve as control sample has the best ultimate tensile strength of 230.87 MPa followed by the samples B with ultimate tensile strength of 215.77 MPa which more than the values obtained for sample A with ultimate tensile strength of 211.69 MPa.

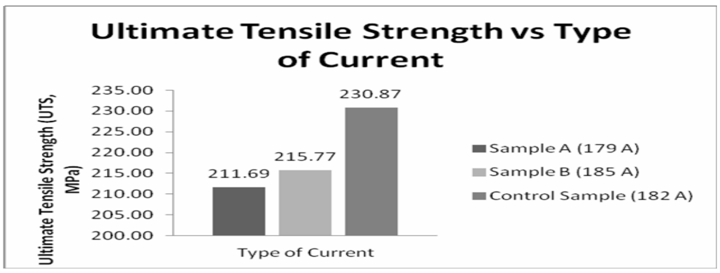


Fig. 3. Average values of the ultimate tensile strength of the samples at the various current welding conditions

4.2 Effect of Variation of the Welding Current on the Charpy Impact Properties

From Figure 4, it showed that the impact strength of the control sample has the best value with an average value of 18.17 J while the others welded sample has low impact strength with respect to the control sample. This is followed by the samples B with impact strength of 14.00 J. Sample A has the impact strength of 12.50 J. The impact energy is a measure of the toughness of the materials.

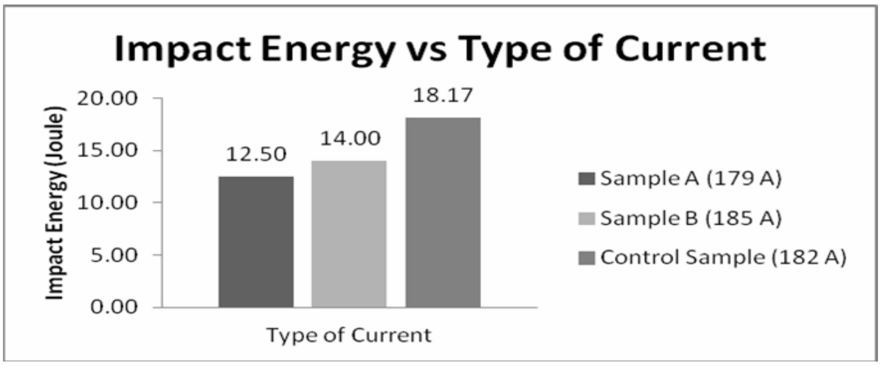


Fig. 4. Average values of the impact energy of the samples at the various current welding conditions in Joule

4.3 Effect of Variation of the Welding Current on Hardness Properties of the Base Metal Area

Figure 5 shows the average hardness on base metal area for Rockwell hardness test. Sample A has the highest hardness value of 78.16 Rockwell followed by sample B with value 76.61 Rockwell and control sample with value of 75.66 Rockwell. The hardness value is a measure of the resistance of a material to indentation.

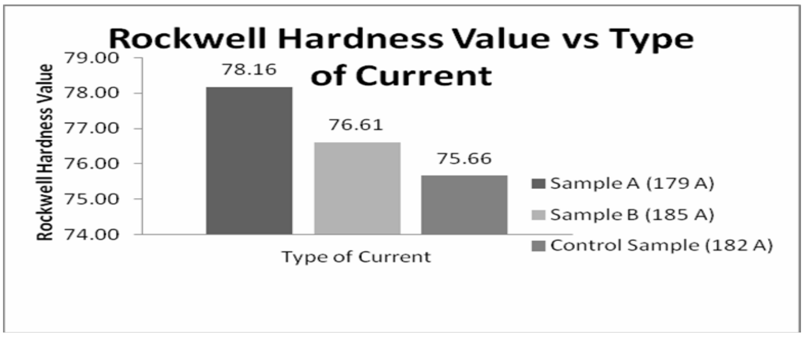


Fig. 5. Average values of base metal area of the samples for Rockwell indenter at the various current welding condition

4.4 Effect of Variation of Welding Current on Hardness Properties of Heat Affected Zone (HAZ) Area

Figure 6 shows the average hardness on heat affected zone (HAZ) area. Sample A has 77.50 Rockwell hardness followed by sample B of 77.46 Rockwell whereas control sample has the highest value of 78.19 Rockwell at HAZ area.

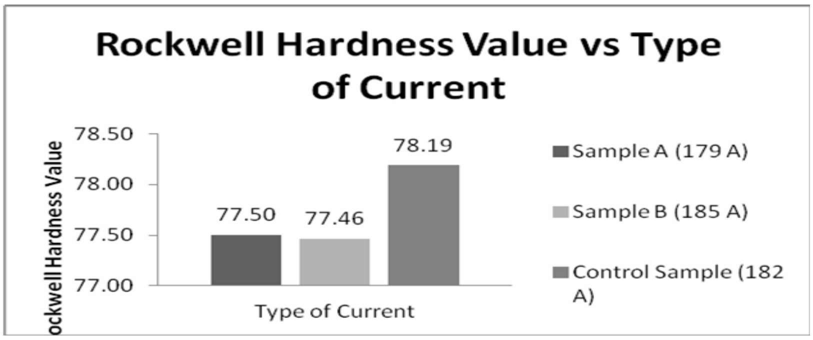


Fig. 6. Average values of heat affected zone (HAZ) area of the samples for Rockwell indenter at the various current welding conditions

4.5 The Effect of Variation of the Welding Current on Hardness Properties of the Weld Metal Area.

Figure 7 shows the average Rockwell hardness test on welded metal area. Sample A has the highest hardness value of 83.28 Rockwell followed by sample B and control sample which was 79.58 and 79.66 respectively.

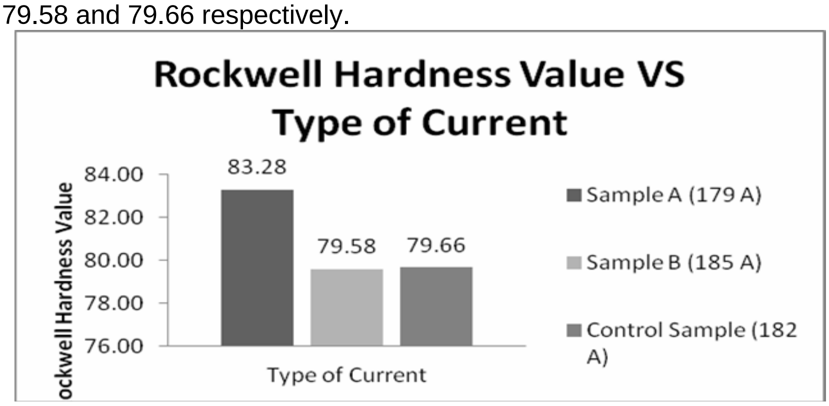
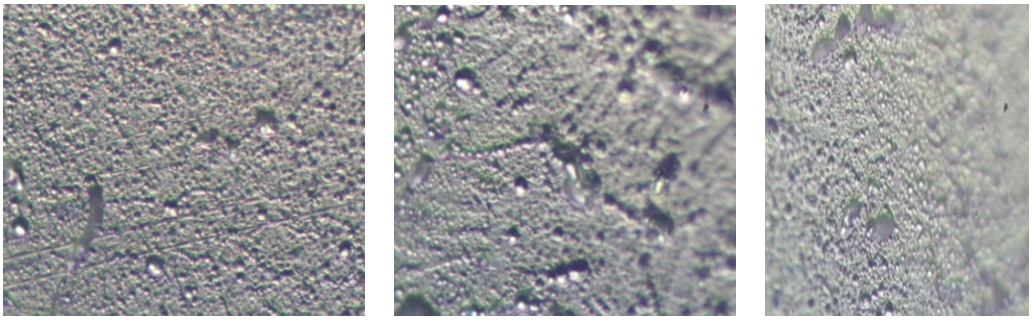


Fig. 7. Average values of weld metal area of the samples for Rockwell indenter at the various current welding conditions

4.6 The Effect of Variation of the Welding Current on the Microstructure of the Samples

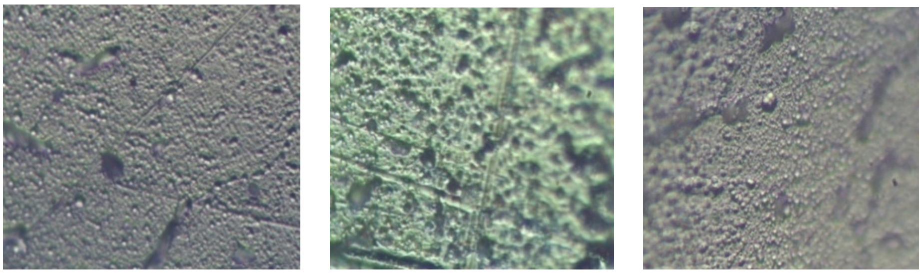
The micrographs show the melting reaction of secondary magnesium (Mg) particles surrounding Al's matrix. The general behaviour of the different samples depends on the effect of precipitation that takes place at the microstructure level as shown in the Figure 8-10. The micrograph of welded sample A subjected to current 179A shows well diffused Mg compound in the Al matrix. These fine particles are responsible for the high hardness values and improved ultimate tensile strength and impact strength obtained.

The micrographs of welded sample B subjected to current 185A shows fine grains of well diffused size compound of Mg in Al's matrix. This structure also enhanced good mechanical properties for the sample in terms of the ultimate tensile strength and impact strength. Whereas the micrograph for control sample shows fine grains of well diffused Mg compound in the Al matrix. It possesses the best ultimate tensile strength and impact strength with good hardness values as shown in previous figure. These fine particles are responsible for the good mechanical properties obtained.



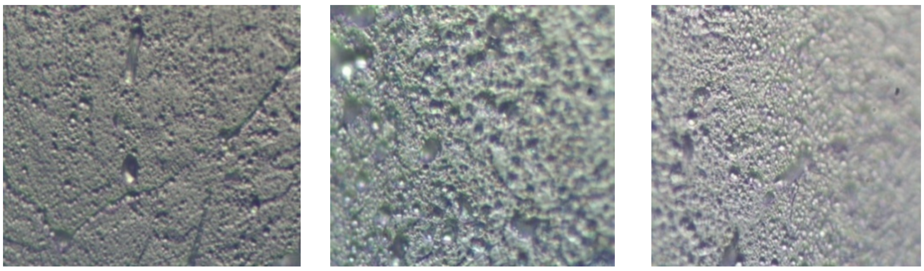
Control Sample (182A) Sample A (179A) Sample B (185A)

Fig. 8. Weld metal section (x100 magnification)



Control Sample (182A) Sample A (179A) Sample B (185A)

Fig. 9. Heat affected zone section (x100 magnification)



Control Sample (182A) Sample A (179A) Sample B (185 A)

Fig. 10. Fusion zone section (x100 magnification)

The above results shows that the 5083 aluminium alloy which serves as control sample had the highest ultimate tensile strength of 230.87 MPa and impact strength of 18.17 J. The hardness value competes favourably with the hardness values from the welded sample A as shown in above figure. Samples B that was welded at current 185A was observed to have the best performance close to the control sample with ultimate tensile strength of 215.77 Mpa, hardness value of 77.64 Rockwell and impact strength of 14.0 J. These were followed by samples A that were welded at current 179A. It has the best hardness value of 79.13.

It was observed that increasing the welding current caused the decreasing in mechanical properties of welded metal. These phenomena can be related to metallurgical behaviour of weld melt during solidification and chance of formation the defects in different conditions of welding. It related when increasing in arc voltage and welding current or reducing in welding speed increases the welding heat input. With increasing the input energy, grain size in welded microstructure increases and grain boundaries are reduced in the background. Reduction in grain boundaries as locks for movement of dislocations, increases possibility and amount of dislocation movement as line defects in structure. It will cause a reduction in strength and hardness of welded metal.

5. CONCLUSIONS

As a conclusion, the increasing of arc welding current in 5083 aluminium alloy will increase the welding heat input. Accordingly, the chance of defect formation such burns in welded metal also increases. This will affects on the mechanical properties and quality of welded metal badly. Besides that the high welding current also reduces the yield strength, ultimate tensile strength and toughness value of 5083 aluminium alloy welded metal.

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THE ADVANTAGES OF THE COMPOSITE MATERIALS USED IN SHIPBUILDING AND MARINE STRUCTURE

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This paper presents the advantages of using the composite materials in shipbuilding and marine structure. The volume and number of applications of composite materials have grown steadily, penetrating and conquering also the marine industry. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated applications.

Keywords: *composite materials, marine structure, design process*

1. INTRODUCTION

We can easily notice the growth of the use of composite materials for different structures. Composite materials are vital to industry because they have the ability to produce lightweight and stronger materials. It is also obvious that the production of these materials must not result in a prohibitive cost, which itself depends on their area of use. One estimate is that 30 – 40% of new marine applications are made of composite materials.

Composite laminates are used throughout the marine industry for numerous applications including primary and secondary structure, superstructures, piping, shafts, foundations, ducts, and gratings. Most applications are in small commercial vessels and recreational craft, with composites use in offshore structures rapidly growing (Niță, 2005).

2. THE DESIGN PROCESS OF A COMPOSITE FOR MARINE INDUSTRY

The design process with composite materials has the advantage that there are a large number of options available to the designer. The reinforcement type and its form produce an infinite variety. Thus stiffness and strength properties can be selected from a range that is comparable with thermoplastic materials to those, which are greater than high performance steel.

In the case of optimum design of composites not only is the geometry (shape) designed but also the material itself. The design process consists of several iterative stages, which result, hopefully, in the designer reaching a satisfactory solution to his problem and the designer must to take care of certain problems of the composite materials, which will be explain thereunder.

Anisotropic nature is relatively straightforward to design with materials that are isotropic such as steel and aluminium. However complications arise when the material to be designed is anisotropic such as a fibre composite. For example, a composite may consist of unidirectional fibres but with the fibre pointing off axis. If a tensile load is applied to the strip it will stretch as would be expected but it will also deform in shear.

Similarly in the case of a laminate strip reinforced with two layers of unidirectional fibre each offset from the axis by small but opposite angles. When a tensile load is applied to the axis the strip extends but will also twist. The resulting stresses and strains must be determined and this requires the use of laminate analysis methods.

Mechanical behavior of the composite materials depend of their architecture. If we are dealing with laminates and sandwich materials, you can see in figure 1 the composite material structure.

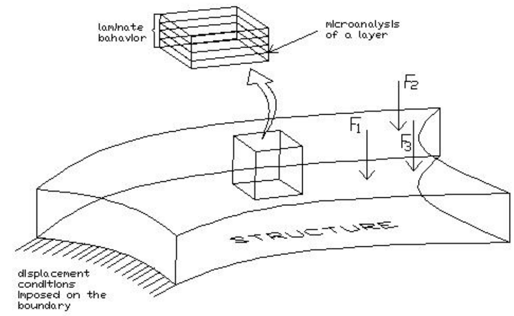

Fig. 1. One of the composite material structure

The analysis of the mechanical behavior of a composite material structure is shown schematically in figure 2. The study will comprise two stages:

1. The study of the mechanical behavior of each layer, sometimes called the micromechanical or microscopic behavior of the composite. This study is quite often described by microanalysis of the composite material.
2. The study of the global behavior of a laminate constituted of several layers. The global behavior of a laminate is generally called the macroscopic behavior of the composite or the laminate behavior.

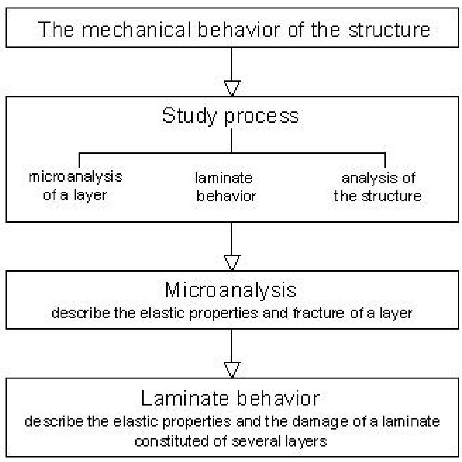

Fig. 2. Mechanical behavior analysis of a composite structure

Material choice is another important parameter that must be considered. The designer of composite systems has available an extraordinary degree of variety in choice of fibre, fibre geometry, matrix and amount of fibre present, which is an important benefit for the marine industry. In order to achieve the most effective design the designer has the option to optimise not only the construction but also the shape of the component by, for instance, putting the fibres in the direction of the principal stresses. Thus every design can have a different construction depending on the stresses being applied.

Methods of Modelling and Analysis. Statically determinate structures may be analysed by the usual methods of structural analysis. Indeterminate structures should be analysed by finite element analysis. Some finite element packages support modelling composites as layered shells in which the stacking sequence is specified as a section property. The following points should be noted:

1. Laminates should be modelled as anisotropic or layered plates;
2. Linear elastic material behaviour should generally be assumed;
3. Shear deformations should be taken into account, particularly in the case of sandwich structures;
4. Large deflection analysis may be necessary depending on the slenderness of the structure;
5. Stress concentrations should be taken into account;
6. Time-dependent creep effects should be taken into account;
7. Hygrothermal effects should be taken into account.

Design Guidelines. When checking laminates for strength, the multi-axial stress state should be taken into account, using a multiaxial failure criterion such as the Tsai-Hill criterion or the tensor polynomial criterion. It should be noted that the strength of composites varies according to direction and whether the stress is tensile or compressive. The Tsai-Hill criterion for a group of laminates of same type is:

$$\frac{\sigma_l^2}{\sigma_{lr}^2} + \frac{\sigma_t^2}{\sigma_{tr}^2} - \frac{\sigma_l \sigma_t}{\sigma_{lr}^2} + \frac{\tau_{lt}^2}{\tau_{ltr}^2} \leq 1 \tag{1}$$

where σ_{lr}, σ_{tr}, τ_{ltr} represents tensile stress of rupture of one laminate on direction l of the fiber and on direction t normal to the fiber, respectively shear stress of rupture to traction of a laminate. The ratios of shear strength and compressive strength to principal tensile strength are considerably less for most orthotropic composite laminates than for steel or aluminium plate (Potter, 2005).

3. BENEFITS OF THE COMPOSITE USED IN MARINE STRUCTURE

The performance of future marine ships requires novel and innovative material and structural systems to meet ever increasing design requirements. The application of composite materials for the primary structure of shipbuilding surface combatants offers the potential to meet these performance goals in the areas of increased payload fraction, reduced life cycle costs and improved survivability.

Fiber/matrix composite laminates as well as cored, composite sandwich systems have consistently been shown, in both military as well as industrial applications, to result in weight savings of up to 70% compared to traditional metallic structures. This weight savings can be used to maintain the necessary stability criteria as a ship accommodates additional payload or weapons systems and increases in tonnage throughout its service life. The reduced weight may also be used to increase ship speed or mission range.

The layered configuration of laminated structures allows opportunities to embed and integrate specialized materials into the composite lay-up which provide improved electromagnetic performance (Soumitra, 2010).

A further challenge is that even as current composite applications become more accepted and standardized in design and manufacturing, the underlying technology and threats continue to move forward. Next generation composite ship structures will need to provide better performance to meet more severe blast, ballistic, and electromagnetic requirements than ever before. Achieving this in an affordable system will require improved resin systems, better core materials and a total integration of technologies into a true multi-layered, multi-functional structural system. Incorporation of these technologies and many others will forever change the appearance, design, and performance of the navy's future surface ships, as you see projected in Figure 3.

Fig. 3. Evolution of the surface ships

4. CONCLUSIONS

Composites are able to meet diverse design requirements with significant weight savings as well as high strength-to-weight ratio as compared to conventional materials. Some advantages of composite materials over conventional one are mentioned below:

- ✓ Tensile strength of composites is four to six times greater than that of steel or aluminium;
- ✓ Improved torsional stiffness and impact properties;
- ✓ Higher fatigue endurance limit (up to 60% of the ultimate tensile strength);
- ✓ 30-45% lighter than aluminium structures designed to the same functional requirements;
- ✓ Composites are less noisy while in operation and provide lower vibration transmission than metals;
- ✓ Composites are more versatile than metals and can be tailored to meet performance needs and complex design requirements;
- ✓ Long life offers excellent fatigue, impact, environmental resistance and reduced maintenance;
- ✓ Composites enjoy reduced life cycle cost compared to metals;
- ✓ Composites exhibit excellent corrosion resistance and fire retardancy;
- ✓ Improved appearance with smooth surfaces and readily incorporable integral decorative melamine are other characteristics of composites;
- ✓ Composite parts can eliminate joints/fasteners, providing part simplification and integrated design compared to conventional metallic parts.

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FUZZY LOGIC METHODS USED IN MARITIME CONTAINER TERMINALS

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The goal of this paper is to present the results in the development of a methodology to integrate simulation, forecasting and planning to support day by day and long term decisions for operators working in intermodal container terminals. Congestion and increasing cargo dwell times is a common scene in many of the world's ports. Government authorities such as customs and health may delay containers from reaching their destinations due to inspections. Shipping lines are unconcerned if there is a poor terminal productivity, as long as their vessel sails on time.

***Keywords**:* maritime container, Fuzzy Logic, model optimization, forecasting

1. INTRODUCTION

In maritime container terminals, a large number of containers is handled day by day. The containers arrive at the terminal by truck, ship, or train. Before leaving the terminal, containers are usually stored in the terminal's yard area. In the yard's storage blocks, the containers are arranged in stacks, one beside the other in several rows. Transport between the storage positions in the yard and the terminal's exit points is usually handled by straddle carriers, by automated guided vehicles, or by transtainers. This increase requires improved, intelligent logistics.

2. HYPOTHESIS

Combinatorial optimization models apply for instance when assigning vessels to berths, when planning the tours for each transport vehicle, or when computing good storage positions for the containers. The berth planning problem is modeled by Lim (Lim, 1998) as a rectangular packing problem with side constraints. Lim presents a heuristic based on (heuristically) computing longest paths in a graph model. An alternative network flow approach is due to Chen (Chen, 1999).

Different versions of tour planning models for straddle carriers have been considered by Steenken et al. (Steenken, 2000). A linear sum assignment model of the dispatch of straddle carriers for discharging and loading trucks is iteratively solved in real-time (Steenken, 2000).

For each export container, the corresponding loading position is specified in accordance with the stowage plan. This stowage plan is derived from information provided by the shipping company. For each bay position, the shipping company defines properties for a container which may be stored at this position. In particular, the shipping company specifies the discharge port, the container type, and its weight. Even restrictions on stored goods may apply.

3. FUZZY VERSUS PROBABILISTIC APPROACH

The probabilistic approach to design accounts for the uncertainties existing in the parameters of engineering design problems. This method uses probability theory to combine the effects of uncertainties to create a prediction about the reliability of the resulting design. In a simple yet typical probabilistic design problem, a designer might be asked to find the optimal section dimensions for a beam to minimize the probability of structural failure, when the beam is subjected to an external load which has known probability distribution.

Mathematically, probability is defined as a number assigned to events of a universal set (the set of all possible events or outcomes of an experiment). Probability satisfies the three axioms of Kolmogorov (Papoulis, 1965), which dictate that: a) the probability of any single event occurring is greater or equal to zero; b) the probability of the universal set is one (since the universal set includes all possible outcomes, we are certain that an experiment will create an outcome) and c) the probability of the union of mutually exclusive events is equal to the sum of the probabilities of these events. This last axiom is called the “additivity axiom”.

There are two principal interpretations of probability, the objective and the subjective.

According to the objective interpretation, probability is *the relative frequency of occurrence of an event* (Siddall, 1983). In this objective sense, probability must be estimated from a large number of observations.

Using Fuzzy Logic for example, suppose you were advising a driving student on when to apply the brakes, would your advise be like: “Begin braking *74 feet* from the berth”, or would it be more like: “Apply the brakes *when approaching the berth*”? Obviously the latter, since the former instruction is too precise to easily implement. Everyday language is the cornerstone example of vagueness and is representative of how we assimilate and act upon vague situations and instructions. It may be said that we all assimilate and use (act on) fuzzy data, vague rules, and imprecise information, just as we are able to make decisions about situations which seem to be governed by an element of chance. Accordingly, computational models of real systems should also be able to recognize, represent, manipulate, interpret, and use (act on) both fuzzy and statistical uncertainties. Fuzzy interpretations of data structures are a very natural and intuitively plausible way to formulate and solve various problems.

4. SHIP AND TRANSPORT PLANNING

Containers are assigned to bay positions without consideration of the necessary transportation times between storage positions in the yard and the quay cranes. As mentioned before, for each bay position, the preliminary stowage plan only assigns a container type. For each bay, the dispatcher chooses a loading strategy which specifies a linear order of export container types (Steenken, 2000). Since bays consists of stacks, there are two straight-forward strategies used in real-world ship planning:

Loading column-wise or loading layer by layer. For reasons of visibility, the quay cranes always start with the bay positions at the water-side of the vessel. This fixes a loading sequence for both strategies. Two examples of these common loading strategies and the resulting loading sequences are presented in Figure 1.

Each bay may be partitioned into some partial bays which are considered separately. These partial bays correspond to the bay positions on deck or in the hold of the vessel. Moreover, the bay is partitioned into areas that correspond to the hatches. For each partial bay of the vessel, the loading strategy implies a linear list of container types to be loaded. After the dispatcher has decided for each bay which loading strategy will be used, for each bay we obtain a fixed loading sequence of bay positions. In combination with the stowage instructions provided by the shipping company, this results in a sequence of container types to be loaded into the bays.

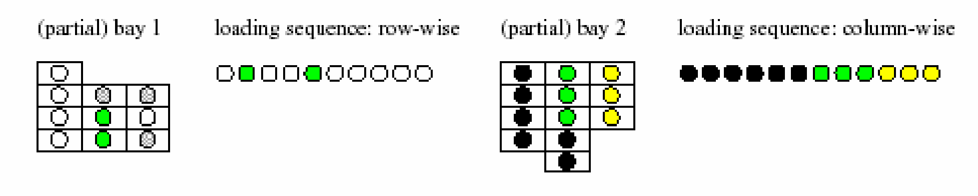

Fig. 1. Loading sequence

Each bay area will be served by one quay crane. This step is called crane split. Based on availability information of cranes, a crane split can be computed by solving a partitioning problem with some operational side constraints.

Since the number of cranes available for the loading process is small, an optimal solution of this partitioning problem can be computed within acceptable time.

More formally, we are given a set of bays (or partial bays) {1,…,B} b_i denotes the number of containers to be loaded into bay *i, bi*>0. This number is defined by the stowage plan provided by the shipping company. The vessel will be loaded using C quay cranes each of which has capacity *qi*, $1 \le i \le C$. The capacity corresponds to the time the crane will be available.

We search for a partition Q1, Q2,…,Q_C of {1,…,B} where each bay area Qi contains only consecutive bays, i.e., *Qi={j_i+j_i, …,j_i+k_i } for all* $1 \le i \le C$. Obviously, for a given partition, the resulting absolute load is $Q_i = \sum_{j \in Q_i} b_j$ i.e. the total number of export containers for bay area Qi. A good choice of a partition may balance the resulting relative loads Q_i/q_i for all quay cranes $1 \le i \le C$ as much as possible. Minimizing the maximum imbalance, we find:

$$\min \underset{\mathrm{i,\,j} \in \{1,\ldots,\mathrm{C}\}}{\max} \left| \frac{Q_i}{q_i} - \frac{Q_j}{q_j} \right| \tag{1}$$

For *C*, a value between 2 and 6 is reasonable for real world container terminals. The number of bays may vary between 20 and 50. Consequently, we may solve this partitioning problem by straight-forward enumeration. An initial upper bound can be derived from the weighted average loads:

$$\mu_i = \frac{q_i}{\sum_{i=1}^{C} q_i} \sum_{j=1}^{B} b_j \tag{2}$$

A corresponding "partition" may recursively be constructed. Let Q_i ={1,2,…,k_1} Where k_1 is chosen minimal such that $Q_1 \ge \mu_1$. Then Q_2 is defined by $Q_2 \ge Q_1 + \mu_2$. The remaining partition is analogously constructed except for the last bay area which contains all remaining bays. Better upper bounds may easily be obtained by slightly varying the values of k_i.

5. APPROACHING THE PROBLEM

In the above Stowage planning-hypothesis we consider the container ship consisting of a single bay for container stowage and the ship starts its service route at port 1 with its bay empty of containers, and it sequentially visits ports 2, 3,…, *N*.

The real container ship (Avriel, 1998) consist in several bays for container storage. The container terminal acting like container source on container depot.

We have m container sources S1, S2,…, Sm (container depot, trucks, etc.);

The ship contains n stowage bays B1, B2,…, Bn;

k specifies the number of objective points Z1, Z2,…, Zk;

k optimal for minimal value;

Source Si have reserve in and Dj have a level of demand;

For every objective Zk we can associate penalty c_{ij}^{k} with container transfer from source to destination (Chen, 1999);

x_{ij} number of containers transferred between S_i and D_j;

For extended formulation of the compromise (Raicu, 2005) fuzzy problem is:

$$\min_{\left\{x_{ij} \in X\right\}} \mu\left(\left\{x_{ij}\right\}\right) = M_{w}^{(\alpha)}\left(\Phi_1\left\{x_{ij}\right\}, \Phi_2\left\{x_{ij}\right\}, \ldots, \Phi_k\left\{x_{ij}\right\}\right) \quad (3)$$

6. CONCLUSIONS

It is clear that is very difficult to solve the complete problem at once. This is the reason we chose to start from a relatively simplified version of it, including initially only the most important constraints. This will help to acquire a deeper understanding of the specific problems involved and test the method. After this is done it would be easier to introduce the rest of the constraints.

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SIMULATION OF COMBUSTION PROCESS OF A DIESEL ENGINE FUELLED WITH BIOFUELS

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A thermodinamic model has been used to investigate the combustion performance of a four cylinder direct injection diesel engine fueled by biofuels The numerical simulation was performed at constant speed. The indicated pressure, temperature diagrams are plotted and compared for different fuels. The emissions of soot and nitrous oxide are computed with phenomenological models. The experimental work was also carried out with biodiesel diesel blends, to validate simulation results with experimental results, and observed that the present model is successful in predicting the engine performance with biofuels.

***Keywords**:* biofuels, thermodinamc modeling, NOx, soot

1. INTRODUCTION

Simulation has contributed enormously towards new evaluation in the field of internal combustion engines. Mathematical tools have become very popular in recent years owing to the continuously increasing improvement in computational power. Diesel engines occupy a prominent role in the present transportation and power generation sectors. There have been many methods tried and are in use to reduce pollutant emissions from a diesel engine. The main options to reduce pollutants are the usage of biofuels and adopting some modifications to the combustion process. Diesel engine simulation models can be used to understand the combustion performance; these models can reduce the number of experiments.

Depending upon the various possible applications different types of models for diesel engine combustion process have been in use. In the order of increased complexity and increased computer system requirements these can be classified as thermodynamic zero dimensional models, quasi dimensional phenomenological models and multidimensional computational fluid dynamics models [1-6].

Biofuels have become an alternate to petro diesel in the view of the faster depletion of petro diesel. Understanding the aspects of biodiesel combustion is now possible with the simulation models. Many researchers throughout the world have developed such models. Rao et al [8] has developed a one dimensional, quasi-steady multi zone model from a fuel injection sub model to predict performance and emissions for variables of speed and injection timing. The model successfully predicted the effect of injection timing on the engine and emission parameters. Many other contributions are available on the combustion performance of diesel engine fueled by biofuels [7-10]. However, certain complex models are used nowadays to predict the combustion process more accurately. The literature says that even some zero dimensional models are simple and the efficiency can be compared with the complex models.

2. THE MODEL FOR ENGINE SIMULATION

An attempt has been made to develop a simple model that can predict the engine combustion performance with different fuels and with selected options. Engine performance, emission parameters obtained from the computer program has been compared to validate the experimental results. The model has been used to find cylinder pressure, heat release rate, brake thermal efficiency and with possible phenomenological models to predict the ignition delay, soot formation, No formation. Initially the blends of biodiesel diesel blends B10, B20 & B100 were tested in the engine with the predetermined test procedure. For engine simulation the design input conditions of an engine speed 1500 RPM (synchronous speed for 35kVA Diesel generator T650 made by Tractorul S.A) and fuel injecting timing of 19^0 BTDC are used, the appropriate other initial conditions were assumed.

Assumptions used in the model

1. Zero-dimensional flow conditions inside the cylinder;
2. The gas in the cylinder moves through the equilibrium states
3. No gas leakage through the valves and piston rings so that the mass remains constant
4. Uniform crank speed
5. The cylinder gas is air and it obeys the gas laws
6. The specific heats of the gas mixtures are calculated as a function of temperature
7. Pressure and temperature in the cylinder are uniform and vary with crank angle
8. The details of the computer program start from solving the energy equation, the gas properties calculation, heat release analysis, ignition delay model, calculation of frictional power and emission formation models for finding soot formation, NOx formation

Fuel pump and injection

To simulate the fuel-injection rate m_n (kg/s), the following expression proposed by Ferguson [7] is used:

$$\frac{\dot{m}_{fi}}{M_{tot}} = \frac{\omega(\varphi)}{\varphi_d \Gamma(n)} \left(\frac{\varphi - \varphi_s}{\varphi_d} \right)^{n-1} \exp\left(\frac{\varphi - \varphi_s}{\varphi_d} \right) \tag{1}$$

where $\ln\Gamma(n) = (n-0.5)\ln(n) - n + 0.5\ln(2\pi) + 1/(12n) - 1/(360n^3) + 1/(1260n^5)$ with n = 3.6. Here, φ_s is the crank angle where injection begins, φ_d the duration of injection, and M_{tot} the total amount of injected fuel per cycle, which is found by using experimental data under steady-state conditions for the applicable engine-speed and fuel-pump rack position.

Combustion

For the study of combustion processes, the model proposed by Moran, and Shapiro, is used [5], i.e we include preparation-limited and reaction-limited combustion rates. The corresponding equations are:

$$P = K_1 M_i^{1-x} M_u^x p_O^y \text{ (kg of fuel /ºCA)}, \tag{2a}$$

for the preparation rate, which controls the rate of burning of most of the fuel, and

$$R = \left(K_2 p_O / N\sqrt{T}\right)e^{-Eact/T}\int\left(P - R\right)d\varphi \text{ (kg of fuel /ºCA)}, \quad (2b)$$

for the rate responsible for the early part of combustion. Here, $M_i - \int_{\varphi_i}^{\varphi}\left(dm_{fi} / d\varphi\right)d\varphi$ is the total mass (kg) of injected fuel up to the crank angle φ and $\varphi dm_{fi} / d\varphi$ is the injection rate known from Eq. (1). Also, $M_u = M_i - \int Pd\varphi$ is the total mass (kg) of unprepared fuel, act is the reduced activation temperature (K) which accounts for the ignition delay, and p_O is the partial pressure of oxygen (bars). The constants x, y, K_1, and K_2 are found from calibrations against experimental data under steady-state conditions.

It is vital for proper simulation of transient responses that combustion modeling takes into account the continuously changing character of the operating conditions. The constant K_1 in the (dominant) preparation-rate equation is correlated with the Sauter mean diameter (SMD) of the fuel droplets by the relation $K_1 = 1/(SMD)^2$. The empirical expression of Hiroyasu is used, i.e.

$$SMD = 23.9(\Delta p)^{-0.135}\rho_g^{0.12}V_{tot}^{0.131} \text{(μm)} \quad (3)$$

where Δp is the mean pressure drop across the injection nozzle in MPa, pg the air density in kg/m3 at the beginning of injection, and Vtot (in mm3) is the amount of fuel delivered per cycle per pump stroke.

The ignition delay time was calculated whit the formula proposed by Baert [9]

$$\tau_{aa} = \tau_{ao} + k_1 p^{-n1}\exp\left(\frac{E}{\Re T}\right) + k_2 p^{-n2} \text{[ms]}, \quad (4)$$

$\tau_{ao} = 0.36$, *k_1=1.154*10^{-4}, k2=2550, n1=0.75, n2=2.45,* $E/\Re = 9495$.

The injection law considered was a linear one, but supplementary parabolic and polynomial (second degree) we have been taken into account.

Prediction of NOx formation

NOx formation is modelled using the Zeldovich Mechanism, the amounts of NOx formation for each thermodynamic cycle have been predicted using the procedure explained by Kannan, and Udayakumar [3]. After establishing the temperature and pressure data at each crank angle using zero dimensional model the equilibrium concentrations of the nitrogen and oxygen can be predicted, which is used for better prediction of NOx formation. The nitric oxide emissions are computed using equation (5).

$$\frac{d[NO]}{dt} = 2k_{1f}\left(\frac{k_p\ p^0}{RT}\right)^{0.5}[N_2][O_2]^{0.5} \quad (5)$$

$$k_{1f} = 1.8210^{14}\ e^{\left[\frac{-38370}{T}\right]},\ k_p\ p^0 = e^{\left(\frac{-\Delta G^0 T}{R_u T}\right)} \quad (6)$$

Where $[O_2]$ is the equilibrium oxygen concentration in moles, $[N_2]$ is the equilibrium nitrogen concentration in moles.

Prediction of soot formation

Soot has been predicted using the relation proposed by Lakshmi Narayanan, and Aghav, [4] which give the values of soot formation in gm/sec with assumed data. The constants C_{BS} needs to be modified for prediction of soot with the exhaust gas reconciliation process. The following equation (7) has been used for prediction of soot:

$$\frac{dm_s}{dt} = C_{BS}\,\Phi\, m_f\,\sqrt{p}\,e^{(-E_{sf}/R_a T)} \qquad (7)$$

Heat transfer

The model of Annand is used to simulate heat loss to the cylinder walls, is,

$$dQ_L/dt = F\left[a(\lambda/D)\mathrm{Re}^b(T_w - T_g) + c(T_w{}^4 - T_g{}^4)\right] \qquad (5)$$

where $F = \pi D^2/4 + \pi Dx$ is the surface and *x* the instantaneous cylinder height in contact with the gas; λ is the gas thermal conductivity (W/mK) and the Reynolds number Re is calculated with a characteristic speed equal to the mean piston speed and a characteristic length equal to the piston diameter *D*. For transient engine operation, a hysterysis expression is used to update the wall temperature T_w at each consecutive cycle, which changes as a result of the increase in speed and/or fuelling [10].

Mechanical friction

To calculate the friction inside the cylinder, the following expression based of Millington and Hartles is used [9]:

$$(fmep)_{st} = 0.123CR + 4.774\cdot 10^{-4}N, \qquad (6)$$

where *(fmep)*st is the friction mean effective pressure (bar) at steady-state conditions and CR is the engine compression ratio.

3. SOLUTION APPROACHING

The pressure and temperatures at each crank angle step in the cycle are obtained by solving the energy equation; the properties in the combustion period are calculated used heat release model. Pressures and temperatures with crank angle are plotted for the entire cycle. Ignition delay period, adiabatic flame temperature, combustion duration, NOx and soot formation are predicted using empirical models. Brake power and brake specific fuel consumption is calculated by using appropriate formulae.

Using the mass of fuel burnt in each step of the cycle calculation we may determinate the value of heat release dQ_c:

$$dQ_c = dm_c\,Q_i\,, \qquad (7)$$

there Q_l is the lower specific heat value of fuel.

The first law of thermodynamics for combustion and detention process in accord whit the rearranged formula is:

$$e = \lfloor E_{j+1}(T_{j+1}) - E_{j+1}(T_s) \rfloor - \lfloor E_j(T_j) - E_j(T_s) \rfloor + dW - dQ_c - dQ_L \, , \tag{8}$$

where T_s is the reference temperature for the chemical reaction and the others terms in the equation has the form expressed previously.

A solution is obtained when $e \to 0$ ($|e| < .001$) The numerical method used may be the Newton-Raphson method [9]. In this method if $(T_{j+1})_{q-1}$ is the estimated value of T_{j+1} will be given by the expression:

$$(T_{j+1})_q = (T_{j+1})_{q-1} - \frac{e_{q-1}}{MCv[(T_{j+1})_{q-1}]} \, . \tag{9}$$

In this case the pressure to the end of step and the initial start iteration have the following formulae:

$$V_{j+1} = \frac{V_s}{\varepsilon - 1} + \frac{V_s}{2}\left[\left(1 - \cos\left(\frac{\pi n}{30} t_{j+1}\right)\right) + \frac{S}{8L}\left(1 - \cos(2\frac{\pi n}{30} t_{j+1})\right)\right] \tag{10}$$

$$p_{j+1} = \frac{m_{j+1}}{m_j} \frac{V_j}{V_{j+1}} \frac{T_{j+1}}{T_j} p_j \, , \tag{11}$$

$$T_{j+1} = T_j \left(\frac{V_j}{V_{j+1}}\right)^{\frac{\Re}{Cv(T_j)}} + \frac{dQ_c}{m_j C_v(T_j)} \tag{12}$$

The detention stroke was considered simultaneously whit the combustion process as a continuation of the last one.

After obtaining the primary engine parameters, it is necesar to calibrate the solutuin.The solution calibration means in principal the calibration of the combustion model constants util a good agreement between indicating pressure calculated and measured is achived.

4. RESULTS AND DICUSIONS

The pressure and temperature histories obtained from the program have been analyzed for different fuels. The pressure crank angle diagram can be used to assess the thermodynamic behavior of the engine. The peak pressures are observed near TDC position, the higher pressures can be observed during the combustion phase of 340 in 380, and the higher peaks can be observed at higher loads than that of lower and part loads

The peak cylinder pressures are low with biodiesel blends in comparison to diesel since the heating value of biodiesel is lower than that of diesel resulting in lower heat release. Poor atomization and slow heat release rate also the reason for lower peak pressure for pure biodiesel. However, these effects will be negligible for small quantity blends (B10) and the results are closer to diesel. The indicated pressures versus crank angle graphs are shown in Figure 1 and Figure 2, for 100% and 50% load. The results is give after full calibrations of models.

The best results are obtained for 100% load as expected. At partial loads the combustion process is too complex to be properly modeled by thermodynamic models used. But the results are in good agreement with measurements for the test speed 1500 rpm.

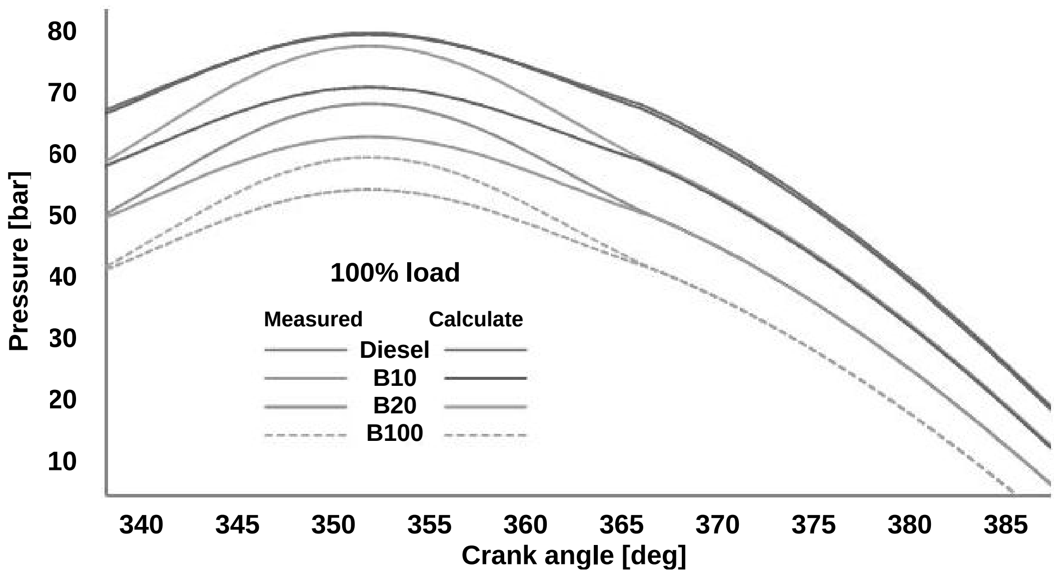

Fig. 1 Pressure versus crank angle at 100% load for diesel and biodiesel fuel

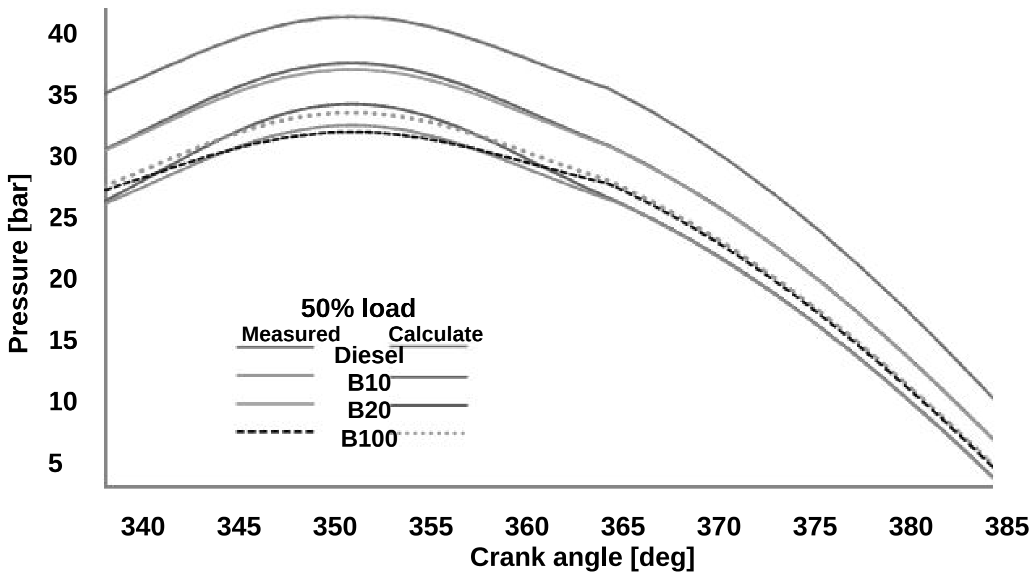

Fig. 2 Pressure versus crank angle at 50% load for diesel and biodiesel fuel

Maximum temperature values are decreased with biodiesel-diesel blends due to a reduction in heating values of blends in comparison to neat diesel. This effect is observed for almost all biofuel blends. The temperature plots for the different fuel blends are shown in Figure 3

The ignition delay value for diesel on full load condition is (cetane number 50) obtained as 0.52 10^{-3} seconds.The ignition delay values for different fuels at full load are: 0.543, 0.552, and 0.431 for B10, B20 and B100 respectively. The low value of ignition delay with B100 was observed since the assumed value of cetane number for biodiesel is 60.

Nitric oxide formation calculation is based on Zeldovich mechanism. At full load B10 (2194 ppm) showing higher NOx emissions among all are due to the presence of the fuel oxygenate in the diesel enhancing the combustion quality causes an increase in maximum combustion temperatures.The NOx emission with crank angle with different fuels is shown in Figure 4. The NOx emissions are little lower for B100 (950 ppm) in comparison to diesel. The present model calculates the NOx formation based on temperature, practically biodiesel combustion results in higher NOx emissions due to effects like higher bulk modulus, higher fuel consumptions due to higher densities and the presence of fuel nitrogen in the biodiesel.

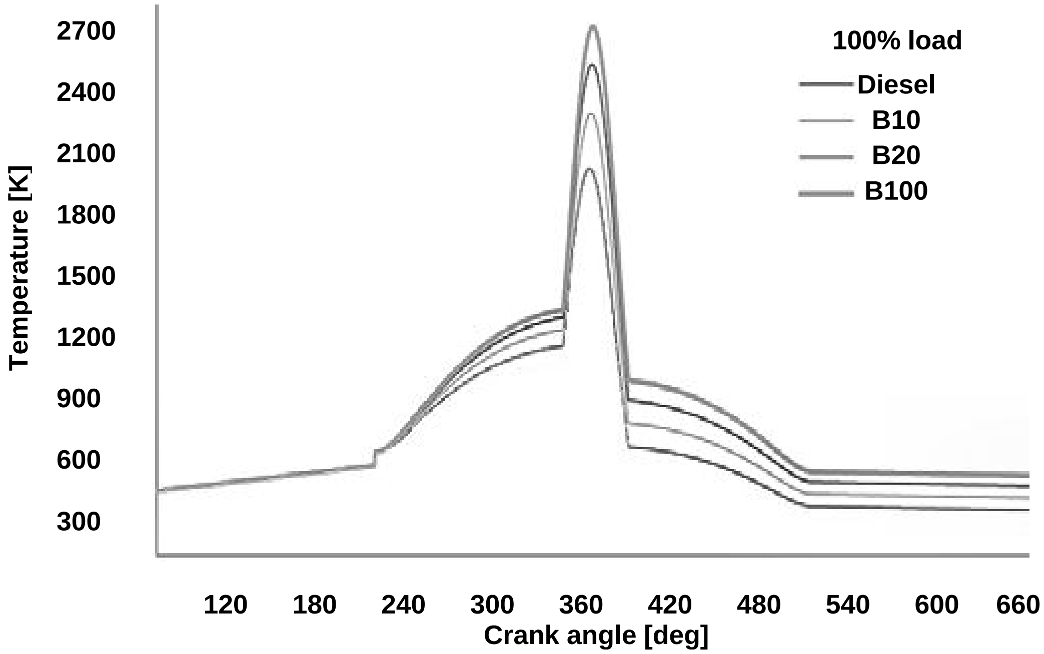

Fig. 3 Temperature versus crank angle at 100% load for diesel and biodiesel fuel

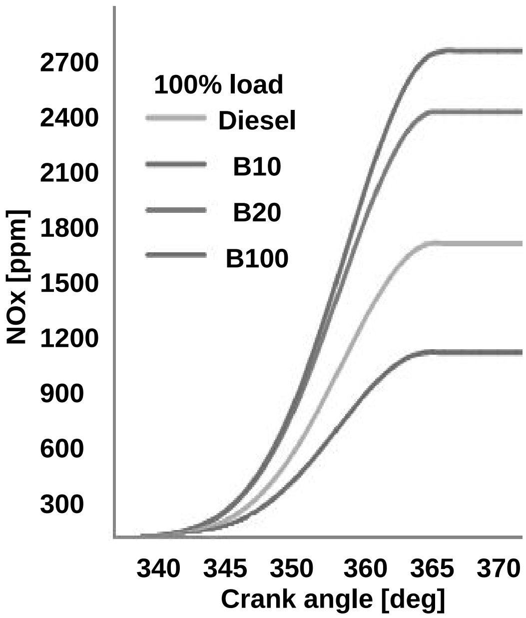

Fig. 4 NOx at 100% load

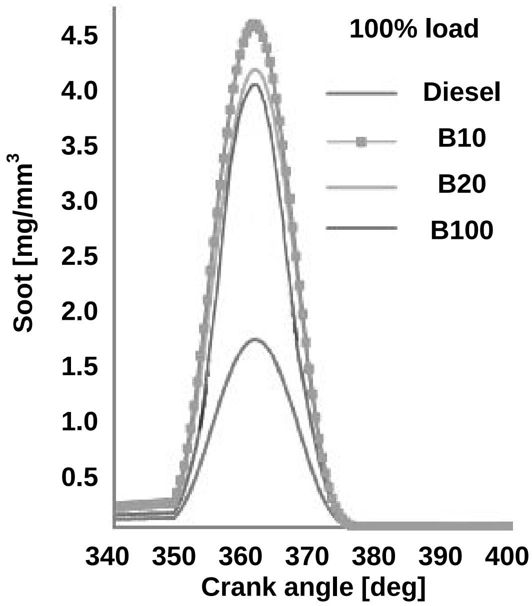

Fig. 5 Soot at 100% load

The soot emissions increase with the load because of higher fuel consumptions and the higher combustion temperatures. Soot emissions with crank angle are shown in Figure 5 at full load of engine operation. The same results can be observed with almost all biofuel blends. When the comparison is made for biofuel blends with diesel, only pure biodiesel showed an observable reduction in soot emissions.

5. CONCLUSIONS

1. A thermodynamic zero dimensional combustion model simulation has been carried out to predict the four cylinders constant speed diesel engine performance.
2. The engine performance is improved with low quantity blends of biofuels to diesel, this indicated by higher maximum combustion temperatures and pressures when compared with neat diesel.
3. The nitric oxide emissions are increased with biodiesel blends due to the presence of fuel nitrogen in the biodiesel
4. The smoke emissions are reduced with biofuel operation in a diesel engine
5. The simple model developed has predicted the performance of the given constant speed engine, as an alternate to a complex methodology of multidimensional modeling.
6. The results of the present model are well in agreement with experimental results

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MARITIME EDUCATION AND TRAINING QUALITY (METQUAL); AN APPLICATION ON DOKUZ EYLUL UNIVERSITY MARITIME FACULTY

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The concept of quality and satisfaction related to education services have been discussed enthusiastically in last 30 years. Nowadays, almost all societies and organizations have established their own ISO 9001 – 2000 quality system with a certain accreditation association. Quality standards in maritime education have been exposed with International Convention of STCW 78/95. In quality systems to improve services and expand activities feedbacks and user's satisfaction should be taken from users of these services. Dokuz Eylul University Maritime Faculty is taking many feedbacks from graduated students. The first version of the instrument used in this paper was developed and adopted from education service quality instrument by NAS (2000). The last version of the instrument, called as "METQUAL", was developed considering MET needs and "Accreditation Board for Engineering and Technology". The validity and reliability of "METQUAL" was found satisfying in the pilot studies. In this study, the quality of the education and training service in Maritime Faculty (MF) of Dokuz Eylul University (DEU), Marine Transportation Engineering Department (MTED) is evaluated with the instrument of "Maritime Education and Training Quality" by the graduates from between 1999-2008. At the end of research, the results of faculty's service quality are presented according to graduates perception of service quality and the activities are explained, which should be done to develop and improve service quality of the faculty.

Keywords: quality, maritime education and training, graduates

1. INTRODUCTION

Nowadays, a real competition exists among all societies and organizations; also quality is the most important matter on every product and service. All customers react erroneous products and services. Therefore, an organization which produces a product or service emphasizes quality in order to meet their consumers' needs and catch up with competitive powers on the market. Over the past years education service quality gave the opportunity of competitive advantages to higher education institutes. Moreover ''Quality concept'' is so important for the industry to choose high quality graduates. Also the quality concept is so important for parents to choose the qualified university for their child. At this moment, parents have to answer a question: Which university is the best and gives the best quality education (Turker, 2003)? The service quality of education is improved by graduates' satisfaction. Quality on education means determining the students' requirements and expectations. It is not easy to determine service quality on higher education. On this purpose, Gatfield, Barker and Graham (1999) made focus group studies, interview and literature review to determine the student's quality perceptions. At the end of these researches following variables were determined; research and education facilities, education level (lesson program, lesson contents, exam types and numbers), percentage of theoretical and experimental lesson, relationship with markets, quality of lecturers, quality of campus building (classrooms, laboratory, library, refectory etc.), social activities, medical facilities, registration services, consulting services, etc. (Gatfield, Barker and Graham, 1999).

1.1. SERVICE QUALITY

Quality may mean different things to different people who have different quality expectations and methods of assessing quality. Harvey and Green (1993) describe quality as a “relative concept”. It means different things to different people; indeed the same person may adopt different conceptualizations at different moments. This raises the issue of whose quality? (Harvey & Green, 1993). The last two decades have witnessed the increased acceptance and use of quality in the service sector with service quality being an important factor for growth, survival and success. However, there is a lot of confusion over the numerous orientations and perspectives in defining quality, due to its characteristics, which tend to differentiate services from goods (Parasuraman et al., 1985; Zeithaml et al., 1985; Bitner, 1992; Ghobadian et al., 1994).

1.2. QUALITY IN HIGHER EDUCATION

Many researchers used different approach to measure of quality of education. The most common argument was SERVQUAL, which was developed by Parasuraman and Zeithaml (1988) in Higher Education (O’Neil 2002). Aldridge and Rowley (1998) studied on satisfaction with developing questionnaire based on the student perceptions. O’Neill (2002) stated that it is important to understand the effect of time on student perceptions of educational service provision. Other impressive result of SERVQUAL is importance of “student to student interaction” (Clewes 2003). In education, it has been significantly adapted to form LibQUAL, which is used to measure academic library service quality (Cook & Thompson, 2000). In maritime education training, there is a regulative standard for the quality management. Under the section A- I/8 “Quality Standards” of STCW Code; parties (commonly training institutions) are required to ensure that all training, assessment of competence, and certification activities are continuously monitored through a quality standards system to ensure achievement of defined objectives. The most important question to be answered is “who can monitor education and training services of the MET Institutions?” Many of MET institutions determined the stakeholders to monitor their education and training services. Nas (2004) determined the students as an internal stakeholder and Nas, et all. (2004) determined the Turkish Maritime Industry as an external stakeholder. In this study, graduates, formerly called as internal stakeholder - currently called as external stakeholder, were participated to monitor MET service quality in Dokuz Eylul University, Maritime Faculty.

2. RESEARCH METODOLOGY

The aim of this study is to measure the quality of the education service in Marine Transportation Engineering Department (MTED) of Dokuz Eylul University, Maritime Faculty with METQUAL instrument which was applied to the graduates of MTED. The first version of the instrument was developed and adopted from service quality in the MET by NAS (2000). The last version of instrument was developed according to the results of the studies (Nas, 2004; Nas, et al., 2004; Gatfield, Barker and Graham, 1999). Also new variables were developed considering needs of maritime industry and “Accreditation Board for Engineering and Technology”. The reviews of the academics, involved MET, were taken for the variables of the instrument. Some of the variables were corrected or changed in this period. Finally 34 variables were developed to measure the adequacy of the MET services provided by the institutions and were put into the 5-point Likert scale (1: Completely Disagree, 5: Completely Agree). Some of the profile data were added to the instrument. Final instruments were applied on a small group of students as a pilot study. Validity and reliability of instruments was found satisfactory. As a result, instrument was called “METQUAL”.

2.1. DATA COLLECTION

In this study, quantitative research methods were used to collect data. The data were collected with the help of a questionnaire prepared. The questionnaire was applied from August 2009 to January 2010 to the graduates. The population of the study consists of alumni who graduated from DEU MF MTED between 1999 - 2008. The first alumni graduated from Marine Transportation Engineering Department in 1999 with bachelor degree. During this study, researchers tried to reach all members of the population. A great proportion of graduates were working on ships all over the world, which made it difficult to reach all the population. The questionnaires used to collect data were delivered to the respondents via e-mail, Facebook and alumni forums on the web. As a result, 67% of the population has been reached.

3. ANALYSIS AND FINDINGS

SPSS 15 (Statistical Package for the Social Science) was used for data analysis. SPSS data analysis techniques were used in the analysis of frequency distribution and percentages. Total 34 variables, Factor Analyze, Correlation Analyze used to measure the service quality in this study. During the study, out of a total number of 314 graduates, 213 respondents were reached. 212 questionnaires were evaluated in the study. Table 1 shows the profile information of graduates. In general, 67% of the targeted number of 10-year graduates took part in the study. Marine licenses of participated graduates are as follows; 20,3 % of graduates have ship master license, 39,6 of graduates have a chief officer license and 40,1 graduates have deck officer license. The average sea service duration of graduates was found 38,6 month.

Table 1. Participation percentages of graduates responding the questionnaire

Years of Graduates	Number of Graduates	Number of Graduates Reached	Percentage
1999	17	16	94,12 %
2000	13	6	46,15 %
2001	18	15	83,33 %
2002	30	22	73,33 %
2003	29	17	58,62 %
2004	40	21	52,50 %
2005	36	15	41,66 %
2006	45	31	68,88 %
2007	41	31	75,60 %
2008	45	37	82,22 %
TOTAL	**314**	**212**	**67,51 %**

The reliability analysis test on the variables of the “METQUAL” was found as fully satisfied. As a result of the reliability analysis, 34 variables were scaled to be 0,9253 (Cronbach Alfa). According to the Likert Scale means, the METQUAL variables evaluated by the graduates, the highest scored variables were found to be as follows: “Graduates to be proud of the faculty" (3,95); "Faculty recognition within the industry" (3,92); "Professional knowledge and skills of the lecturers" (3,86). The highest scored variables and the means of the scales are given in Table 2.

Table 2. The highest scored variables of the METQUAL

No	The METQUAL Variables	Mean*[1]	St. Dev.*[2]
1	Graduates to be proud of the faculty	3,9481	0,89344
2	Faculty recognition within the industry	3,9245	0,98518
3	Professional knowledge and skills of the lecturers	3,8632	0,91598
4	Technological infrastructure, laboratory and simulator facilities	3,8585	0,93827
5	Qualifications of the graduates for the maritime industry	3,8302	0,92333
6	To gain the maritime customs and manners	3,7830	1,05314
7	Relations with the maritime industry of the faculty	3,7689	0,93807
8	Recommending the faculty to the relatives	3,7547	0,98627
9	To acquire professional responsibility	3,7123	1,02908
10	Adequacy of vocational education	3,6934	1,01428

*[1] 5-point Likert scale- 1: Completely Disagree, 5 : Completely Agree *[2]Standard Deviation

The lowest scored variables were found to be as follows: "Number of the lecturers" (2,55); "Relations and cooperation with international institutions" (2,77); "Scientific studies" (2,87). The lowest scored variables and the means of the scales are given in Table 3.

Table 3. The lowest scored variables of the METQUAL

No	The METQUAL Variables	Mean*[1]	St. Dev.*[2]
1	Number of the lecturers	2,5472	1,17342
2	Relations and cooperation with international institutions	2,7736	1,07345
3	Scientific studies	2,8726	0,97252
4	Social and cultural activities in the faculty	2,8726	1,14693
5	Meeting the expectations of the students	2,9764	1,01851
6	Adequacy of the time for practical lessons	2,9858	1,18233
7	Communication between lecturers and the alumni	3,0755	1,17798
8	To receive feedback for the faculty to develop	3,2358	1,05356
9	To acquire awareness of environmental protection	3,2547	1,12752
10	To provide on board training and job opportunities	3,3160	1,28023

*[1] 5-point Likert scale- 1: Completely Disagree, 5 : Completely Agree *[2]Standard

The correlation test was performed between the years of graduates and their feedbacks. The changes on the scores of METQUAL variables, considering the years of graduation, were examined with the feedbacks of the graduates. Due to the page limitation, only significantly correlated variables are shown in Table 4.

Table 4. Correlation test results on the variables of the METQUAL and the year of the graduates

No	The METQUAL Variables	Pearson Correlation	Significant (2-tailed)
1	To provide on board training and job opportunities	+ 0,249	0,000
2	To gain the ability to work as a team	+ 0,209	0,002
3	English language education	+ 0,206	0,003
4	To gain lifelong learning skills	+ 0,197	0,004
5	Relations with the maritime industry of the faculty	+ 0,173	0,012
6	To gain the maritime customs and manners.	+ 0,161	0,019
7	Hierarchical system implemented at the faculty	+ 0,143	0,037
1	Number of the lecturers	- 0,201	0,003
2	Relations and cooperation with international institutions	- 0,191	0,005

The METQUAL variables, which are significant and positive correlated with the years of graduation, were found to be as follows; “To provide on board training and job opportunities”, “To gain the ability to work as a team”, “English language education”, “To gain lifelong learning skills”, “Relations with the maritime industry of the faculty”, “To gain the maritime customs and manners”, “Hierarchical system implemented at the faculty”.

The METQUAL variables, which are significant and negative correlations, were found to be as follows; “Number of the lecturers”, “Relations and cooperation with international institutions”.

To reduce the number of METQUAL variables and to detect structure in the relationships between METQUAL variables, factor analysis, first introduced by Thurstone (1931), was applied as a data reduction method. General rule in the factor analysis, size of the sample must be 5 or 4 times more than number of the variables (Hair et al., 1998; MacCallum et al., 2001; Malhotra, 2004). In this research, the ratio of variables and sample size has been found satisfactory. Then principal components analysis, with varimax rotation, was used to assess how the 34 variables are grouped in “METQUAL”. The variables of METQUAL are grouped in 8 factors through the factor analysis. Table 5 analysis the eight sets of factors. Proportion of variance explained by factors was 67,226 %.

These factors are summarized as dimensions of METQUAL. The eight dimensions of METQUAL in the order to their reliability are respectively; (1) Developing the Non Technical Skills, (2) Numbers and Qualifications of the Lectures, (3) Relations with the Stakeholders, (4) Responding the Industrial Expectations, (5) Developing Maritime Culture, (6) Providing Career Opportunities, (7) Developing Strategic Awareness, (8) Providing Social Environment.

Table 5. Dimensions of the METQUAL

Factors / METQUAL Variables	Alpha	Mean*1	SD.*2	Factor Loading
	0,9253			
1. Developing the Non-technical Skills	**0,8528**	**3,6100**		
– to provide the ability to communicate orally		3,6274	1,00605	0,819
– to provide the ability to communicate in writing		3,4953	1,00942	0,741
– to gain self-confidence		3,5377	1,01341	0,710
– to gain the ability to work as a team		3,6745	1,01305	0,659
– to gain lifelong learning skills		3,6132	1,03558	0,594
– to acquire professional responsibility		3,7123	1,02908	0,494
2. Numbers and Qualifications of the Lectures	**0,7708**	**3,4840**		
– professional knowledge and skills of the lecturers		3,8632	0,91598	0,816
– scientific aspects of the lecturers		3,6038	0,89421	0,809
– the ability to educate of the lecturers		3,6509	0,95929	0,806
– recommending the faculty to the relatives		3,7547	0,98627	0,436
– number of the lecturers		2,5472	1,17342	0,683
3. Relations with the Stakeholders	**0,8457**	**3,7936**		
– relations with the maritime industry of the faculty		3,7689	0,93807	0,852
– faculty recognition within the industry		3,9245	0,98518	0,836
– relations with maritime administrations and official institutions		3,5330	0,94585	0,753
– graduates to be proud of the faculty		3,9481	0,89344	0,659
4. Responding the Industrial Expectations	**0,8225**	**3,4158**		
– adequacy of the time for practical lessons		2,9858	1,18233	0,775
– to receive feedback for the faculty to develop		3,2358	1,05356	0,691
– English language education		3,6840	1,18806	0,522
– meeting the expectations of the students		2,9764	1,01851	0,509
– updating the curriculum to meet new needs		3,5047	1,09500	0,498
– adequacy of vocational education		3,6934	1,01428	0,454
– qualifications of the graduates for the maritime industry		3,8302	0,92333	0,433
5. Developing Maritime Culture	**0,8637**	**3,7123**		
– hierarchical system implemented at the faculty		3,6415	1,20574	0,848
– to gain the maritime customs and manners.		3,7830	1,05314	0,847
6. Providing Career Opportunities	**0,6982**	**3,2052**		
– to provide on board training and job opportunities		3,3160	1,28023	0,690
– relations and cooperation with international institutions		2,7736	1,07345	0,651
– scientific studies		2,8726	0,97252	0,640
– technological infrastructure, laboratory and simulator facilities		3,8585	0,93827	0,521
7. Developing Strategic Awareness	**0,7156**	**3,4843**		
– to acquire awareness of environmental protection		3,2547	1,12752	0,656
– to acquire awareness of safety		3,6038	0,95569	0,573
– effort in achieving the mission of the faculty		3,5943	0,90578	0,465
8. Providing Social Environment	**0,5317**	**3,1761**		
– communication between lecturers and the graduates		3,0755	1,17798	0,697
– communication between lecturers and the students		3,5802	0,97270	0,595
– social and cultural activities in the faculty		2,8726	1,14693	0,469

*1 5-point Likert scale- 1: Completely Disagree, 5 : Completely Agree *2Standard Deviation

The correlation test was performed among the METQUAL dimensions. The significant and positive correlations were found and shown in Table 6. All METQUAL dimensions have significant, positive and strong correlations with each other.

Table 6. Correlations among the METQUAL dimensions.

DIMENSIONS		I	II	III	IV	V	VI	VII	VIII
I	Pear.Corr.	1	0,423	0,309	0,573	0,388	0,416	0,617	0,380
	Sig.(2tailed)		0,000	0,000	0,000	0,000	0,000	0,000	0,000
II	Pear.Corr.		1	0,390	0,562	0,279	0,442	0,493	0,467
	Sig.(2tailed)			0,000	0,000	0,000	0,000	0,000	0,000
III	Pear.Corr.			1	0,388	0,205	0,476	0,370	0,352
	Sig.(2tailed)				0,000	0,003	0,000	0,000	0,000
IV	Pear.Corr.				1	0,428	0,475	0,554	0,419
	Sig.(2tailed)					0,000	0,000	0,000	0,000
V	Pear.Corr.					1	0,108	0,310	0,219
	Sig.(2tailed)						0,116	0,000	0,001
VI	Pear.Corr.						1	0,479	0,394
	Sig.(2tailed)							0,000	0,000
VII	Pear.Corr.							1	0,422
	Sig.(2tailed)								0,000
VIII	Pear.Corr.								1
	Sig.(2tailed)								

4. CONCLUSIONS

The main and the most important stakeholders of the MET Institutions are their graduates. Graduates, formerly called as internal stakeholder - currently called as external stakeholder, are the most competent evaluator to monitor MET service quality. This research gives the opportunities to MET Institutions to monitor themselves using the METQUAL instruments.

The scores of METQUAL variables give the steering command to the Maritime Education and Training Institutions. The highest scored METQUAL variables show the strengths of the MET Institutions. These should be maintained and sustained. The lowest scored METQUAL variables show the weaknesses of the MET Institutions. These should be calibrated and developed.

Significant positive correlations have been found between some of the METQUAL variables and the years of graduates. The highest correlation on "*To provide on board training and job opportunities*" is a result of the new services in DEUMF. This service is called "Model of Student Career Choice" Nas (2009). Faculty career service gathers all job offers from ship management companies. Then "Model of Student Career Choice" gives students the opportunity to choose from the job offers of the ship management companies according to their own success. This model has been applied successfully since 2006. Significant negative correlations have been found between some of the METQUAL variables and the years of graduates. The highest negative correlation on "*Number of the lecturers*" is a result of the increasing work load of academicians in the faculty.

All METQUAL variables can be summarized in eight dimensions. Significant, positive and strong correlations have been found among all these dimensions. This means all METQUAL dimensions affect each other. Therefore, each dimension is of vital importance.

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NON-ISOTHERMAL MODEL OF LINEAR RESISTANCE IN PIPELINES PART I. THEORETICAL RESEARCH

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The article presents and discusses results obtained from a non-isothermal research and modeling of hydraulic linear pipeline resistance. Main objective of the work is to determine the linear resistance coefficients for pipelines of circular cross-section. The effect of the temperature variation is taken into account by the change in the viscosity value of the working fluid (hydraulic oil). The issue of thermal optimization of the flow regime is discussed as a way to reduce the head losses in the pipeline.

Keywords*:* pipeline, linear resistance, flow regime, Reynolds number

1. INTRODUCTION

The connecting pipelines as hydraulic conduits are important and indispensable part of hydraulic power systems. The problem with the precise determination of the hydraulic linear resistance losses along pipeline is solved by many authors. Generally this problem is reduced to determining the coefficient of linear hydraulic resistance λ as a function of the Reynolds number Re and the relative roughness of the pipe wall ε/d, i.s. $\lambda=\lambda(Re, \varepsilon/d)$.

One of the recent fundamental works in this scientific field is that of (Moody, 1944). The results obtained by Prof. Lewis F. Moody are represented by the so called "Moody Diagram", which gives the value of the hydraulic resistance $\lambda=h_L/(l/d*c^2/2g)$ for different values of the Reynolds number *Re* and the relative roughness ε/d of the pipe. There are four distinctive zones in this diagram:

- laminar flow regime: $Re<2000$;
- transitional regime: $2000<Re<4000$;
- partially turbulent flow: $4000<Re<12500$;
- fully developed turbulent flow: $12500<Re<10^8$.

Other fundamental works are the monograph (Schlichting, 1974) and the handbook of hydraulic resistance (Idelchik, 1975). Contemporary refinements are introduced with the works (Churchill, 1999; Donald at al., 2001; McKeon at al., 2004; Ghanbari at al., 2011). A comparison between results obtained with formulae created by 10 well-known authors for determining the resistance losses in a pipeline is made in the article (Ghanbari at al., 2011). A statistical estimation of the numerical results is carried out. A refined and easy for implementation formula is submitted for the range : $Re=2100\div10^8$ и $\varepsilon/d=0\div0,05$.

An interesting and original approach for determining the head losses in a pipeline is presented in (Beazit, 2010) based on a hydroelectric analogy.

2. GENERAL DEPENDENCIES

The subject of the study is the steady (or quasi-steady) flow in a pipeline with circular cross-section.

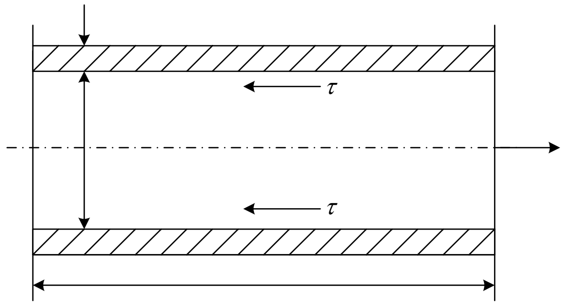

Fig. 1 Quasi-steady flow in a pipeline with circular cross-section

The pressure losses along the pipeline are calculated with the classic formula:

$$\Delta p_L = p_1 - p_2 = \lambda\left(\mathrm{Re}, \frac{\varepsilon}{d}\right)\frac{l}{d}\rho\frac{c^2}{2}, \qquad Pa \quad (N/m^2) \tag{1}$$

where: λ – coefficient of linear resistance;
l – pipeline segment length;
d – internal diameter;
ρ – fluid density;
c – mean fluid velocity.

The pressure drop in the pipeline determines the resultant pressure force needed to ensure the flow through the pipeline:

$$F_p = \left(p_1 - p_2\right)\frac{\pi d^2}{4} = \Delta p A, \qquad N \tag{2}$$

where: A – cross-section.

This pressure force is counterbalanced by the resistance force resulting from the friction in the pipeline walls:

$$F_\tau = -\tau \pi d l, \qquad N \tag{3}$$

where: τ – tangential stress.

From the steady flow equilibrium conditions follows:

$$F_p + F_\tau = 0 \tag{4}$$

Substituting F_p, F_τ in (4) and subsequent processing result in following equation for the tangential stress:

$$\tau = \frac{\lambda}{4}\rho\frac{c^2}{2} = \frac{f_F \rho c^2}{2}, \qquad Pa \quad (N/m^2) \tag{5}$$

where: $f_F = \lambda/4$ – the Fanning friction factor, named after John Thomas Fanning.

It should be noted that most of the contemporary authors prefer to use the factor f_F instead of λ. If we transform the friction losses in form of hydraulic head, this will result in the following equation:

$$h_L = \lambda \frac{c^2}{2g}\frac{l}{d} = \frac{2 f_F c^2 l}{gd}, \qquad m \tag{6}$$

where: $\lambda = 4f_F$ – the linear hydraulic resistance coefficient.

3. NON-ISOTHERMAL MODELS

They are based on suitably chosen, refined and numerically verified general models (Churchill, 1999; Donald at al., 2001; Dinu, 1999; Ghanbari at al., 2011; Idelchik, 1975; Komitovski, 1999; McKeon at al., 2004;Metluk and Avtushko, 1980;Moody, 1944) for "Fanning friction factor" f_F in the operational range: $Re=0\div10^5$ and $\varepsilon/d=0,001\div0,01$. The latter refers to hydraulically smooth pipelines, which is the general case in hydraulic power drive systems. The general models are extended by adding the expression (Nikolova and Tomov, 2011), describing the temperature dependency of the cinematic viscosity, i.e. $\nu = \nu(T)$. It applies to hydraulic oil grades as per ISO standard. In reality $\nu = \nu(p,T)$, but as the pressure impacts the viscosity to a lesser degree than the temperature, its influence could be disregarded. Below are presented three different cases for determining the factor f_F by taking into account the expression $\nu = \nu(T)$.

Case I

Laminar flow: *Re<2000*, Hagen-Poiselle formula:

$$\begin{cases} f_F = \dfrac{16}{\mathrm{Re}}; \qquad \mathrm{Re} = \dfrac{cd}{\nu}, \\ \nu = \nu(T) = a_1 \exp(b_1 T) + a_2 \exp(b_2 T). \end{cases} \tag{7}$$

where: $a_{1(2)}$, $b_{1(2)}$ – experimentally determined coefficients.

Turbulent flow: $Re>3000\div10^5$ (hydraulically smooth pipeline)-formulae of Blasius and Prandtl after transformation:

$$\begin{cases} f_F = \dfrac{0.316}{4\,\mathrm{Re}^{0.25}}, \\ \dfrac{1}{\sqrt{f_F}} = 4\lg\left(2\,\mathrm{Re}\sqrt{f_F}\right) - 1.6, \\ \nu = \nu(T) = a_1 \exp(b_1 T) + a_2 \exp(b_2 T). \end{cases} \tag{8}$$

In (8) the Prandtl formula is more accurate, but the dependency for f_F is presented in implicit form, which complicates the solution. On other hand the calculation range is broadened to *Re=3,6.10*^{6}.

Case II

Laminar flow: *Re<2000* – dependency (7) is employed.

Turbulent flow: *Re=2100÷10*^{8}. Here the relative roughness *ε/d=0÷0,05* is taken into consideration. The precise formula from (Ghanbari at al., 2011) is employed:

$$\begin{cases} 4f_F = \left\{-1.52\log\left[\left(\dfrac{\varepsilon/d}{7.21}\right)^{1.042} + \left(\dfrac{2.731}{\mathrm{Re}}\right)^{0.9152}\right]\right\}^{-2.169}, \\ \nu = \nu(T) = a_1\exp(b_1T) + a_2\exp(b_2T). \end{cases} \tag{9}$$

Case III

1) It covers the whole range – laminar and turbulent flow, with the use of generalized and refined formula: *f_F=f_F(Re, ε/d)* (Churchill, 1999).

$$\begin{cases} \left(\dfrac{2}{f_F}\right)^{1/2} = \left[\begin{array}{l}\left(\dfrac{8}{\mathrm{Re}_D\left(f_F/2\right)^{1/2}}\right)^{12} + \\ + \left(\left\{\dfrac{37500}{\mathrm{Re}_D\left(f_F/2\right)^{1/2}}\right\}^{4} + \left|2.5\ln\left\{\dfrac{1.108\,\mathrm{Re}_D\left(f_F/2\right)^{1/2}}{1+0.3012\left(e/d\right)\mathrm{Re}_D\left(f_F/2\right)^{1/2}}\right\}\right|^{8}\right)^{-3/2}\end{array}\right]^{-1/12}, \\ \nu = \nu(T) = a_1\exp(b_1T) + a_2\exp(b_2T). \end{cases} \tag{10}$$

2) It also covers the whole range of Re and ε/d, but it employs a simplified and explicit dependency *λ=4f_F* of St. Churchill (Komitovski, 1999):

$$\begin{cases} 4f_F = 8\left[\left(\dfrac{8}{\mathrm{Re}}\right)^{12} + \left(A+B\right)^{-1.5}\right]^{1/12}, \\ A = \left[-2.457\ln\left\{\left(\dfrac{7}{\mathrm{Re}}\right)^{0.9} + 0.27\dfrac{\varepsilon}{d}\right\}\right]^{16}, \\ B = \left(\dfrac{37530}{\mathrm{Re}}\right)^{16}, \\ \nu = \nu(T) = a_1\exp(b_1T) + a_2\exp(b_2T). \end{cases} \tag{11}$$

3) It covers again the whole range – laminar and turbulent flow, with the implementation of (after precise processing) the approximation formula of (Metluk and Avtushko, 1980):

$$\begin{cases} f_F = \dfrac{55}{\pi \,\mathrm{Re}} + \dfrac{0.443 k_\varepsilon}{\sqrt{\pi}}, \\ \nu = \nu(T) = a_1 \exp(b_1 T) + a_2 \exp(b_2 T), \end{cases} \tag{12}$$

where: k_ε – an approximation coefficient, which is determined from a table dependency by choosing values for *ε/d*.

4. MODEL EXAMINATION

It is carried out by using “Matlab” software. The three cases presented above in section 3. of this article are numerically examined. The obtained graphical results are presented and discussed as follows:

The study starts by examining the impact of the temperature upon the working fluid viscosity and thus upon the flow regime in a pipeline of a circular cross-section. The following parameters are chosen for conducting the study: hydraulic oil - *VG 46* ; pipe size *16x2 (d=12 mm)*; constant mean speed of the fluid *c=5 m/s* . The dependency $\nu = \nu(T)$ is presented in Figure 2, and *Re=Re(T)* in Figure 3.

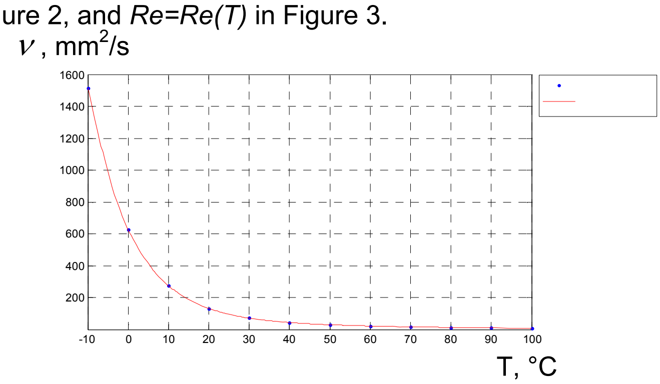

Fig. 2 Relation between viscosity and temperature in a tube of circular cross section

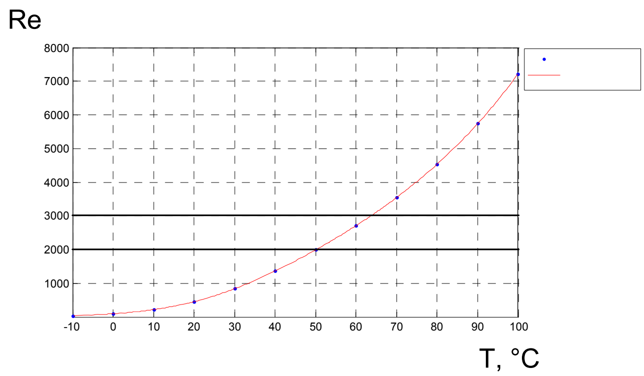

Fig. 3 Relation between Reynolds number and temperature in a tube of circular cross section

The strong temperature dependency of the viscosity is obvious and thus the strong impact of the temperature upon the Reynolds number. This causes changes in the hydrodynamic state of the flow, i.e. changes in the flow regime. Hence the hydraulic losses caused by the friction in the pipe wall could be actively influenced by the temperature.

Case I

Laminar flow: Re<2000, based on formula (7). The numerical solution is visualized on Figure 4.

Turbulent flow in hydraulically smooth pipe: Re>3000÷10^5, based on formula (8). The solutions are visualized on Figure 5.

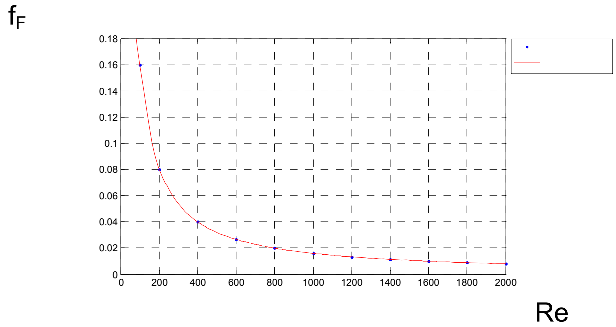

Fig. 4 Relation between friction factor and Reynolds number

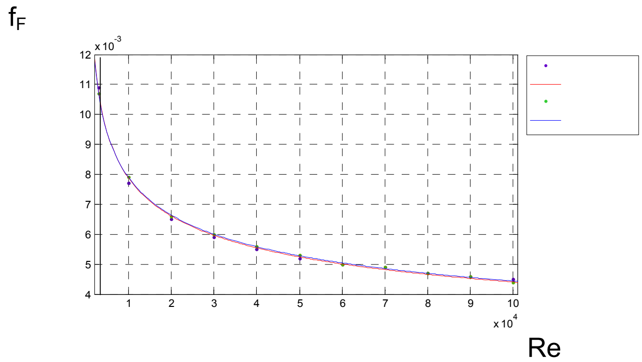

Fig. 5 Relation between friction factor and Reynolds number

The analysis of the obtained numerical solutions shows that in the case of laminar flow under low fluid temperature the values for the friction factor are significant, but the head losses can be reduced on account of lower flow velocities. That is the established practice in the field of hydraulic power systems. Furthermore an additional influence over the process can be achieved by active temperature control of the fluid in the piping system.

The results obtained by using the formulae of Prandtl and Blasius are very close, thus the Blasius formula can be employed in the calculation procedures.

Case II

Laminar flow – the results obtained with (7), are presented in Figure 4.

Turbulent flow in hydraulically rough pipes is examined by using (9) for the following ranges *Re=2100÷10^8* and *ε/d=0÷0,05*. The results obtained for *ε/d=0,001* and *ε/d=0,01* are presented on Figure 6.

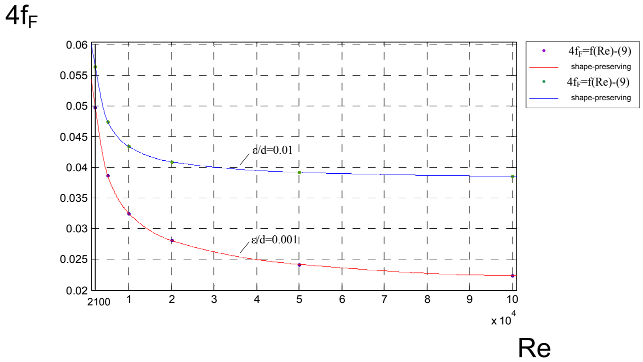

Fig. 6 Relation between coefficient of linear resistance and Reynolds number

Case III

It concerns the whole operating range and the model examnination is carried out by employing three subcases, respectively with the formula (10), (11) and (12). A variance in the relative roughness is used.

Initially individual numerical solutions for f_F are obtained. It aims performance testing of calculation methods which in the case of (10) are complicated, due to the implicit expression form for the Fanning friction factor f_F. The solutions for *ε/d=0,001* are presented below in the following sequence:

Figure 7 – a solution obtained by means of formula (10) Stuart W. Churchill. It is very precise formula, which derives accurate solutions in the whole range of *Re* and *ε/d*. The only problem is the complicated calculation, due to the implicit expression of f_F.

Figure 8 – a comparison of the results obtained from model experiments with the formulae (10), (11) and (12). Obviously all three formulae are applicable but they ensure different degree of accuracy.The most accurate and hardest to solve is formula (10) of Stuart W. Churchill. In spite some inaccuracy in the transitional zone the formula (12) of Metluk N., V. Avtushko is very easy to use and has adequate accuracy in the other two flow regime zones.

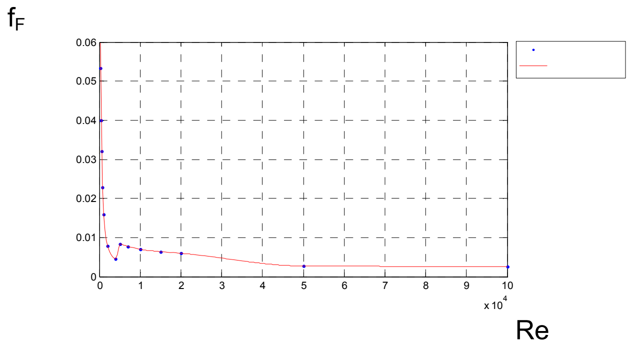

Fig. 7 Relation between friction factor and Reynolds number

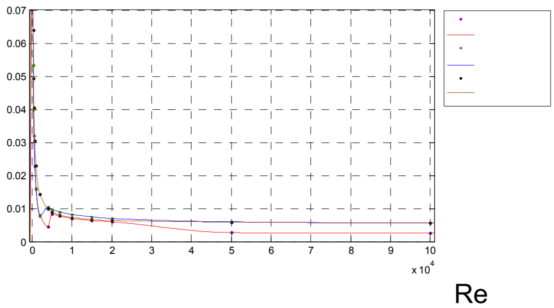

Fig. 8 Relation between friction factor and Reynolds number

5. CONCLUSIONS

As a result of the conducted theoretical study in Part I of this paper some analytical dependencies in a non-isothermal form are specified regarding the derivation of the Fanning friction factor f_F. The area of application of the formulae proposed by some well-known scientists is extended depending on specific real conditions. The performance of the calculation methods employed in this article is verified. The possibility for thermal optimization of the flow regime and friction losses reduction is confirmed.

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NON-ISOTHERMAL MODEL OF LINEAR RESISTANCE IN PIPELINES PART II. EXPERIMENT

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The article presents and discusses results obtained from an experimental examination of the general and linear resistances of a pipeline. The impact of the fluid temperature over the friction losses is examined. Satisfactory similarity is encountered by comparing numerical and experimental results. The possibility of head losses optimization by means of temperature change is confirmed.

***Keywords**:* pipeline, linear resistance, flow regime, the Reynolds number

1. EXPERIMENT CONDITIONS

The subjects of the experiment are two available flexible hydraulic hoses, part of the hydraulic kits in the "FESTO" laboratory of Naval Academy "N. Y. Vapcarov". Flexible hoses are widely used onboard ships in hydraulic power and control systems. This type of hydraulic conduit can be considered hydraulically smooth. In this particular case the hoses have the following dimensions:

total length: Long hose, $L_1=1600\ mm$;
Short hose, $L_2=704\ mm$;
length without the ferrule: $l_1=1392\ mm$;
$l_2=496\ mm$.

The flexible part of the hose represents externally braided polyamide tube with inner diameter $d=6,3\ mm$.

The experiment employs an available pump unit, which is part of the "FESTO" testbed and has the following parameters:

Maximum pressure $p_{max}=60\ bar$ (relief valve adjustment)

Nominal flow rate $Q_n=2,16\ l/min$ (with $p_n=50\ bar$).

The grade of the hydraulic oil is "Mobil DTE-22"($\nu=22\ mm^2/s$, with $T=40\ ℃$).

A general view of the examined hoses is shown in Figure 1, while Figure 2 and Figure 3 show the experimental installation used for the research. The hydraulic flow diagram of the installation is shown in Figure 4.

Both of the hoses are manufactured with identical joints, ferrules and inner and outer diameters of the flexible parts.

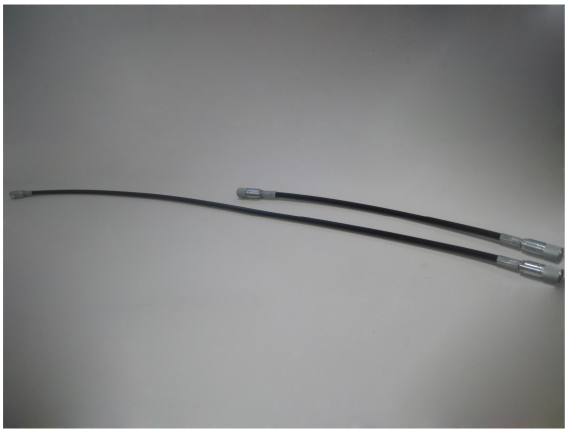

Fig. 1. General view of the examined hoses

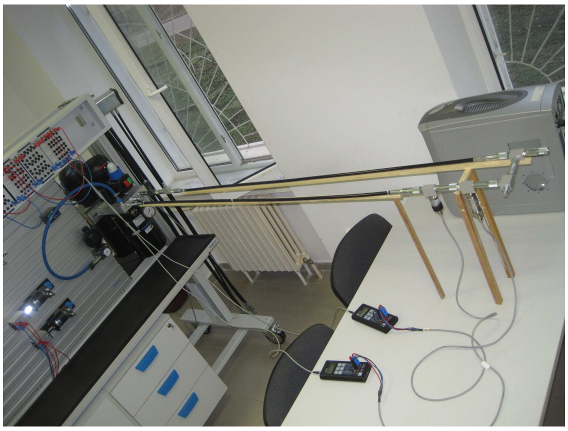

Fig. 2. The experimental installation used for the research in the long hose

Fig. 3. The experimental installation used for the research in the short hose

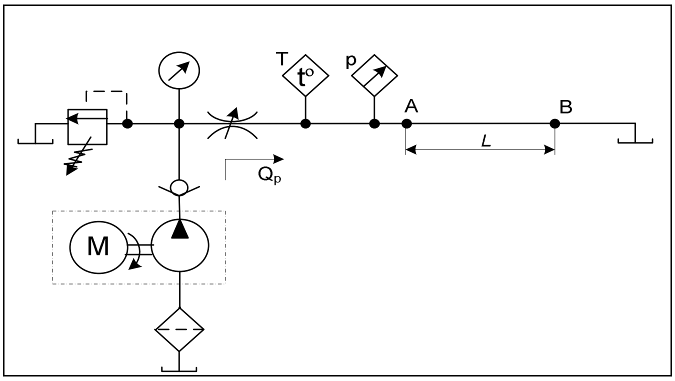

Fig. 4. The hydraulic flow diagram

The thermometer used for taking the measurements has resolution of ±0.1 ℃ and is calibrated.

2. EXPERIMENT SETUP

The experiment has the following logic: The general resistance of the pipeline is the sum of the linear and the local (of the joints) resistances, i.e.:

$$\Delta p_{\Sigma_1} = \Delta p_{L_1} + \sum_{1}^{3} \Delta p_{M_i}, Pa \tag{1}$$

and

$$\Delta p_{\Sigma_2} = \Delta p_{L_2} + \sum_{1}^{3} \Delta p_{M_i}, Pa, \tag{2}$$

where: the indexes 1 and 2 designate, respectively, the long and the short hose.

On the other hand the pressure drop Δp_{L1} caused by the linear resistance of the long hose could be expressed in the following way (as linear resistances connected in series):

$$\Delta p_{L_1} = \Delta p_{L_2} + \Delta p_L, Pa, \tag{3}$$

where: Δp_L is the excess of linear resistance in the long hose.

By subtracting the like terms of (1) and (2):

$$\Delta p_{\Sigma_1} - \Delta p_{\Sigma_2} = \left(\Delta p_{L_2} + \Delta p_L\right) + \sum_{1}^{3} \Delta p_{M_i} - \Delta p_{L_2} - \sum_{1}^{3} \Delta p_{M_i} = \Delta p_L, \tag{4}$$

i.e.:

$$\Delta p_{\Sigma_1} - \Delta p_{\Sigma_2} \equiv \Delta p_L = \left(4 f_F\right) \frac{l}{d} \rho \frac{c^2}{2}, \quad Pa \qquad , \tag{5}$$

where: f_F – “Fanning friction factor”;

l – excess length of the long hose without the joints and the ferrules.

In this particular *case* $l = l_1 - l_2 = 1392 - 496 = 896$ *mm*.

Which means that the excess of the general resistances of the flexible hoses 1 and 2 represents the net linear resistance of a hose with inner diameter *d=6,3 mm* and length *l=896 mm*.

3. EXPERIMENTAL RESULTS

Figure 5 and Figure 6 illustrate the obtained processesed experimental data for the general resistance, respectively, in the long and in the short hose.

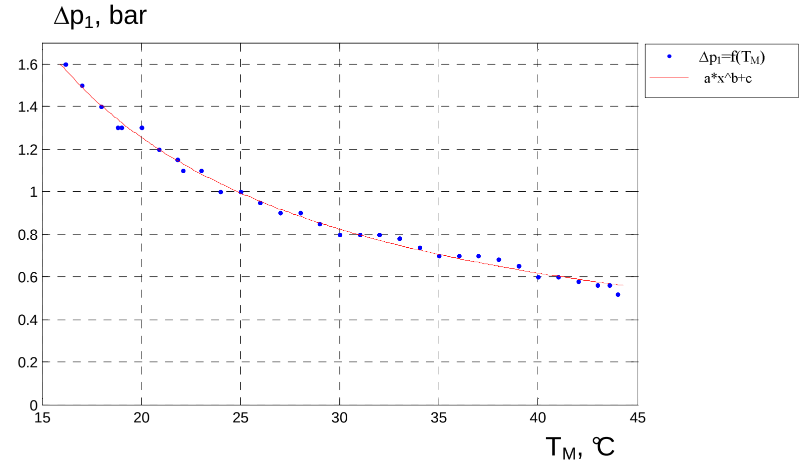

Fig. 5. The obtained processesed experimental data for the general resistance in the long hose

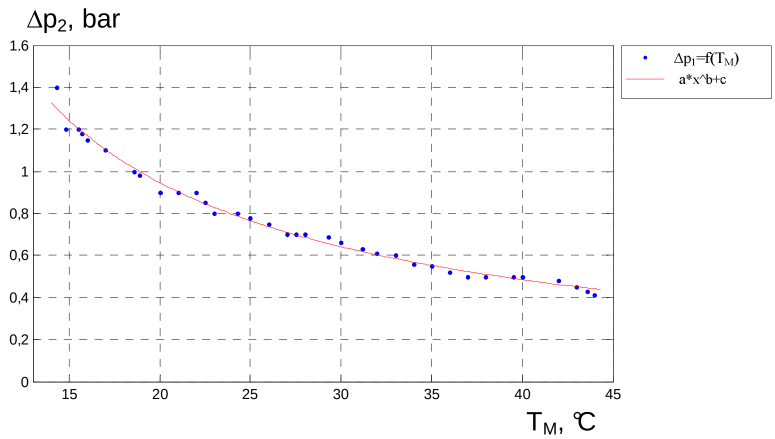

Fig. 6. The obtained processesed experimental data for the general resistance in the short hose

The experimental data is approximated with the following analytical dependency:

$$\Delta p_{\Sigma} = aT^{n} + b,\ \ 10^{5} Pa, \tag{6}$$

where: a,b – coefficients;
n – exponent.

Table 1. Values of the coefficients (a and b) and exponent (n)

Long hose		Short hose	
a	34,59	a	15,17
b	0,08042	b	-0,03853
n	-1,129	n	-0,9128

On the basis of expression (6) additional experimental data is obtained for the temperature range *T=14÷45 ℃* with a step of *1 ℃* by using the formula (4). The preliminary data verification shows that the flow regime is laminar: *Re=97,3289 … 408,9424*. The numerical calculations are conducted in the same temperature range with the same step for the purpose of data comparison. They are obtained with the Poasielle formula:

$$\begin{cases} 4 f_F = \dfrac{64}{\mathrm{Re}}; \quad \mathrm{Re} = \dfrac{cd}{\nu}, \\ \nu = \nu(T) = a_1 \exp(b_1 T) + a_2 \exp(b_2 T). \end{cases} \tag{7}$$

and the formula of St. Churchill (Churchill, 1999) for *ε/d=0,001*:

$$\begin{cases} 4 f_F = 8\left[\left(\dfrac{8}{\mathrm{Re}}\right)^{12} + \left(A+B\right)^{-1.5}\right]^{1/12}, \\ A = \left[-2.457 \ln\left\{\left(\dfrac{7}{\mathrm{Re}}\right)^{0.9} + 0.27\dfrac{\varepsilon}{d}\right\}\right]^{16}, \\ B = \left(\dfrac{37530}{\mathrm{Re}}\right)^{16}, \\ \nu = \nu(T) = a_1 \exp(b_1 T) + a_2 \exp(b_2 T). \end{cases} \tag{8}$$

The final results are presented in the chart from Figure 7.

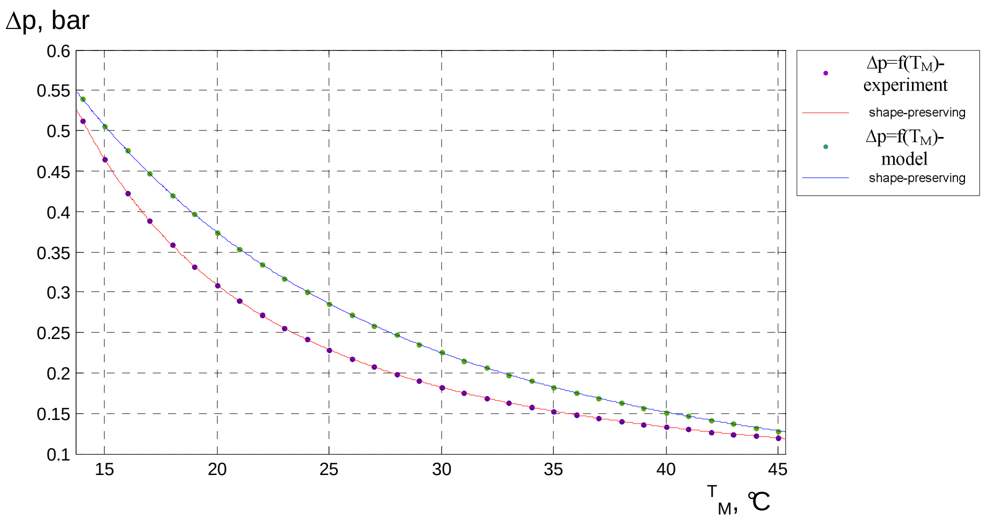

Fig. 7. Comparison between theoretical and experimental data

The theoretical results for Δp_L obtained with (7) and (8) are fully identical. There is satisfactory qualitative and quantitative similarity between theory and experiment, considering the available experimental installation. The difference between theoretical and experimental data decreases progressively with the increase of the temperature of the energy bearing media.

4. CONCLUSIONS

The temperature change of the working fluid has a significant impact upon the linear and local head losses in the pipelines. This influence is especially strong in the low temperature range. The non-isothermal models submitted in Part I of this article are efficient and extend the area of theoretical research and practical implementation. The obtained results are of significant importance in the case of hydraulic power systems onboard ships, which are routed on open deck and operated in cold weather conditions.

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RECREATIONAL BOAT LICENSING, LACK OF UNIFORMITY IN THE EUROPEAN UNION

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Many European countries require the skipper of a pleasure craft to be able to provide evidence of his competence. The pleasure craft operator card or boating license permits people operate a pleasure craft. One of the requirements of this license is intended to decrease the number of boat accidents. This paper analysis the regulation of different European Union countries related on recreational boat licensing and states that there is no uniformity at European level in terms of the requirements for sailing in pleasure boats. Thus, licenses that allow navigation in pleasure boats, the theoretical and practical as well as the requirements for obtaining the qualification and training of future skipper, essential for ensuring the safety of these boats are different depending on the member state of the European Union that we are talking about.
The paper is divided into following sections: Section 1 describes a brief introduction; Section 2 provides the state of art and current Spanish regulation; Section 3 analysis different European countries regulation; Section 4 proposes the need of an European certificate and finally, Section 5 remarks some conclusions and further research.

Keywords: nautical licence, recreational boats, pleasure craft

1. INTRODUCTON

A pleasure craft is defined as any vessel in private ownership used wholly or mainly for sport and recreation purposes. It also covers private vessels that are hired out by third parties, provided that the vessel will be operated only by the hirers and will not require a crew to operate it (Merchant Shipping, 2000).

Many European countries require the skipper of a pleasure craft to be able to provide evidence of his competence. The pleasure craft operator card or boating license permits people operate a pleasure craft. One of the requirements of this license is intended to decrease the number of boat accidents. Figures indicate that there has been an increase in the number of accidents involving pleasure crafts at sea. For instance, at the end of 2009 there were more than 220000 recreational boats on the Register of Spanish ships and the total emergencies during that year was the 51.7% of the total (Salvamento Marítimo, 2010).

For these reasons, it is necessary to regulate the licences for recreational boats at European level to ensure the level of training of the skippers, matching and making compatible the European licenses for pleasure craft navigation and enssuring safety at sea to mitigate operational risks and accidents.

2. RECREATIONAL BOAT LICENCE IN SPAIN

Recreational boats in Spain are regulated in different ways depending on their size, where they can sail and what they are used for. In Spain, ships are registered and entered in a list according to their origin and activity. The total number of lists is nine. For pleasure crafts we can divide into two categories: crafts operated for profit (the assigned list is the sixth) and building crafts or imported dedicated to sport fishing or non-profit organization the assigned list is the seventh).

The previous legislation for the government of pleasure crafts was the Order of the Ministry of Public Works and Transport of June 17, 1997 (Spanish Ministery of Public Works and Transport, 1997). This regulation was replaced by the current in order to adapt it to changes that have taken place and meet safety targets navigation, maritime safety, security human life at sea and marine pollution prevention.

Actually, Spanish legislation regarding the regulation of mandatory licenses for governing recreational craft (non-professional degrees) is the regulation FOM/3200/2007 ORDER of 26 October (Spanish Ministery of Public Works and Transport, 2007). The Ministry of Development of the Government of Spain is the legislation that provides for existing qualifications.

According to the legislation FOM/3200/2007 ORDER of 26 October, the licenses for the government of pleasure crafts in Spanish flag are:

- *Patrón para navegación básica* (basic navigation): Allows the government of pleasure boats up to 8 meters in length if they are sailing and up to 7.5 meters in length if they are motor, motor with adequate power to it, provided that the boat does not sail more than 5 miles in any direction, of a shelter.
- *Patrón de embarcaciones de recreo*: Allows the government of motor yachts and sailing or motor up to 12 meters in length, for navigation is made in the area between the coast and the line drawn parallel to it at 12 miles and the inter-island shipping in the Balearic and Canary Islands.
- *Patrón de yate* (skipper): Allows the government of motor yachts and sailing or motor up to 20 meters in length, for navigation is made in the area between the coast and the line drawn parallel to it at 60 miles, so as inter-island shipping in the Balearic and Canary Islands.
- *Capitán de yate* (Yacht Captain): Allows the government of motor yachts and sailing or motor for navigation without limitation, regardless of engine power and features of the boat.
- For motor boats with a maximum power of 11.03 Kilowatts (kW) and up to 4 meters in length, sail up to 5 meters, it is not necessary to have any license, as long as the navigation is daytime and area bounded by the Maritime Authority (Harbour Master).

A part of the licenses noted, the legislation reflects the nautical sports federations sailing and boating (Federation Authority) may issue licenses for the government of boats up to 6 meters and a maximum engine power adequate to the same and in any case less than 40 kW of power valid for navigation done during daytime in areas delimited by the Maritime Authority.

Boat operators are required by law to pass a test and realize some mandatory practices. The license holder will then be allowed to legally operate a recreational boat in that particular area where the licensing board has authority and must be available for presentation to any authority upon request when the license holder is operating a recreational boat. Table 1 shows the mandatory and the optional practices depending on the type of lincense. Besides the obligatory sailing practice on passing the theory exam, practicals in radio communication are now also mandatory to help the skippers to handle a radio station correctly.

Table 1: Practical content of the titles (Source: FOM/3200/2007 ORDER of 26 October)

License	Mandatory practices	Optional practices
Federation Authority	Any	Any
Patrón para navegación básica (basic navigation)	Basic safety practices and navigation a period of not less than 12 hours. Radio practices, a period of not less than 2 hours, be made on the ground in a simulator approved.	Sailboats: practices may be made 20 hours or a specific practice eight hours.
Patrón embarcaciones de recreo	Basic safety practices and navigation a period of not less than 16 hours. Radio practices, a period of not less than 2 hours, be made on the ground in a simulator approved.	Sailboats: Practices for sailing is performed only once, and shall be valid to accessany license. Its duration is not be less to 20 hours
Patrón de yate (Yatch skipper)	Basic safety practices and navigation a period of not less than 24 hours of which at least 8 hours of night navigation. Radio practices, a period of not less than 4 hours, be made on the ground in a simulator approved.	
Capitán de yate (Yacht captain)	Basic safety practices and navigation a period of not less than 48 hours of which at least 12 hours of night navigation. Radio practices, a period of not less than 8 hours, be made on the ground in a simulator approved.	

3. ANALYSIS AND COMPARATION OF DIFFERENT EUROPEAN COUNTRIES REGULATION

Every European country has its own boating rules, laws and regulations, and the requirements for obtaining a boaters license will vary from country to country. The main purpose of this section is to analyze some examples of required licenses for boating of different member states of the European Union and compare them. The diversity of licenses and permissions makes complicated the equivalence between the licenses issued in different countries of the European Union. We have analysed France, United Kingdom and Italy countries.

First of all, in France, licenses are not required for sailing boats, or boats with a motor less powerful than 4.5 kW sailing sea or inland waters. The French law changed in 2008 wiped out the licenses *Permit "A", "B", "C*" and *Carte Mer.*

On 1 January 2008, a new system was introduced (French regulation, Décret 2007-1167, 2007). *The Permis Plaisance* is available for four different purposes. There are four permit types, one each for sea and inland waters, each of which can be extended. A theory and practical test must be passed before the permit is issued. The current licenses are necessary if engine power is greater than 4.5 kW. There is an exception, navigation with a sailboat (may take a motor) can be done without a permit.

Table 2: Licenses for pleasure craft in France

Licenses	Permission
Option "côtière" equivalent to the previous permis côtier	To navigate to 6 miles from a shelter.
Extension "hauturière": equivalent to the previous permis hauturier.	To navigate more than 6 miles from a shelter.

In the United Kingdom, the responsibility for issuing certificates of competence for sail and power vessels is given to the Royal Yachting Association (RYA) by the British Government through the Maritime and Coastguard Agency (MCA). The MCA is an agency of the Department of Transport.

The RYA is authorised to qualify examiners, provide examinations and issue certificates on behalf of the MCA for the following qualifications:

- Yachtmaster Ocean certificate of competence
- Yachtmaster Offshore certificate of competence
- Yachtmaster Coastal (previously known as Coastal Skipper certificate of competence)
- Day Skipper certificate of competence
- Advanced Powerboat certificate of competence
- Powerboat Level 2
- Day Skipper shorebased certificate
- Coastal Skipper/Yachtmaster Offershore shorebased certificate
- Yachtmaster Ocean shorebased certificate

Table 3: Licenses for pleasure craft in the United Kingdom (Soure: Royal Yachting Association)

Licenses	Permission
COASTAL SKIPPER	Able to skipper a yacht on coastal passages by day and night.
YATCHMASTER COASTAL	The Yachtmaster Coastal has the knowledge needed to skipper a yacht on coastal cruises but does not necessarily have the experience needed to undertake longer passages.
YATCHMASTER OFFSHORE	The Yachtmaster Offshore is competent to skipper a cruising yacht on any passage during which the yacht is no more than 150 miles from harbour.
YACHTMASTER OCEAN	A person holding a Yachtmaster Ocean qualification is experienced and competent to skipper a yacht on passages of any length in all parts of the world.

Finally, in Italy, the rules governing navigation on pleasure crafts is *Decreto del Presidente della Repubblica 9 ottobre 1997, n.431* (Italian rules, 1997).

The new regulation on licensing of pleasure boats came into force on January 16, 1998. There are three types of navigation licenses shown in table 3 required by Italian law (within 12 miles or over 12 miles).

Table 3: Licenses for pleasure craft in Italy

Licenses	Permission
Patente nautica entro le 12 miglia a motore	Allows navigation within 12 miles.
Patente Senza limiti	No limitations.

Patente Navi da diporto	Over 24 meters in length, must hold the Patente Senza limiti at least 3 years.

The diversity in Europe for licenses pleasure boats detailed above and the training of the skippers would require a new legislation by a new European directive for reassurance that vessel operators are competent to ensure safety of navigation and protection of the environment as they moved from one country to another.

There is already an initiative that addresses this issue but has not settled and solved the problem completely because is not mandatory for the European Union states. Is the International Certificate of Competence (ICC) -International Certificate for Operators of Pleasure Craft .

An International Certificate of Competence (ICC) is a certificate, which may be issued to anyone who has successfully completed certain national boating licenses or has successfully passed an examination to prove the necessary competence for pleasure craft operation.

Although only guaranteed to be accepted in countries that have adopted the relevant UN Resolution, the ICC is a useful document to carry and will generally be accepted where proof of competence is required.

In very general terms an ICC is required for the inland waterways of Europe and for inland and coastal waters of Mediterranean countries. For the coastal waters of Northern Europe the ICC is generally not required, however to all of these generalisations there are exceptions.

The ICC is a product of the United Nations Economic Commission for Europe Inland Water Committee (UN ECE IWC) Resolution 40 (United Nations Economic Commission for Europe, Inland Transport Committee, 1998). It states that the ICC may be issued by a government of one state to its nationals and residents who may be on the waters of a foreign state, on condition that both accept the requirements and conditions set out in Resolution 40. Governments may appoint competent authorities to issue ICC on their behalf. For example, in the United Kingdom the Royal Yachting Association (RYA) but globally International Yacht Training Worldwide (IYT) is such a competent authority.

Only 16 EU member states have adopted either resolution so far. Spain, Greece and Portugal, for example, have not adopted Resolution 40 but are still most likely to ask visitors for an ICC.

Table 4: Requirements International Certificate for Operators of Pleasure Craft

Requirements
1. For the issue of an international certificate the applicant must (a) have reached the age of 16, (b) be physically and mentally fit to operate a pleasure craft, and in particular, must have sufficient powers of vision and hearing, (c) have successfully passed an examination to prove the necessary competence for pleasure craft operation. 2. The applicant has to prove in an examination (a) sufficient knowledge of the regulations concerning pleasure craft operation and nautical and technical knowledge required for safe navigation on inland waters and/or coastal waters and (b) the ability to apply this knowledge in practice. 3. This examination shall be held with regard to the zones of navigation (i.e. inland waters and/or coastal waters) and must include at least the following specific subjects: 3.1 Sufficient knowledge of the relevant regulations and nautical publications: Traffic regulations applicable on inland waters, in particular CEVNI (European Code for Inland Waterways), and/or in coastal waters, in particular the Regulations for Preventing Collisions at Sea, including aids to navigation (marking and buoyage of waterways),

3.2 Ability to apply the nautical and technical knowledge in practice: (a) General knowledge of craft, use and carriage of safety equipment and serviceability of the engine/sails, (b) Operating the craft and understanding the influence of wind, current, interaction and limited keel clearance, (c) Conduct during meeting and overtaking other vessels, (d) Anchoring and mooring under all conditions, (e) Manoeuvring in locks and ports, (f) General knowledge of weather conditions, (g) General knowledge of navigation, in particular establishing a position and deciding a safe course. 3.3 Conduct under special circumstances: (a) Principles of accident prevention (e.g. man over board manoeuvre), (b) Action in case of collisions, engine failure and running aground, including the sealing of a leak, assistance in cases of emergency, (c) Use of lifesaving devices and equipment, (d) Fire prevention and fire fighting, (e) Avoiding water pollution.

4. CONCLUSIONS

Undoubtedly, nowadays, in the European Union rules on boat licences are very different depending on the country. There is no coordination and equivalence between the European Union licenses for recreational crafts. The training patterns are very different depending on the country, leading to problems of safety of navigation. There is no single criterion for the minimum age required to obtain a license.

In spite of the initiative of the International Certificate for Operators of Pleasure Craft, it would be necessary to create a European directive that it regulates licenses required for recreational boating throughout the European Union. This new European directive must be applied in all member countries creating a common certificate of competence for all boaters and a common training program for all skippers, thus improving boating safety on our coast.

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CORROSION BEHAVIOR OF ALUMINIUM ALLOY IN SEAWATER AT TWO DIFFERENT SITES OF KUALA TERENGGANU COASTAL AREA

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An investigation on the corrosion behavior of aluminum at different sites of sea water in Kuala Terengganu was investigated. The method of corrosion assessment was by the use of potentiodynamic polarization scan (PP) and weight loss test. Aluminum alloy 1508 was employed in this study. This metal was immersed in seawater at different sites of Kuala Terengganu coastal area with different distance from the shore. Results obtained from electrochemical test techniques shown that lower corrosion effect of the metal significantly reduced the corrosion densities (i_{corr}) and corrosion rate. The solution of seawater affects the corrosion rate according to their chemical and physical behavior of the sea water parameter

***Keywords**: corrosion, potentiodynamic polarization, seawater, weight loss*

1. INTRODUCTION

It is well known in this modern era that the use of aluminum alloy in marine environment such as ships construction are the main material replacing wooden craft used many years ago. As for aluminum, its light weight and proven in reducing maintenance work in term of underwater hull and saving fuel consumption is becoming popular and is the main choice for high speed craft construction. Technological advances have allowed aluminum to meet or exceed the minimum strength requirements for normal strength steels currently used in the ship building industries.

The main cause of the high corrosion rate reported for coastal atmospheres is the deposition of marine aerosol particles. The influence of the distance from sea constitutes one of the most important aspects of atmospheric corrosion in coastal areas taking into consideration the intensity and direction of the winds (Corvo et al, 2007). Seawater is inherently chemically aggressive, and therefore, constructional materials used in seawater handling and processing systems including desalination plants are subjected to varying degree of corrosion depending upon the nature of the materials and operational conditions (Fozan and Malik, 2009).

The basic corrosion reaction is the same for metal immersed in seawater as they exposed to the atmosphere. However, the difference is the processes that occur. In seawater, the availability of oxygen is an important factor, whereas in atmosphere corrosion does not occur in the absence of moisture. Under immersed conditions there are more factors to be taken into account than the atmospheric corrosion. Seawater is an extremely complex, heterogeneous solution. It contains a large amount and diversity of dissolved solid material, dissolved gases, and various species of biological organisms. Corrosion reaction and its mechanisms by which materials corrode in seawater are not clearly understood. The most important seawater parameters toward corrosion are salinity, pH, dissolved oxygen concentration, temperature, pH and conductivity. However, the main factor in determining the type and extend of corrosion are the dissolved solids (which influence the conductivity, hardness and pH of the water), dissolved gases (oxygen and carbon dioxide) and organic matter.

2. MATERIALS AND METHODS

1. Sample preparation. The metal employed was aluminium alloy 1508 (25 × 25 × 3 mm). The samples were mechanically polished using 400, 800, 1200 emery paper respectively. After that the metals were lubricated using distilled water. The polished samples were cleaned with acetone, washed using distilled water, dried in air and stored in desiccators. They were weighed for the original weight. The samples were immersed in seawater at Kuala Terengganu coastal area shown in Figure 1.

Fig. 1a. Location of immersion (site 1).

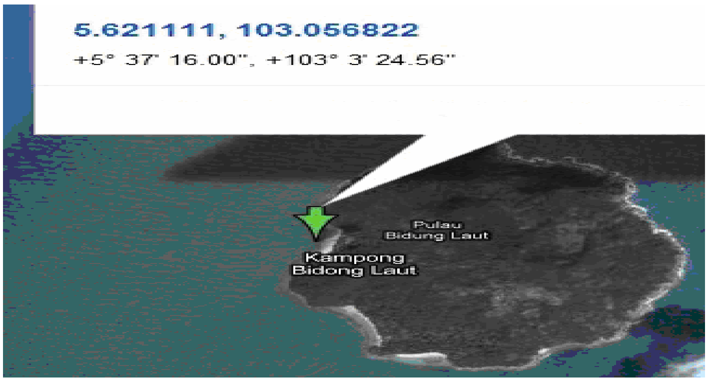

Fig. 1b. Location of immersion (site 2)

2. Weight loss analysis. Before the samples were cleaned with acetone, the samples were weighed for the original weight (w_o) by using Sartorius Cole-Polmer analytical balance readability: 0.0001g) and placed at site 1 and site 2 as shown in Figure 1a and 1b for 42 days. Then one sample was taken out in 7 days interval for 42 days. Before weighing, the sample was cleaned with distilled water and dried. Then the sample was immersed in nitric acid (H_2NO_3) to remove the corrosion products. Finally, the sample was washed with distilled water, dried and weighed in order to obtain the final weight (w_1).

Corrosion rate is calculated assuming uniform corrosion over the entire surface of the coupons. Corrosion rates, *CR* are calculated from weight loss methods. The formula used to calculate corrosion rate is as in Equation 1 (Venkatesan et al, 2009).

$$CR \text{ (mm /y)} = 87.6 \times (W / DAT) \tag{1}$$

Where: W = weight loss in milligrams
D = metal density in g /cm^3
A = area of sample in cm^2
T = time of exposure of the metal sample in hours

3. Potentiodynamic polarization. The cell used is a conventional three electrodes with a platinum wire counter electrode (CE) and a saturated calomel electrode (SCE) as reference to which all potentials are referred. The working electrode (WE) is in the form of a square cut so that the flat surface will be the only surface in the electrode (Rosliza et al, 2008). The potentiodynamic current-potential curves record the data after the electrode potential was automatically changed from -100mV to +100mV with the scanning rate of 10mVs^{-1}. The results were analyzed using the fit program GPES. Corrosion current (I_{corr}) was calculated by using the Stern-Geary where b_a is anodic Tafel slope, b_c is cathodic Tafel slope and R_p is polarization resistance (Ashassi- Sorkhabi et al, 2008):

$$I_{corr} = \frac{b_c \times b_a}{2.303 R_p (b_c + b_a)} \tag{2}$$

4. Seawater parameter. In measuring seawater parameter in this study, the instrument in used was YSI 556 multi-parameter system. This instrument is ready-to-use, handheld system for field measurements of dissolved oxygen, salinity, conductivity, pH and temperature. The display shows temperature in °C along with temperature compensated conductivity (milliSiemens/cm), salinity in part per million (ppm) and dissolved oxygen in mg/l. The YSI 556 multi-parameter system is placed in the sampling area to measure the seawater parameter. Seawater parameter was measured during interval of metal immersion period and compared between site 1 and site 2.

3. RESULTS AND DISCUSSION

The corrosion performance of aluminium alloy was studied by using weight loss method. As seen from Figure 2, the weight loss of aluminium alloy in seawater increases with respect to time.

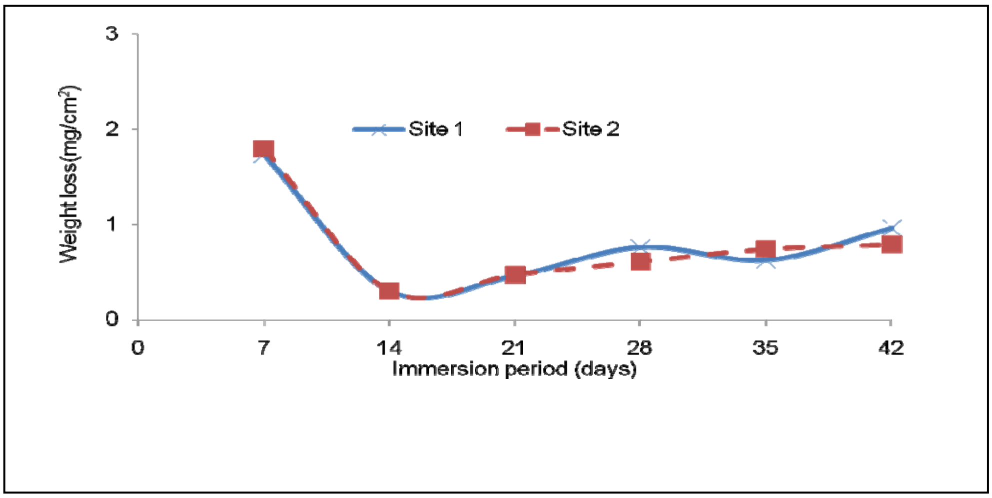

Fig. 2. Weight loss of aluminium alloy in seawater

As the immersion period increase, the percentage of weight loss also increase. The percentage of weight loss for site 1 is higher than site 2. The temperature and salinity data gained from both sides show that temperature for site 1 is higher than site 2 as shown in Figure 3a and 3b. Corrosion because of hydrogen evolution will increase the corrosion rate for every 30°C rise of temperature. Even though the temperature rise of the two sites did not exceed 30°C, a little rises in temperature affects the increasing in corrosion rate. Therefore, weight loss percentage was also increased as immersion period increase.

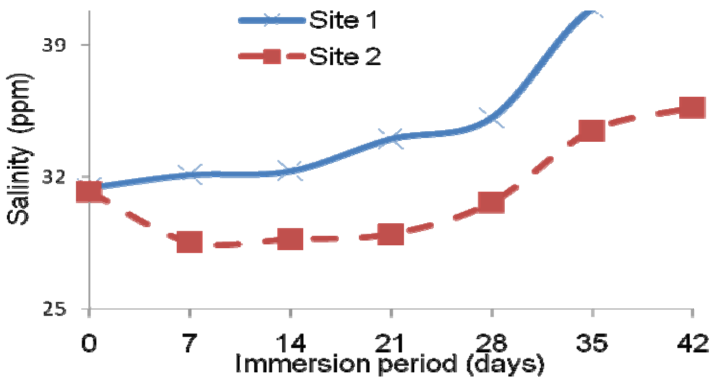

Fig. 3a. Salinity data for seawater.

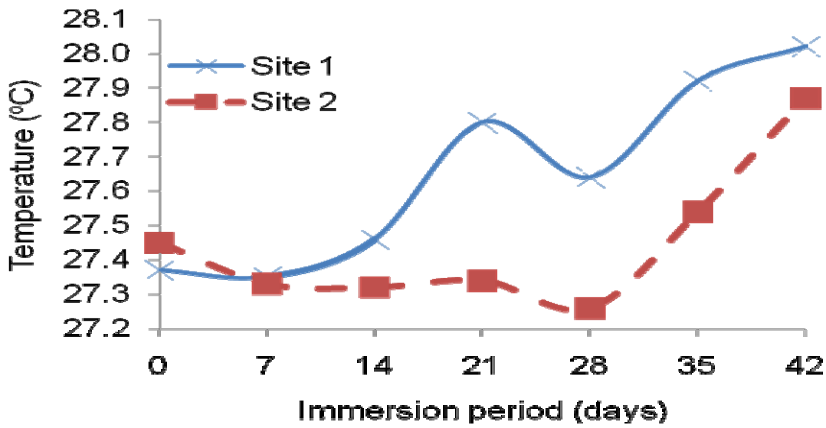

Fig. 3b. Temperature data for seawater.

The electrochemical parameters (i_{corr}, E_{corr}, anodic Tafel slope (b_a) and cathodic Tafel slope (b_c) were acquired from potentiodynamic polarization scan at different immersion time for the aluminum alloys as tabulated in table 1.

Both cathodic current (b_c) and the corrosion current density (i_{corr}) are relatively related to the corrosion rate where corrosion rate increase with the increasing of cathodic current and also corrosion current density. The corresponding corrosion potential, E_{corr}, corrosion current density (i_{corr}) that estimated from the intersection of the anodic & cathodic lines, anodic Tafel slope (b_a) and cathodic tafel slope (b_c) listed in table 1 show that the values of corrosion current density (i_{corr}) for most samples increase with the immersion time, and recorded as higher at site 1 compared to site 2. The change in E_{corr}, is assumed to be related to the growth of a passive layer at the surface of the samples which is naturally occurred to aluminum samples as a protection.

Table 1. The electrochemical parameters of AA1508 in seawater at different sites

Solutions	Days	Potentiodynamic Polarization			
		E_{corr} (mV)	i_{corr} (µA cm^{-2})	b_a (mV dec^{-1})	b_c (mV dec^{-1})
Site 1 1508	7	-1044	0.652	138	135
	14	-745	0.410	73	93
	21	-727	0.089	144	176
	28	-796	0.385	183	266
	35	-746	0.474	91	134
	42	-757	1.187	202	178
Site 2 1508	7	-932	1.063	367	357
	14	-734	1.072	251	350
	21	-735	0.117	140	208
	28	-786	0.295	150	198
	35	-784	1.116	230	208
	42	-817	1.246	185	194

The value of E_{corr} gained from polynomial regresion line decreasing with respect to immersion period and samples immersed in site 1 show highest E_{corr} value compare to samples in site 2. As the value of Ecorr shifted to more negative value, the system tends to increase its metal dissolution and hydrogen evolution process (Phanasgaonkar and Raja, 2009).

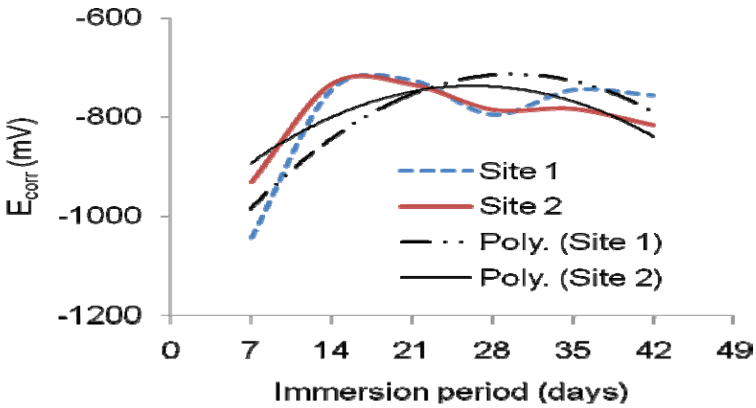

Fig. 4. Corrosion potential, E_{corr} versus immersion period.

As seen in Figure 4, the polynomial regresion line for site 1 is lower than site 2. It is clear that the value of i_{corr} can be used to calculate the corrosion rate where site 1 shows lower corrosion rate compare to site 2. This is well proven if the data of temperature in figure 3b is eferred. The existence of this cracks and pores allows the electrolyte to flow through it and directly react with metals where corrosion process begins to arise (Atta et al, 2011). The early stage of corrosion mechanism usually involves the reactions which follow conventional electrochemical rules (Evans, 1960; Jones, 1996).

At this stage, the reaction is controlled by activation energy of the reaction and consecutively the reaction later is controlled by oxygen kinetics transport. As this reaction occur, the metals tend to lose its weight as this reaction is a function of surface roughness and dissolve oxygen. This is the reason why the i_{corr} increase at early immersion period. As the immersion period increases, the value of i_{corr} decreases. The rate of oxygen supply at this point has sufficiently inhibited by the gradual build up of corrosion product (Melchers, 2003). Therefore, the corrosion rate was also decrease. The data of E_{corr} was plotted in Fgure 5.

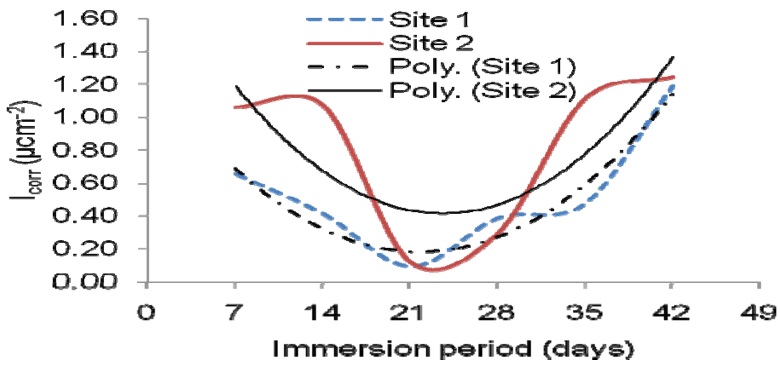

Fig. 5. Corrosion current, i_{corr} versus immersion period.

4. CONCLUSIONS

The result obtain from the weight loss method, potentiodynamic polarization scan and frequency response analysis (FRA), sample from site 1 seem to be more corroded compared to sample from site 2. This occurred due to of seawater parameter differences between the two sites such as the temperature, salinity, and dissolved oxygen (DO) which seems to be some factors of contribution to the corrosion activities. When the temperature higher, the corrosion rate also increase and proved by site 1 sample where the temperature is higher than site 2. It also can be noticed that high salinity affects the corrosion rate increment. As for the dissolved oxygen (DO), it shown that it is decreased by immersion period of the test due to no circulation in the test solution. In the first week, the reading shows that the DO decreased significantly from the initial value and this explained why the corrosion rate for the first week is higher than the second week.

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