Journal of Marine Technology and Environment

Vol.I, year 2022

ISSN: 1844-6116

Editura NAUTICA


UNIVERSITATEA
MARITIMA
CONSTANTA

ISSN (Print): 1844-6116

ISSN (Online): 2501-8795

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

This Journal has been founded in 2008 as a biannual publication of Constanta Maritime University/ROMANIA

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NAUTICA PUBLISHING HOUSE CONSTANTA, ROMANIA

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STUDY OF CORROSION BEHAVIOR OF 1C45 STEEL COATED WITH ALUMINUM AND COPPER

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Abstract: In the context of the judicious use of natural resources, the obtaining of the mechanical, electrical or protection or resistance characteristics necessary for their use and the economic optimization, it is necessary to study new methods. The method of deposition of surface layers with the help of pulsed lasers offers new directions of development. The deposition of aluminum or copper on cheap basic materials is economically justified but it is necessary to study their corrosion behavior. The study was performed on a 1C45 base material and on samples of the same material with a surface layer of aluminum and copper. The immersion of the samples for a period of 195 days provided measurable results which led to conclusions on the behavior of these materials in the marine environment. Contrary to expectations, the corrosion was manifested in copper, and aluminum showed a high protection capacity. However, the effects of the environment on the strength of the treated surface must also be taken into account during use.

Key words: aluminium, copper, corrosion, PLD (Pulsed Laser Deposition), thin layer.

1. INTRODUCTION

A thin film physical vapour deposition (PVD) techniques is named Pulsed Laser Deposition (PLD). Any compound existing in nature or made by theoretical model can be obtained, using the pulsed laser deposition method. This type of layers, deposits of superconducting materials, metals, semiconductors and dielectrics, piezoelectric , ferroelectric materials, nitrides and carbides, oxide binary or tertiary compounds, polymers, or many other materials have been subject for many studies[11].

This paper aim is to determine the behaviour of the sample covered using PLD technique and determine also the corrosion resistance of the thin films on carbon steel.

2. EXPERIMENTAL PROCEDURE

A thin-film deposition layer, as result of this technique, using high-energy laser pulses to vaporize the surface of a solid target inside a vacuum chamber is the PLD process. To form a thin layer, up to a few micrometres in thickness, the vapour are condensing on a substrate of the sample [10].

The pulsed laser deposition plant, PLD, consists mainly of four components: a laser, a reaction chamber, a During the transfer of material from the target to the substrate, the stoichiometry is preserved, target and a substrate [6]. The material removed from the target is condensed on a substrate and forms a thin film, the process can take place, depending on the desired environmental conditions: in a vacuum, in an atmosphere of inert gas or reactive gas.

Figure 1 shows a typical PLD process.

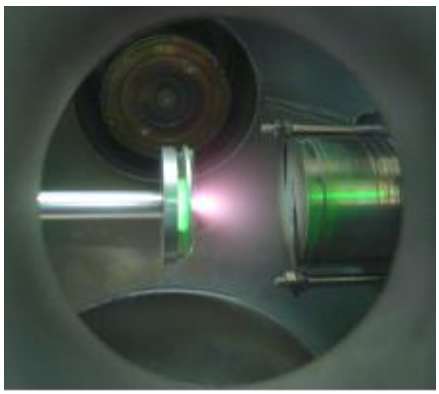


Figure 1 Image during a typical laser deposition process PLD

The kinetic energies of the particles deposited by the laser ablation method are usually high enough to diffuse to the surface of the base material, but not high enough to cause damage. Thus, PLD can create thin film deposits from a wide range of materials: metals, semiconductors and insulators with excellent adhesion to the base material [7]. Because PLD has a high cooling rate during the formation of the surface layer, films with a nano crystalline or amorphous structure result. Some of

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.01
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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these films have been applied in order to create protective barriers for the base material in corrosive environments or as thermal barriers.

For this experimental research we use 1C45 carbon steel as sample and for superficial deposition using pulsed laser deposition [1], [13].

On 1C45 carbon steel samples, with dimensions of 2x20x20 mm, was covered with a single face with thin films. [2], [3]. The material used for laser ablation is aluminium and copper. The samples were immersed for 195 days in static seawater at ambient temperature and was individually weighted on the analytic balance at different time intervals, determining the corrosion process speed.

This material are used to see influence on corrosion resistance in sea water for superficial layers [4].

Through the corrosion research process using the gravimetrical method, the parallelepiped samples covered through PLD, with the surface of 0,00127512 m^2 where suspended with an synthetic line (nylon) of $\phi = 0{,}2\,mm$ in a plastic material tub at 4 cm above the tubes liquid level (see water), being immersed 195 days in static see water at the environments temperature [2].

The major disadvantage of the gravimetric method is the long holding time of the sample in the corrosion medium [12], necessary to obtain sufficiently large differences in weight between the initial and final weighing, which can be accurately detected at the analytical balance [8].

The corrosion study was also done by electrochemical methods, determining the density of the instantaneous corrosion current and the penetration rates for 1C45 steel and the deposited layers.

3. RESULTS AND DISCUSSIONS

The speed corrosion variation results from immersed samples in sea water (195 days), is presented in figure 2.

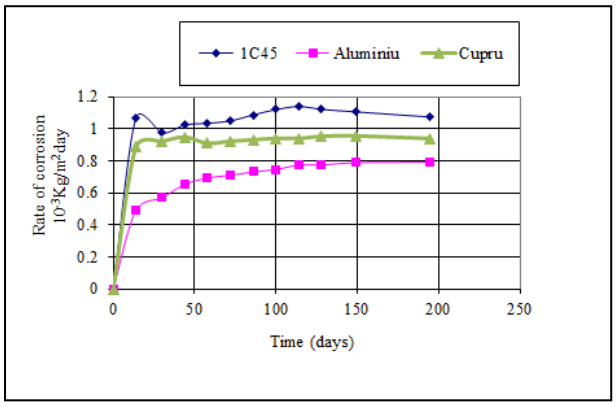


Figure 2 Rate of corrosion

Following the experimental results, analysing the corrosion resistance of 1C45 carbon steel coated by pulsed laser deposition, with aluminium and copper, after the time interval of 30 days it is found that 1C45 steel coated with Al is the most stable.

In the early stages of corrosion (0-30 days) the corrosion rate increases rapidly, and the results of short-term corrosion tests are inconclusive for long-term corrosion [9], [5].

On the surface layers exposed in sea water, at the beginning it is found that the corrosion rate increases progressively, this being due to the deposition of the layers only on one side.

Instantaneous corrosion current density was calculated with Equation[14]

$$J_{corr} = \frac{b_a \cdot b_c}{2.303(b_a + b_c)\cdot R_p'} \left[mA/cm^2\right] \qquad (1)$$

The values of the Tafel slopes (ba and bc) the polarization resistance (Rp) and the instantaneous corrosion current density (Jcor) [15], [16] for the studied samples are presented in tables 1 and 2.

Table 1. Corrosion parameters for support steel

Parameter	OLC-45
Tafel anodic slope, (b_a), [mV]	24
Tafel cathode slope, (bc), [mV]	-67
Polarizing resistance, Rp [ohm.cm^2]	1400
Instantaneous corrosion current, J_{cor}, [mA/cm^2],	0,00548

Table 2. Corrosion parameters for the covered sample

Parameter	Al	Cu
b_a, mV/decade	30	40
b_c, mV/decade	-60	-70
R_p, ohm.cm^2	10000	2250
Jcorr, mA/cm^2	0,00087	0,00491

The densities of the instantaneous corrosion current (which are obtained by simply immersing the sample in the electrolyte) [16] are compared in Figure 3

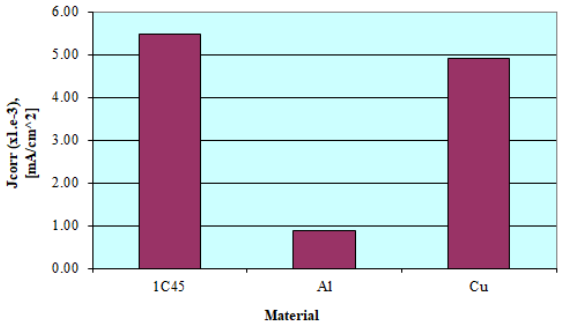


Figure 3 Instantaneous corrosion current density for 1C45 and deposition layers

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.01
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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The corrosion rate, expressed as penetration rate (expressed in mm / year) was calculated with the relation (2), considering for the instantaneous current density the values from table 1and table 2[17].

$$v_p = 3{,}27.\sqrt{\left(\frac{A}{z}\right)}.\frac{J_{cor}}{\rho} \qquad (2)$$

In the calculations the constants given in table 3 were used:

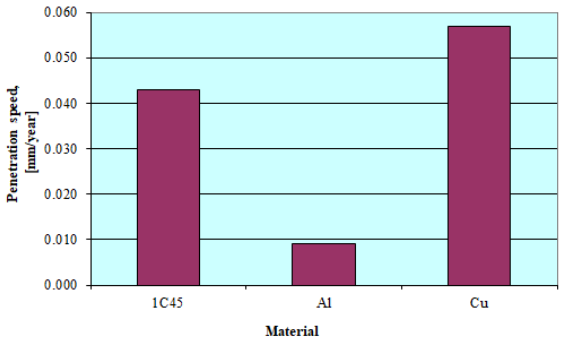
Table 3. Constants used in determining the penetration rate

Metal	Masa (g/mol)	Density (g/cm^3)	z
Fe	55,85	7,80	3
Al	27,00	2,70	3
Cu	63,50	8,96	2

In the case of the supports, only iron was taken into account and for the sparked samples only the deposited material.
The penetration rate values are shown in Table 4 and are compared in Figure 4.

Table 4. Corrosion rate for substrate and coated materials

Material	Corrosion speed [mm/year]
1C45	0,043
Al	0,009
Cu	0,057



[in mm/year]
Figure 4 Speed penetration for 1C45 and deposition layers.

Contrary to expectations, the highest corrosion current was obtained for copper-coated samples and the lowest for aluminium-coated samples [18].

This is not surprising because the corrosion potential implies a steady state, while the penetration speed is directly related to the process kinetics and depends on many factors, such as: solubility of corrosion products, adhesion of insoluble products to the surface of the alloy, transfer of substance to and from the electrode in solution, ion mobility, etc.

4. CONCLUSIONS

As a general conclusion regarding the process of corrosion of metals coated with sparks by metals, it can be appreciated that this process does not ensure a marked increase of the corrosion resistance.

This should not necessarily be considered as a shortcoming as spark coating does not have the ultimate goal of reducing corrosion but of modifying mechanical and aesthetic properties. However, the effects of the environment on the resistance of the treated surface to the environment must also be taken into account during use.

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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.02

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

THE STUDY OF A JIB CRANE FROM A CARGO SHIP

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Abstract: This paper presents the study of a jib crane from a general cargo ship. There are numerous different types of vessels operating today in the various markets worldwide. Besides, thousands of cargo vessel ply the world's oceans and seas each year, handling the bulk of international trade. The cranes from cargo ship is required to be adequate stability and strength for each load. All cranes from vessel are mounted on deck of the ship. Having regard in particular to the stress induced at its mounting or fixing points, adequately ballasted, securely anchored and supported by outriggers as necessary to ensure its stability when lifting. A jib from a crane from cargo ship is a type of overhead lifting device that is often used in a smaller work cell area for repetitive and unique lifting tasks. The extreme values of the stresses and reaction forces are determined by the finite element method. In this manuscript, the design of the cargo ship and the study of a jib crane are made using NX software from Siemens.

Key words: jib, crane, ship, cargo, stress.

1. INTRODUCTION

A general cargo ships is a freighter is a merchant vessel that carries goods from one harbor to another. The most used cargo vessels are, [1]:

- Bulk-cargo ship.
- Container cargo (boxship)
- Livestock vessels
- Reefer ship.

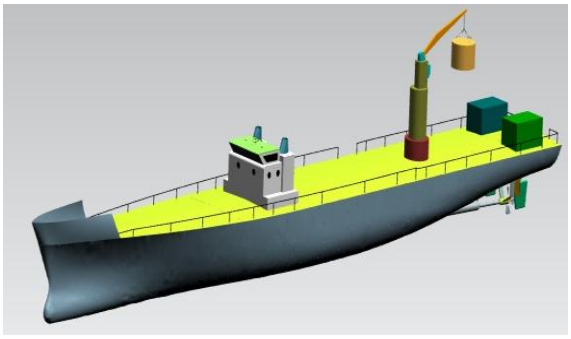


Figure 1 General cargo ship

Some cargo ships are equipped with cranes and other mechanisms to load and unload, Fig. 1.
Cargo ships are generally classified according to: deadweight tonnage (DWT), cargo capacity and vessel dimensions. In fact, the vessel presented in the paper is small in size (carrier of 22,000 TDW), [2].
General cargo ships generally have a life expectancy of 25 to 30 years before being scrapped.

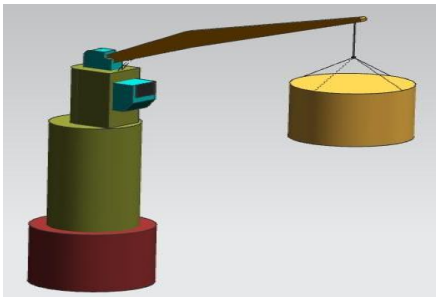


Figure 2 Crane cargo vessel

Often, the main parts of the crane on the ship are: pedestal, column (main support), cabin, jib, etc. [3]
Usually, the cabin is attached to the column of the crane. Because, the operator working in the cabin must have a higher visibility. But, the jib crane is above the body and the cabin. The jib crane is raised with two hydraulic cylinders, Fig. 3.

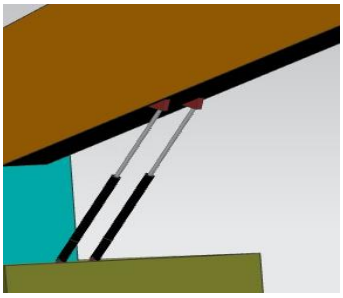


Figure 3 Crane hydraulic cylinders

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.02
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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Moreover furthermore, there are many types of ship crane. Usually, the ship crane are more complex to lift or lower a heavier load , Fig. 4.

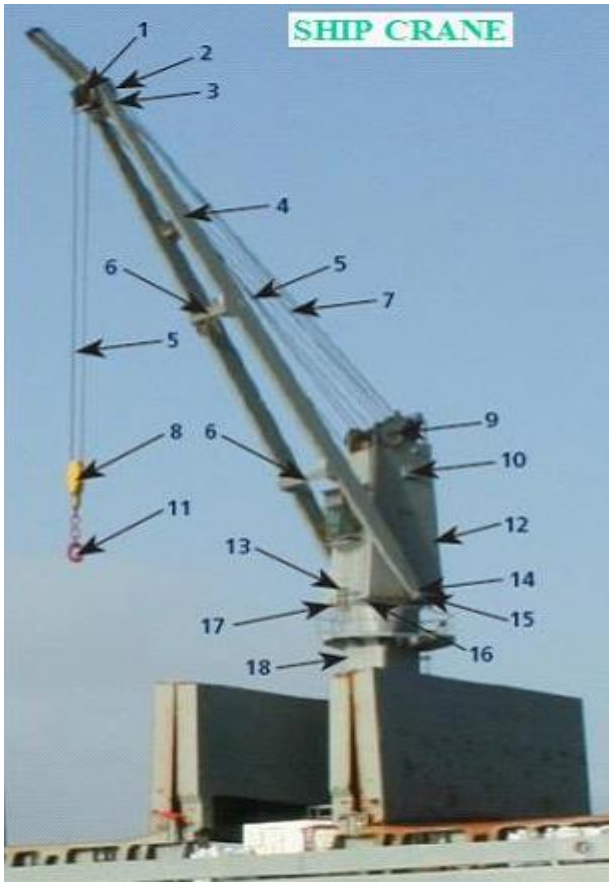


Figure 4 Ship crane

Table 1. The components of a ship crane

No.	Description
1	Jib head
2	Jib head sheaves
3	Luffing sheaves
4	Main chords of jib
5	Cargo hoist ropes
6	Transverses
7	Luffing ropes
8	Hook block
9	Slew column head
10	Jib stop
11	Hook
12	Slewing column
13	Machinery deck
14	Jib heel
15	Jib heel pin
16	Slew ring bearing
17	Slew ring bolts
18	Pedestal

Jib crane from cargo vessel has the following motions:

- Derricking/luffing motion.
- Hoisting motion.

Slewing column with jib has slewing motion.

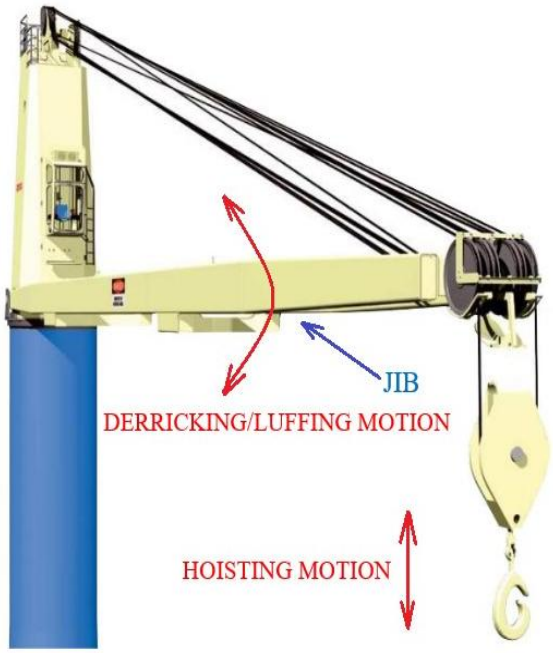


Figure 5 Jib crane motions

2. THE STUDY OF A JIB CRANE

A jib is a horizontal or nearly horizontal beam used on cargo ship cranes.
In fact, these frames are used in many types of cranes to support the load away from the main support.
The beam of the cranes are primary used to transport, lower loads and lift, Figure 4.
On the jib are mounted: trolley, hook block, hoist wire rope, etc, [4].

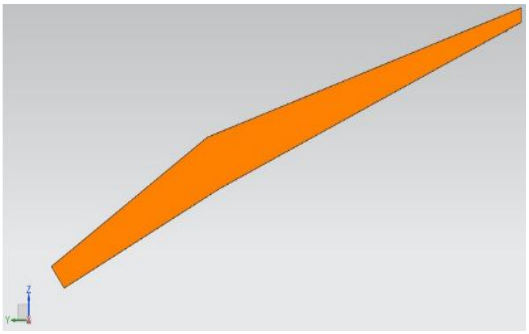


Figure 6 Crane hydraulic cylinders

The study of crane frame is performed using the finite element method. Thus, creating a mesh model with 1069 type CTETRA(10) finite elements, [5].

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.02
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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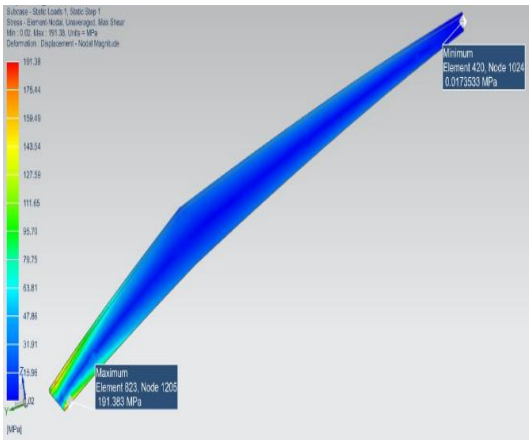


Figure 7 Shear stress – Jib crane

The maximum shear stress τ_{max} =191.383 MPa is at node 1205 in the finite element 823. But the minimum shear stress τ_{min} = 0.017 MPa is at node 1024 in the finite element 420, Fig. 7.

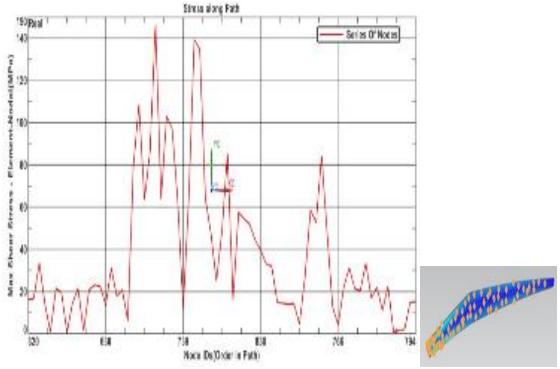


Figure 8 Diagram of shear stress – Jib crane

In order to achieve the diagram of shear stresses, we must choose the most important nodes. From the diagram, it can be seen that all the values of the shear stresses are positive.

Thus, in the diagram the minimum shear stress is and the maximum shear stress is τ'_{max} =191.383 MPa, Fig. 8.

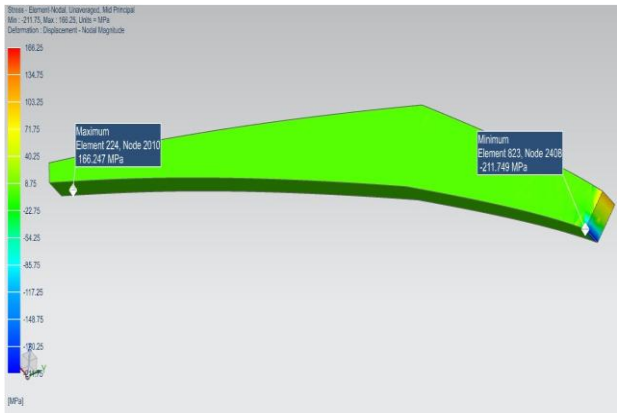


Figure 9 Normal stress – Jib crane

At node 2408 of element 823 is the minimum normal stress σ_{min} = -211.749 MPa, [6].

But, at the 2010 node in element 224 is the maximum normal stress σ_{max} = 166.247 MPa, Fig. 9.

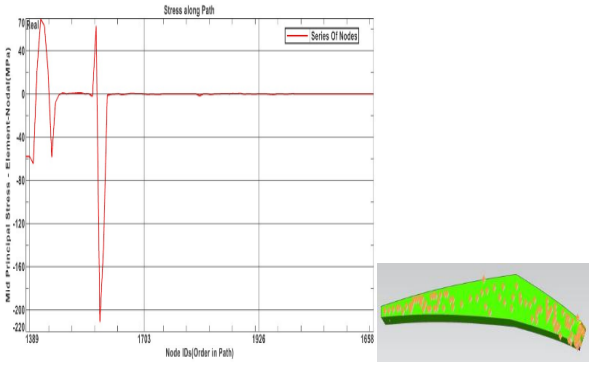


Figure 10 Diagram of normal stress – Jib crane

In the normal stresses diagram, the extreme values are: minimum normal stress is σ'_{min} = -211.749 MPa and the maximum normal stress is σ'_{max} = 220 MPa , Fig. 10.

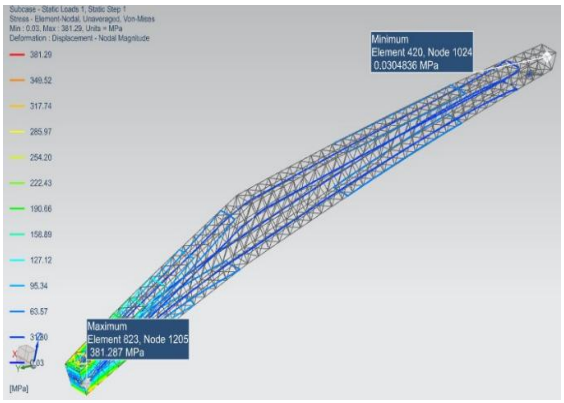


Figure 11 Von Mises stress – Jib crane

The maximum von Mises stress $\sigma_{v\,max}$ = 381.287 MPa is at node 1205 from element 823, [7].

But, the minimum von Mises stress in this case is $\sigma_{v\,min}$ = 0.030 MPa which is located at the node 1024 from element 420, Fig. 11.

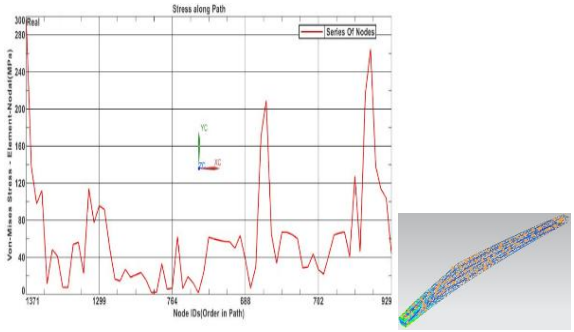


Figure 12 Diagram of von Mises stress – Jib crane

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.02
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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All values in the von Mises stresses diagram are positive. In the diagram the extreme values of the Mises stresses are: the minimum stress is $\sigma'_{v\,min} = 0$ MPa and the maximum stress is $\sigma'_{v\,max} = 300$ MPa , Fig. 12.

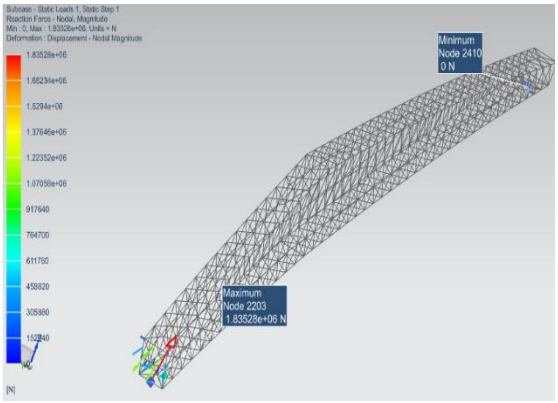


Figure 13 Von Mises stress – Jib crane

The maximum reaction force $F_{max} = 1.835 \cdot 10^6$ N is in the node 2203.

However, the minimum reaction force $F_{min} = 0$ N is in the node 2410, Fig. 13 .

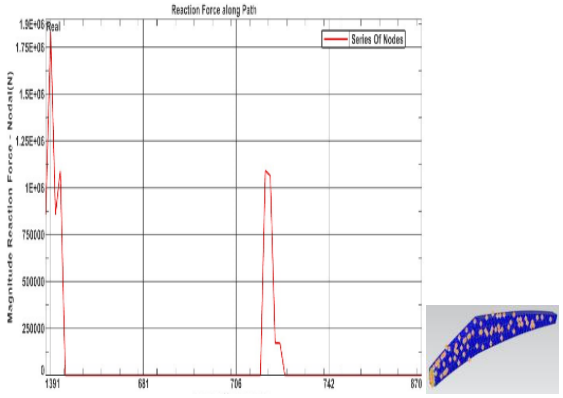


Figure 14 Diagram of reaction force

In the diagram of reaction forces, most values are null, [7]. Only at the beginning of the chart is there a maximum value $F'_{max} = 1.9 \cdot 10^6$ N, Fig. 14.

3. CONCLUSIONS

The jib cranes of cargo vessels have a relatively simple design and structure. They are easier to control and don't require a lot of servicing.

On the cargo ship, the jib can be deformed in the following cases: great winds, storm, during loading/unloading of goods, etc.

Authorized repairs should only be carried out on shipyards by specialized crane personnel. They must repairs to crane jibs by cropping and welding inserts over damaged or wasted sections.

Because, the jib crane are made of high-tensile for which special procedure have to be observed during repairs.

On general cargo ships, it was reported that the ship's staff had carrier out unauthorized repairs to crane frame by cropping and welding sections.

In fact, any damage noticed to crane jibs must be reported to the general cargo vessel and also advice sought before carrying out any kind of repair. It is recommended that during the maintenance of the cargo vessel, the strength structure of jib crane be checked.

In paper, extreme values were determined from a jib crane with finite element methods. These extreme values are of the shear stressess, normal stresses, von Mises stresses and reaction forces.

On the future, we want to develop the study for the jib from a crane on other ships.

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Vol.I,DOI:10.53464/JMTE.01.2021.03.

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.03

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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A COMPARATIVE ANALYSIS OF INDOOR POSITIONING TECHNOLOGIES IN SHIPYARD DIGITALIZATION CONTEXT

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Abstract: *Purpose*: In the last few decades, there has been an increasing growth in research into the use of positioning technologies in open environments. Most of the technologies developed for outdoor environments are used successfully, however, they cannot be considered as fully successful indoors. In this context, various technologies based on Radio Frequency, Infrared, Ultrasound, Magnetic, Optical, and computer vision are proposed to improve positioning indoors. In addition to their individual use, it is also seen in hybrid applications. In particular, Radio Frequency based technologies have potential use in shipyard environments. For this purpose, technologies such as Bluetooth, Ultra broadband, Wireless Sensor Network, Wireless Local Area Network, Radio Frequency Recognition and Near Field Communication are seen as suitable technology options for shipyards. The indoor positioning system is a technology that has the potential to significantly improve work efficiency and safety in the shipyard area. It is difficult to achieve a successful digital transformation of the complex shipyard environment without identifying an Indoor positioning technology for the shipyard. In this study, it is aimed to design a positioning technology that will be most appropriate for the shipyard. *Methodology*: This paper analyses the challenges for the selection of Indoor positioning system for shipyards in evaluating Indoor-positioning technologies. The methodology followed in this study is a comprehensive comparative analysis of existing IPS technologies on how to digitize shipyards. This article provides an advanced assessment of indoor positioning technologies and their use in the challenging shipyard site. In this context, it provides an evaluation framework for different positioning measures such as accuracy, coverage, scalability, cost, privacy and usability of technologies that can be used within the scope of IPS. *Results*: The work carried out here on indoor positioning systems and components makes a significant contribution to the shipyard industry. Because it has a great impact on the suitability of technologies, especially in relation to the shipyard environment. Both the evaluation model and solution method, and the Bluetooth-based positioning technology, which stands out at the end of the evaluation, are important contributions of the study. *Conclusion*: To determine which indoor positioning systems are more suitable for the shipyard environment, both a detailed analysis of the shipyard environment and an evaluation were made to select the most suitable technology. The comparison was made based on observations of the shipyard site and the available literature on the field. This article makes important contributions to future shipyards' application of positioning technologies.
Key words: Indoor positioning systems, Indoor positioning technologies, Shipyard, IoT, wireless technologies,

1. INTRODUCTION

The shipyard sector, like other sectors, wants to benefit from the developments by implementing Industry 4.0 principles and is struggle to realize digitalization [1]. The positioning of objects in shipyards is the first step of this process and forms the basis of its digitization. This is achieved by positioning systems (PS). Positioning is defined as the determination of the position of objects or people in a closed area using radio waves, magnetic fields, acoustic signals and sensor data collected by mobile devices [2].

The most popular among location-based services is the Global Positioning System (GPS) [3]. The GPS for locating and tracking the position of an object indoors is hardly recommended for indoor use, since the signals transmitted from a satellite to a device indoors are weakened due to obstacles indoors. The GPS cannot provide location information with the same accuracy in closed areas due to the negative effects of blockers and insufficient signal level in closed areas, so in open areas, IPS are indispensable technologies due to their high accuracy and low cost. Indoor positioning systems (IPS) can be considered as a special version of GPS for indoor areas [4].

IPS offers great convenience in locating and tracking living and non- living objects in indoor areas. Therefore, the IPS have become a new research focus in technology. In recent years, various technologies have been proposed for positioning indoors [5]. The IPS is

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.03
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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considered a useful system in indoor environments such as large buildings, shipyard, construction sites, campuses, hospitals, schools, shopping malls, and helps to give the most accurate results in other large complex closed structures.

The IPS are used to find and track the location of a particular object. In today's world, where the PS are becoming more and more widespread, different solutions are being discussed. The IPSs can be designed in different ways. Positioning can be done by receiving the signal information sent by the objects, whose location is desired, by the fixed nodes whose location is known beforehand, and by performing the necessary calculations by these devices, or by receiving the signals from the fixed node points whose location is known beforehand, by the object whose location is desired to be determined.

In order to determine the positions of the objects in the closed area, it is necessary to obtain the signals from the fixed and mobile devices in the area to be positioned. For this, signal measurement techniques are used. Among the signal measurement techniques used in the IPS, arrival time, arrival time difference, arrival angle, round-trip time, received signal strength indicator (RSSI) are the commonly used signal measurement techniques. It is necessary to design an ideal system that can meet the requirements according to the closed area where the positioning will be made, the expected sensitivity, and the cost criteria.

According to the technique to be positioned, the fixed device whose location is known beforehand or the object whose location is desired can perform the necessary calculations, or the central device can also perform the positioning calculations by sending the received signal properties to a central device.

The RSSI technique is a signal measurement technique that is often used to detect the positions of objects in the IPS. The RSSI value, which is a standard feature in many technologies such as Bluetooth and Wi-Fi, can be obtained without the need for external hardware. For this reason, PSs based on RSSI measurement technique are preferred more than other signal measurement techniques because they provide convenience in terms of time and cost. The fingerprint method, on the other hand, consists of two parts, the training and the positioning. During the training, a reference signal intensity map is created that characterizes the indoor area [6]. At this stage, measurements are taken from fixed devices placed at reference points at certain intervals in the form of a grid inside the closed area, and these measurements are recorded on a server and the training phase is completed. These processes are called field analysis. During the positioning phase, the signal intensities of the device to be located and the devices placed at the reference points are measured, and these measurements are determined by determining which point is closest to the signal strength map recorded on the server during the field analysis phase. In PSs performed with the fingerprint method, which makes positioning independent of angle and distance, the number of signals obtained during the training phase, which is the characteristic of the indoor area, and the increase in the number of transmitters emitting signals can increase the positioning accuracy [7]. Machine learning methods such as artificial neural networks, N-nearest neighbor, and random forest are used to increase the accuracy of location estimation when analyzing the measured signals with the signals on the map created during the training phase. Since RSSI values can be obtained easily from Wi-Fi and Bluetooth devices, fingerprint method is the most commonly used method in the IPS [8].

More and more devices are joining the IoT world. More importantly, IoT devices are improving manufacturing processes, from quality control to production floor monitoring. Providing these IoT devices will make businesses life easier, but first you have to understand how it all works. The first step is to understand the many wireless technologies around IoT connectivity, such as LoRa, Wi-Fi, ZigBee, Bluetooth, and 5G. This study comparatively explains each wireless technology in detail to help you understand them better.

The following sections in the article are arranged as follows: first, characteristics of shipyard and challenges for IPS were determined. Then, comprehensive information was given about the IPS for the area and presented a framework for performance meter for IPS. Finally, a comparison of discussed systems was made and the results obtained were discussed.

2. CHARACTERISTICS OF SHIPYARD AND CHALLENGES

This section discusses the general characteristics of shipyard environments and outlines the challenges IPS will face in shipyards. Shipyards are complex and dynamic environments, vast areas where a wide variety of ships are built as well as repairs. The ships themselves are gigantic products, and the interior is very complex, resembles a multi-storey enclosed building, and consists of metal walls [9].

Considering the IPS related challenges, shipyards are covered with a multitude of obstacles and blockers. These barriers are dynamic barriers that change over time and constantly generate interference for signals. Large metal blocks, oversized cranes, heavy tonnage equipment and machinery, and large numbers of people working in motion are objects in shipyard environments [10]. All these assets in the shipyard environment are not only obstacles, but also their positions must be constantly monitored. In these conditions, choosing an IPS that is resistant to these challenges is a difficult process. Shipbuilding is an environment where closed areas are dense as well as open areas. For this reason, it is among the places where GPS fail or cannot provide sufficiently precise data.

The shipyards are also production environments where there are liquids, metal-weighted, acid and salt-intensive environment, corrosive substances, many obstacles, high temperature values, toxic gases are

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.03
ISSN (Print): 1844-6116
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intense, and mobility is high. Determining the most suitable indoor positioning technologies (IPT) that is resistant to these constraints significantly affects the success of the digitization performance of the shipyards. IP systems are needed to obtain functional information about the positions and movements of people, welding machines and other moving and stationary resources in the shipyards [11]. The IPS system has the potential significantly to improve work efficiency and safety in the shipyard area. Successful digital transformation of the complex shipyard environment cannot be achieved without selecting an IP technology that is best suited to the shipyard environment. This article analyses potential difficulties in determining the most suitable IP technology in shipyards and makes a comparative evaluation of IP technologies [12].

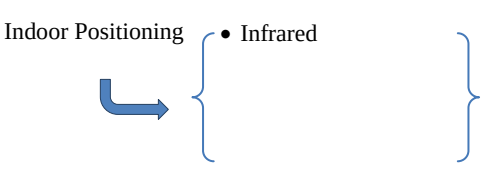
Some of the currently available technologies, such as camera systems, audio and light technologies, are ignored because they do not adequately meet any of the challenges of shipyard requirements, that is, they are not suitable for shipyards [13]. Since the remaining technologies meet the technical requirements of the shipyards at different rates, that is, some of them are good in terms of some criteria, some of them are insufficient in terms of other criteria, therefore, the advantages and disadvantages of these technologies should be analyzed comparatively.

3. INDOOR POSITIONING SYSTEMS

This section introduces the IPS, which will significantly increase shipyards' efficiency, productivity and safety. So far, researchers have proposed IPS that work and perform well, appropriate for different industries in different fields. IPS is covered extensively in the literature and is well defined and classified. Comprehensive assessments have been made in literature [13 - 15]. In addition, it is a fact that comprehensive evaluations about which technologies are resistant to difficulties and suitable for shipyards are not made at a sufficient level and studies in this area are still lacking.

The IPS are made of the technologies, the techniques and the methods. The basic components that make up the IPS are shown in Figure 1. The techniques applied in IPS primarily depend on the technology used. Methods for the IP are algorithms used to calculate the position of a target object. They depend on the technology and techniques used.

Based on the technological perspective IPSs are divided into RF signals or not. A basic classification for SPSs is (1) radio frequency (RF) based, (2) light-based, (3) audio-visual and non-audible, (4) Inertial sensor based systems, and (5) computer vision systems [16]. Recently, hybrid technologies have been developed in which these technologies are used together. Thus, by combining the strengths of technologies, systems that are resistant to difficulties are developed.



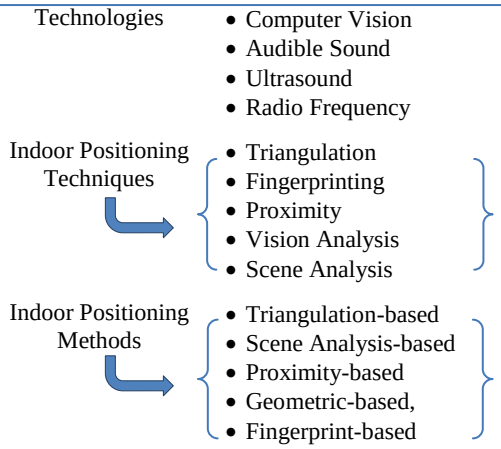


Figure 1 Indoor positioning systems

IPS can be classified into 4 groups according to their size, namely the geographical area they cover: i) WPAN (Wireless Personal Area Network). IR can be given as an example. ii) WLAN (Wireless Local Area Network). It allows users to access the internet wirelessly. Wi-Fi is an example. iii) WMAN (Wireless metropolitan area networks). It provides the connection of multiple networks with each other. For example, inter-building wireless networks. WiMAX can be given as an example, iv) WWAN (Wireless Wide Area Network). It is used in very large areas. They use satellites. 5G, GSM connections are examples of WWAN (Figure 2).

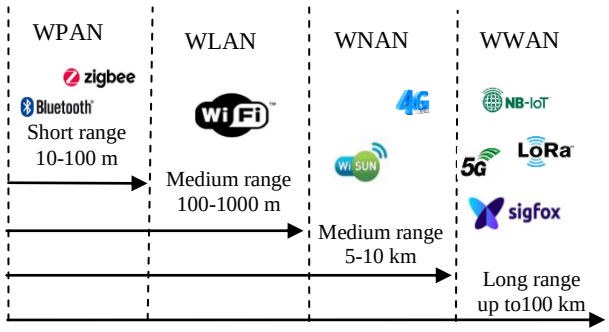


Figure 2 Classification of the IPT

3.1 Radio Frequency Based Systems

RF-based PSs usually consist of receivers and transmitters that communicate with each other via radio signals. These are named as receiver, transmitter and RF radio signal. Wireless network technology is a communication method in which electromagnetic waves emitted from the air are transmitted from one point to another in a certain frequency channel without a physical connection. The receiver receives radio waves flawlessly as they energize a distant receiver. The system was first developed under the name RADAR [17]. The goal of these researchers was to track and locate people in indoor areas through radio signal strength data collected from pre-placed transmitters at different points. Many studies have been carried out to produce a reliable and highly accurate IPS. Despite the popularity of GPS in

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.03
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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detecting people's positions in open areas, this technology cannot be used indoors because satellite signal waves cannot pass through walls and thus the connection between satellite and receiver is interrupted [18]. Since radio waves have the ability to pass through obstacles such as walls, floors, and the human body, RF-based technologies are extremely suitable for use in IPS with wide coverage areas.

3.2 Systems Based on Infrared

An infrared (IR) signal is an electromagnetic signal that is longer than the wavelength of visible light but shorter than the wavelength of the radio wave. Infrared is just below the visible spectrum of light in frequency and is strongly emitted by hot bodies. Many objects such as humans, vehicle engines, airplanes, etc. generate and retain heat and are thus particularly visible in the infrared wavelength of light compared to background objects. Infrared cannot pass through walls and obstacles. Those detected by heat detectors are those with the longest wavelengths. Approximately, wavelengths are between 0.8 microns and 1000 microns. Therefore, it has a very limited area in closed environments. Indoor lighting interferes with this type of signal and creates a problem in correct detection. Compared to ultrasonic devices, infrared devices are generally smaller. Today, infrared is used to provide communication between the remote control of electronic devices such as televisions and videos and the device. These infrared receivers and transmitters operate with a frequency between 36-40 KHz. Transmission is unidirectional since there is only one transceiver pair. It can be used in single-storey closed areas where there is no obstacle between the infrared transceiver. Infrared provides communication between two points that see each other via ultra-low frequency infrared light waves. It is used for short distances not exceeding a few meters. It is used for data communication in portable computers devices such as mouse and printer in personal computers. Because these devices communicate with infrared rays, a direct line of sight must exist between the two devices.

3.3 Sound-Based Systems

Ultrasound is sound waves that propagate at a frequency too high for the human ear to hear. Ultrasound-based systems provide much more efficient information than BLE or Wi-Fi technology in buildings with many rooms, such as hotels and hospitals, and require less infrastructure. The Time of Arrival algorithm is used as the calculation algorithm in ultrasound systems. However, since the power of ultrasonic sound waves is not enough to pass through walls, each indoor room must have its own system. Although ultrasound operates in the low frequency bands, it has good sensitivity for position detection at the slow propagation speed of sound compared to the other signal technologies. A medium is required for sound to be transmitted. The propagation of sound is the transport of energy from one place to another. The speed of propagation of sound waves depends on the density of the medium. The advantages of ultrasonic devices are their simplicity and low cost. Ultrasound cannot pass through walls, but it is reflected from many interior barriers. It has a short range of 3 to 10 m, with a distance; measure resolution of 1cm. Operating temperature affects the performance of ultrasound.

3.4 Visible light communication

Light-emitting diode (LED) technology has developed rapidly in recent years. Thanks to this technology, illumination was provided in an economical and efficient way, and at the same time, visible light communication at high speeds was also enabled. Visible light communication (VLC) has several advantages over conventional RF communication in many ways. Some of those; VLC systems can be used in many RF sensitive environments such as power plants, mines, hospitals. At the same time, since VLC use existing lighting systems used indoors, they can be adapted to existing systems with little expense and little modification. Until now, many solution approaches have been proposed for positioning in VLC-based systems. In these systems, LED light sources act as emitters, while photodiode and image sensor act as receiver. Positioning algorithms used for VLC-based the IPS; proximity algorithm, fingerprint algorithm, triangulation algorithm, vision analysis and hybrid algorithms. The fingerprint method needs a database where the received signal strength (RSS) information is kept. RSS information of a channel is pre-recorded under various conditions such as low light, high light environment, etc. and then this information is used during location determination.

3.5 Computer Vision-Based Systems

Vision-based systems use omnidirectional cameras, 3D cameras or built-in smartphone cameras to obtain information about internal environments. Cameras are actively used in structural systems; they detect and monitor the location of people in closed environments. There are various approaches to the use of image detection devices for example, video cameras used for security purposes in buildings. Image detection based position detection systems are divided into two categories considering different working principles. In the first category, the target user whose location will be detected carries a mobile image detection device, while the working principle of the second category is based on a fixed camera detecting the moving users by analyzing the images obtained. The high cost of an advanced image processing system and the need for comprehensive hardware in this direction is stated as the main disadvantage of these systems. The fact that installation, testing, and system performance verification is a difficult and time-consuming process, and privacy concerns arising from the continuous monitoring of living and

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.03
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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working areas are also listed as other constraints on the spread of image detection-based systems.

A general view of the technologies evaluated within the scope of this study can be seen collectively in Figure 3. In the following section, only RF-based technologies are introduced, as non-RF-based technologies are not suitable for shipyard environments or cannot meet the desired performance. Infrared technology is not suitable for the shipyard, as the rays cannot pass through the walls, as any solid object blocking the lights blocks the Infrared connection. Likewise, since ultrasonic waves cannot pass through obstacles such as walls, they are not suitable technologies for shipyards. The other non-RF technologies are not considered suitable for similar reasons.

4. RF - BASED TECHNOLOGIES

RF-based technologies are the most widely used in IPS. Heavy and oversized metal blocks are located inside the ships under construction at the shipyard and in other enclosed shipyard environments, and they can significantly weaken the signals. This can significantly adversely affect the coverage of some types of signals, for example, red light, ultrasound and infrared [19]. Despite the significant contributions made by many researchers to IPS technologies over the years, gray areas still exist that need to be addressed as the technology matures.

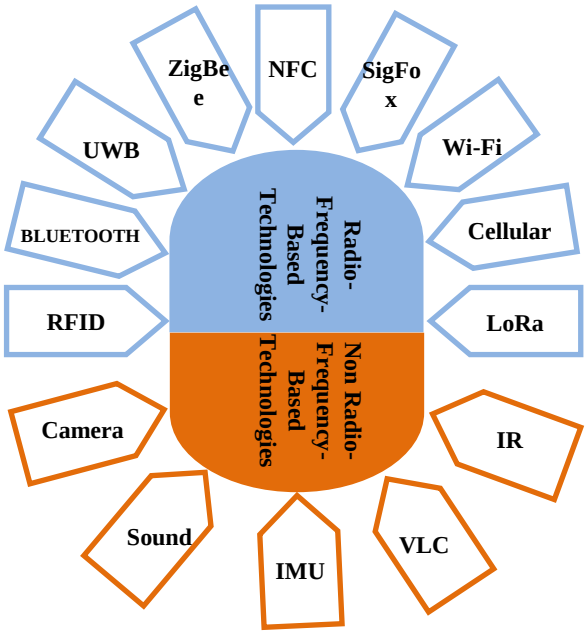


Figure 3 A classification scheme of IPT

In today's world, the IPS have been widely adopted in many parts of the world. Because IoT is diverse and versatile, there is no one-size-fits-all networking solution. Each communication solution best serves a particular area. There is wireless technology out there now, and as technology advances and people's needs change, there are possibilities for more in the future. It is common for most people to use these terms interchangeably, although they are quite different. It all comes down to the layer of the telecom device with which the network interacts. Descriptions of the most commonly used IPTs are described below. A comparative graph in terms of data rate, power consumption and range is shown in Figure 4.

4.1 WLAN (Wi-Fi)

Wi-Fi (Wireless Fidelity) is the common name of the IEEE 802.11 standard. Wi-Fi has ability to expand easily as their coverage can be increased by adding new access points. The very popular and widely used Wi-Fi has been applied in various places such as campuses, buildings, hospitals, museums and so on. At the same time, Wi-Fi has been integrated with all types of electronic devices such as mobile phones, laptops, tablets and televisions. It has a reading range of 100-150 Meters.

Wi-Fi - based systems also have some disadvantages. Negative effect of changing equipment layout on radio signal values, high initial setup cost for structures without the necessary infrastructure, high variability of Wi-Fi signal strengths over time, and the possibility of interference of radio signals with signals from other devices are the main issues against Wi-Fi based systems.

4.2 RFID Based Indoor Positioning Systems

RFID is a general term used to describe systems used to wirelessly transmit object or person identification information via radio waves. The system generally consists of two main components. The IPS infrastructure is created by forming the system components as the tag, which is considered as a transmitter connected to this tracked target, and the receiver, which receives the transmitted radio wave signal and performs the positioning process. There are two types of labels; Inexpensive, small and short-range passive and expensive, active tag with higher coverage and working as a transceiver. The disadvantages of the RFID-based IPS are that it is not easy to integrate with other systems and has a small coverage area. It has a reading area of 3 meters.

4.3 Ultra Wide Band Indoor Positioning System

Ultra Wide Band (UWB) is a wireless technology that transmits large amounts of data with a wide range of low power and short-range frequency bands as it has a bandwidth of more than 500 MHz. It makes it possible to filter the reflected signal from the original, thus guaranteeing a high precision system. The advantages of the UWB system are that it effectively penetrates walls and passes through obstacles, is isolated from any existing RF signals and does not cause any interference. Finally, UWB is a very high precision system. The disadvantage of this system is that it is a costly system

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.03
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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and liquid and metallic materials cause interference. This interference situation prevents the system from operating with correct sensitivity. Its effective range is limited to 100 meters. Ultra-wideband technology is based on the principle of exchanging data with very short radio signals. An UWB-based PS consists of unique tags to be carried by the targets to be located, fixed radio signal receivers and a positioning management platform. UWB-based systems have high precision positioning capability with low energy consumption without the need for a clear line of sight. Since radio signals emitted from UWB tags use a wider radio spectrum than signals emitted from other RF-based devices, they are not affected by surrounding signals and are resistant to multipathing in signal propagation. In addition, the wide bandwidth of UWB technology enables high resolution in position detection and tracking, both in terms of position and time. Although UWB-based PSs allow higher sensitivity and accuracy than all other systems in position determination, its use has not become widespread due to the need for a comprehensive signal receiver-signal transmitter infrastructure and being a very costly technology.

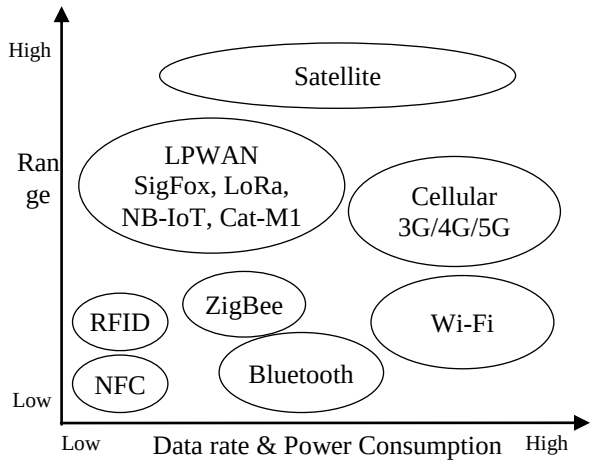


Figure 4 Characteristics of the technologies

4.4. Bluetooth Based Indoor Positioning Systems

Bluetooth is a common technology embedded in various devices such as mobile phones, laptops, and so on. The total gross bitrate of Bluetooth is lower compared to Wi-Fi and it is disadvantageous in distance compared to effective Wi-Fi up to about 30 meters. In addition, Bluetooth is a low-cost device and low-power equipment. The latest emerging technology to use Bluetooth for the IP is Apple's iBeacon device. Apple introduces BLE technology to iBeacon technology to provide location-based information and services to all iPhone smartphones and iOS devices. BLE ensures months of use of batteries due to low power consumption. IBeacon sends a universally unique identifier received by an operating system or an application. The received identifier is used to indicate the location of the device.

4.5 ZigBee Based Indoor Positioning System

ZigBee is the name given to the standard consisting of a number of communication protocols that provide wireless short distance and low speed data communication. The ZigBee has some similarities with Wi-Fi and is easily affected by the environment, which is an IEEE 802.15.4 standard. ZigBee equipment is capable of working for years without the need for battery replacement. One of the most important features of the ZigBee standard is the mesh network capability. In a large mesh network, the message is transmitted from one device to another until it reaches a remote destination. Similarly, when honeybees dispersed over a wide area want to convey a message to the hive, they convey their message with a similar approach. The bee that wants to convey a message creates a dance figure by moving in a zigzag pattern, and other bees close to the hive repeat this figure until it reaches the hive. Since the communication of the devices in the network with each other is similar to the communication of bees, the technology in question has been defined as ZigBee. ZigBee system consists of three different devices. These devices are coordinator, router and endpoint device.

4.6 Near Field Communication (NFC) is a Radio

Frequency Identification based technology that enables two electronic devices to communicate in short distance, high frequency and low bandwidth. Near Field Communication (NFC), which also supports existing RFID technologies, is preferred in applications where security is at the forefront. NFC enables contactless data exchange between two devices at a distance of up to 10 centimeters. NFC technology is very similar to RFID, which is still being used successfully, but it also brings brand new features. It is also compatible with contactless technologies such as Bluetooth, Wi-Fi and RFID. FC communication operates at 13.56 MHz frequency, which does not require a license all over the world. The maximum data transfer rate of NFC is 424 Kbit/s. This is quite slow compared to Bluetooth's 2.1MBit/s. The data communication distance of NFC is also below 20 cm. This distance is below the range of Bluetooth. However, the short distance increases the safety. NFC devices consume less energy than Bluetooth devices.

4.7 Cellular Networks

Cellular networks refers to a long-range wireless network distributed over the cells where each cell is served by at least one fixedly located transceiver known as a base station. It is the equivalent of a wireless

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.03
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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network created with radio cells. It works with higher capacity and lower energy requirement than normal networks. It requires more base stations for positioning to give good results. There are studies with cellular networks that give accurate results up to 2.5m.

2G/3G/4G: Although it is true that in some countries the 3G network is already being dismantled, it is already going to 4G but with an eye on 5G, the one that will best resist is 2G because today there are many devices that use this network deployed around the world. It has the advantage of almost global coverage, but against it is that the consumption of communications is much higher and therefore the duration of the batteries. 5G will be the standard that will be valid for everything. Of course, 5G is going to be a revolution in terms of data speed, latency, number of connected devices, etc. Thanks to it, real time will not be limited to sending sensor measurements, but rather, at the image sending level, the impact will be more than notable.

NB-loT is a cellular, licensed band and transmission range of less than 10 km, which is a radio technology standard developed by 3GPP. NB-loT is used for waste management, utilities and transportation. By installing these sensors, the fill level of the container can be centrally monitored. In one study, it showed great benefits in cost reduction, environmental impact and collection efficiency.

LTE-M is a cellular technology, which has super low latency and can support voice. This network technology is extremely energy efficient and also has non-static applications and voice support. It has been applied in many life-saving medical applications. If the device is used, perhaps on a public beach or swimming pool, a message is automatically sent to the paramedics. LTE-M has also been used in mobile telemetry systems that require high reliability, such as voice-controlled emergency wristwatches that must be able to transmit small data volumes. When the user says a trigger word, the device sends an alert message.

Devices that require batteries, at least for now, will continue to use other communication networks that minimize their replacement. The implementation of 5G in these types of devices will be closely linked to their improvement. Currently, different technologies are being worked on to improve batteries, recharging or the use of communications, but in the short term the typical IoT communication networks will remain. Another different thing is the case of devices that do not use batteries and that are connected to the network, there it will be much easier for them to be updated with communication modules that support 5G and that they can enjoy its advantages.

4.8 LoRa

LoRa allows sending small data packets and lets the creation of private networks. Its low consumption means that its maintenance is minimal due to the long life of the battery. At an industrial level and in projects in the water sector, it is having great relevance. Paredes et al. conducted tests in Italy to measure the performance of LoRa, including three different scenarios. In the first two scenarios, the point-to-point communication method consisting of receivers and transmitters was used, and in the last scenario, a star network topology consisting of a receiver and more than one transmitter was used [20].

4.9 SigFox

SigFox is suitable for a variety of applications. Large construction sites with many moving parts and many workers may have several cranes on site, each of which must be operated by lift attendants. With the optional service system, there is no attendant in each elevator; one person operates more than one elevator. The button solution serves to call the elevator attendant/driver to the respective elevator. While it may seem simple enough, it can deliver huge efficiency gains in large infrastructure and building projects. Its main characteristic is that it sends small data packets and at most six times per hour. It may seem scarce, but the reality is that it may be more than enough in some scenarios, such as weather stations in the agricultural sector. These small shipments of information also make your consumption minimal, so your battery can last for years.

5. PERFORMANCE METRICS FOR IPS

First, when choosing technology, you should consider the structure of the region, the local ecosystem, the efficiency you need etc. You need to make your choice by determining your future goals. If you are going to carry out a monitoring project, you need to analyze the current situations with users and project managers. Factors such as the current state of technology, possible conditions, device location, and battery level are critical. It will then be necessary to define different technology information with a dashboard to verify this information. Accordingly, you can expand your network knowledge, include new application criteria and increase your viewing range. In order to create a successful PS, some references must be calculated and well defined in terms of cost, accuracy and precision, scalability, coverage and limitations. References such as different dimensions, money, time, space will affect the system. Since the IPS works in real-time environments, it must perform with high precision. At the same time, it has the ability to notify the desired number of places by entering more than one command. The locations of more than one person can be determined in the same time period and the desired results can be obtained at the same time.

The following metrics can be evaluated as performance criteria in the IPS [21] [22]:

Accuracy: Different systems provide different accuracies. Accuracy is assessed by how accurately location information is given in terms of the IPT. Accuracy is one of the most important criteria in PSs, shows the performance of the system according to the closest points calculated to reach the target object. As the

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.03
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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margin of error between the values obtained from the system and the actual position values decreases, the accuracy of the system increases. Most IPS solutions provide poor accuracy under some adverse conditions. So far, only visible light and magnetic systems have been tested to show a high level of accuracy. In general, the accuracy of a technology determines its reliability.

Precision: It refers to the speed at which the instant location is updated for the tracked individual in motion. If the location for the tracked individual can be updated simultaneously, the system has been successful. It is used to measure how accurately the precision system works and the consistency between the results obtained from the PS. It can also be defined as the standard deviation in the IP errors and is defined in percent (%) format.

Coverage Area: In the IPS, the larger the area that the system can reach, the more efficient the system is. Coverage is another factor that must be considered before the selection of IPT. The coverage area defined the area covered for the correct indoor localization. Diverse IPT has not the same characteristics for coverage. Consequently, short-range technology may need more devices that will cover the same area.

Scalability: Scalability: It means that the system has a wider coverage area and performs well when applied to other areas easily. It is a desired feature in almost every system. Two basic aspects affect the size of the system: Geography and the number of users. As the size of these two elements increases, the need for intervention in the system does not increase at the same rate, which is a feature that should be in a successful system.

Cost: When the concept of cost is mentioned, financial situations are directly associated in the human mind. However, although money is an important criterion in the IPS, situations such as time, energy and covered area are also included in the cost. Successful systems are systems that achieve maximum efficiency at minimum costs. Cost refers to the maximum savings of extra infrastructure, additional bandwidth, space, weight, time, money, energy and material of the distributed technology in a PS. To calculate the total cost incurred for an IPS, three different cost need to be considered: the purchasing, the installation, and the maintenance.

Data Size: When the data reaches the end user, it should not be too large and should be transferred to the user on a minimum scale as filtered and meaningful data as much as possible.

Robustness: In cases where the signal is not available, the transmitter malfunctions, or previously unseen RSSI values or angle characters are seen, the system is least affected by the errors that may occur, means the robustness of the system.

Complexity: It refers to the computational complexity of positioning methods depending on the hardware, software and operating factors in a PS. If the positioning operations are performed on the server side, the positioning can be calculated quickly due to the powerful processing capacity and sufficient power supply.

Response Time: Response time measures how fast the IPS systems can update the location information to the user after the location query is sent. Response time is an important criterion for the implementation of IPS in the shipyard, as targets such as people often operate in motion. The faster a system is, the more successful it is. At the same time, the more frequent the duration of the detection pulse in the coverage range, the less likely the individual will not be detected. However, frequent detection at short intervals means more processing frequency, which means more power consumption. For a successful system, the size of the region included in the coverage range, speed and power consumption should be configured in the most optimal and most balanced way.

Integrality: In the IPS, various integrations can be made in order to add additional functions to the system or to strengthen existing functions. An efficient system must be compatible with being integrated.

Power consumption: Power consumption measures the average power consumed in an IPS under the same usage rate. More energy is consumed to transmit more data. The choice of policies and algorithms determines the amount of memory consumption and computation time to perform the location estimation, which affects the energy consumption per location query.

Security: Regardless of the content of the transported data, security is perhaps the first of the topics that should be kept at the forefront. The airborne transmission of RF provides the opportunity to be tracked by undesirable persons. Point-to-point transmission systems are difficult to monitor communication methods; however, point-to-multipoint transmissions are a type of communication that is technically easier to monitor. Wireless network technologies have security features that are almost equivalent to wired networks.

Confidentiality: It is a strong access control when collecting, processing and storing users' data.

6. RESULTS AND DISCUSSION

The article provides a detailed description of the different indoor localization technologies for shipyard suitability. The assessment considers various criteria of IPT such as energy efficiency, accuracy, scalability, reception range, cost, latency and availability. Existing IPS approaches when examined, it has been determined that RF based approaches are more applicable than others for the shipyard. However, it is seen that there is no widely accepted and used indoor location system among the wireless approach for Shipyards. The advantages and disadvantages of IPTs are summarized in Table I.

The key challenges facing IPS endeavors in shipyards were highlighted. A key challenge in shipyards is the multipath effects and noise. Signals can be reflected and interrupted at the shipyard by obstacles, metals and even people in some cases. This feature has a significant impact on accuracy. This problem can be

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DOI: 10.53464/JMTE.01.2022.03
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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solved with energy efficient and noise suppression algorithms.

IPS operate with higher energy to provide higher accuracy and better range, however energy efficiency is a very important factor and is not ideal for energy efficiency. The main challenge to IPS adoption is privacy. No one is willing to share data about their location. They ignore the current IPS privacy concern and are more concerned with accurate and effective indoor localization. For IPS to develop better, security issues that may arise because of lack of trust and privacy breach must be resolved comprehensively. Therefore, privacy and security is an area that requires further research.

Widespread adoption of a system for positioning is measured by the cost-effectiveness of IPT, low energy use, high accuracy, low latency, and high scalability. However, it is a known fact that a technology will not meet all these criteria at the highest level for each application area. Luo et al. compared Cellular Based, UWB, Wi-Fi, RFID and Bluetooth in detail in terms of sensitivity, accuracy, complexity, scalability and robustness [23]. Cil et al. criticized and classified the IPT. The performance comparisons such as accuracy, precision, complexity, scalability, robustness and cost are provided using MCDM methods [12]. The most important parameters of positioning approaches in indoor areas are precision and accuracy in positioning. There is a trade-off between accuracy in geolocation and other system features in most studies where efforts have been made to provide a reliable geolocation approach. For example, in UWB-based approaches, where the accuracy in location determination is achieved at very high levels, the installation and maintenance costs are very high. Similarly, the accuracy rate decreases as the spatial sensitivity value increases. Optimizing all system features is essential to produce a widely applicable IPS. Although the main purpose of location detection systems is to detect the location of objects as accurately and accurately as possible, it is a useful and viable approach when issues such as ease of system installation and testing, extensibility based on needs, system cost and minimizing system maintenance need are not taken into account [24].

Table 1. Advantages and disadvantages of the IPT

	Advantages	Disadvantages
Wi-Fi	Receivers and transmitters do not need to see each other directly. There is no need for any additional equipment A low cost solution as it does not need extra devices. Pretty good signal strength in most environments.	Poor performance in very dense areas. Variable signal strength due to signal reflection and dynamic network structure. Fingerprint method is time consuming.
RFID	Receivers and transmitters do not need to see each other directly. The signal can pass through any solid material. It can work in any environment. Active tags have 100m distance Very light and small tags, Long lifetime of labels. Large data storage facility in tags and Cheap passive tags	It is not easy to integrate into other systems. The signal cannot pass through metal materials. Passive tags may experience a power outage. Distance is less than 3 m and active tags are expensive. Low coverage.
BLUETOOTH	Variable reading distance and Requires low transmission power. Small-scale installations are relatively inexpensive. Available on most mobile devices and Low cost system. Long-time operation with thin batteries.	Costly in large-scale In a complex environment is not efficient. Short connection distance Distance is about 30 meters Delay in real time data,
WUB	It does not cause any interference with the existing RF signal. High accuracy system and wide frequency range Requires low transmission power & Low interaction with other devices, Ability to pass through building elements.	Costly and Expensive equipment. Interaction with metal materials. Limitation of the working area to 100 meters Mixed signal structure.
ZigBee	It requires less energy. It does not require much network bandwidth. Has higher latency	It needs extra hardware. Attenuation of interference and signal strength. Not connecting by phone.
NFC	Low cost, high accuracy. It provides secure and private navigation.	Accuracy depends on the number and proper placement of tags.
LoRa	Long range, covers large area and It serves larger active nodes. It consumes very low energy and Devices have long battery life Ideal for single building and LoRa devices work effortlessly Easy to set up and manage personal network	There may be signal attenuation. Long distance between server and device. Low data rates Long/High latency
SigFox	Costs are low and It consumes very low energy. Long range, covers large area and It serves larger active nodes. It send small data at a slow rate.	Data transfer is difficult when assets are mobile. Long distance between server and device. Signal attenuation outdoor to indoor

When comparing Lora, which is one of the newer technologies, and other older technologies (such as Wi-Fi), the following can be said. LoRa is better in that it has a wide communication range and improves receiver

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ISSN (Online): 2501-8795
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sensitivity. Any network type can have only two of the three properties; Long distance, low power consumption, and high bandwidth. While Wi-Fi excels when it comes to bandwidth, it suffers when it comes to battery life and range. Most networks have struggled to work in the past 15 meters, which is not suitable for distributed IoT devices. By comparison, LoRa's low power and long-range nature makes it ideal for these devices. Still, LoRa will struggle to send a single image, let alone large files. It is good at sending small packets of data, such as temperature and humidity. Z-Wave and ZigBee are quite similar in that they are both low-power networks that operate under a network protocol and are designed for short to medium distance data exchange. Numerous criteria such as accuracy, scalability, cost and coverage. These criteria are used in most projects and are used to identify the benefits of certain technologies for developing an IPS. These criteria can be used because they have been widely described in other studies and guide the choice of one technology over others in a particular application. In Table 2, the some criteria for different technologies are summarized in a tabular form. Each technology corresponds to an IEEE standard. Obviously, Wi-Fi and UWB offer a higher data rate, while ZigBee and Bluetooth provide a lower data rate. Other important features are shown in the Table 1.

Table 2. Features of the indoor positioning technologies

IPT	Data Rate	Frequency	Range	Power	Cost
LoRa	50 kbps	Unlicensed	5km - 20 km	Low	Medium
SigFox	100 bps	Unlicensed	10 km-40 km	Low	Medium
NB-IoT	200 kbps	License LTE	1km -10 km	High	High
ZigBee	250 kbps	2.4Ghz	300 feet	Low	Medium
Bluetooth	1-3 Mbps	2.4Ghz	300 feet	Low	Low
Wi-Fi	0.1-54 Mbps	2.4,5 Ghz	<300 feet	Medium	Low
2G/3G/4G/5G	~10 Mbps	Cellular Bands	Several km	High	High
Z-wave	40 kbps	subGhz	100 feet	Low	Medium

7. CONCLUSIONS

The comparative study presented in this article systematically introduces current IPT and evaluation criteria. Each different technology, with its own advantages and disadvantages, contributes to the shipyards with its specialty in certain areas. In addition, it will also make an important contribution that the technology can be used as a hybrid to increase the performance of IPS to be applied in shipyards.

This article provides a broad overview of a wide range of IPT. It gives special importance and priority to RF-based technologies in terms of being more suitable for shipyards. It is not meant to draw any conclusions about which is superior, as the technology to be applied is greatly influenced by practical shipyard applications where many factors are involved. In any case, each shipyard will require them to evaluate according to their particular circumstances, taking into account the cost, accuracy, scalability and criteria described in the previous sections.

Although GPS gives satisfactory results outdoors, it does not seem appropriate to use in these environments due to the weakening of the signals from the satellite indoors by the solid materials in the shipyards, and therefore, IPSs are needed. In many studies on the IPS, it has been observed that the most common technologies are Wi-Fi-based, Bluetooth-based, RFID-based technologies. With these technologies, RSSI or fingerprint approaches are usually combined. The reason for this is the high cost of devices that require high precision in terms of hardware for approaches such as arrival angle and time of arrival. Even if the selection of technologies and approaches used together is made carefully, it is seen that the manipulative effects on the signals due to various reasons, interaction and environment behavior cannot be completely avoided.

One of the interesting results in this study is that standards may need a third space between the local area (closed area) and the large area (open area). There are large open spaces that are still semi-private, such as shipyards, campuses, ports, airports, and convention centers. What is important here is the necessity of determining a standard for the areas where both open and closed areas are together, and the development of IPS systems in line with this standard. There is a need for another standard that focuses on the main area. The new standard to be developed will be cost-effective, flexible enough to be flexible and more qualified for both indoor and outdoor areas. IPS is an emerging technology that is gaining interest among researchers. These technologies not only provide commercial benefits to their implementers, but stand on the side of shipyards as an imperative of technology push strategy.

9. ACKNOWLEDGMENTS

TUBITAK TEYDEP supported this study with project number 1190128.

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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

THE PROSPECTIVE POSTURE OF MARITIME EDUCATION IN SUPPORT OF SMART SHIPPING

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Abstract Maritime education covers the main seafarer's education, but after emerging of a new profession in the maritime sector it has started to cover some other aspects of the industry such as port management, fleet management, shipyard management, etc. Additionally, the exponential development of technology enforced education planners to review and revise their programs frequently to meet the expectation of new technological and management structures. Realizing this situation, academicians in the maritime field should understand the new posture of the maritime industry and define their role and missions in the light of the new requirements of the maritime sector.

This research aims to investigate the new role and the missions of maritime education institutes considering developments in science and technology in the next decade. In the first step, it is important to understand technological development affecting the maritime sector and imagine the future structure and requirements of the sector. Based on the results of this study a comprehensive study must be done to define what must be done in the education system to respond to new requirements. This research must be exhaustive and detailed. The problem areas are clearly defined and summarized as findings at the end of this step. These requirements must be adopted with academic programs. Adaptation of these corrective proposals to existing academic programs should be discussed considering how these new proposals are associated with the existing programs and/or matched with other related programs

This study will assist the academicians and researchers who work on the development of the maritime education and training system using the results of this study.

Key Words: Maritime Education and Training in Digital Era, Exponential Technologic Development, Smart Shipping and Ports, Automation, Robotics Application in Maritime Sector .

1. INTRODUCTION

Digitalization is becoming widespread rapidly in the maritime sector as in all other sectors. Smart systems are replacing classical systems not only in the technical field, but also in the operational field and, education and training methods. The development of communication facilities and IT capabilities, the commercialization of space technologies, the development of human-IT interfaces, and the development of robotic technologies have brought the definition of Smart Shipping to the glossaries.

The area of interest of maritime industry today to transform smart technologies may be resumed as:

- Cheap and uninterrupted online communication with the use of satellite communications;
- Large-scale information transfer via broadband communications;
- Using Artificial Intelligence in operations planning and risk management;
- High Computing Power in support of ship management especially in the ship and port cargo operations.

While these developments occur, new risks emerge in the maritime sector, which is a multi-risk business; Cyber Security (IT Intensive) Digital Inattention (Habit) Traditional Ability Loss, Redundancy, Autonomous Domination (Artificial Intelligence), Superiority in Technological Countries (Strategic IT), Marine Loss (Robotics).

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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1.1. Smart Shipping

The shipping term covers all aspects of the maritime from ships to shipyards, marinas, yachts, tourism, suppliers, etc. But two key elements are the backbone of the industry which are ships and ports always are interacting.

As far as concerning smart shipping, the following subjects are under discussion in many platforms of the shipping industry:

- the new perspective of shipping operations;
- digital transformation and opportunities to support regulatory compliance;
- the future operating system of trade;
- digital shipping and trade finance convergence: easy transfer and transaction commercial, financial and official documents;
- contract management in a digital era of shipping;
- digital transformation in the management of marine assets;
- integrating ship and port operations through digitization and active collaboration;
- new perspectives on the shore-based work-force;
- new roles and duties for seafarers ;
- designing the jobs of the future, defining new professions which industry requires.

1.2. Automation

The main feature of automated systems and robotics is based on the remote control which is a combination of sensors and actuators. The combination of sensors and actuators creates a digital nervous system. Leonhard [1] explains this system with a figure below (Figure 1) [3]. Location data using GPS (Global Positioning System) sensors. Eyes and ears using cameras and microphones, along with sensory organs that can measure everything from temperature to pressure change.

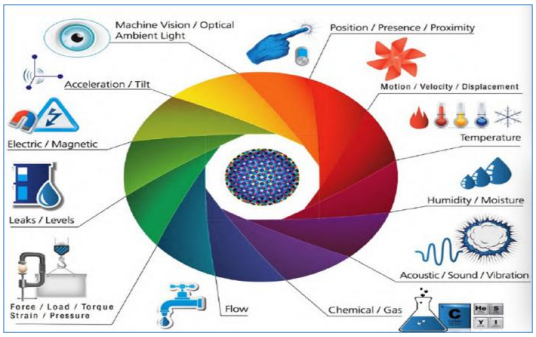


Figure 1 Sensors and actuators [3]

1.2. 1.3. Autonomous Ship

Autonomous (unmanned) vehicles are extensively used in air space which has had more freedom of movement compared with land and sea. But the use of autonomous vehicles also started at road traffic as well as sea transportation. The use of unmanned sea vehicles for survey vessels and military purposes in constricted areas has already been started in the 1960s. Now researchers are looking for unmanned huge oceangoing vessels for maritime transportation.

The marine community, both research, and industry are working on increasing the ratio of unmanned systems, including full-size vessels, in operation at sea. The level of control differs on those platforms, from remote operation beyond the line of sight to almost full autonomy on the prototype, However, the exploitation of this kind of vessel at all control levels, requires solving several issues regarding the safety of equipment, potential cargo, and other sea users [1].

The development from Manned ship to Autonomous Ship is simply explained in Figure 2 which is introduced by MUNIN [3].

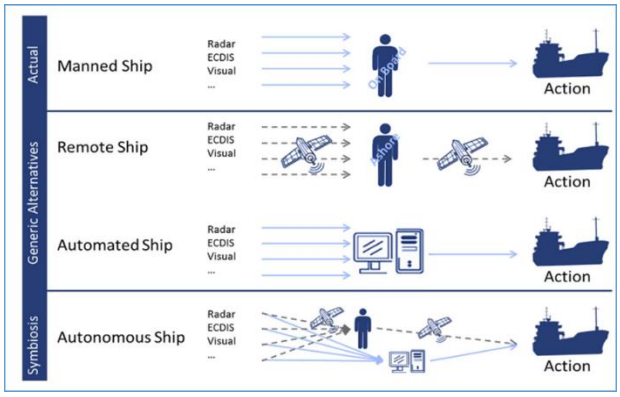


Figure 2 From Manned to Autonomous Ship [3]

3. METHOD

Maritime education was covered mainly seafarers' education, but after emerging of new professions in the maritime sector it has started to cover some other aspects of the industry such as port management, fleet management, shipyard management, etc. Additionally, the exponential development of technology enforced education planners to review and revise their programs frequently to meet the expectation of new technological and management structures. Realizing this situation, academicians in the maritime field should understand the new posture of the maritime industry and define their role and missions in the light of the new requirements of the maritime sector.

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

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Adaptation of these corrective proposals to existing academic programs should be discussed considering how these new proposals are associated with the existing programs and/or matched with other related programs

This study will assist the academicians and researchers who work on the development of the maritime education and training system using the results of this study [4].

3. RESEARCH AND DISCUSSION

3.1. Role and importance of education

Education and learning is an important part of all aspects of our life. Challenging economic, technological, and socio-cultural development increased the importance of education and learning. Enhanced delivery methods facilitate to reach education sources even from distance places, Lifelong Learning applications assisted the professionals to update their knowledge, skills, and competencies to enable them to follow rapid changes in technology.

Mainly the vision of education is adding value to world cultural heritage and economy for the prosperity of the human being. The mission of education is to provide covers a large spectrum; preparing qualified people for all job sectors, assisting the development of the individuals to be ornamented with values of modern society, having a modern culture in a continuously improving learning environment, enabling them to conduct research and produce innovation to get maximum advantage from the rapid development of technology.

In the light of this vision and mission, the expectation of the society from education may be defined in the following paragraphs:

- Development of the education and learning methods and content to provide qualified human resources to fulfil the requirement for existing and developing professions necessary to create sustainable social, cultural, and economic life on both national and international scale,

- Achievement scientific research in support of continuously developing technology to provide better opportunities to get the maximum benefit from all available sources,

- Creating a suitable environment for innovation to provide scientific data which requires producing knowledge for all communities of the world to provide a better living condition for humankind.

The role of education, in particular for higher education is to prepare the people not to meet today's requirements but also for the requirement of foreseen future of the world. The content of the education program was changing in the decades but now we need education systems that are flexible, open the modification, and continuously observe the technologic developments.

The technological developments caused new formations in the education institutes. The specification of these formations may be summarised in the following headlines.

- University networks for innovation in particular in Technology and Engineering fields
- Digitally supported cross-campus and cross-disciplinary teaching activities
- Transcending traditional engineering education with an entrepreneurial mind-set
- Cooperation between education institutes and public and private sector and citizens
- Using International cooperation between education institutes to create a 'great muscle' to facilitate data flow and transfer of best practices
- Creation of inclusive alliance of entrepreneurial, change-focused education institutes

Universities are the most important and fertile places for research. To follow developments in the other part of the world, a network to connect the universities and research centres is required to accelerate the technologic development as well as coping the industrial requirements and research objectives of the universities.

3.2. Technologic development

Futurist Gerd Leonhard [3] explains "disruptive technology" which has a significant impact on the five essential elements of digitalization as follows:

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

- Automation of knowledge work
- Advance Robotics

- Autonomous vehicles

- The internet of Things

- Mobile internet

It is clear that all the above-mentioned elements are directly related to the maritime industry, and all are applicable on board and change the ship operations at sea and port. Leonhard also summarizes the main characteristics of the digital era has as; change is gradually then suddenly, exponential, combinatorial, and interdependent.

All these characteristics of the digital era enforce us to take speedy action to catch the benefits of the digital era and do not miss its advantages. More importantly, the growth of technology and its impacts are not linear but exponential in the era we live in. The disruption between linear and exponential growth is identical and this requires us to take immediate action in all areas of our life (Figure 3)[4]. The systems onboard, at shipyards and ports are quickly changing and this trend will continue.

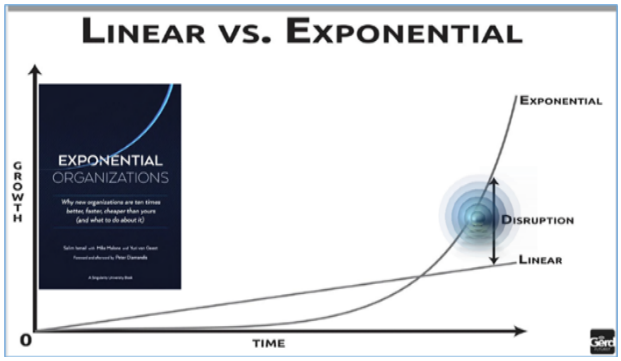


Figure 3 Linear versus Exponential [4]

Salim Ismail [4] has estimated "Likely Breakthrough Technologies" in their famous book, Exponential Organization:
- Sensors and Internet of Things (IoT)
- Artificial Intelligence (AI), Data Science & Analytics:
- Virtual & Augmented Reality
- Bitcoin and Blockchain- Neuro-Feedback

Ismail has also introduced Likely Meta-Trends as:

- Perfect Knowledge:
- Neuro-Feedback, and satellite systems
- Virtual
- Virtual Worlds
- 3D Printing
- Exponential Payment Systems:
- Autonomous Vehicles

The idea of a futurist is important for suggesting the future. Futurist Alwin Toffler has introduced our internet in the 1970s when the United States has only a "Bridge System" which provides low-speed connection only between some users and is available during working hours. He has also made the description of High Technology in his famous book 'Third Wave'. If we make "second-guessing- using the other's opinion for the future, we can imagine requirements for the near future. These are commonly agreed on the posture of the future.
- Spread of use of Internet of Things (IoT)
- Broad use of Artificial Intelligence (AI)
- Interaction through Blockchain in trade
- Simulators and laboratories equipped with virtual systems
- Broad use of satellite-based communication and observation systems
- Use of more capable automated systems and robots assisted with AI
- High speed and a large amount of data transfer
- Automated vehicles

The education system should consider all these improvements and take revise its programs to overcome requirements for future systems. The reflection of these developments will enforce us to review and revise our existing education system, such as:
- Data mining to get sufficient and suitable data from huge information sources
- Use of AI for search and innovation not for basic sciences but also social sciences
- Understanding automation theory including its capabilities and limits
- Use of virtual world in education in particular simulators and laboratories
- Use of improved command-control-communication systems to handle automated vehicles
- Application 3-D printing and nanotechnologies to facilitate material development.
- Development of modular/easily revisable academic programs to follow exponential technologic advancement

3.3. Maritime Industry in transformation

This rapid change will also cause continuous and rapid changes in the overall education system. The following Figure 5 shows close relations between education and technological improvements. The important steps start from the internet to robotics have already been outreached. There is a continuation between the technologic developments which each one triggers the other and speed up the improvement Technologic developments and application of these developments in our life are interlinked. As it has been seen in Figure 4, 3-D Printing, Renewable Energy, IoT,

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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and Nanotechnology directly affect the emergence of qualified and more capable Autonomous vehicles.

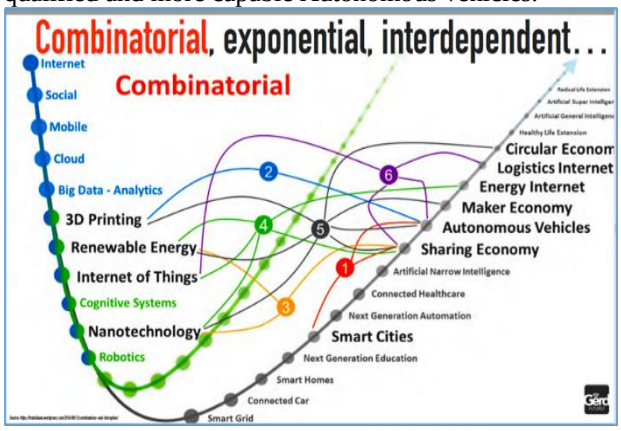


Figure 4 Technologic improvements and their effect on our life [1]

The maritime industry is in close relations with technology needs to consider this development continuously and rapidly. Technological improvements do not affect only manufacturers but also system users/operators. For that reason, the individuals responsible to operate these systems should understand the basic philosophy, capacity, and limitations of the new technologies to refrain from any causalities during operations.

3.4. Seafarer Training

Traditional seafarer training has always focused on the acquisition and use of practical skills. The prevailing view is that, while this approach addresses a degree of cognitive skills, it focuses on and gives much more emphasis to the acquisition of hands-on practical skills for the performance of specific tasks. On the other hand, academic education has been seen to be much more focused on the development of in-depth analytical and critical thinking skills; cognitive skills that are less reliant on hands-on task-oriented training, but stress critical reading and discussion. The global trend in maritime education and training is increasingly to link an essentially vocational education that provides specific and restricted competence outcomes with more general or deeper academic components leading to an academic qualification [5]. Considering technological developments and their reflection on maritime business, it is clear that the new generation of marine professionals requires deeper academic knowledge to understand the operation of state of art systems they handle.

Most of the maritime professions are multi-disciplinary professions and composed of such as mechanical engineering, industrial engineering, electric/electronics engineering, business management, management science. In the beginning, mariners started with foundation science to conduct navigation and cargo works using mathematics and geometry, physics, and chemistry. After application of the steam-powered systems mechanical and electronics engineering are included in their background a new profession namely marine engineering has emerged. After the emergence of radar, wireless, automated pilots, electronic navigation equipment electronics gained importance and were included in programs. The wide use of computers lies behind the inclusion of computer science and automation in limited content.

Being an international business International maritime Organization (IMO) regulates maritime education and training by STCW (Standards for Training, Certification and Watchkeeping Standards) Code [5]. STCW is first published in 1978, changes were made in 1995 and 2010, and a forthcoming change is likely will be made soon to cover new requirements as a result of technological changes.

One of the major problems in education is late adaptation and transfer of newly developed industry into education institutes. Manuel [6] explains his solutions to this subject for the maritime industry. "It allows for easier migration of seafarer experience and talent to other parts of the maritime industry. At the national level, it has significantly enhanced the exposure and reputation of MET (Maritime Education and Training) and seafaring as a career option as it aligns more with the main expression of higher education in many jurisdictions. Furthermore, with the enhanced role of technology in the world, such education allows for the industry as a whole to have more versatile professionals in place for future changes in ship operation.

To correct these misconceptions, the experts at CrewConnect Global [7] agree that better education is the key to showing what seafarers' lives can be after their time at sea. Education can give them a goal to aspire to and in return, their aspirations will have an impact on what skills they want to nurture to be ready for the future. Mentoring, training courses, and work placements are all opportunities where seafarers can have a taste of a potential career in maritime.

To deliver up-dated information to the people will be use of Continuous Professional Development (CPD) Courses. Considering the condition of the workers in the maritime sector, in particular, working onboard the best method will be the use of distance learning with electronic resources.

According to Makashima [8], the criteria used in the evaluation of electronic resources, required for distance education are:

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ISSN (Print): 1844-6116
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– Ease of access to resources.
– Affordable cost of network materials.
– Ability to assist users and training of users.
– Stability of network resources.
– The possibility of obtaining long-term access to network resources.
– Facility of license agreements.
– Delays in access to materials due to congestion.
– Determination of the degree of reliability of the seller and the possibilities of further co-operation with them.
– The degree of potential use (based on numbers of users and frequency of access to materials);
– Easy computer interface for users, etc.

Seafarers, in particular, seafaring officers are key personnel in the maritime sector, they can be deployed not only as workers on board but also in the following professional areas having a perfect background in the maritime business.

- Auditors/inspectors
- Marine Surveyors (Port State Control, Classification Societies, Insurance Companies, Draft and Cargo Surveying, Average adjustors,
- Lecturers/Instructors in Maritime Education Institutes
- Logistics Expert (Planning, Routing, Cargo Operation, Warehouse Management)
- Port Management/Operation (Stevedoring, Lashing, Cargo Handling Systems)
- Coast Guard Officer
- Quality and OHS (Occupational Health and Safety) Managers
- Engineers at Ship Yards (Repair and Maintenance Planning, Ship Liaison Officer)
- Sea Trail, Test and Acceptance Officer
- Management, Technical and Commercial Branches of Shipping Companies
- Adviser/Consultants in their field
- Business at Harbour Master offices

Seafaring officers having an opportunity to be deployed to other professions in the maritime sector, should be educated not as ship operators but also in managerial roles. As far as concerning cargo operation the ports and ships are integrated and the level of success of this integration will provide a great economic value. Inclusion of port management subjects into Maritime Transportation Management (Deck Officer) programs and inclusion of shipyard management and ship construction subjects into Marine Engineering programs is considered beneficial.

3.5. Change of Business Methods and Competencies in the Digital Era

Following significant changes in technology, business methods in the high technology-dependent sectors have been drastically changed starting from the last two decades of the 20th century. The main factors which cause this change are as follows, Development of communication facilities, Increased IT capabilities and Interfaces, Development of Robotic Technologies, Reflection of Space technology in the classical industry.

The following Figure 5 helps us to understand the technological developments in the last 40 years and expectations for the near future.

1980	1990	2000	2010	2020	2025 - 2030
Personal Computers Electronic based Automation in many sectors Cellular Phones	Growing up us of internet Wide spread of Automation Unmanned vehicles and Drones	Enhancement of capable robots in the industry Born of the internet supported Social Media Nano Technology Speedy and cheap internet	Emerging IT platforms for education, business and trade etc. Data Mining and Artificial Intelligence Advance Satellite Communication Robotics Genomics	Quantum Technologies Big Data Internet of Things Blockchain applications Advanced Robotics Genomics for animal and agriculture Nano Technology applications	Introduction of Metrology, Sensing, Computing in different fields of life Easy access of Big Data and Advance Artificial Intelligent applications Improved Internet of Things application for automation and robotics Developed Blockchain application in the trade and industry Intelligent Robots and drones Genomics for medical science Growing Nano Technology application for space and oceans Advance Integrated Communications systems Smart vessels and production lines

Figure 5Technologic developments in the last 40 years and expectations for the near future

This figure is based on the opinion of different futurists and any argument on this figure is acceptable. This table aims to reverberate the past improvements in technology and following consequences of achievements to create a possible posture in the next decade. Finally, it is intended to proposals based on the possible developments to respond to future requirements. Not only the business methods but changed but also some new jobs have appeared as some jobs disappear or change their formation to meet new requirements. During this transition new jobs in particular at shore facilities raised.

If we look at common characteristics of digitalization, these are availability of huge data; data mining to use huge data banks; artificial intelligence to

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ISSN (Print): 1844-6116
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facilitate decision making; a high level of automation; high speed online data transfer.

These applications the expectations of the business from the human being at work. Most of the researchers have described the most important human competencies needed soon are as follows:

• Leadership
• Expressing himself well
• Processing large amounts of data from various human-machine interfaces
• Focus on critical issues rather than details.
• Working with teams in remote locations
• Understand automation and its limitations
• Manage change
• Continuous learning
• Coping with increased stress
• Ability to communicate effectively

The seafaring officers should be prepared as a high technology system user, able to work in a group(s), bear to increased stress, capable to communicate in different levels of people from different nations as well as a leader. All these expected competencies should be considered when arranging MET.

3.6. Automation and avoiding accidents related to automation failure

The application of automated systems has facilitated the management and operating functions of transportation systems. They have reduced the workload of the users and provided better control of the management and operation activities as well as simplifying record keeping and establishing more sensitive and automatic fault warning alarm and control units. But not having a common sense which is only a human being, still, these highly improved systems are reliable. As a result, automation systems must always be under the supervision of the human element to ensure safe and reliable operations. Any failure on automated systems navigation and/or command control systems may cause serious accidents even the total loss of a ship as well as ships and port facilities.

Although these systems are products of high technology, unfortunately, operators are not equipped with sufficient information on the working principles and specifications. This weakness will reduce their reaction capability to avoid any mishaps in case of failure in the autonomous system.

Application of automation technology is emanating in all parts of shipping, and rapid change of technology brings new automation applications and develops existing automated systems. This improvement also reflected operation procedures and processes as well as training methods. It is time to revise our training systems to meet the new requirements introduced by automated systems.

These systems require employees to be donated with engineering skills to fully understand the automation philosophy, the limitation of automated systems, and the role of the human being to supervise these systems. An employee equipped with sufficient engineering skills would be more suitable to operate these state-of-art systems. Additionally, it is needed to revise our existing education and training programs to cover new technologies, especially automation-related subjects. Not now but shortly, we will see the deployment of robots in the shipping sector, and our education and training system is to be revised to cover robotics applications.

The main aim of the SURPASS, a European Union Leonardo Project [9] is to fill this gap created as the result of the emergence and application of the automated systems in the education and training of seafarers by the provision of a training course enabling them to have a full understanding of automated systems, and these systems' weaknesses and limitations.

The research has shown that the older generations who received their education and training two or three decades ago are less familiar with the new technology than the younger generations who have become familiar with computer systems in their everyday life. But even for the younger generations, it is important to provide an education that introduces the subject of automation, operation, and management of automated systems used onboard ships and, the use of safety-critical systems [10].

We get benefits from the CPD (Continuous Professional Development) methods to introduce new developments in the industry and provide new technology applications to the people at work. CPD covers a large spectrum of delivery methods that may fit people working in different environments and different types of works.

3.7. Developed Management Systems

Developing information and communication technologies provided distance-controlled management information systems for the maritime industry enabling online transactions between the ships and management offices at the shore.

Figure 6 shows an example of a developed management system incorporating four parties of shipping; ship, shipping company, manufacturer, and

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

overseas repair and shore storage facility. The control and alarm system of the ship generates ship records which include information about main and auxiliary engine activities. Manufacturer generates stock control and maintenance information and, overseas repair and shore storage facility generates stock control and repair/maintenance information.

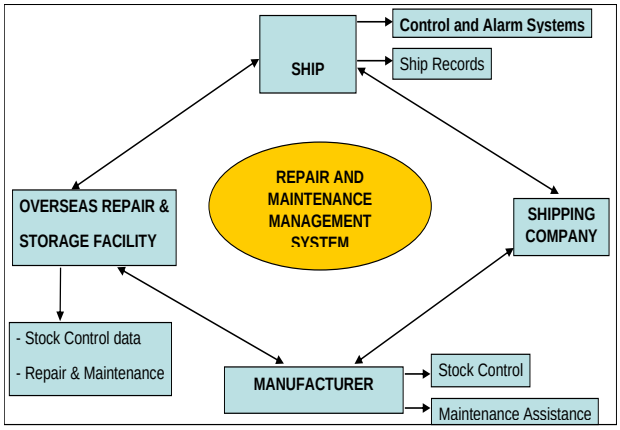


Figure 6 Initial (proposed) Model for Shipping Company

IoT (*Internet of Things*) application is embedded in the system to provide direct communication between systems that need no human interaction. All management systems are interfaced with by computerized communications. The ship and shipping company management system is integrated with manufacturer and overseas repair and shore store facility to provide connection promptly, and they can communicate and interact with each other through the interfaced ICT system.

It is clear that the workforce onboard, at shipping companies, ports and shipyards should have sufficient background on the IT systems to fully understand and sufficiently use the technical equipment under their responsibility.

3.8. Robotics and Automation and Autonomous Vessels

- *Robotics*

By and large, the study of the mechanics and control of manipulators is not a new science, merely a collection of topics taken from "classical" fields. Mechanical engineering contributes methodologies for the study of machines in static and dynamic situations. Mathematics supplies tools for describing spatial motions and other attributes of manipulators. Control theory provides tools for designing and evaluating algorithms to realize desired motions or force applications. Electrical engineering techniques are brought to bear in the design of sensors and interfaces for industrial robots, and computer science contributes a basic for programming these devices to perform the desired task [11]

- *Automation*

Automation means "the technique of making an apparatus, a process, or a system operate automatically." ISA [12] definition for automation is "the creation and application of technology to monitor and control the production and delivery of products and services."

Automation is used in monitoring and controlling the production and delivery of products and services. More common areas using automation are manufacturing, defence, safety and security services, modes of transportation, energy production, and transfers, Operation management. Automation is also a tool for integration, interfacing, and interoperation of the different but compatible systems.

- *Autonomous Vehicles*

An autonomous vehicle is a tool that can operate itself perform necessary functions without any human intervention and have the ability to sense its operating environment.

An autonomous vehicle utilizes a fully automated driving system to allow the vehicle to respond to external conditions that a human driver would manage. There are six different levels of automation and, as the levels increase, the extent of the driverless car's independence regarding operation control increases [13]. By MASS (Maritime Autonomous Surface Ships) UK Code of Practice, these levels are Manned, Operated, Directed, Delegated, Monitored, and Autonomous [14].

Developing technology will provide monitoring and control functions of ships both onboard and from the shore using speedy and reliable communication facilities as well as advanced decision support systems.

This description implies two generic alternatives that are combined in an autonomous ship (see also Figure 1) [2]:

- The remote ship where the tasks of operating the ship are performed via a remote control mechanism e.g., by a shore-based human operator and

- The automated ship where advanced decision support systems onboard undertake all the operational decisions independently without the intervention of a human operator.

The main reason for most accidents at sea and ports is because of the automation failure which subsequence may cause total loss or fatal damages. The user of the

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
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robotic systems and automated systems requires sufficient knowledge to fully understand the main system philosophy, ability, and limitation of automated systems as well as robotics theory.

3.9. Autonomous Ships

There are many discussions on the suitability, reliability, and acceptability of autonomous ships as well as some discrepancies on insurance and legal issues. Another issue, which seems to be crucial for the safety of unmanned vessels operation, is a robust and reliable self-diagnosis system on the unmanned vessel to provide the operator with performance quality indicators and an alarm regarding any malfunctions, loss of input data, and unforeseen behavior of specific devices or unexpected changes in positioning, speed, heading and attitude measurements systems data [15].

Ships are the largest vehicles and any failure in the propulsion, communication, command control or cargo handling systems may cause serious, even fatal accidents. The application of automation onboard propulsion and steering systems is now expanding. And any automation failure may cause unacceptable accidents with damage to human life, the environment, the ship(s), port facilities, and the goods being transported.

Automated systems facilitate ship management functions and are comparably more effective than manual systems, but they do not have the decision-making capability. What this means is that automation systems must be controlled by the human element at all times. These systems are products of high technology and users should be aware of their working principles, specifications, and limitations of them to be able to avoid any accidents in case of failure in such systems [16].

An ITF Study showed that 80 percent of seafarers voiced their anxiety about possible job losses with the advent of automation. This view shows that automation is very likely to face opposition from seafarers and their unions who believe if introduced in a manner that focuses primarily on the rush to be first and cost-cutting for the sake of cost-cutting that it will affect livelihood and safety if changes are not communicated properly [17].

The autonomous ship is a reality, and they are navigating in non-confined waters. There are many studies to solve major problems involving safety and legal issues, doubling with operator control, monitoring, and supervision of autonomous ships. Considering the lack of “common sense” of the autonomous system the community still has some negative concerns. Until solving these problems, we may assume that we will need some monitor and supervision crew to secure autonomous ship operation. To this end, we should educate our cadets on robotics and automation to prepare them for future unmanned autonomous ship operations.

3.10. Smart Ports

The use of up-to-date technology is an essential part of the management and running of a port/terminal efficiently. A wide variety of technology applications available are available to support port and terminal management. Nowadays products and IT systems are continuously upgrading to optimize cost and operational effectiveness.

The role of the management information systems (MIS), its quality and content are improving as well as IT expenditure of ports. The coverage of IT technology is now empowering providing integrity, interface and interoperability thorough different elements serve different purposes. The role of Information Technology in ports varies to cover all aspects of functions.

- Management of the Business
- Administrative system support
- Financial Systems
- Human Resource Systems
- Sales and Marketing
- Material management
- Argo Operation management
- Warehouse management
- Overall cargo planning and running
- Safety and Security Control
- Serving and supporting vendors
- Resource management
- Enterprise planning
- Knowledge support centre.

To command and control, such a huge IT system following issues should be determined.

- Information Requirement and Information Exchange matrixes
- Architecture design study to define IT infrastructure (core-intermediate-final)
- The level of the technology requires (not best, not minimum but optimum)
- Cost and efficiency assessment
- Vendors for software and hardware considering support of an open-end system.

Park et al [18] made a comparative study on ‘*Port Management Information System towards Privatization*’. This research covers the following information systems: PORT-MIS of Busan port, DAKOSY of Hamburg, PACE (Port Automated Cargo Environment) of London, PORTNET of Singapore, HIT of Hong Kong (Hong Kong International Terminals). The PORT-MIS of

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
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Busan before 2004 was a typical information system among many state-run ports. The researchers have also taken into account a previous study made by Partridge et al [19] which shortly explains PSA (Port of Singapore Authority)'s success factors.

- A business-cantered system should be developed.
- IT system has to be compatible with its business.
- Infrastructure is required to be flexible and expandable.
- Creativity and reformation are critical factors.

By applying PSA success factors to BPA (Busan Port Authority) information system, Park et al [18] propose the following reconstruction directions:

- As BPA's management goal is to be a hub port in Northeast Asia, its information system should correspond to the management goal.
- To be a hub port in Northeast Asia, BPA must improve customer services. To this end,
- It is to build up a community information system and e-business information system. Instead of VAN (value-added network) -based EDI (*Electronic Data Interchange*) system, Internet-based network infrastructure should be established.
- To pursue creativity and reformation in the IT sector, CIO (Chief Information Officer) system should be organized directly under the CEO.
- To enhance software function and to build a business-oriented system, a combination of outsourcing and in-house development is desirable.
- For long-term system development, the following three-stage plan is recommendable:

(1) 1st stage: stabilization stage- The stage to mirror PORT-MIS to stabilize overall business of BPA

(2) 2nd stage: cooperation stage - Introduction of a cargo inventory system just like PACE of PLA and PORTNET of PSA

(3) 3rd stage: e-business stage

- Introduction of PSA's customer-oriented e-commerce system and portal system
- Customer-centred tailored services and specialized services toward each individual & group.

Korea Logistics Network Corp. published an introductory report on "Port Management Information System in Korea" [20]. Integrated Data Network for Port network is comprised of two parts:

- PORT-MIS (Port Management Information System)
- EDI Network for Logistics (Electronic Data Interchange)

Port Management Paradigm (*Past and Future Port*) is also explained to highlight the future requirements and expectations in this report. Figure 7 extracted this report explains 'Port Management Paradigm (Past and Future Port)'. The characteristic of future ports is defined as High value-added activities, Integrated Logistics center, Hub Port, Transhipment Cargo handling, Business profit-oriented, Aiming service quality. Advanced information and automation, high productivity will support the transformation to the future (Figure 7)[20].

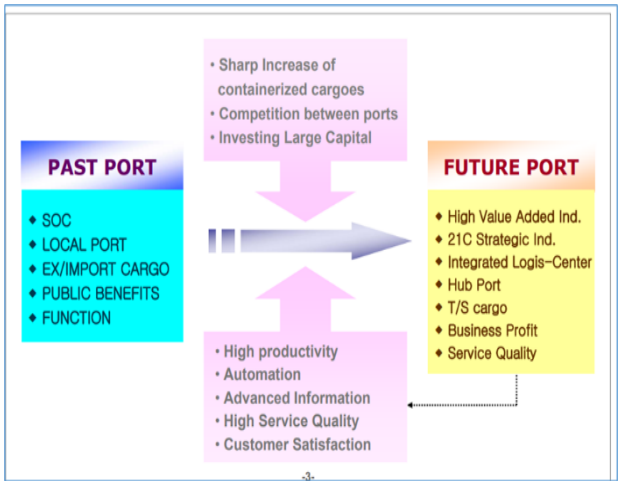


Figure 7 Port Management Paradigm (Past and Future Port) [20]

In the same report, there is a figure that shows the relations between 'Requirements of Terminal' and Features of ATOMS (Advanced Terminal Operation & Management System)' which connects all the ports in Korea. The ATOMS consists of three elements to meet requirements: Planning, Operation, and Management system (Figure 8)[20].

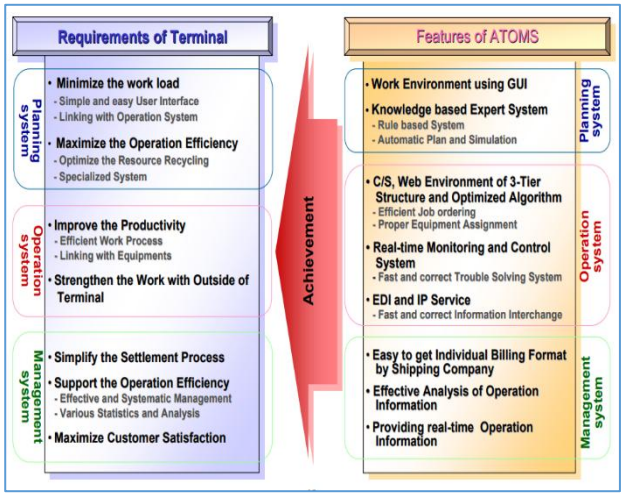


Figure 8 Port Management Requirement and Features [20])

In the light of the above-mentioned facts following are proposed.

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
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- All the ports require an MIS connected with other respective authorities/parties to handle their planning, operation, and management system effectively. This system should be open-end which permits modification on a required basis.
- All ports should establish their own MIS, Hardware, and Software support systems. MIS of ports in a country should be connected in some cases as well as contiguous ports in the neighboring countries.
- The management level should be eligible to understand IT applications. In particular content of IT Courses delivered to Maritime and Port Management programs should be revised and enhanced to ensure that the students fully understand IT applications.
- The cargo handling equipment used in the ports are now huge electrical, hydraulic, and mechanical systems supported with electronic and IT systems. The port management programs should be supported with basic engineering science courses to enable understanding the fundamentals of engineering.

3.11. Quantum Technologies

European Commission [21] has published a Strategy document on Digital Single Market, namely 'Quantum Technology Flagship Program Final Report'. In this document, it has been stated that "Supporting research and innovation in advanced computing is key to the development of the computing systems of tomorrow, which will go beyond the limitations of today's technology in terms of speed, reliability, and efficiency".

The QT Flagship program should be structured in five domains, each of which should be reflected in a call for proposals. Four vertical domains (not necessarily of the same size in terms of allocated resources) address vital application areas of a future knowledge-driven industry (Figure (9)[21].

- Communication, to guarantee secure data transmission and long-term security for the information society by using quantum resources for communication protocols.
- Computation, to solve problems beyond the reach of current or conceivable classical processors by using programmable quantum machines.
- Simulation, to understand and solve important problems, e.g., chemical processes, the development of new materials, as well as fundamental physical theories, by mapping them onto controlled quantum systems in an analogue or digital way.
- Sensing and Metrology, to achieve unprecedented sensitivity, accuracy, and resolution in measurement and diagnostics, by coherently manipulating quantum objects.

This gives us a clear understanding of the main features of education and training for the future. Communication, Computation, Simulation, Sensing, and Metrology will be included in the programs related to engineering and management professions to enable students to understand and apply quantum technologies. And the importance of basic science will always continue.

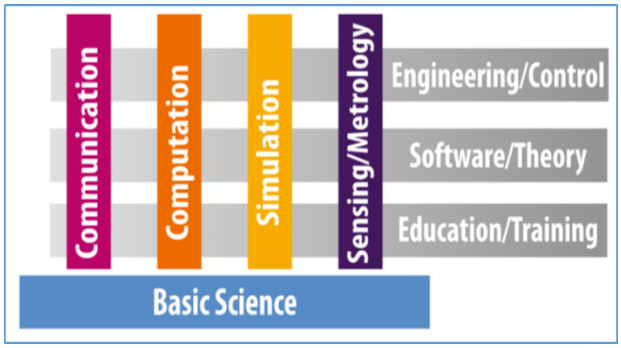


Figure 9 Structure of the Strategic Research Agenda [21]

Related to the area of interest and modus operandi of each profession, the following subjects should be added,

- Engineering and Control: If the profession is covering design, control, construction, and use of new technologies to make the transition

- Software and Theory: If the profession is related to developing quantum algorithms, protocols, and applications, and connecting to tools for control.

- Education and Training: If the profession is embracing training programs for the new generation of skilled technicians, engineers, scientists, and application developers in Quantum Technology, as well as to enable senior managers to understand QT and their benefits.

We should always address Education and Training to prepare the maritime community to understand QT which is the raising concept of the near future.

4. CONCLUSION

The role of education, in particular for higher education is to prepare the people not to meet today's requirements but also for the requirement of foreseen future of the world. The content of the education program was changing in the decades but now we need education systems that are flexible, open the modification, and continuously observe the technologic developments.

Universities are the most important and fertile places for research. To follow developments in the other

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.04
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

part of the world, a network to connect the universities and research centers is required to accelerate the technologic development as well as coping the industrial requirements and research objectives of the universities.

The disruption between linear and exponential growth is identical and this requires taking immediate action in all areas of our life The systems onboard, at shipyards and ports are quickly changing and this trend will continue.

The education system should consider all these improvements and take revise its programs to overcome requirements for future systems. The reflection of these developments will enforce us to review and revise our existing education system for the development of modular/easily revisable academic programs, such as Data mining, use of AI, innovation, virtual laboratories &simulators, 3-D printing, and nanotechnologies.

The maritime industry is in close relations with technology needs to consider this development continuously and rapidly. Technological improvements do not affect only manufacturers but also system users/operators. For that reason, the individuals responsible to operate these systems should understand the basic philosophy, capacity, and limitations of the new technologies to refrain from any causalities during operations.

Seafaring officers having an opportunity to be deployed to other professions in the maritime sector, should be educated not as a ship operator but also in managerial roles. As far as concerning cargo operation the ports and ships are integrated and the level of success of this integration will provide a great economic value. Inclusion of port management subjects into Maritime Transportation Management programs and inclusion of shipyard management and ship construction subjects into Marine Engineering programs is considered beneficial. The seafaring officers should be prepared as a high technology system user, able to work in a group(s), bear to increased stress, capable to communicate in different levels of people from different nations as well as a leader. All these expected competencies should be considered when arranging MET.

The research has shown that the older generations who received their education and training two or three decades ago are less familiar with the new technology than the younger generations who have become familiar with computer systems in their everyday life. But even for the younger generations, it is important to provide an education that introduces the subject of automation, operation, and management of automated systems used onboard ships and, the use of safety-critical systems.

We get benefits from the CPD (Continuous Professional Development) methods to introduce new developments in the industry and provide new technology applications to the people at work. CPD covers a large spectrum of delivery methods that may fit people working in different environments and different types of works.

It is clear that the workforce onboard, at shipping companies, ports and shipyards should have sufficient background on the IT systems to fully understand and sufficiently use the technical equipment under their responsibility.

The main reason for most accidents at sea and ports is because of the automation failure which subsequence may cause total loss or fatal damages. The user of the robotic systems and automated systems requires sufficient knowledge to fully understand the main system philosophy, ability, and limitation of automated systems as well as robotics theory.

The autonomous ship is a reality, and they are navigating in non-confined waters. There are many studies to solve major problems involving safety and legal issues, doubling with operator control, monitoring, and supervision of autonomous ships. Considering the lack of “common sense” of the autonomous system the community still has some negative concerns. Until solving these problems, we may assume that we will need some monitor and supervision crew to secure autonomous ship operation. To this end, we should educate our cadets on robotics and automation to prepare them for future unmanned autonomous ship operations.

All the ports require an MIS connected with other respective authorities/parties to handle their planning, operation, and management system effectively. This system should be open-end which permits modification on a required basis. The management level should be eligible to understand IT applications. In particular content of IT Courses delivered to Maritime and Port Management programs should be revised and enhanced to ensure that the students fully understand IT applications.

The cargo handling equipment used in the ports is now huge electrical, hydraulic, and mechanical systems supported with electronic and IT systems. The port management programs should be supported with basic engineering science courses to enable understanding the fundamentals of engineering. This gives us a clear understanding of the main features of education and training for the future. Communication, Computation, Simulation, Sensing, and Metrology will be included in the programs related to engineering and management

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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professions to enable students to understand and apply quantum technologies. And the importance of basic science will always continue.

Related to the area of interest and modus operandi of each profession, the following subjects should be added; Engineering & Control and Software and Theory.

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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.05

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

DEFICIENCY ANALYSIS IDENTIFIED IN PSC INSPECTIONS USING EVENT TREE ANALYSIS

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Abstract: In the study, PSC inspections data performed in Paris MoU between the years 2016 and 2020 were analysed with the purpose of providing reasonable decision supports for key stakeholders such as ship operators, national and international authorities, cargo owners and classification societies in terms of enhancing safety on board ship and minimizing sub-standard ships in maritime transport. The probabilistic analysis is conducted with the help of Event Tree Analysis (ETA) method on deficiency risk areas respect to the number of deficiencies in each area. In the analysis, the deficiency risk areas are prioritized respect to the different combination of ship type and ship age. In the analysis made on the inspections data, it was found that the number of deficiencies detected under each relevant main item (deficiency risk areas) show significant variation for type of ship and age of ship. With the conducted analysis, in the study, it is aimed to contribute to the more effective inspection by focusing on certain deficiency risk areas in line with the ship type and ship age in the ship inspections.
Key words: deficiency risk area, Event Tree Analysis (ETA), Port State Control (PSC), ship inspection

1. INTRODUCTION

With a total transportation volume of 11.08 billion tons reached in 2019, maritime transportation is the indispensable instrument of the global freight transportation, and it is expected to expand by 4.8 percent in 2021 [1]. On the other hand, maritime transportation is one of the most dangerous industries with its hazardous shipboard operations [2]. Therefore, it is an essential issue for shipping companies to ensure the safe transport of cargoes with the aim of minimizing potential damages to life, property and environment. In order to provide the safety of life, property and environment in the maritime transportation and to prevent irreversible accidents and incidents and to reduce the existing risks, the shipping companies are responsible for ensuring the ships under their management comply with the requirements of the international maritime regulations. According to the researches, one of the critical causes of the increasing number of accidents in maritime transportation are defined as the sub-standard ships. Researchers such as Bateman (2011) [3] and Pike et al. (2012) [4] examined the effects of sub-standard ships in shipping accidents. Ship-related accidents can cause serious losses both for the maritime industry and for society [5].

The primary responsibility of assuring the ships to comply with the international maritime standards rests with the flag states. However, the accidents experienced show that the flag states cannot fully fulfil this responsibility at the desired level. With the inspections carried out by the port states, this inadequacy is tried to be eliminated with the aim of the determination substandard vessels [6]. Therefore, port state control (PSC) inspections have been accepted as a one of the critical safety barriers in maritime transportation since from the marine accidents caused catastrophic consequences such as Amoco Cadiz accident in 1978 and Castillo de Bellver accident in 1983 [7]. Subsequently was signed in in 1982, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Switzerland and the United Kingdom signed a Paris Memorandum of Understanding (Paris MoU) on PSC and with the inspection of the ship with foreign flags has started. The coordination of PSC activities by groups of port states working under a Memorandum of Understanding (MoU) has enabled a more unified approach to inspection. Today, after the Paris MoU, eight more MoUs have been signed and port state controls have been expanded worldwide: Vina del Mar Agreement (1992), Tokyo MoU (1993), Caribbean MoU (1996), Mediterranean MoU (1997), Indian Ocean MoU (1998), Abuja MoU

Journal of Marine
Technology and Environment
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ISSN (Print): 1844-6116
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(1999), Black Sea MoU (2000), and Riyadh MoU (2004). The general purpose of the nine MoUs established with the participation of port states is to inspect all foreign flagged vessels approaching ports and detection of substandard vessels.

Factors such as the increase in the number of ships, growth of the handled volumes and acceleration in port activities affect the logistic performance of coastal countries in terms of speed [8]. However, the limited number of PSC Officers in charge of the inspections is an important constraint for the efficient inspection of all foreign flagged ships at ports. With the aim of improving the efficiency of PSCs with the limited human resources, in 2011, a new inspection regime (NIR) was introduced by Paris MoU. Within the scope of the inspection regime, parameters such as ship type, ship age, ship flag performance, ship class performance (recognized organization), ship company, number of detention and number of deficiencies are evaluated and ship risk profiles are calculated for each ship entered to ports. The general ship risk profile calculation model introduced by Paris MoU is presented in Table 1 [9], [10].

Table 1. Ship Risk Profile [9], [10]

				Profile			
				High Risk Ship (HRS)		Standard Risk Ship (SRS)	Low Risk Ship (LRS)
Generic Parameters				Criteria	Weighting points	Criteria	Criteria
1	Type of ship			Chemical tanker Gas Carrier Oil tanker Bulk carrier Passenger ship NLS-tanker	2	neither a high risk nor a low risk ship	All types
2	Age of ship [1]			all types > 12 y	1		All ages
3a	Flag	BGW-list [2]		Black - VHR, HR, M to HR	2		White
				Black – MR	1		
3b		IMO-Audit [3]		-	-		Yes
4a	Recognized Organization	Performance [4]	H	-	-		High
			M	-	-		-
			L	Low	1		-
			VL	Very Low			-
4b		Organizations recognized by one or more Paris MoU Member States		-	-		Yes
5	Company	Performance [5]	H	-	-		High
			M	-	-		-
			L	Low	2		-
			VL	Very Low			-
Historic Parameters							
6	Number of def. recorded in each insp. within previous 36 months		Deficiencies	Not eligible	-		≤ 5 (and at least one inspection carried out in previous 36 months)
7	Number of Detention within previous 36 months		Detentions	≥ 2 detentions	1		No Detention

Considering the ship risk profiles, it is aimed to make an efficient inspection planning by determining the type and period of the inspections. However, in the introduced inspection regime by Paris MoU, there are some prerequisites for determining the type of inspection in line with the ship risk profile. Carrying out the expanded inspection to ships with low and standard risk profile, the ship age has to be over 12 years and ship type has to be a bulk carrier, a tanker and a passenger ship, or clear ground has to be detected by the PSCO for detailed inspection [11]. This situation narrows the scope of the inspection by determining the type of inspection as initial inspection for ships with low and standard risk profile. There are a limited number of studies in the literature on solving this problem. Most of the studies in the literature have focused on solving the relationships between the Ship Risk Profile (SRP) criteria, rather than the SRP, and the deficiency risk areas by different methods for an effective ship inspection. As a one of the example studies, Mejia at al. (2010) analysed the deficiency risk areas and the variables of ship age, ship flag, ship type, ship class using the probit regression model and it was determined that focusing on certain deficiency risk areas by evaluating the ship parameters can increase the inspection efficiency [12]. Another example study, Cariou at al. (2012) found that the ship type and deficiency risk area are the parameters that affect the ship detention and stated that these parameters should be examined while determining the inspection period [13].

In this study, to present a solution for the above-mentioned problem, it is aimed to shape ship inspections within the framework of risky areas arising from ship age and type with using the Event Tree Analysis (ETA). In the shaping of ship inspections, a new approach based on the ship risk profile based on the Paris MoU inspection regime has been tried to put forward an inspection model based on the relationship between ship risk factors and deficiency risk areas. It is aimed to contribute to the more effective inspection by focusing on certain deficiency risk areas in line with the ship risk factors in the ship inspections to be conducted with the inspection model.

2. EVENT TREE ANALYSIS (ETA)

The ETA was first introduced in the atomic energy field and extended to other fields in the following years [14]. The ETA is an inductive risk analysis technique to assess likelihood (in a probabilistic context) of an accident [15]. It is applied in order to analyse an initiating event which has influences on a variety of results and it is a suitable way to analyse the reasons for a disaster. In the ETA, an initiating event such as the malfunctioning of a system, process, or construction is considered as the starting point and the predictable accidental results, sequentially propagated from the initiating event, are presented graphically. It is called an event tree because the graphical presentation of sequenced events grows like a tree as the number of events increase. An event tree consists of an initiating event, probable subsequent events and final results caused by the sequence of events. Probable subsequent events are independent to each other and the specific final result depends only on the initiating event and the subsequent events following. Therefore, the occurrence probability of a specific path can be obtained by multiplying the probabilities of all subsequent events existing in a path. The main steps to perform ETA can be described as follows [16]:

Journal of Marine Technology and Environment
DOI: 10.53464/JMTE.01.2022.05
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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1. Identification of the initiating events
2. Identification of the safety barriers
3. Identification of the intermediate events
4. Building of the event tree diagram
5. Description of the (potential) resulting accident sequences
6. Determination of the event failure probabilities
7. Calculation of the probabilities for the identified consequences
8. Presentation of the analysis results

ETA provides the possibility of bottom-up approach for each path and enables comparing/estimating of various paths in the tree [17]. It also provides a quantitative evaluation by calculating the probability values of each possible outcome. In this way, it makes it possible to rank among the results and to identify the riskier paths for taking preventive measure. Therefore, ETA method is widely used in safety critical industries such as chemical and nuclear industries [18], [19]. From the perspective of the maritime industry, there are some studies utilizing ETA for risk assessment such as ship collision [20], marine accident [21], mooring operation [22], and marine pollution [23]. Different from these studies, we use ETA to analyse the PSC inspections data to obtain precious findings for the improvement of PSC efficiency.

3. ANALYSIS OF PARIS MoU INSPECTIONS: 2016 – 2020

In this study, PSC inspections data performed in Paris MoU between the years 2016 and 2020 were analysed. In the preliminary analysis made on the inspections data, it was determined that the number of deficiencies detected under each relevant main item (deficiency risk areas) show significant variation for type of ship and age of ship. Accordingly, the probabilistic analysis is conducted using Event Tree Analysis (ETA) method on the deficiency risk areas with respect to the number of deficiencies in each area. In the analysis, the deficiency risk areas are prioritized respect to the different combination of ship type and ship age. The analysis procedure of this study is structured on the steps in Section 2 and it is illustrated in Figure 1.

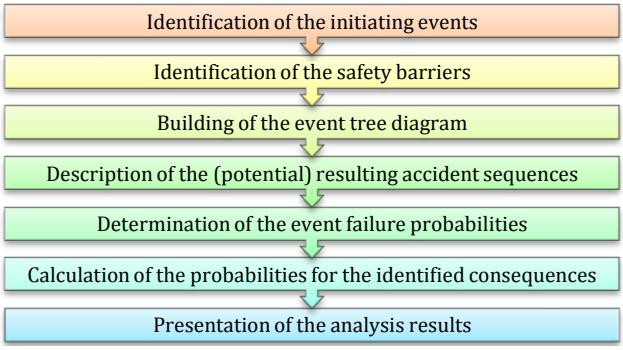


Figure 1 Flowchart of ETA [16]

With respect to the analysis, it is aimed to contribute to the more effective inspection by focusing on certain deficiency risk areas in line with the ship type and ship age. Additionally, it is expected to provide reasonable decision supports for key stakeholders such as ship operators, national and international authorities, cargo owners and classification societies in terms of enhancing safety on board ship and minimizing sub-standard ships in maritime transport.

3.1 Step-1/Identification of the initiating event:

In the study, 84.824 ship inspections performed under the Paris MoU between 2016 and 2020 obtained from THETIS [24] database were examined. According to the analysed dataset it is seen that 2.871 ships were detained. In this study, ship detention was considered as the initial event for examining risky areas in ships.

3.2 Step-2/Identification of the safety barriers:

In the Paris MoU inspection regime, "ship age" and "ship type" parameters have great importance in the definition of the ship risk profile [25-33]. When calculating the ship risk profile, 2 points are given if the ship type is in high risk group and 1 point is given if the ship age is in high risk group. This rating indicates that ship type is more important than ship age when determining ship risk profile. So, while the ship risk profile is handled with the event tree, the first safety barrier is identified as ship type and the second is the "ship age".

3.3 Step-3/ Building of the event tree diagram:

In the ETA, deficiency risk areas were analysed with respect to the safety barriers identified in Step-2 for the detained ships to define which deficiency risk areas are affected by ship age and ship type. Deficiencies detected in ships inspected under the Paris MoU are classified 17 different risk areas presented in Table 2. In this way, it is aimed to determine the risky areas that should be concentrated in ship inspection by considering ship age and type.

Table 2. Deficiency Risk Areas [34]

Codes	Deficiency Risk Area	Codes	Deficiency Risk Area
R1	Documentation	R10	Safety of navigation
R2	Structural condition	R11	Lifesaving appliances
R3	Watertight/ Weathertight condition	R12	Dangerous goods
R4	Emergency Systems	R13	Propulsion and auxiliary machinery
R5	Radio communications	R14	Pollution prevention
R6	Cargo operations	R15	ISM
R7	Fire safety	R16	ISPS
R8	Alarms	R17	MLC 2006
R9	Living and working conditions		

Journal of Marine Technology and Environment
DOI: 10.53464/JMTE.01.2022.05
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

According to the aforementioned information, the constructed event tree diagram is illustrated in Figure 2.

3.4 Step-4/ Description of the (potential) resulting accident sequences:

In the analysis, detained ships were selected as initial condition. Followingly, detained ships were categorized according to the ship age and ship type respectively. Finally, the obtained intermediate events are divided into the deficiency risk areas as seen in Figure 2.

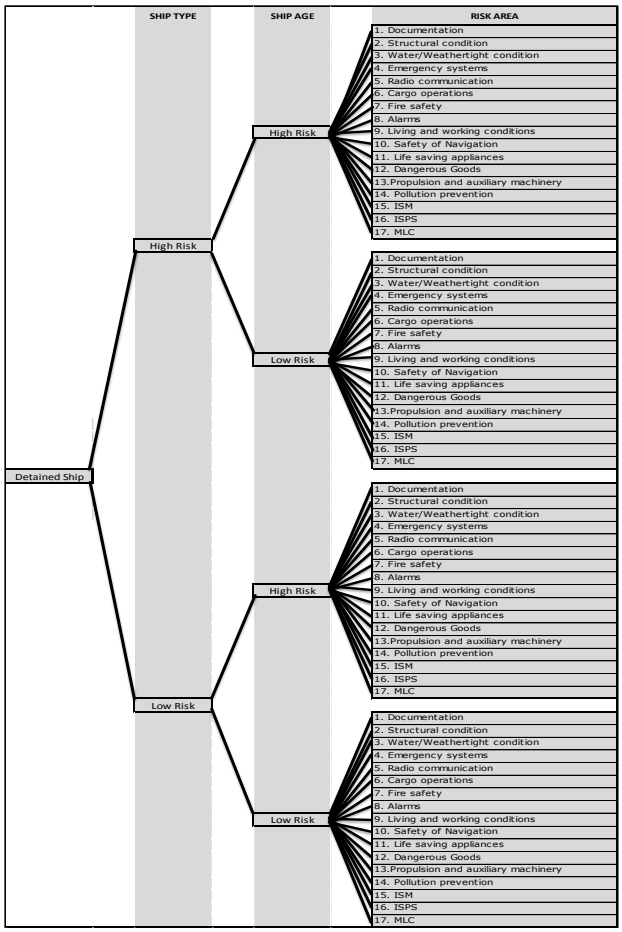


Figure 2 The structured Event Tree Diagram

3.5 Step-5/ Determination of the event failure probabilities:

To calculate the detention rates of ships for ship type risk, ship age risk and deficiency risk areas the following equation is used:

$$P_{detention} = \frac{Number\ of\ Detained\ Ship}{Number\ of\ Inspected\ Ship} \qquad (1)$$

3.6 Step-6/ Calculation of the probabilities for the identified consequences:

The probabilities for the deficiency risk areas according to the ship age and ship type were calculated by Equation (2).

$$P_{(Deficiency\ Risk\ Area\ |\ Ship\ Detention)} = P\left(T_i \cap A_j \cap R_k\right) = P_{T_i}.P_{A_j}.P_{R_k} \qquad (2)$$

where T is risk of ship type with i is neither high risk or low risk.

where A is risk of ship age with j is neither high risk or low risk.

where R is deficiency risk area with k is 1, 2, 3, 4, 5, 6, ……, 17.

3.7 Step-7/Presentation of the analysis results:

With the help of Equation (1) and (2), the calculated probabilities for the ship type risk, ship age risk, deficiency risk areas, and consequences of each scenario are presented in Figure 3.

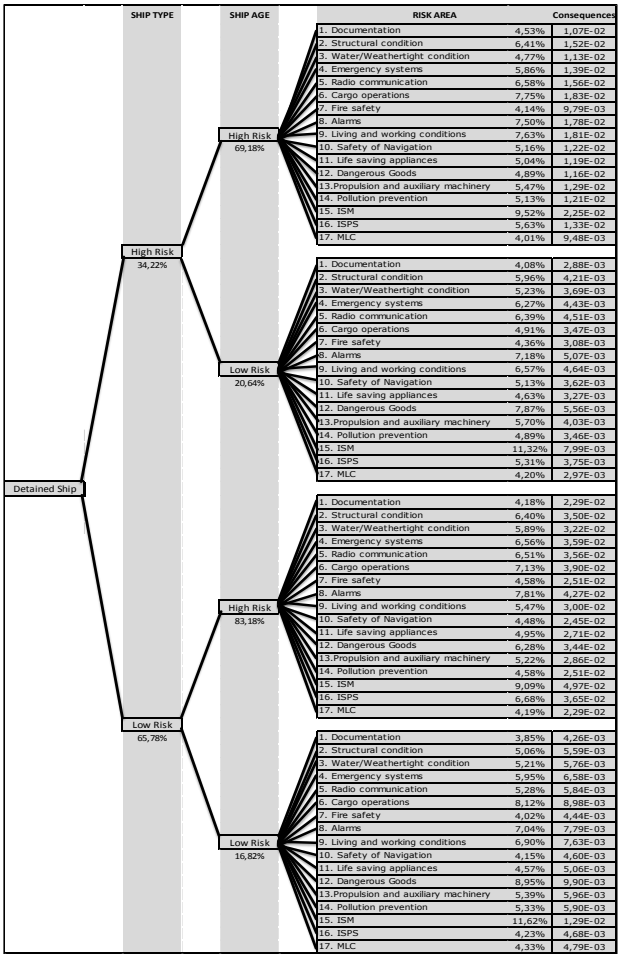


Figure 3 The results of the Event Tree Analysis

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.05
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

4. FINDINGS & DISCUSSION

In the study four different event tree scenarios were analysed: (i) high risk ship type – high risk ship age, (ii) high risk ship type – low risk ship age, (iii) low risk ship type – high risk ship age, (iv) low risk ship type – low risk ship age. The findings of the research show that, the deficiency risk areas that cause the ships to be detained show variations according to the ship age and ship type factors. In Figure 4, the obtained results for each event tree scenario were graphically presented with the line colours defined as follows:

- High risk type - high risk age (HR.T-HR.A blue line)
- High risk type - Low risk age (HR.T -LR.A red line)
- Low risk type - High risk age (LR.T-HR.A green line)
- Low risk type - Low risk age (LR.T-LR.A grey line)

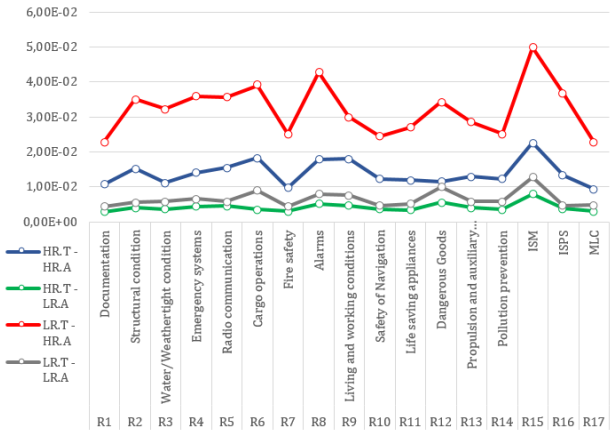


Figure 4 Ship detention probabilities based on ship risk factors and deficiency risk areas

It is seen from the result the highest detention rate belongs to the low-risk ship types with high risk ship age, while the lowest detention rate belongs to the high-risk ship types with low risk ship age. In each event tree scenario, "International Safety Management (ISM)" deficiency risk area has the highest detention probability. Therefore, improvement of the implementation effectiveness of the ISM Code still is an important issue to be focused on in maritime transportation. The ranking of the deficiency risk areas with respect to their probabilities for each event tree scenario are presented in Table 3 in descending order.

For the high-risk ship type with high risk ship age, ISM (R15), cargo operations (R6) and living and working conditions (R9) are the top three deficiency risk areas respectively to be concentrated on. For the high-risk ship type with low risk ship age, ISM (R15), Dangerous Goods (R12) and Alarms (R8) are the highest deficiency risk areas. ISM (R15), Alarms (R8) and Cargo operations (R6) are found as the highest deficiency risk areas for the low-risk ship type with high risk ship age. ISM (R15), Dangerous goods (R12) and Cargo operations (R6) are found as the highest deficiency risk areas for the low-risk ship type with low risk ship age. The findings of the study present information about the deficiency risk areas that should be focused on for the port authorities, and for the ships will be inspected, it gives information about which deficiency risk areas they should prepare before the inspection. Additionally, the findings help to optimize necessary measures to be taken to improve the safety.

Table 3. Ship deficiency risk area rankings as per event tree scenarios

Ranking	High Risk Type - High Risk Age	High Risk Type - Low Risk Age	Low Risk Type - High Risk Age	Low Risk Type - Low Risk Age
1	R15	R15	R15	R15
2	R6	R12	R8	R12
3	R9	R8	R6	R6
4	R8	R9	R16	R8
5	R5	R5	R4	R9
6	R2	R4	R5	R4
7	R4	R2	R2	R13
8	R16	R13	R12	R14
9	R13	R16	R3	R5
10	R10	R3	R9	R3
11	R14	R10	R13	R2
12	R11	R6	R11	R11
13	R12	R14	R7	R17
14	R3	R11	R14	R16
15	R1	R7	R10	R10
16	R7	R17	R17	R7
17	R17	R1	R1	R1

5. CONCLUSION

Port state controls is one of the essential instruments to ensure the safety in maritime transportation via monitoring and detecting substandard ships. At this point, increasing the efficiency of PSCs through development of the optimized inspection plan can be accepted as a significant consideration. In this study, PSCs performed in Paris MoU between the years of 2016 and 2020 were analysed using ETA to figure out most frequently detected deficiency risk areas depending on ship age and ship type factors. As a result of the analysis, unlike the risk factors (ship age and ship type factors) accepted in the Paris MoU inspection regime, the higher detention rate of the ships with low risk indicates that the inspection regime can be improved. On the other hand, it is possible to give priority to different risk areas according to ship risk factors and thus it will possible to perform more efficient PSC. In addition, the results obtained in the study concretely reveal which

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

deficiency risk areas should be paid attention by the ship management companies in the PSCs depending on the ship type and ship age factors.

In conclusion, the findings of this paper provide precious information for maritime industry stakeholders. For port states, it provides information to increase the effectiveness of PSC inspections. It offers a new approach for flag states to monitor and to analyse the inspection performance of ships flying their flags. For ship management companies, it provides information that can improve the inspection performance of the ships under their management. Further researches will be focused on improving the analysis results by including other risk factors used in the determination of ship risk profile to perform an in-depth analysis.

6. ACKNOWLEDGMENTS

The article is produced from PhD thesis research entitled “Safety Based Intelligent Ship Inspection Analytics for Maritime Transportation” which has been executed in a PhD Program in Maritime Transportation Engineering of Istanbul Technical University Graduate School of Science, Engineering and Technology and the article's abstract is presented at Global Maritime Conference in 2021.

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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.06

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

MEANS OF REDUCING THE IMPACT ON ARCTIC ENVIRONMENT OF AN ICEBREAKER BALLAST SYSTEM

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Abstract: Generally, icebreakers have been built as nuclear-powered Arctic ships, but for reasons related to the protection of the environment, and especially the Arctic environment, this trend has begun to change. A nuclear icebreaker is a type of nuclear-powered motor vessel for use in ice-covered waters. In winter, the ice along the North Sea route varies in thickness from 1.2 to 2.0 meters. The ice in the central parts of the Arctic Ocean has an average thickness of 2.5 meters. Nuclear icebreakers can pass through this ice at speeds of up to 10 knots (19 km/h). In ice-free waters the maximum speed of icebreakers is up to 21 knots (39 km).

Key words: icebreaker, Arctic, ballast, environment, design.

1. INTRODUCTION

Arktika-class icebreakers are used to break ice for the benefit of merchant and other vessels along the North Sea route, which includes the eastern part of the Barents Sea, the Pechora Sea, the Kara Sea, the Laptev Sea and eastern Siberia, Bering Strait. Important ports served by these icebreakers include Dikson, Tiksi and Pevek. Of the six Arktika-class icebreakers built between 1975 and 2007, four are currently in operation.

Two super-nuclear breakers, Vaygach and Taymyr, were built for shallow water and are commonly used from the Yenisei River to the Dikson, where they pass through ice, followed by Igarka timber merchant ships and ore and metal merchant ships. from the port of Norilsk Company in Dudinka.

Icebreakers have been used and are still used for a number of scientific expeditions in the Arctic. On August 17, 1977, the Arktika was the first surface ship in the world to reach the North Pole. Since 1989, some have been used for several Arctic cruises.

In total, ten civilian nuclear-powered ships were built in the USSR and Russia. Nine of them are icebreakers, and one is a container ship with a bulb specially designed for ice. All six Arktika-class icebreakers were built at the Baltic Shipyard in St. Petersburg. Vaigach and Taimyr were built at the Helsinki Shipyard in Finland and then brought to Russia for the installation of reactors and turbogenerators.

Russia plans to start building new icebreakers, the 22220 project after 2020. In June 2008, Rosatom head of state Sergei Kiriyenko said: *"It is important not only to use the existing icebreaker fleet, but also to build new ships, and the first new-generation nuclear icebreaker will be built by 2025. It should be an icebreaker capable of moving on rivers and seas"* he said. He went on to say that the St. Petersburg Iceberg Design Office will prepare the icebreaker project by 2019.

According to the BBC, the LK-60 (LK60Y) will be the largest icebreaker ever built. Vladimir Putin said in 2020 that Russia is building at least three new-generation nuclear breakers between 2022 and 2030.

The construction of a nuclear icebreaker takes eight years, the fuel resource lasts about 25 years. According to the Ministry of Transport, Russia needs six new icebreakers in the future.



Figure1 Norwegian icebreaker *Roald Amundsen* built for Arctic tourism (no nuclear propulsion)

Icebreakers generally try to navigate routes with the least ice to make faster progress and make sure they are not caught in too much ice and break them. In the 1970s and 1980s, ground aircraft observed and mapped ice to help choose routes. Over time, most of this work has

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.06
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

been taken over by satellite surveillance systems, sometimes aided by helicopters carried by ice.

Since 1989, nuclear icebreakers have also been used for tourism purposes and carry passengers to the North Pole. Each participant pays up to $ 25,000 for a three-week cruise.

2. ASRV *LAURENCE M. GOULD* ICEBREAKER

ASRV *Laurence M. Gould* is an icebreaker used most of the time by researchers at the National Science Foundation in the United States. The ship is being operated for research in the Southern Ocean. The ship is named after Laurence McKinley Gould, an American scientist who had explored both the Arctic and Antarctica. He was the second commander of Admiral Richard E. Byrd's first expedition to Antarctica from 1928 to 1930. He helped establish an exploration base at Little America on the Ross Ice Whaling in the Gulf of Whales.

ASRV Laurence M. Gould is operated under the Antarctic Support Agreement (ASC) on a long-term charter from Edison Chouest Offshore (ECO). The ASC shall incorporate the ship with a charter representative to coordinate the planning and scheduling of voyages and expeditions and shall provide on-board specialized technical personnel to support scientific operations. ECO shall provide the master of the ship, the pilot for navigation in ice-covered areas, and the crew prepared for this purpose.



Figure 2: ASRV icebreaker *Laurence M. Gould*

The construction of the ship was completed in 1998, and as main construction features has a length of 115 meters and is classified according to ABS-A1, capable of breaking ice with a thickness of 2 meters at a specific pace with continuous forward movement. ASRV Laurence M. Gould can accommodate 37 scientists on board, as well as crew members in cabins with one or two people. Upon request or need, the vessel acts as a supply vessel and conducts long-term environmental research (LTER), especially in the Drake Passage and the Antarctic Peninsula, the route normally approached being between Punta Arenas, Chile and Palmer Station, Antarctica. It replaced the RV Polar Duke as the main supply ship to the US Palmer research station.

The main technical characteristics of the ASRV Laurence M. Gould are the following:

- Owner: Offshore Service Vessels LLC;
- Builder: North American Shipbuilding, USA;
- Year of construction: 1997;
- Classification: Icebreaker of ice class ABS A1;
- Flag: United States of America;
- Total length: 72.2 m;
- Length between perpendiculars: 64.7 m;
- Construction width: 14.02 m;
- Width with ice reamers: 17.1 m;
- Draft: 5.49 m;
- Construction depth: 7.85 m;
- Weight of the empty ship: 2799 tons;
- Deadweight: 1041 tons;
- Displacement at the loading line: 3841 tons;
- Gross tonnage: 2966 tons.

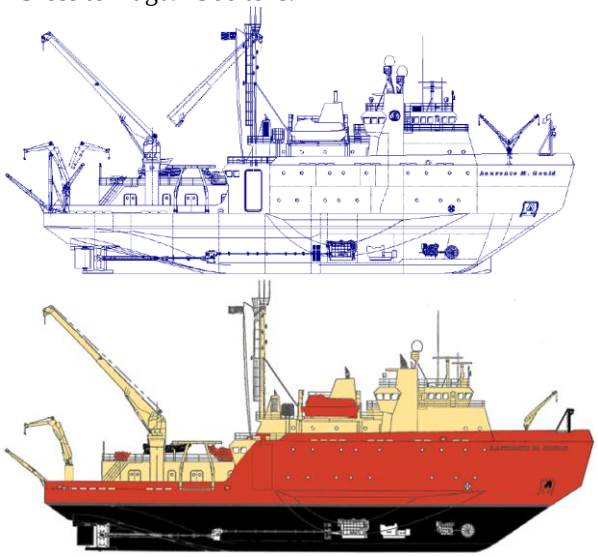


Figure 3: Construction diagram and arrangement of the main installations on board the ship

The ship has a series of spaces, compartments, equipment and installations exclusively intended for research activity, from which can be exemplified:

- Wet Laboratory: 40 m^2;
- Hydro Laboratory: 51 m^2;
- Dry Laboratory: 35.6 m^2;
- Computer Room: 46 m^2;
- Laboratory Aquarium: 27 m^2;
- Environmental Laboratory: 5 m^2;
- Laboratory microscope: 5 m^2;
- Scientific workshop: 38 m^2;
- Baltic Room: 42 m^2.

3. PARTICULARITIES OF SHIP BALLAST SYSTEMS

Ballast systems for general use

For general, passenger, refrigerated, fishing and other cargo ships, a single centralized ballast system is

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.06
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

used to correct both the flag and the axle. An exception to this centralized system is the ballast tanks of the bow of the oil pumps of the autonomous pump, arranged in one of the bow compartments. On these ships, in the race without payload, the ballast in the cargo tanks is introduced through the Kingston valves, through the free flow, or with the help of the loading pumps and the afferent pipes (which serve for him).

The ballast system of each ship must be serviced by at least one pump, and as a reserve pump others can be used, which have a sufficient flow (fire pumps can only be used if the system is not intended for the storage of liquid fuel).

The piping of the ballast system must be so arranged that the filling and emptying of the various tanks can be carried out independently, both when the ship is on the right keel and when it is inclined. The ballast system must be operated with as little ballast as possible, which will ensure the necessary stability and immersion of the propellers in the empty course of the ship. For general cargo ships the ballast does not exceed 20% of the ship's displacement. It takes 6-8 hours to load the entire amount of ballast, and it usually takes less than 2 hours to fill or empty the larger tank.

Specialized ballast systems

In particular, they are found in icebreakers, container ships, barge carriers, floating docks and submarines.

In the case of icebreaker ships, the problem is that the ballast systems generate oscillations during the ship's stationary oscillations with very large periods, so that, during the stationary ship, the ship is not caught in the ice. In the case of container vessels, barges or Ro-Ros, which carry very large concentrated loads, there is the problem of quickly correcting the inclinations caused by the eccentric arrangement of the weights on board. There are barge carriers at which the loading of barges is done by ballasting the base ship. For the submarine, the ballast system determines the condition of immersion and lifting to the surface.

Ballast systems for list correction

Transversal inclinations may occur during the operation of ships as a result of incorrect loading of goods, uneven fuel consumption or other causes. The transverse inclination worsens the ship's management, the operation of the machines, the mechanisms and the installations, it makes the service difficult. The transverse inclination must also be corrected in the case of damaged vessels.

The ballast system for the correction of the transverse inclination must meet the following conditions:

- not to influence the position of the ship;
- not to worsen the transversal stability;
- to request a minimum quantity of ballast arranged in ballast tanks located in the double bottom or side or even in fuel tanks (mixed tanks).

On icebreakers, the ballast systems must be automated to ensure the oscillation of the ship with a certain period. The ballast should be arranged in compartments located in the middle region of the ship (as sideways as possible) to ensure a lever arm and so on, as high a moment of transverse inclination as possible. In the case of damaged ships, the ballast shall be arranged as low as possible, so as not to further reduce the transverse stability.

The loading of ballast tanks with water from the outside of the ship, the transfer and refuelling of the board can be carried out with the pumps of the installation or with the pumps of the installations of longitudinal ballast, bilge, rescue (emergency) and sometimes with heat. In order to correct the inclinations of the ships, the ballast is embarked by the free flow through the Kingston valves, which simplifies the construction of the installation. For the same purpose, the pipes between the side tanks can be used, through which the water can flow freely from one board to the other.

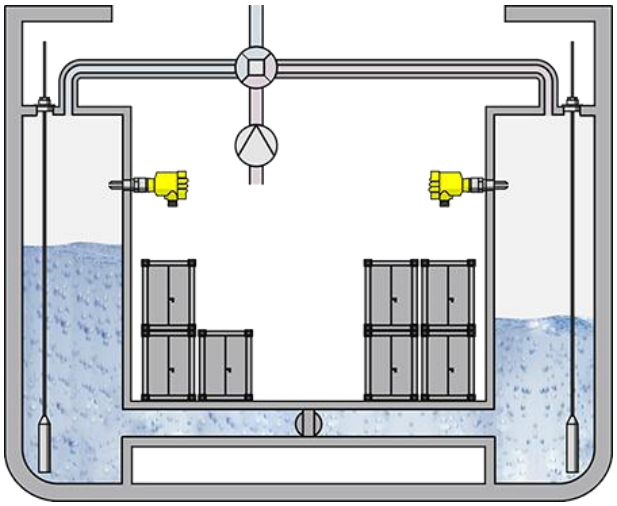


Figure 4: Schematic diagram of a specialized ballast system

Shipbuilders use the stand-alone scheme for ice breakers. In each watertight compartment in which two ballast tanks are located, autonomous pumps are fitted. The use of axial pumps on the double bottom platform ensures a good operation and the possibility of transferring water from one board to another in a period of 1-3 minutes, which is sufficient for the operation of ice breakers.

In order to ensure the vitality of the ships, the ballasts of the ballast installation of the different compartments (built according to the autonomous principle) are in communication with a transfer pipeline provided with a manoeuvring valve.

Ballast systems for axial correction

The system for the correction of the axle list must meet certain requirements imposed by the type of ship, the qualities of navigation and the longitudinal stability.

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.06
ISSN (Print): 1844-6116
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If, by flooding a sealed compartment, the ship acquires a dangerous longitudinal deviation from the point of view of longitudinal stability or flooding, the list must be corrected within a maximum of 5-10 minutes. On transport ships with high longitudinal stability, even in the event of damage to the extreme compartments, the ship can be returned to the raft line in 20-60 minutes, if special conditions are not foreseen by the design.

Ballast systems for the correction of the axial list are provided for on ice breakers which usually have during operation an almost constant displacement, as is the ARSV ship *Laurence M. Gould*. On ships carrying bulk cargo, on tanks, on passengers etc. no special ballast installations are provided for the correction of this. For the operation of these systems, it is necessary for the ballast to be disposed of in the ballast or fuel tanks at the ends of the ship. Ballast tanks can be placed at body height anyway, as the centre of gravity of the ballast has little influence on the longitudinal metacentric height.

If the ballast is admitted through a bottom valve, the tank must be placed as low as possible below the waterline in order to have the highest suction pressure and the shortest possible filling time. The installations intended for the correction of the axial list (in case of damage) are executed with group or autonomous control, and in the case of ice breakers and with centralized control (with main piping).

On relatively large vessels, one part of the tanks can be filled through the bottom valves, and the other part (upper tanks) with the help of pumps. In order to ensure the necessary reserve, the piping of the ballast installation for the correction of the axis will be in communication with other water pumps. The construction of the installation allows the filling of the tanks through the bottom valves or with the help of the pump that serves and the emergency systems.

The emptying of the tanks is also carried out with the pump. The control of the level in the tank is done with the help of a float valve, which automatically interrupts the water intake in the tank, when it has reached the set level. A similar vent can be mounted on the suction line to prevent air from entering the piping at the end of emptying the tank and thus defusing the pump. These valves can transmit impulses to the signalling system, which indicate the degree of filling or emptying of the tank, completion of filling or emptying.

4. LAURENCE M. GOULD'S BALLAST SYSTEM. GENERAL DESCRIPTION

Ballast water aboard ARSV *Laurence M. Gould* is loaded into ballast tanks arranged in a graphic representation corresponding to the ship's documentation, and their capacity is detailed below in the table below.

Table 1: Load capacity of ballast tanks aboard ARSV *Laurence M. Gould*

Compartment		**Location**	**capacity**	
		Frame	**At 100% load**	
			m^3	**MT**
No.1 WBT tank	(C)	122 – 130	236,75	242,67
No. 2 WBT bord tank	(P)	112 – 122	37,18	38,11
No. 2 WBT bord tank	(S)	112 – 122	245,36	251,49
No. 2 WBT double bottom tank	(C)	112 – 122	245,36	251,49
No. 3 WBT bord tank	(P)	102 – 112	36,16	37,06
No. 3 WBT bord tank	(S)	102 – 112	36,16	37,06
No. 3 WBT double bottom tank	(P)	102 – 112	201,55	206,59
No. 3 WBT double bottom tank	(S)	102 – 112	201,55	206,59
No. 4 WBT bord tank	(P)	92 – 102	65,11	66,74
No. 4 WBT bord tank	(S)	92 – 102	65,11	66,74
No. 4 WBT double bottom tank	(P)	92 – 102	197,16	202,09
No. 4 WBT double bottom tank	(S)	92 – 102	197,16	202,09
No. 5 WBT bord tank	(P)	82 – 92	94,16	96,51
No. 5 WBT bord tank	(S)	82 – 92	94,16	96,51
No. 5 WBT double bottom tank	(P)	82 – 92	149,35	153,08
No. 5 WBT double bottom tank	(S)	82 – 92	152,56	156,37
No. 6 WBT bord tank	(P)	72 – 82	94,42	96,78
No. 6 WBT bord tank	(S)	72 – 82	94,42	96,78
No. 6 WBT double bottom tank	(P)	73 – 82	118,41	121,37

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No. 6 WBT double bottom tank	(S)	73 – 82	118,41	121,37
No. 7 WBT bord tank	(P)	62 – 72	93,71	96,05
No. 7 WBT bord tank	(S)	62 – 72	93,71	96,05
No. 7 WBT double bottom tank	(P)	62 – 72	148,67	152,39
No. 7 WBT double bottom tank	(S)	62 – 72	151,87	155,66
No. 8 WBT bord tank	(P)	52 – 62	50,53	51,80
No. 8 WBT bord tank	(S)	52 – 62	50,53	51,80
No. 8 WBT double bottom tank	(P)	52 – 62	195,	199,87
No. 8 WBT double bottom tank	(S)	52 – 62	195,00	199,87
No. 9 WBT tank	(P)	13 – 22	162,37	166,43
No. 9 WBT tank	(2)	13 – 22	162,37	166,43
TOTAL			**3984,2**	**408,38**

The water is introduced or removed from the ballast tanks to allow the maintenance of a proper ballast, but also to the ship, as well as to ensure optimum stability, thus the forces to which the ship's body is subjected and limited. Ideally, no more than one ballast tank should be partially filled at any time during the operation of the ballast plant, as long as the free surface of the tanks can generate an effect that can be stable. more tanks to be only partially filled to adjust the ship's GM.

Anti-list tanks, more precisely ballast tanks Nr. 6 of the curbs, make exceptions to this rule, while they are only partially filled to maintain the inclination of the vessel within normal limits when loading and unloading the containers on the vessel. The water is pumped from the anti-tilt tanks, the water being circulated between them, through an anti-tilt pump, to maintain the right position of the ship, although the anti-tilt tanks are filled and finally emptied from the pump ballast.

In ballast systems, centrifugal pumps are used, characterized by a relatively high yield, a safety and a long service life, reduced mass and gauge, simple construction and operation. By placing them pumped to the lower level of the circuit on which they serve, their self-priming is also ensured. Moreover, after stopping the engine, the pumps of this type do not block the connection between the suction and discharge. The aim is to ensure the free circulation of the cooling fluid in the engine (the so-called thermosyphon effect), resulting in the continuation of the cooling process of the engine parts and a uniformization of the temperatures.

In accordance with the functional characteristics of centrifugal pumps, their flow rate varies in direct proportion to speed. If the pump drive is carried out by the engine, then at reduced speeds the flow of pumped water may be insufficient and the engine may overheat. This results in the need to choose a coefficient to increase the flow rate for the pumps driven by the engine. In the case of electric drive of the cooling pump, the flow rate is kept approximately constant. This time, at reduced engine loads, the water flow is exaggerated, with a high energy consumption. For this reason, it is reasonable for the flow rate of the water conveyed by the cooling pump to correspond to the operating speed of the engine.

The electric drive is characterized by a high safety in operation, by the possibility of using the pump in several circuits, as well as by the possibility of rapid transition to operation with the reserve pump. There is also the possibility of a better location of the components of the cooling system in the car compartment. Among the shortcomings of this shareholder system is the dependence of their operation on the supply of electricity, as well as a specific consumption of higher energy.

Mult-stage centrifugal pumps are provided with several rotors fixed on the same shaft. The working fluid is driven in turn by each rotor, its pressure increasing after each stage, so that after the last rotor, at the pump outlet, it is approximately equal to the product of the resulting pressure and the resulting number stages). Centrifugal machines are not generally self-priming. In order to be put into operation, it is necessary to fill the suction pipe with liquid or to evacuate the air from the priming pipe:

- insecure clerk;
- valve operation with suction check valve;
- employee with priming station. In general, the priming station comprises in its structure a volume pump or an ejector;
- coupling to the same shaft on which the rotor of the centrifugal pump of a pump is fixed with the water ring.

The pumps that support the ballast installation aboard the ship ARSV *Laurence M. Gould* are the following:

Ballast pumps

- Manufacturer: Desmi A / S;
- Number of seats: 2;
- Type: Vertical, arranged in line, centrifugal, with self-priming;
- Model: NSL300-415 / E14;
- Capacity: 50 m^3 / h at 10 mth.

Ballast ejector pumps:

- Manufacturer: Ki-Won Industrial Co ;
- Number of seats: 2;

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DOI: 10.53464/JMTE.01.2022.06
ISSN (Print): 1844-6116
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- Capacity: Training: 700 m^3/h;
  Aspirations: 150 m^3/h;
- Training pressure: 3.0 kg/m^2.



Figure 5: DESMI NSL300-415/E14 pumps fitted in the ballast system on board the ARSV *Laurence M. Gould*

Ballast pumps can suck water from the salt water junction dedicated to cooling the main engine in the engine room to ensure ballast water and the operation of the pressure driven ejector. Ballast pumps, during ballasting, discharge water through their ballast lines directly to the board, or through ballast ejectors when ballast tanks are stripped or washed. Although the water level in the anti-tilt system ensures a certain transfer of water, the pumps are ordered separately, the anti-tilt tanks are initially filled or gradually emptied through the ballast pumps. The ballast system is controlled by the central system of the ship or from the wheelhouse at the operator's station, which ensures the control of the pumps, start and stop, sending commands to open to the valves to close automatically. The valves are hydraulically operated. The remote control system of the valves is described in the next section.

5. SYSTEMS USED BY LAURENCE M. GOULD'S TO REDUCE THE ENVIRONMENTAL IMPACT OF ITS BALLAST SYSTEM

The ARSV icebreaker *Laurence M. Gould* is compliant for navigation in unrestricted areas, but also built in accordance with the MARPOL 73/78 Protocol, being an icebreaker with a special ballast system that is transported in the fore peak and other six pairs of winged tanks (the extreme sides of the keel) arranged along almost the entire length of the ship. The fore peak tank can be used frequently as a ballast tank.

The ship is designed with sufficient ballast capacity to meet buoyancy requirements in severe weather conditions, as well as to meet any weather conditions without the need to load additional ballast.

The potential performance of ballast voyages must take into account the seasonal weather conditions that the ship will encounter and therefore there can be no generally valid rule on the condition of ballast tanks in these conditions. The draft read from the markings in the middle of the vessel must not be less than 4.66 m and the trim must not exceed 1.195 m from the stern in these conditions for navigation in ice-covered areas. According to the data in the ship's technical data sheet the ship shall meet the following conditions of draft and stability in relation to the ship's ballast:

- On departure from port:
  - o Average draft: 8.00 meters;
  - o Trim: 1,129 meters at the stern;
- Upon arrival in port:
  - o Average draft: 8.00 meters;
  - o Trim: 0.805 meters at the stern.

The main ballast water tanks on board the ARSV Laurence M. Gould are served by two electrically operated centrifugal pumps and each has a capacity of 50 m3 / h. The ballast pumps are located in the pump chamber and are equipped with a Kingston ballast caisson. The electric drive motors are located on the mezzanine deck, and these pumps have drive shafts that pass through the seals in the pump chamber. The pumps are connected to a discharge overboard by a 600 mm tubular line ending approximately 0.5 m above the deepest ballast line on the starboard side.

Ballast pumps can be connected to the cargo tank system via the manually operated valve, 440 V (shown in Figure 3.5), by inserting a dedicated part for feeding the coil, the manually operated valve, 085V and the check valve 084V. Under normal circumstances, this connection would not be used to ballast cargo tanks intended for use for this purpose only due to severe weather conditions.

The ballast dedicated to the operation of the ship in severe weather conditions will be directed to the cargo tank designated by a main cargo pump, after a basic wash of it. The main ballast lines have a diameter of 500 mm and each ballast tank has a suction line of 350 mm, including the fore peak tank.

Ballast water contains a variety of organisms, including bacteria and viruses, adult forms and larvae of many marine plants and animals, but especially those from coastal areas. While the vast majority of these organisms will not survive to the point where ballast is unloaded, some may survive and thrive in their new environment. These so-called "non-native" (or invasive) species, if successfully established in a certain area, can have a serious ecological, economic and public health impact on the host environment.

The transfer of invasive marine species to new environments through ballast water has been identified as one of the major threats to the world's oceans. In response, the United Nations Conference on Environment and Development (UNCED), held in Rio

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.06
ISSN (Print): 1844-6116
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https://www. jmte.eu

de Janeiro in 1992, in its Agenda, item no. 21, called on the International Maritime Organization (IMO) and other international bodies to take steps to address the issue and find solutions to minimize the impact of this phenomenon.

At the right time, the IMO was already looking for a solution for more than 10 years. In 1991, it published a regulation called the Guidelines for the Prevention of the Introduction of Unwanted Organisms and Pathogens from Ships' Ballast Waters and Sediment Discharges. This regulation was updated in 1993. Further, in 1997, the IMO published Guidelines for the control and management of ship's ballast water to minimize the transfer of harmful aquatic organisms and pathogens, also officially known as Resolution A. .868 (20).

In February 2004, the IMO adopted the International Convention on the Control and Management of Ballast Water and Sediments on Board Ships (Ballast Water Management Convention or BWM Convention) to regulate the level of ballast water discharges and to reduce the risk of introducing non-native species from ship ballast. To complement the BWM Convention, the IMO has adopted more than 15 sets of guidelines and regulations, as well as other documents contained in the resolutions and circulars of the Committee on the Protection of the Marine Environment (MPEC).

The BWM Convention imposes a difficult standard in the ballast water discharge process. In response to this regulation, a number of technologies have been developed and marketed by various suppliers. Many originate in terrestrial applications for municipal and industrial water and effluent treatment, being adapted to meet the requirements of the BWM Convention and shipboard operations. These systems must be tested and approved in accordance with the relevant IMO guidelines.

Thus, in order to achieve the standards imposed by the rules on the management of ballast water, shipowners and seamen on board must take into account:

1. Ballast water and sediment management in accordance with the Ballast Water Management Plan - Ensure that all ballast and sediment water discharges are managed in accordance with the requirements of the BWM Convention and in accordance with the procedures in the Management Plan of ballast water approved and existing on board the ship. It shall ensure that records of ballast operations and sediment management are properly recorded in the Ballast Water Logbook.

2. Update of the Ballast Water Management Plan and the Ballast Water Logbook - Periodic reviews of the Ballast Water Management Plan will be carried out and updated as necessary.

3. Ensure that the necessary checks are carried out within the permitted deadlines - The necessary annual, interim and renewal checks shall be organized in a timely manner and shall ensure that they are carried out within the permitted deadlines.

4. Carrying out maintenance operations on the equipment in accordance with the manufacturer's instructions - The ballast water treatment system must be used and maintained properly, in strict accordance with the manufacturer's instructions. The procedures in the Approved Ballast Water Management Plan will reflect this requirement.

5. Constant monitoring of treatment system performance - System performance should be monitored using installed monitoring equipment or using dedicated sensors. The parameters that this system monitors will vary depending on the type of system you are installing. These include: wash rate / frequency; dosing rate of the active substance; neutralizer dosing rate; energy consumption; TRO (total residual oxidant used); and pH (acidity / alkalinity). The assistance and periodic verification of the system by the manufacturer and the periodic performance of biological efficacy checks will contribute to ensuring the operation of the system as designed and certified.

6. Ballast water and sediment management in accordance with USCG requirements, if applicable - Ensure that all ballast and sediment water discharges are managed in accordance with USCG requirements and in accordance with the procedures in the USCG Water Management Plan. ballast approved and existing on board the ship. It shall ensure that records of ballast operations and sediment management are properly recorded in the Ballast Water Logbook.

An EcoBallast H2233 treatment system is installed to optimize the operation of the ship in the Arctic, as well as the operation of the ballast system on board the ARSV Laurence M. Gould. In principle, the EcoBallast system consists of the filter unit, the UV reactor, the cleaning unit and its control unit. The system is controlled via the PLC installed in the control panel.

The filtration unit can significantly reduce the amount of sediment that comes from ballast water and can also remove a large part of marine organisms (which are larger than 50 microns in size). The filter works fully automatically to influence the filtration process, and its wash water is returned to the seawater on site. The filter unit only works during the ballasting process. During the ballasting process the unit is bypassed.

The UV reactor, which is specially designed for the EcoBallast type system, is intended to reduce the space required within the installation and to maximize its efficiency by using high intensity, but also ultraviolet lamps at medium pressures. This means that the ballast water is treated again to destroy any type of organism during the ballasting process that could have developed inside the ballast water tank during the voyage.

The control system controls the entire ballasting process, all event logs and generates alarms whenever something happens. The ballast card in the system control panel adjusts the power of the UN lamp. The CIP (cleaning in-place) unit is an automatic service device that cleans the quartz bushes that cover the ultraviolet lamps after performing any ballasting-ballasting

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Technology and Environment
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operation. The operation is performed to avoid any type of deposition that may come from seawater, which could, in fact, reduce the efficient treatment of the ultraviolet reactor.

Ballasting - Seawater is sucked in through the suction box. The water then passes through the filtration unit, which reduces the amount of sediment in it, but also removes some of the marine organisms and particles larger than 50 microns. The water finally reaches the UV reactor which generates UV radiation which kills the organisms and breaks them down. The filter unit is then washed back to keep the filter clean. The return wash water is to be poured directly into the sea.

The ballasting process begins with a preliminary phase called initialization which can begin when the power supply level is reached through the ship's onboard power management system (ship's PMS).

Ballast water reaches the filling line, the UV reactor and the filter unit in Sea-to-Sea mode. The filling flow must be as low as possible to prevent hydraulic shock from occurring in the network and in the filling chambers directly from the initialization step. Hydraulic shock can damage the filter element and the quartz bush to protect the lamp from ultraviolet light. Therefore, the intermediate valve (BT-05) must be gradually opened up to 20% in order to prevent the formation of the pressure shock and at the same time to maintain a minimum flow. It is then necessary to open the valve completely to allow maximum flow and to operate all ultraviolet lamps automatically.

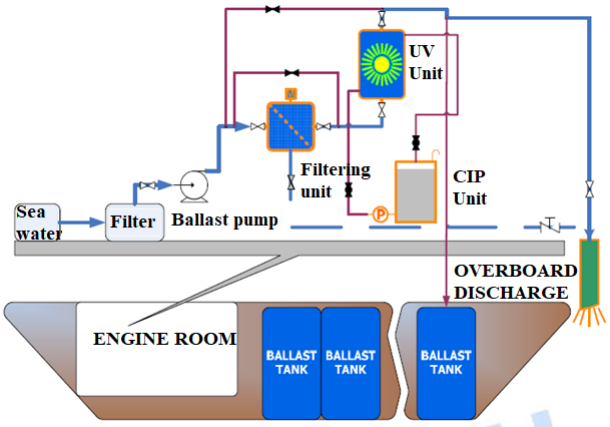


Figure 6: The water circuit in the ballasting process of the *EcoBallast* system

The flow process is monitored by the flow meter installed on the unit to ensure that the "maximum flow" is not exceeded. If the flow value exceeds the nominal value or if it is lower than the nominal flow value, an alarm will sound and the whole system will be switched off automatically.

Upon completion of the above-mentioned starting procedures, the actual ballasting process begins, and the water is directed to the ballast water tanks to fill them with pure, treated ballast water.

De-ballasting – de-ballasting is a procedure similar to ballasting except that a bypass is made on the installation filter. Ballast water is only treated again by the UV reactor to destroy any type of organism that could have grown back inside the tanks during the voyage. The figure below shows the water circuit in the ballast plant during the ballasting process.

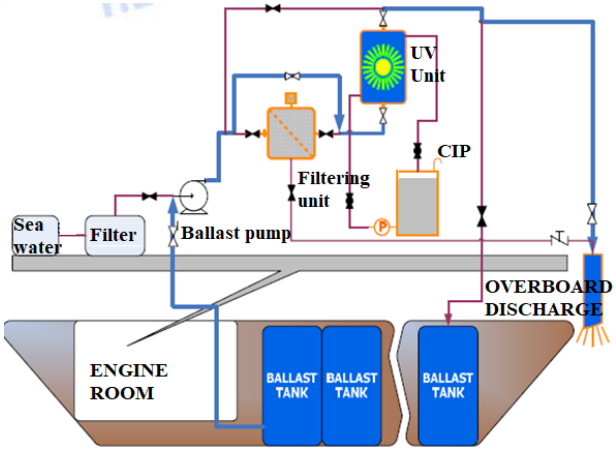


Figure 7: The water circuit in the de-ballasting process of the *EcoBallast* system

System cleaning process - After each ballast procedure, a cleaning cycle takes place in the UV reactors. This cleaning can be performed automatically or manually after each ballast procedure. This cleaning fluid is reused between cleaning operations.

Emergency operation bypass - The emergency bypass operation is performed for ballasting and ballasting procedures without affecting the operation of the conventional ballast water pump.

Preparations and preconditions - Before starting the EcoBallast ballast installation, follow the preparation steps below:

- Ensure that the UV reactor and filter unit are filled with water;
- The main power supply must be connected to the system;
- All valves outside the ballast system must be open or closed in the appropriate position for ballasting / ballasting as shown in the tables below;
- The valves in the EcoBallast system must be in the following positions, depending on the selected operating mode.

6. CONCLUSIONS

If 10 years ago ballast water was apparently not a danger to the environment, today regulators have noticed the negative potential of the ballast installation on the environment through which the ship passes. The potential performance of ballast voyages must take into account the seasonal weather conditions that the ship will encounter and therefore there can be no generally valid rule on the condition of ballast tanks in these conditions. The draft read from the markings in the middle of the studied vessel shall not be less than 4.66 m and the trim shall not exceed 1.195 m from the stern in

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Technology and Environment
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ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

these conditions of navigation in ice-covered areas, for the ASRV Laurence M vessel. Gould. The discharge valves of the ballast pump are of proportional type, ie they can be opened between 0 and 100%. The main suction valves on the ballast tanks and the isolation valves of the suction line are all of the simplistic type and can only be operated in open / closed positions. The main danger to the environment is invasive species that can be transported by ballast water. The main legislative norm is the BWM Convention, which entered into force 12 months after its ratification by 30 states, representing 35% of the world's shipping tonnage. This provision covers 7 key points regarding the ballasting and unloading of ships. An EcoBallast H2233 treatment system is installed to optimize the operation of the ship in the Arctic, as well as the operation of the ballast system on board the ARSV Laurence M. Gould. In principle, the EcoBallast system consists of the filter unit, the UV reactor, the cleaning unit and its control unit. The system is controlled via the PLC installed in the control panel. Thus, the last part of the study describes the principles and stages of operation of the ballast water treatment plant on board the reference icebreaker.

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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.07

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

EFFICIENCY STUDY ON THE AIR CONDITIONING SYSTEM ONBOARD A PASSENGER SHIP

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Abstract: In the conditions of normal operation of ships, due to the release of heat from various machines and people, the increase in humidity as well as due to various releases of gases from on-board systems or goods being transported, the air in the rooms it degrades, requiring its replacement and processing. In the following we will present the issue associated with ensuring the comfort parameters on board ships, a matter regulated by international provisions on ensuring living conditions for crews - International Code for Safety Management and Pollution Prevention (ISM Code).

Key words: HVAC, ship, cabin, efficiency, analysis.

1. INTRODUCTION

The artificial microclimate installations have the role of thermally and humid-thermically processing the air, so that inside the naval compartments the corresponding state parameters are maintained:

- comfort conditions in living rooms;
- storage conditions of the goods;
- operation of machines and units.

Artificial microclimate installations include: ventilation installations; heating installations; cooling installations; conditioning (complex processing) installations.

The ventilation installations have the role of realizing the air circulation, without a homeothermic processing, eliminating the releases of heat, noxious gases (noxious) and of the humidity.

The heating and cooling installations perform the thermal treatment of the air in the living compartments.

Air conditioning systems ensure:

- for surface vessels: complex homeothermic processing of the air so that its state parameters are maintained at the comfort values automatically;
- for ships with watertight compartments and submarines: in addition to the parameters it achieves for surface ships, it also ensures a processing of the chemical composition to complete the oxygen consumed and the retention of carbon dioxide released on board.

The efficiency of the operation of ventilation, heating or air-cooling installations depends on the processes that take place in the rooms served, as well as on the meteorological conditions of the external environment. In this way, the meaning of the processing on the installation is dictated by the season, taking into account the extreme situations, corresponding to the summer and winter seasons.

The profitability of choosing one or more groups of installations on the ship is determined according to the operating conditions of the various rooms, the volume of labour incorporated in the installations, the location, closely correlated with the problems of size and weight, noise, etc. Therefore, artificial microclimate installations must meet the following basic conditions:

- to maintain in the rooms the optimal air parameters, avoiding the existence of dead areas where there is no air circulation;
- not to cause harmful air currents;
- not to make noise above the normal limit;
- not to allow gas and dust to enter from one room to another;
- to be reliable, with weights, dimensions and minimum energy consumption.

The normal conditions of comfort of the navigating personnel on board the ships, the keeping of the cargo in good condition and the normal operation of the aggregates, depend on the temperature, humidity, speed and chemical composition of the air. The determination of the air parameters in the living rooms is made on the basis of the physiological and hygienic-sanitary norms, taking into account the specific navigation conditions (small volume of the rooms, different climatic conditions, navigation area, etc.). In the case of rooms intended for machines and units, the determination of air parameters is done, on the one hand, according to their functional parameters, and on the other hand, to ensure the working conditions for the crew.

The parameters of the outdoor air are prescribed for different periods of the year and for different navigation

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Technology and Environment
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areas, the recommended values having a statistical character.

For naval air conditioning systems, the calculation and operation parameters are provided in the standards. In the preliminary calculations and in the design, other norms will be considered, such as the conditions of increased comfort for the passenger ships or the operating conditions for cars, units and devices, etc.

2. HVAC SYSTEMS USED ONBOARD SHIPS

The role of ventilation, heating and air conditioning systems is to process the air so that living conditions for crew and passengers are maintained in the ship's spaces, storage of goods and ammunition in the case of military ships and operation of equipment in optimal conditions.

Heating is the process by which the temperature of the air in the compartments is raised from a heat source or by the introduction of hot air. The ventilation system circulates the air, eliminating heat, noxious substances, water vapor and smoke without processing the humid-thermal air.

The air conditioning system performs a complex air processing (heating, cooling, humidification, drying) to achieve comfort and working parameters. In the case of submarines and military ships with watertight compartments, the air conditioning system replenishes the oxygen consumed and retains the carbon dioxide retained on board.

The basic design considerations for HVAC systems for marine applications are similar to those for onshore systems, except those marine systems must meet several requirements. Here are some of them:

- The space for equipment, pipes and components is smaller;
- A ship is mobile and solar heating can affect any external walled compartment above the water line;
- The ship can withstand extreme weather conditions during a day;
- HVAC systems must withstand the corrosive action of seawater and salt air;
- HVAC systems must be capable of normal and efficient operation in severe conditions of ship movement;
- HVAC systems must have a high degree of reliability as supply and intervention at sea are low and the ship must carry spare parts and tools with it;
- Enclosed spaces on the ship are small and noise and vibration transmitted through the ship structure and air must be minimized;
- The design of HVAC systems must prevent water from entering the ship in bad weather;
- The position of the openings through which the air intake and the evacuation from the ship are made are critical due to the small space available, the protection at the water entrance in the ship and the minimization of the air routes that cross the corridors for passengers and crew;
- An HVAC system must achieve satisfactory performance in compartments with a multitude of functions: living compartments, bathrooms, warehouses, compartments with propulsion equipment and electric generators, compartments with electrical and electronic equipment, etc.;
- Smoke control and fire safety are critical due to the limited fire-fighting and rescue conditions.

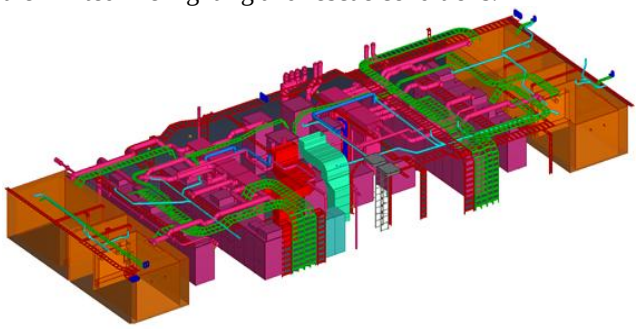


Figure 1 Detailed diagram of an HVAC system on board a passenger ship

In the case of military ships, in addition to the above requirements, there are others given by their specificity:

- Systems and equipment must be designed to withstand shocks and vibrations that occur in combat conditions;
- Due to the complexity of systems on military ships, the space for HVAC systems is smaller;
- Weight is a critical parameter and therefore HVAC systems on military ships are designed with minimum weight;
- Military ships have compartments with a high density of equipment that generates a high thermal load but which varies greatly. HVAC systems must be able to pick up thermal load peaks;
- HVAC systems must contain modules with standardized components that can be easily replaced in combat or emergency conditions;
- Unlike projects on merchant ships, systems on military ships must operate continuously even in the face of combat damage;
- In order to operate even under the conditions of a backup energy source, the HVAC system is divided into modules so that the vital compartments benefit from services continuously and in non-vital compartments the services can be temporarily suspended;
- The hydraulic balance of the distribution networks must be ensured in all operating conditions, even when certain routes are suspended.

It is the responsibility of the HVAC specialist engineer to develop systems that meet the required parameters.

The air conditioning system has become a common system for marine applications due to the comfort requirements required by crew and passengers. In

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general, one can talk about the comfort of people in a room if the following factors are taken into account:

- personnel factors:
  - o the type of work performed inside the rooms;
  - a clothes worn by staff.
- environmental factors:
  - o air temperature and humidity;
  - an air speed;
  - o temperature of the surrounding walls, ceiling and floor;
  - o the influence of the sun through the windows;
  - o radiation from lighting fixtures and other heat sources.

The air conditioning systems have as applications:

- systems to ensure human comfort and living conditions for animals;
- systems that ensure the operation of electrical and electronic equipment and appliances;
- systems for storing goods and ammunition.

The designer of the air conditioning system takes into account the criteria related to the outdoor climate and the indoor climate. The design of the air conditioning system begins with the analysis of the temperature and relative humidity of the external environment, which means knowing the navigation routes of the ship. Exterior conditions influence the air parameters in the interior of the ship. Exterior conditions are different day and night. To establish the external conditions, maps with all regions of the world are used, which contain the average values of temperature and humidity. With regard to the indoor climate, the requirements of the crew and passengers must first be taken into account. Other factors that influence the indoor climate are:

- heat from the sun;
- heat transfer through walls;
- the degree of occupation of the space;
- heat from cars and electrical equipment.

Because the air in the ship's spaces becomes contaminated with bacteria, viruses, smoke, water vapor, carbon dioxide, dust, etc. it must be replaced with clean air. Nowadays the volume of supply air is estimated at 30-35 [m3 / h] for one person in smoke-free spaces and 45-50 [m3 / h] in smoke-free areas. The amount of air supplied to a volume depends on that volume. For example, the volume of air supplied to a ship's cabin in one hour is 6-10 times the cabin volume, which means 6-10 shifts per hour.

If the space is ventilated, the outside air must be heated or cooled separately and mixed with the recirculated air to reach the desired temperature. There are areas that need to be given more attention to fresh air supply and exhaust air. It is advisable to divide the spaces into smoking areas and non-smoking areas. Smoking areas are supplied with more fresh air than non-smoking areas to achieve the same result. The evacuation capacity at smoking areas will also be higher.

Sanitary, public or private spaces are provided with separate evacuation. Medical facilities such as hospitals, consulting rooms, etc. where sick people receive care, they have ventilation facilities separate from the facilities for the other spaces.

Laundries have hot spots represented by boilers, washing machines, irons, etc. The amount of air supplied and the amount of air evacuated must remove heat and humidity in order for these parameters to be within certain limits.

Cargo spaces are supplied with air to remove generated odors, water vapor, heat, etc. The amount of air supplied depends on the cargo carried by the ship.

It is important to create a depression in the ventilation of kitchens (the air pressure in the kitchen must be lower than in the surrounding spaces). This prevents the spread of kitchen odors in other compartments of the ship. If the kitchen has a separate space for cooking meat, a temperature below 16 ° C will be kept here.

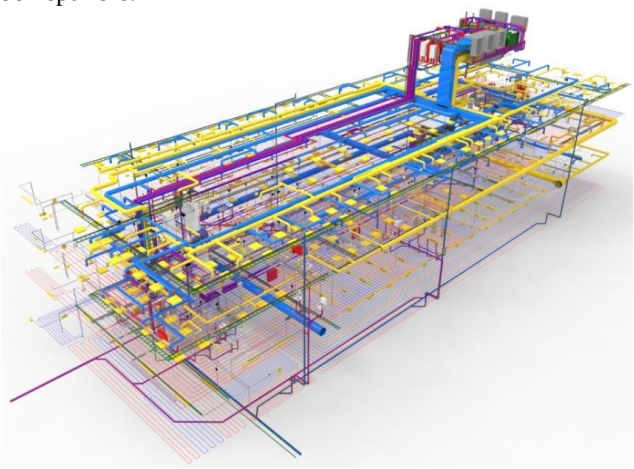


Figure 2 Pipping diagram of an air conditioning system fitted on board a passenger ship serving several decks

Engine rooms/engine compartments require special attention. Current engines are compact and generate a large amount of heat. Engine heat loss data is provided by the engine manufacturer. It is important that the temperature in the car compartment is controlled, values of 50 ° C or more affect the health of the staff. In addition to the heat dissipation, the ventilation system in the engine compartment also provides the necessary air for the operation of the main engine and auxiliary engines.

The air in the rooms in the process of processing to meet the requirements of comfort and operation is heated, cooled, dried or humidified. These transformations can be made on the basis of wet air diagrams, the most widely used of which is the diagram drawn by Moeller.

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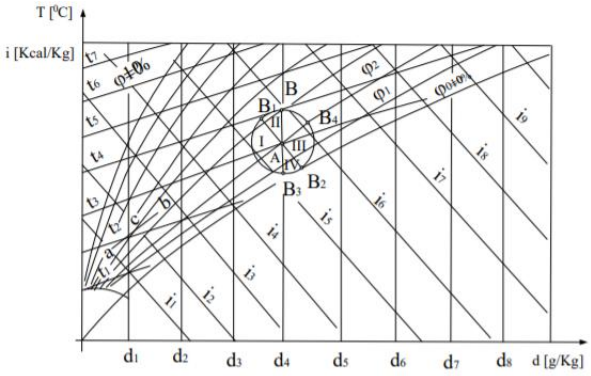


Figure 3 Moeller diagram

In this diagram, the total enthalpy of humid air ($\boldsymbol{i}$) is drawn in order and the moisture content ($\boldsymbol{d}$) in the abscissa. The relative humidity curve $\boldsymbol{\varphi_0}$ = **100**% is called the saturation limit curve because it separates the domain of unsaturated moist air from the fog domain (supersaturated air). This curve connects the saturated humidity points $\boldsymbol{d}_{\text{saturation}}$ for different temperatures. Above the saturation limit curve $\boldsymbol{\varphi_0}$ are the relative humidity curves $\boldsymbol{\varphi}$ <**100**%, drawn to the vaporization isotherm. The isotherms are denoted in the diagram by $\boldsymbol{t_1}$, $\boldsymbol{t_2}$… $\boldsymbol{t_7}$. Any point in the humid air diagram corresponds to four state parameters: $\boldsymbol{t}$ - temperature, $\boldsymbol{\varphi}$ - relative humidity, $\boldsymbol{i}$ - enthalpy, $\boldsymbol{d}$ - moisture content.

With this diagram you can characterize the state of the air in a room knowing only two of these parameters. Any wet-thermal process that produces the transformation of the initial state characterized by these two parameters into a final state, by exchange of heat and humidity, can be studied with the Moeller diagram. We assume that in a room we have the temperature $\boldsymbol{t_A}$ (measured with a thermometer) and the humidity $\boldsymbol{\varphi_A}$ (measured with a psychrometer). These state parameters correspond to point $\boldsymbol{A}$ in the diagram. If the state parameters of the point $\boldsymbol{A}$ change as a result of a thermal process with heat release without changing the absolute humidity, reaching the point $\boldsymbol{B}$ ($\boldsymbol{t_B}$, $\boldsymbol{\varphi_B}$), the segment $\boldsymbol{AB}$ in the humid air diagram represents a moist thermal process. The coefficient of the humid thermal transformation is defined $\boldsymbol{\epsilon}$ the ratio between the enthalpy variation and the humidity variation ($\boldsymbol{\epsilon} = \Delta\boldsymbol{i}/\Delta\boldsymbol{d}$) or the ratio between the sum of the heat flows entering the process and the sum of the humidity releases ($\boldsymbol{\epsilon} = \sum\boldsymbol{i}\ \boldsymbol{\Phi i}/\sum\boldsymbol{i}\ \mathbf{d}\boldsymbol{i}$).

The ship's spaces must be heated or cooled for a day or a year. The thermal load may vary for the whole vessel or for part of it. Changes in the air characteristics are made in the treatment unit. There are two basic systems, one centralized with a main piping from which branches that supply air to all spaces of the ship and a decentralized system that contains several treatment units that serve the areas where the ship is divided. Air conditioning systems can provide treated air to large spaces such as lounges, dining rooms, passenger ship docks or a small group of cabins such as dry goods vessels.

Air conditioning is provided to each space to meet the maximum comfort requirements. A mixture of outside air and recirculated air is filtered and conditioned (preheated, dehumidified and cooled if necessary) in a central station and distributed to the individual heaters in the spaces served. The automatic dampers on the fresh and recirculated air supply are controlled by two sensors mounted on the piping, one for the heating cycle and one for the cooling cycle. The master thermostat records the outside air temperature. It is recommended that the terminal heater (from the cab) be with hot water or electric heating as it allows a finer adjustment of the temperature than in the case of steam.

The air ducts are made of galvanized steel sheet or aluminum sheet. It can be circular or rectangular. In general, circular tubing is cheaper than rectangular tubing.

3. MAIN PARAMETERS OF THE HVAC SYSTEM FITTED ONBOARD PASSENGER SHIP

In the operation of air conditioners, the compressor is one of the elements with a major role in regulating the temperature in a room. In a traditional system, it goes through two states: functioning at maximum capacity or stagnation. In other words, this type of compressor will work at maximum capacity, from the moment of start-up, until the moment when the temperature in the room reaches the desired level, when it closes. This is the periodic start and stop of the compressor and is, in fact, responsible for the high consumption of electrical energy.

The compressor operates at a variable speed, which allows a suitable consumption of energy to meet the needs of the temperature in the room. Thus, it does not stop, only the speed of the function of the function is adjusted automatically according to the needs. In an inverted air conditioning system, the compressor operates at maximum capacity until the temperature is brought to an optimum level, after which the speed is reduced.

Any change in temperature in the cabin is automatically detected by existing sensors, and this adjustment can be done by a slight increase in function, without any increase in function. At the first sight, a continuous operation of the compressor, would be considered responsible for a high energy consumption, but which generates, with a real, high consumption. The main advantages of the inverter technology are the following:

- Decrease in electricity consumption - Through INVÈRTER technology the repeated start and stop of the compressor is avoided, which generates a high energy consumption. The additional financial effort to purchase

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.07
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

an air conditioner with investment is soon recovered due to significantly diminished costs;

- Quite operation conditions - represents a considerable advantage for passenger vessels;

- Increased reliability over time - Due to the fact that repeated starts and stops are avoided, the mechanisms and parts of the interior are much less required in one condition than the other.

On the heating part, the heat pump switches and inverts the refrigeration circuit, so that the evaporator becomes a condenser and the condenser becomes a vaporizer. The circuit is similar, with the mention that now the indoor unit is giving off heat to the condenser, and on the outside, it is taking off the heat of the vaporizer.

For the purpose of this study a HVAC system onboard a passenger ship is being considered as operating after a cycle without subcooling and with the following area,

- refrigerant: R134a;
- refrigerating power: Q_C = 340.9 [kW];
- vaporization temperature: t_0 = 8 [0C];
- air temperature: tf '= 15 ^{0}C, tf " = 17 [$_0$C];
- air temperature at the entrance to the subcooler: t_a '= 25 ^{0}C, t_a "= 35 [^{0}C];
- condenser temperature: t_C = 55 [^{0}C];
- subcooling temperature: Δt_{sr} = 0 [^{0}C];
- overheating temperature: $\Delta_{ts\hat{i}}$ = 5 [^{0}C];

Analogically, the parameters of the cooling agent in the vaporizer are established as:

- t^0 = 8 ^{0}C → T_0 = 281.15 [^{0}K];
- p_0 = 1,641 [bar];

The parameters of the agent in the condenser are established as:

- t_C = 55 ^{0}C → TC = 328.15 [^{0}K]
- p_C = 10.98 [bar]

4. EFFICIENCY STUDY ON THE HVAC SYSTEM

In this chapter a simulation of the passenger's ship HVAC system is being presented. This HVAC system supports three identical passenger cabins, the difference between these cabins consisting in the fact that the pipping of the HVAC system is fitted in three different configurations, this simulating the conditions existing on real passenger ships.

All engineering simulations begin with the establishment of geometry to symbolize the aspect, whether it is a powerful aspect of a structural evaluation or a quantum of a fluid. The engineer is at the disposal of the geometry which was created in a CAD system (laptop-assisted layout), which builds the geometry from zero. ANSYS Design Modeler is a generating method the cabin geometry which will be simulated further on in ANSYS. The geometry of the cabin on board the ship is created using the software ANSYS Design Modeler, which is a special concept for the creation and modeling of the geometry. In technical simulations, geometry consists of information that is not currently necessary for simulations. Only the physics involved will be included, simulating such a version completely similar to the geometry of the cabin on board the ship. The figure below suggests the geometry created for the ship's cabin and the way in which the air conditioning pipes are arranged in the room. Thus, the stable dimensions for the room are:

- Height: 4 meters;
- Width: 3.65 meters;
- Length: 6 meters.

The duct that directs the air conditioning in the cabin has the following dimensions:

- Length: 0.5 meters;
- Width: 1.5 meters;
- Height: 0.65 meters.

The model realized in the mentioned program is presented in the figure below:

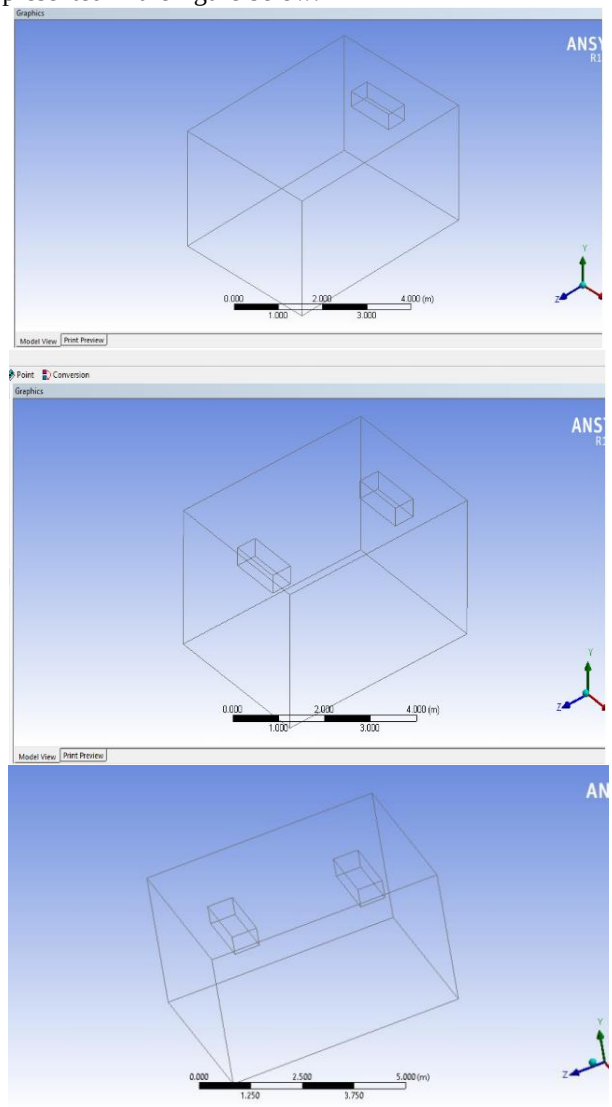


Figure 4 Geometric model of the cabin with air conditioning ducts for the air conditioning system

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One of the complex and enduring events of CFD simulation is the meshing of the computational domain. It is also called that the discretisation or the generating process of geometrical elements that simulate the surface and shape of the simulated object. Analytical solutions to the Navier-Stokes equations exist only for the simplest flows under ideal conditions, in the case of simulations of thermodynamic processes. In order to obtain a solution for real flows, a numerical approach has to be taken by which the equations are replaced with algebraic approximations that can be solved using a numerical method by applying the discretization of governing equations which implies the dividing process of the spatial domain in small finite elements in order to shape volumes using a discrete element of meshing or mass. Pre-set equations are integrated into each volume of control, so that the relevant quantity (mass, momentum, energy, etc.) can be preserved in a single volume.

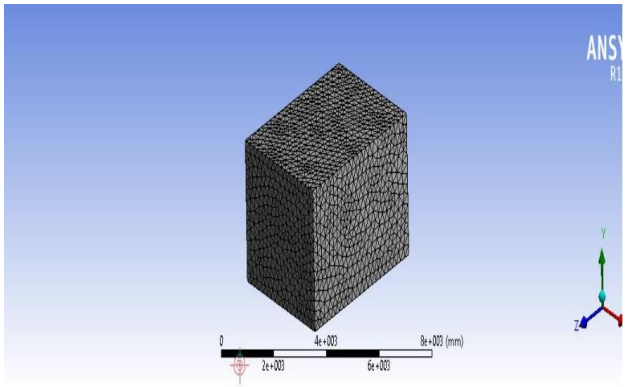


Figure 5 Cabin meshing using triangular elements

The method of discretization in finite volumes takes into account the points that form a set of volumes called cells. Methods with finite elements use sub volumes called elements that have nodes in which variables are defined. The variable values of dependencies, such as temperature, pressure, speed, etc. will be described for each element in the part. The quality of the CFD result strongly depends on the quality of the nodes.

As part of the simulation of the main parameters monitored and analysed:

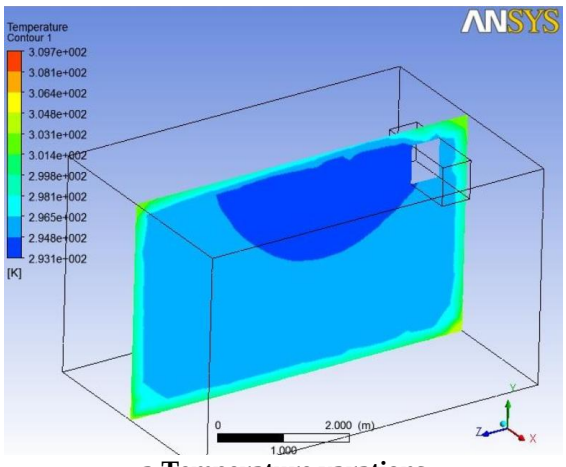
- Temperature - distribution of temperature in the three-dimensional panel of the cabin;
- Density - rate of mass of the air per unit of volume;
- Viscosity - consistency of the air in the conditions of internal friction;
- Specific heat - this is the necessary heat for the unit of mass to increase the temperature in the cabin with a degree Celsius;
- Thermal conductivity - the degree to which a certain material transfers heat, calculated as the ratio of heat flow to the temperature of the temperature.

Computer simulations offer an interesting opportunity to validate related aspects of ventilation, smoke movement, natural airflow, and thermal comfort. The obtained results indicate that different values are obtained for the same cabin dimensions (4 m X 3,65 m X 6 m), depending on the positioning of the air conditioning duct, all simulations being made considering that the temperature in the cabin is 40 ^{0}C, which is higher than the comfort temperature due to the stagnant area of the flow in the back of the chamber.

The three configurations used for the study and the dimensions of the room were the same during the analysis, as follows:

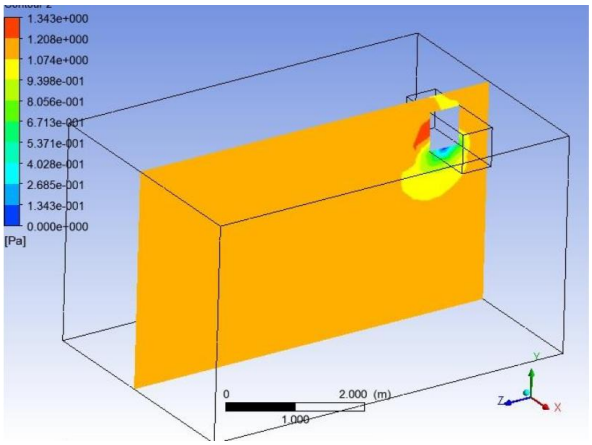
- In case no. 1 the cabin has the specified dimensions, but the air conditioning duct is fitted at a 3 m height above the floor of the cabin, while room temperature is 37 ^{0C}C and the air temperature in the duct at the entrance point of the air conditioning flow is 20 ^{0}C. The temperature of the cabin wall with effect from the temperature of the medium is used in the research is 40 ° C;
- In case no. 2, the conditioning air duct is divided here into two parts: each duct is used at an air flow velocity of 0.39 m/s. Both ducts are placed one in front of the other on the side of the cabin. The first pipe is placed at 3 meters from the base on the left side of the cabin and the second pipe is placed at 3 meters above the base on the right side. The temperature of the cabin is 310 ^{0}K (37 °C) and the temperature of the air at the point of entry of the pipe is 293 K (20 °C), while the speed of the air along both pipes. The temperature of the chamber used in the research is 40 ° C;
- In case no. 3, the pipeline is divided into two parts, each pipeline has an air flow velocity of 0.39 m/s. Both ducts are placed on the roof of the cabin. The thickness of the wall is used for the chamber is 3 cm and the temperature of the cable is 310 ^{0}K (37 °C), and the temperature of the air at the point of the pipe is 29 °C of 0.39 m/s. The temperature of the cabin wall used in the research is 40 °C.

In the figures below are presented the results of the simulation for the other three cases, being also indicated the parameters on which the simulation was concentrated:

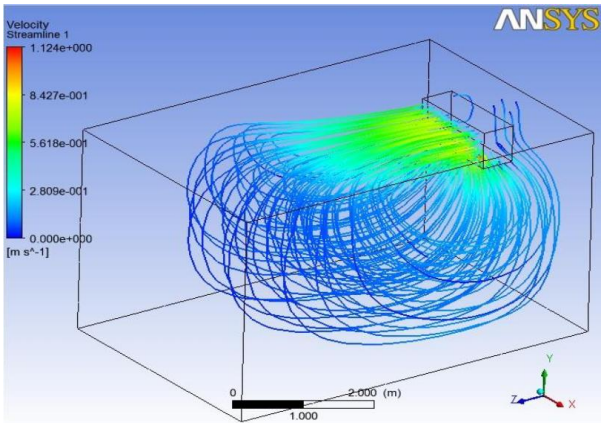


a.Temperature varations

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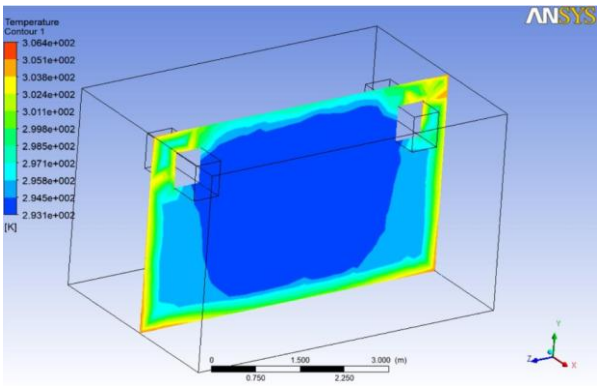


b. Pressure generated by the air conditioning duct

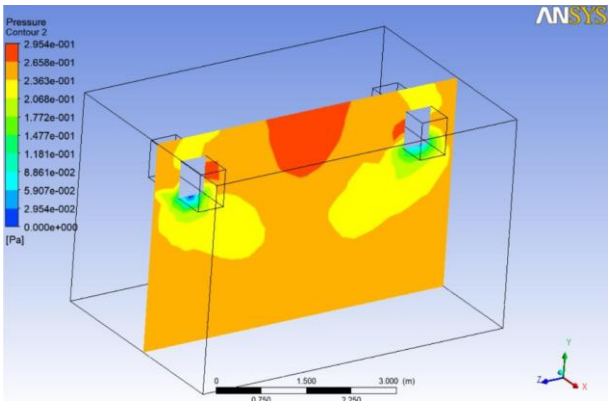


c. Air conditioning flow curves

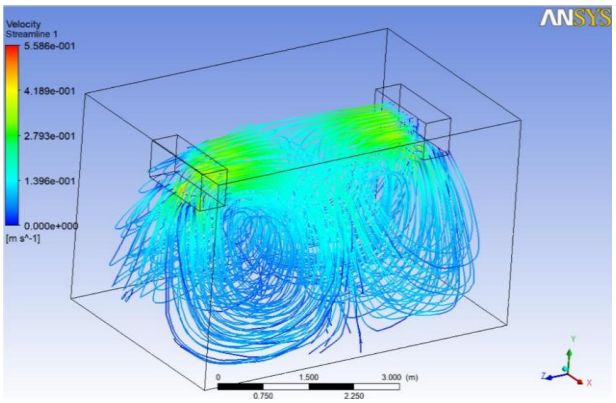
Figure 6 Case no.1 simulations



a.Temperature varations

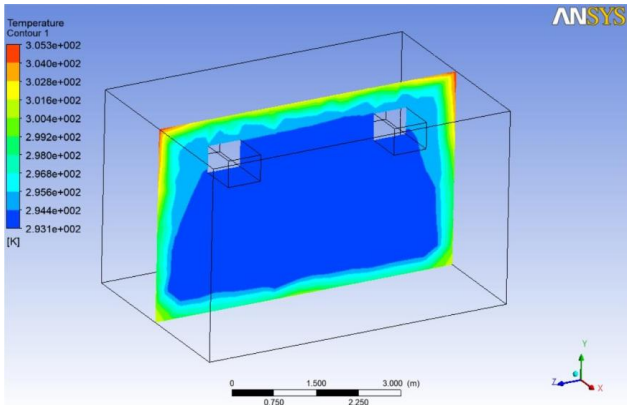


b.Pressure generated by the air conditioning duct



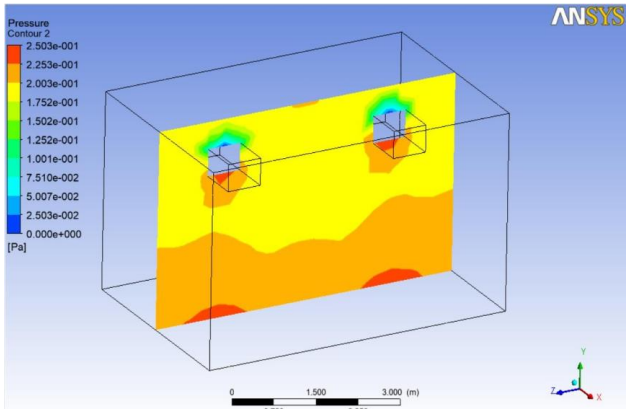
c.Air conditioning flow curves

Figure 7 Case no.2 simulations

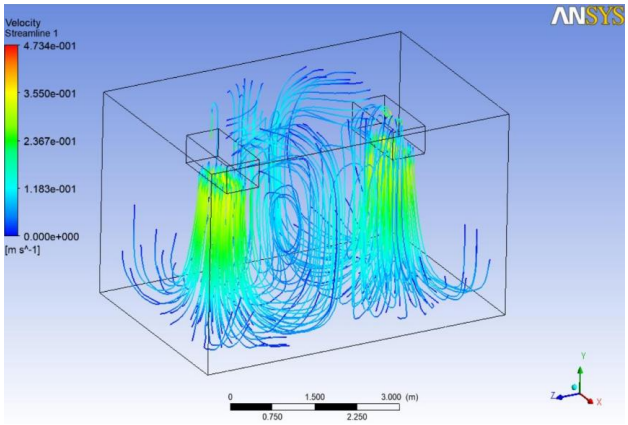


a.Temperature varations

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.07
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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b.Pressure generated by the air conditioning duct



c.Air conditioning flow curves

Figure 8 Case no.3 simulations

The simulation results are presented graphically below:

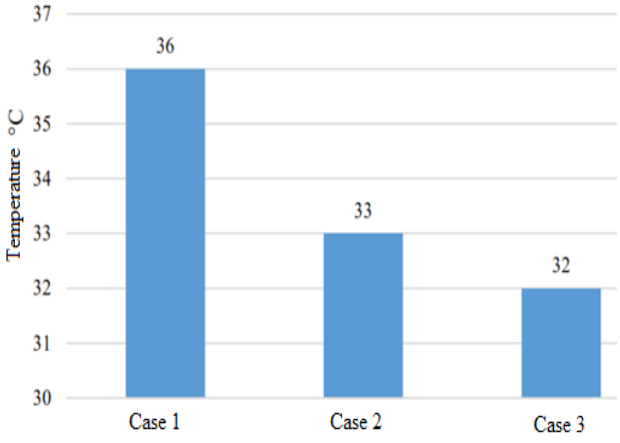


Figure 9 Temperature analysis results

According to the graph above, it was concluded that in case 1, the minimum cooling temperature after an interval of operation is 36 ^{0}C. In case 2 the double pipe used, arranged one in front of the other, led to the attainment of a minimum temperature of 33 ^{0}C, this being recorded somewhere in the middle of the chamber. In case 3, with the double channel used for air flow, but the mass flow rate of the air kept constant, the minimum temperature reached 32 ^{0}C, after the period of operation. Thus, according to the study, it was found that case 3, a double-pipe cabin with air conditioning, but the same mass flow, is a more efficient arrangement for a very short time system.

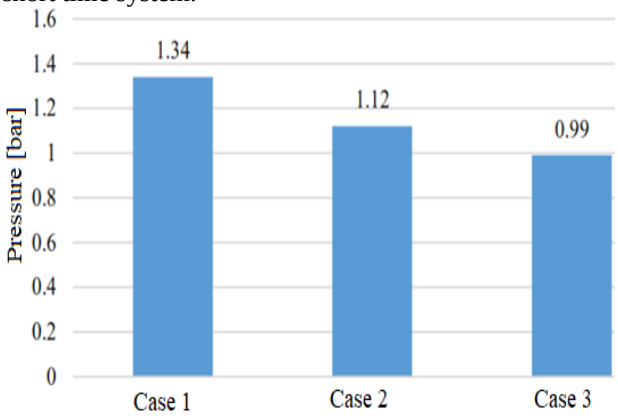


Figure 10 Pressure analysis results

According to the graph above, it is found that in case 1 the cabin has a high pressure inside, compared to others, while in case 3 the cabin has a minimum pressure in front of the other chambers. Therefore, a better circulation of the cooled air in the case is shown.

The way in which the percentage of air volume evolves, as reported in the ambient temperature of the cabin, is presented below:

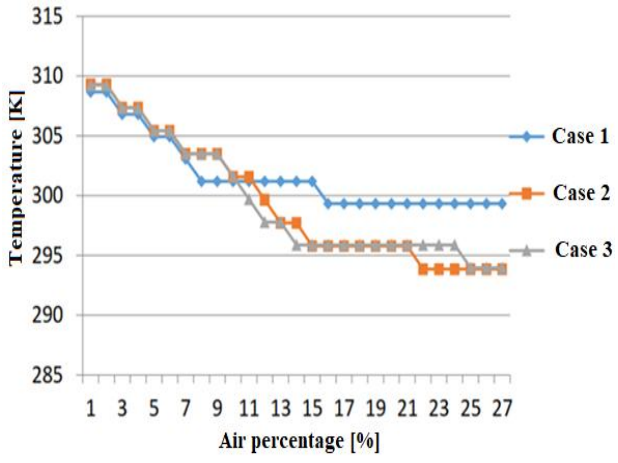


Figure 11 The evolution air percentage reported to the evolution of temperature decrease for the three cases

5. CONCLUSIONS

Cruise ships offer the opportunity to make a special trip, from trips around the world or in unique places to

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.07
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

travel among tropical islands. If at the beginning of the twentieth century cruise tourism was exclusively a luxury tourism and the prerogative of those with very high incomes, today the possibility to make a cruise can be, somewhat, within the reach of anyone. Thus, the choice of the cruise as a holiday destination was burdened by some prejudices: the very high cost, the risks of a sea voyage, the lack of freedom of movement on the ship, the predominant type of tourists present on cruise ships (old, rich, eccentric) etc.

The evolution of the cruise sector in recent years (the replacement of fleets with state-of-the-art vessels, with much increased comfort and safety, the massive renovation of interiors and the addition of new services) have demolished, one by one, these suspicions. In addition, even those prone to seasickness will feel ashore, as ships are equipped with stabilizer systems that reduce the balance almost completely. Compared to traditional holidays, cruising offers some clear advantages, the most obvious of which is the change of scenery every day. At the same time, it allows you to travel long distances and visit in record time places with an extremely diverse nature, culture and civilization.

In order to attract new categories of tourists and to satisfy their most varied tastes, cruises offer them all the services of a five-star hotel: swimming pool, state-of-the-art health treatments and fitness programs, whirlpools, sauna, Turkish bath, shows, bars, restaurants and discos, as well as the prompt and friendly service of the flight attendants. Wheelchair access areas are also available on most vessels, including cabins, showers, special lifts and special health services that can be provided if reservations are made in advance. All these services, which are normally paid separately and in addition to the basic package, are included in the cabin price.

There are no more class I and class II, all services on board being the same for all passengers, the only difference being depending on the floor where the cabins are located and the presence or absence of windows or balcony (a last-minute innovation, which makes some ships real floating hotels). Cruises are not seasonal vacations; there is practically no "dead season" except for destinations like the North Sea, Alaska or South America. Cruises are made in the Mediterranean all year round, as well as in the Caribbean, except in September and October, when there are tropical storms.

Air conditioning systems have played a crucial role in the development of this industry because it has created the necessary conditions to achieve the level of comfort specific to the demands of tourists who prefer such trips.

This simulation is useful for analysing the efficiency of this installation. In this sense, a cabin was imagined for which three variants of installation of the pipe that delivers the air conditioning in the respective area were established. In the first case the cabin was provided with a single pipe, while in the other two cases the cabin was provided with two pipes, arranged in different variants. Using the program design module, the geometry and construction parameters of the cabin were established and the air conditioning ducts were positioned. The main monitored air parameters were temperature, pressure and volumetric percentage. The study allowed to choose the most efficient variant of supplying the cabin with air conditioning in the context of reaching the fastest cooling time of the respective room, an essential criterion for these systems.

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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.08

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

ACOUSTIC SIGNAL ANALYSIS AND CLASSIFICATION BASED ON NEURAL NETWORK ALGORITHMS

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Abstract : This paper presents the results of an innovative approach in the underwater domain of research related to the identification, classification and recognition of maritime targets using acoustic data processed. The "Acoustic Signature" is specific to each target type; it is usually produced by the vibration of the propulsion system of surface vessels caused by their radiation into the water. Therefore, the processing of the frequencies generated by these vibrations is essential for the analysis and the classification of different target type.
The purpose of this study is to build an alternative method to identify and classify targets with passive sonars using the TPWS (Two - Pass Split - Windows) filter.
In this process, the signal generated by the target is processed in time frequency domain. Then a TPSW algorithm is applied in the frequency domain to reduce the background noise and enhance the frequency lines of the target noise. Finally, an artificial intelligence model is applied to classify targets, taking as inputs the narrowband and the broadband analysis. This classification is based on deep learning process, relied on the training, validation, and test phases in order to enhance the accuracy and reduce the loss. Our results showed that the suggested method is accurate (appx 83.5% SNR = 0db), depending essentially on the signal/noise ratio.
Key words: Passive sonar, Target analysis, Submerged target, Classification, Filter, Narrowband Analysis, Artificial intelligence, Target noise.

1. INTRODUCTION

The underwater domain remains a vital domain for various aspects of research. Indeed, civilian and military scientists and operational staff are engaged in a race to apprehend this aera of interest. In this perspective, research based on the most important asset in undersea exploration is the SONAR (Sound Navigation And Ranging) that has a growing importance and cruciality. Due to the complexity of the propagation characteristics of acoustic waves, depending on the effects of absorption or attenuation and the change of undersea celerity [1], the detection and classification of underwater targets remain a vital area of research in need of tangible results.

The processing of undersea acoustic waves generated by various targets is a major way to achieve the objective of classification, identification and localization [2]. In the domain of civilian and military maritime navigation and operations, the processing of the valuable data by sonar is done by two different ways: passive and active [3]. In the first way, a received echo from the bounce of a multi-frequency pulse is processed, in order to locate and classify eventual targets. Differently in the second way, there is no emission by sonar. There is only a continuous reception of environmental sound [4].

Undersea detection relies on sonar systems, which are capable to process any surrounding sounds information to produce and emerge possible sonar contacts [5].

Beside this, the undersea environment suffers from many kinds of noise coming from various sources. This noise could be generated by fish or any other environment event (rain, waves….) causing difficulty to process data from collected sound by sonar. In passive detection, the study of the undersea noise is important in order to extract from raw data the valuable information capable to identify targets.

The conventional solution used today to identify ships and naval systems was based on the acoustic signals radiated by each target. [6]. Therefore, the sonar systems use different techniques to process raw data received by the system in order to identify and classify sonar contacts. The implementation of DEMON (Detection Envelope Modulation On Noise) and LOFAR (LOw Frequency Analysis and Recording) analysis are the keys for sonar processing functions [7]. Indeed, taking more time and less accurate, this conventional

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.08
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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approach has many difficulties to classify undersea targets.

In this perspective, we have opted to implement a new technique for the classification of different underwater targets. In fact, Deep Learning is a new technique based on Artificial Intelligence field, proposed by Hinton in 2006 [8] and which can offer many interesting features. Nowadays, it has made a revolution in the fields of image recognition and sound analysis. In our case, Deep Learning is able to classify contacts from results of LOFAR and DEMON processing using a multi-layer learning algorithm based on Convolutional Neural Network (CNN). Our work aims to use this network to identify the underwater acoustic targets using a valuable dataset of recognized targets.

2. CLASSICAL METHODS

2.1 Genetic Algorithms:

The term genetic algorithm, almost universally abbreviated nowadays to GA, was first used by John Holland [9], whose book Adaptation in Natural and Artificial Systems of 1975 was instrumental in creating what is now a flourishing field of research and application that goes much wider than the original GA. Many people now use the term evolutionary computing or evolutionary algorithms (EAs) in order to cover the developments of the last years. The main drawback of GAs is premature convergence. The chaotic systems are incorporated into GAs to alleviate this problem. The diversity of chaos genetic algorithm removes premature convergence. Crossover and mutation operators can be replaced with chaotic maps.

Tiong et al [10] integrated the chaotic maps into GA for further improvement in accuracy. Moreover, Crossover and mutation operators are the integral part of GAs. Therefore, if the mutation is not considered during evolution, then there will be no new information available for evolution. If crossover is not considered during evolution, then the algorithm can result in local optima. The degree of these operators greatly affects the performance of GAs [11].

2.2 Fuzzy Logic:

Fuzzy logic was first introduced in 1965 by Lotfi A. Zadeh [12] with the concept of fuzzy sets as an extension of the classical set theory formed by crisp sets. Later he defined a whole algebra, fuzzy logic [13], which uses fuzzy sets to compute with words as an extension of the proper operations of classical logic. In most cases a fuzzy logic system is, in fact, a nonlinear mapping of an input data vector into a scalar output where this relation is defined by linguistic expressions which are obviously computed with numbers. Thus, a fuzzy logic system is unique in that it is able to handle numerical data and linguistic knowledge. The richness of this logic is that there are many possibilities which lead to many different mappings. Since the rules are based on predetermined rules, the decision-making process is based on fuzzy logic. If these rules are flawed, the results may not be acceptable at all. Choosing a membership function and basic rules is one of the most challenging parts of creating fuzzy systems. On the other hand, the implementation of fuzzy logic in standard hardware requires multiple and time-consuming experiments and the efficiency of fuzzy logic in recognizing the pattern is less than the neural network in machine learning which it is less covered in Data Science. Moreover, the use of fuzzy logic may become an obstacle to the verification of system reliability and requires tuning of membership functions Fuzzy Logic
control may not scale well to large or complex problems Deals with imprecision, and vagueness, but not uncertainty. [14]

3. NEW APPROACH

3.1 DEMON-LOFAR analysis and neural network algorithms:

LOFAR and DEMON analysis are the most efficient means of signals analysis in signal processing theory [7]. From signal in time domain, the sonar must mainly compute three different features:

- Broadband signal or continuous spectrum;
- LOFAR signal or discrete spectrum;
- DEMON signal allows to assess whether there are intermodulation products such as broadband cavitation noise, which is modulated with low frequency lines from the propeller rotation.

LOFAR (Low Frequency Analysis & Recording) analysis can be considered as a broadband spectral analysis covering the expected range of noise of the controlled object. Signal normalization by implementing a task-specific algorithm, which consists in estimating the background noise present at each spectrum and computing a normalized frequency range, based on the determined normalization factor. This estimation allows ensuring the removal of signal bias and peak equalization. The frequencies of interest are generally in the band [0-1000Hz]. After filtering out all other frequencies, we decimate the output signal according to the Nyquist-Shannon law:

In addition, DEMON analysis is a narrowband analysis used for cavitation noise processing with subsequent accumulation of data obtained from the controlled object. In terms of practical implementation, DEMON analysis allows to separating the cavitation noise from the overall signal spectrum and to estimating the number of shafts, their rotation frequency, and blade rate. Since this analysis provides comprehensive information about the target propellers [15], it is also quite useful for target detection purposes.

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.08
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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The frequencies of interest are usually in a small frequency band limited to [0-400Hz]. To obtain normalized peak energy, we applied a TPSW algorithm [15] with specific parameters adjusted after laboratory experiments to obtain more satisfactory results for LOFAR and DEMON visualization.

3.2 Generating the dataset

In the context of deep learning and in particular supervised learning, we need to have a labelled dataset. Thus, this work is based on three kinds of datasets:

- A set of LOFARgram labelled images
- A set of DemonGram labelled images
- A set of Spectrogram labelled images

Each set has 1200 images of 5 different classes: cruisers, cargo ships, passenger ships, frigates, and fast patrol boats. These images are taken from different hydrophones which are installed in the entrance of a harbour. For a matter of efficiency, we applied some pre-processing techniques on the acoustic raw data to improve the signal to noise ratio. In addition to that, we took precautions to prevent noisy environmental conditions from influencing the signal (by using shielded cable).

The images are labelled by an expert, taking into consideration the data that has been acquitted by the hydrophone and the CCTV installed in the entrance of the harbour. Then, they are sorted per category and per class.

Table 1. Categories and classes

Lofagram	Demongram	text table
Cruiser	Cruiser	Cruiser
Cargo ship	Cargo ship	Cargo ship
Passenger ship	Passenger ship	Passenger ship
Frigate	Frigate	Frigate
Fast patrol boat	Fast patrol boat	Fast patrol boat

3.3 Deep learning approach

We used a standard convolutional network called VGG16 to train our model. The network contains 5 convolutional layers and uses the ReLu activation function. This model takes as input lofargram, demongram and the spectrogram.

The Convolutional Neural Network (CNN) is a multi-layered acyclic network that has two parts quite distinct. As input, an image is provided in the form of an array of pixels comprising 3 layers. The image is represented by three dimensions of depth 3, to represent the fundamental colours [Red, Green, Blue].

The first part of a CNN is the convolutional part itself. It works as a feature extractor from the image.

An image is passed through a succession of filters, or kernels, creating new outputs called map of features. In the end, the map feature is flattened and concatenated in a feature vector. We flatten the output of the convolutional layers to create a single long feature vector. And it is connected to the final classification model, which is called a fully-connected layer, called RNC code. This CNN code on the output of the convolutional part is then connected to the input of a second part, composed of fully connected layers (multi-layered perceptron).

The CNN training then consists of optimizing the coefficients of the network, from random initialization, to minimize the classification error at the output. In practice, network coefficients are modified in order to correct the classification errors encountered, using a gradient descent method. These gradients are back-propagated in the network from the output layer, from which comes the name back-propagation of the gradient given to training algorithms for neural networks. Indeed, to be able to appeal to the back-propagation, one must have a collection of images for which we already know the category to select. In other words, it is necessary to have a multitude of recordings of the acoustic noise radiated from the targets of different categories to generate their LOFAR-GRAM, DEMON-GRAM and Propeller sound of each recording. That being said, we did collect several samples belonging to several targets of different categories.

To start learning the RNC, first of all, we select the data from Training. These are composed of three images of each sample with the corresponding category. It is also necessary to define the maximum number of iterations to be carried out, and finally the maximum learning rate of the network.

For the sake of this project, we aimed to do three experiments using the 3 sets defined previously. Our main objective is to do a comparison of the three methods based on some evaluation metrics such as 'Classification accuracy' and 'Confusion matrix'.

- Classification Accuracy is what we usually mean, when we use the term accuracy. It is the ratio of number of correct predictions to the total number of input samples.

$$Accuracy = \frac{Number\ of\ correct\ predictions}{Total\ number\ of\ predictions\ made}$$

- Confusion Matrix as the name suggests gives us a matrix as output and describes the complete performance of the model.

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.08
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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n=165	Predicted: NO	Predicted: YES
Actual: NO	50	10
Actual: YES	5	100

Figure 1 Confusion Matrix

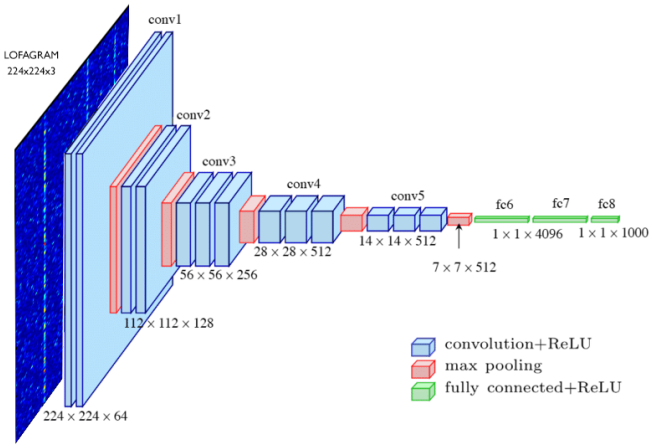


Figure 2 The architectural model used for classification using the Lofagram dataset

4. EXPERIMENTS AND RESULTS

In this section, we will implement the different learning stages from CNN based on the data and methods mentioned above. All classification experiments performed use the same deep learning architecture. The results obtained were validated by data different from those injected during the learning phase.

4.1.Lofagram- Classification using Confusion Matrix.

In the first stage, we tried to explore the classification performances based on lofargram images with a resolution of (224x224). The results of the lofargram study case are promoting. The results are shown in the above figure. As we can see, the proposed architecture predicts well the five classes. Some minor errors are shown in the classification of cruisers, that's because their lofargram is quite similar to cargo ships and to frigates.

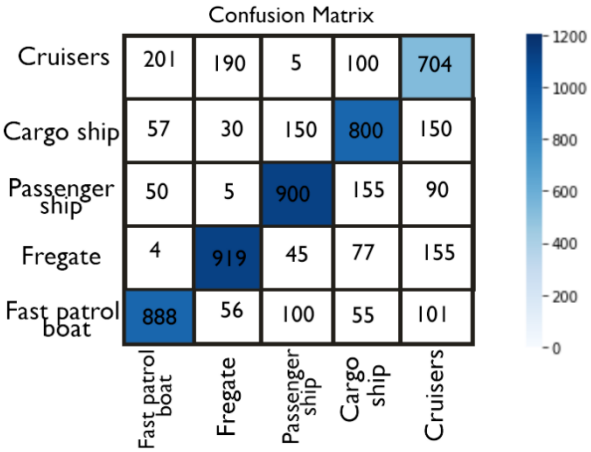


Figure 3 Confusion Matrix of the classification using lofargram dataset.

4.2 Demogram-classification

In the second stage, we took advantage of the demongram dataset to classify the same classes discussed previously. Demongram is likely to consider the speed of the propeller in revolutions/minutes, as well as the number of blades of the target. As a result, the classification has showed some good results, especially when it comes to differentiate between ships which have different blade sizes. In our case, the results are presented in the following table:

Table 2. Categories and classes

Class	Validation Accuracy
Fast patrol boats	83.5%
Frigates	79.2%
Passenger ships	81.6%
Cargo ships	65.8%
Cruisers	80.5%

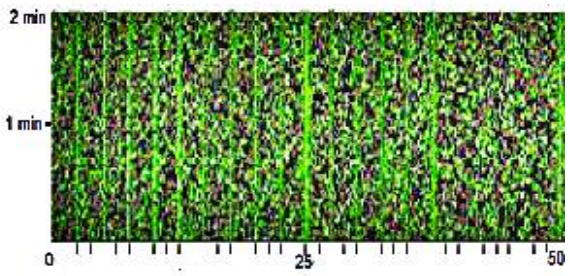


Figure 4 The LOFARGRAM corresponding to a frequency range of 0 to 4200 Hz

4.3 Spectrogram base experiment

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.08
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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In the third stage, our main objective was to find out whether our Artificial Neural Network can predict well the classes of ships based on their spectrogram image. We performed some preprocessing on the dataset to reduce the ambient noise and to convert our raw data to images. The images will construct the main dataset which will be injected to the proposed network. As we can see in Figure 4, the results were not so satisfying. Indeed, we have found that the spectrograms depend on the range between the hydrophone and the ship. In addition to that, our proposed model classifies badly the big ships. It confuses between cargo and passenger ships and can't differentiate between passenger ships and cruisers. However, it classifies well fast patrol boats. The results of this experiment are shown in the graph below.

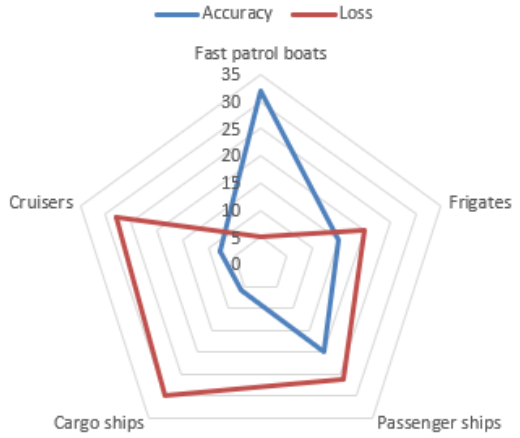


Figure 5 Validation metrics

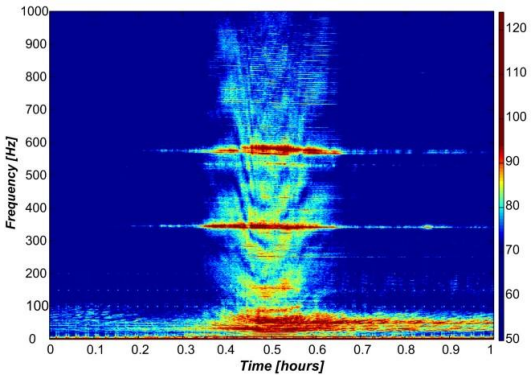


Figure 6 Spectrogram of a container

5. CONCLUSIONS

The main goal of this research was to design a neural network capable of identifying the acoustic signature of a given passive sonar target. To achieve this, we followed these basic steps. First, we processed the signal emitted by many recorded propeller noises and classified them into two categories: ***fishing vessel*** and ***merchant vessel***. Then, we created a program that can generate LOFARGRAM, DEMONGRAM and the Propeller sound of each category. Another program is created to train a CNN model to recognize the target's signature. Once the training was completed, we tested the neural network scheme by providing new target samples that helped us to evaluate the performance of the CNN model.

Our results show that a neural network could be implemented to recognize an acoustic signature by combinig three different steps using separately, Lofagram, Demogram and spectrogram.

We observed that the training of a neural network can process very lengthily, but by optimizing the dataset, adjusting the learning parameters, and using the appropriate threshold function, we could speed up the whole training process. Additionally, we found that by choosing a suitable neural network architecture and combining different training examples, we can significantly improve the overall performance of the CNN model.

Finally, we noticed that neural networks are not 100% foolproof. It is possible that a target maybe identified as another target under certain conditions. This limitation can be improved by retraining the model with a better and large dataset. Moreover, the preprocessing of input data using the appropriate signal processing techniques to improve the signal-to-noise ratio can help specify the performance of the neural network. Consequently, neural networks can be vials in some situations where human pattern identification qualities are required. This technology is a viable option for improving sonar systems. Other categories of vessels will be implemented in the program to classify different kinds of ships. In addition, different signal processing algorithms based on statistical methods such as non-negative matrix factorization [17] and convolutive blind separation [18] may be applied to improve passive sonar target classification. These aspects will be addressed in a future work.

6. ACKNOWLEDGMENTS

This research was partially supported by the CNRST Morocco, program URAC. The authors thank Pr. E.BEN LAHMAR, International IT expert and CEO of DataScienceToday.net, of Hassan II University-Casablanca, for helpful discussion.

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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.09

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

ONLINE THERMODYNAMICS EDUCATION UNDER PANDEMIC TIMES, IN CONSTANTA MARITIME UNIVERSITY

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Abstract: As well known, the day of 11 March 2020 will remain in the history as the day in which The World Health Organization (WHO) has declared COVID-19 a pandemic. Under these circumstances, the international higher education was forced to remove the campus activities in online. Constanta Maritime University is one of the universities across the world which moved the educational process from face- to- face to online learning. This was a challenging task for the academic, managing and technical administration and for the students, as well. This paper focuses on the disciplined entitled Thermodynamics 1, encountered in the curricula of the Electromechanics Faculty, Constanta Maritime University. The paper describes the steps done during the online education along the semester, both by students and lecturers. At the end of the semester, students and lecturers had to face another challenge: the online examination. Since in the new conditions, the students had to gain the same knowledge as during the classic educational process, we are providing the results obtained by our students. Their exam was scheduled on June 26, 2020. The number of students attending the online examination was 108. The online report for the examination, available on the online platform of the university, indicates that online 17 students were not able to pass the examination (grade 5). The same chart data shows that 19 students have obtained grades in the range (8,00- 8,50), while 2 students obtained grades in the range (9, 50- 10,00). These results are considered to be encouraging for lecturers and students. This type of examination it is seen as a potential long term examination manner, given its benefits: online generation of the test, online verification and not last, transparency.
Key words: online, pandemic, students, thermodynamics.

1. INTRODUCTION

The dynamic of international economy is reflected also in the shipping activity, marine engineers having to face the challenge related to the competitivity, as well as engineers from all other sectors. In these conditions, future marine engineer's education has to reply to the need of providing skilled professionals, with high values and creative attitudes [1]. As a result of the economic growth, maritime activities are of great importance in EU, which under pandemic auspices is offering consistent financial resources to its member for reforms and investments [2]. In this context, quality education for students enrolled in maritime higher academic institutions is a pylon of a flourishing maritime sector [3]. Thermodynamics is seen as a discipline with a high level of difficulty that has to prepare students to deal with topics of energy, thermodynamics principles and their application on board the ships [4], [5].

Covid-19 lockdown forced education establishments to suspend their face-to-face educational process and to rapidly adapt to the online learning, with no negative impact on the opportunities, learning experience and employment, by taking into consideration the perspective of long time e-learning activities [6], [7], [8].

In Constanta Maritime University, Thermodynamics 1 is an imposed discipline, found in the curricula of students enrolled in the Electromechanics Faculty, year 2, second semester. The activities specific to this discipline are carried out during 42 course hours and 28 seminar hours. This course aims to ensure knowledge regarding the study and understanding of processes encountered in machines and plants on board the ships, in which energy exchanges occur in the form of heat and work.

In March 2020, Romanian educational system moved online. Under these conditions, thermodynamics lecturers from Constanta Maritime University had to deal with online teaching and learning, providing student skills reflected in a good performance after their final examination. We were motivated by studies indicating that there is no significant difference in the performance between online and face-to-face classroom activities [9].

In this study are described the efforts done by the lecturers in order to ensure the achievement of same knowledge - as during classic educational process. The following challenge faced was the online examination. The assessment of the results obtained by our students is

Journal of Marine Technology and Environment
DOI: 10.53464/JMTE.01.2022.09
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

of a great significance, since they were facing for the first time this type of performance examination. This aspect is very important, since examination represents a strong tool useful to identify individual accomplishment [10].

2. METHODS AND MATERIALS

The online Thermodynamics 1 education activities are delivered through out e-campus platform, developed by Constanta Maritime University. Immediately after lockdown announcement, students and lecturers were intensively trained in the platform use. A guide to a friendly use of the e-learning platform was released. Lecturers have built the online course and seminar materials so that students can take advantage of both synchronous and asynchronous classes, by an easy navigation process. The platform allows students to fulfil their different tasks, by the use of any personal device.

The online Thermodynamics 1 course is structured into an introduction and several units.

The introduction contains information on the following aspects:

- objectives
- course content
- supplementary resources
- methods and instruments of students' performance assessment.

The content of course is divided into units aiming the gradual learning. Each unit is developed in order to be delivered in 100 minutes and it is structured as follows:

- unit objectives
- learning instructions
- theoretical knowledge and examples
- summary and conclusions
- self-assessment tests
- solving and answers for each test
- unit references

According to the schedule, students and lecturers had access to the platform by login with their usernames and passwords. By clicking "curs video", as seen in Figure 1, students and moderator are together in the virtual classroom (Figure 2).

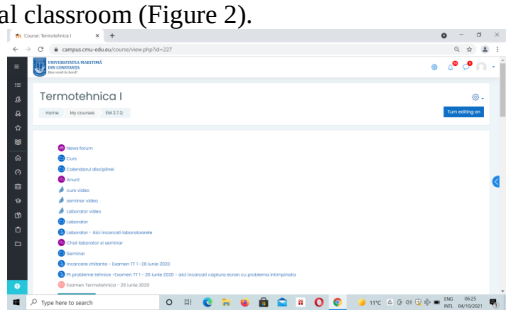


Figure 1 The page of Thermodynamic 1 on e-Campus

Students and lecturers access the page of the discipline. As seen in Figure 1, specific activities are permitted, such as life attending to course or seminar classes (curs video and seminar video) or examination (Examen Termotehnică – 26 June 2020). In special folders, students will find the course and seminars materials, specific to Thermodynamics 1 (Curs and Seminar).

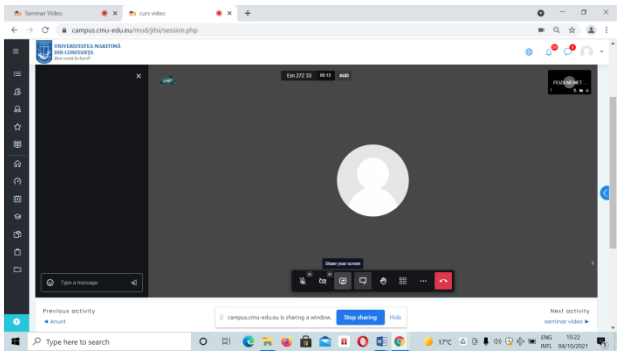


Figure 2 Access to the video course activity

The lecturer is able to present the educational materials by clicking the "share your screen" button.

Students are able to interact with their teacher and mates by starting their cameras and microphones and also by typing a message.

For the final examination of the students, lecturers had to prepare a bank of questions with 300 questions, in order to develop a multiple choice examination. Thus, each question has 3 options, only 1 being the correct one.

The online examination of the discussed discipline took place on 26 June. The lecturers option was that the platform will generate a quizz containing 25 questions, for the solving being allocated 30 minutes. The number of allowed attempts was 1. As seen in Figure 3, 108 students had attempted the examination.

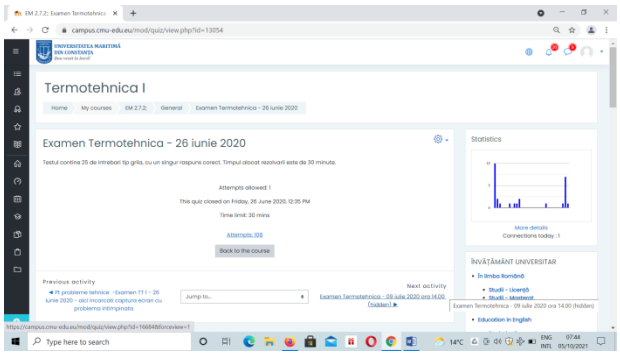


Figure 3 Information regarding the first online examination

The e-Campus platform is able to generate also a chart, indicating the grade ranges achieved by different numbers of students (see Figure 4).

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ISSN (Print): 1844-6116
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In order to continuously improve its educational and training programmes, Constanta Maritime University monitors the performance of its academic staff through-out a final evaluation questionnaire of each discipline, submitted to the students, after their final examination. The questionnaire contains 10 questions, for each question students have to allocate a grade in the range 1÷5, 5 meaning the maximum level of satisfaction.

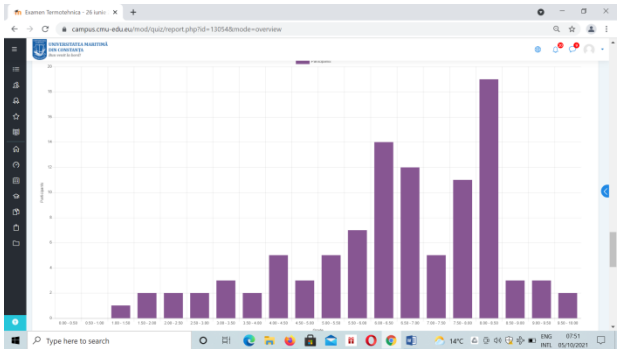


Figure 4. Overall number of students achieving grade ranges

Table 1 Discipline Thermodynamic 1: Evaluation Report

Q1	Are you the beneficiary of clear and useful information by attending to this discipline?	5
Q2	Have you been rigorously inform by your lecturer regarding the objectives, contain and evaluation, at the beginning of the semester?	5
Q3	Do you consider that your lecturer had a proper interaction with you during the online teaching process?	5
Q4	Do you consider that the e-Campus platform was a strong tool for going knowledge?	5
Q5	Do you consider that the seminar activity had a proper contribution to the understanding of the theoretical knowledge provided during course activities?	5
Q6	Do you consider that the course units, available on the page of the discipline had a significant contribution for a better understanding of the delivered information?	5
Q7	Do you consider that the tasks of this discipline present an amount and difficulty level adequate to the student capacity?	4.71
Q8	Do you consider that the online examination properly reflects your gained knowledge?	4.86
Q9	Do you consider that your online evaluation was correctly carried out?	4.86
Q10	Do you consider that during the online teaching and training process were respected the ethics and academic conduct rules?	5

In Table 1 are provided the results of the evaluation questionnaire, specific for Thermodynamics 1, taken from the overall Report of Constanta Maritime University.

3. RESULTS AND DISCUSSIONS

The success of the online education and evaluation of both students and lecturers is reflected into the results obtained by our students after their first experience regarding the online evaluation and also in the student satisfaction-measured through out the above mentioned questionnaire.

The analysis done after the first online examination indicates that 75% of the examined students were able to be successful in their final examination (grades between 5÷10). Good scores are seen for 51% of the students (grades between 7÷10). Very good results were obtained by a number of 27 students, as follows:

- grades between 8.00 – 8.50: 19 students
- grades between 8.50 – 9.00: 3 students
- grades between 9.00 – 9.50: 3 students
- grades between 9.50 – 10.00: 2 students

These results are the reflection of the efforts done by students and lecturers as well, during the pandemic times.

The fact that lectures focused seriously on the transition from the traditional face-to-face class to online activities is reflected in the level of student satisfaction. The overall grade obtained to the questionnaire specific to the evaluation of Thermodynamic 1 discipline is 4.93, 5 being the maximum.

4. CONCLUSIONS

This paper exemplifies how lecturers and students managed to adapt rapidly to the online education and training and examination, during pandemic times. The focus was on the discipline called Thermodynamics 1, hosted in Constanta Maritime University.

After the first semester spent in the virtual environment, the results obtained by our students after their first online examination experience is more than encouraging: 75% of the students have been successful, 16% of the students being able to get grades in the range 8.00-10.00.

The efforts done by the lecturers in the service of this discipline was recognized by the students, which

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.09
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

assessed their activity with a score of 4.93, the maximum awarded score being 5.

In comparison with the results obtained by the students after the classic evaluation, the presented results appear to be better.

Since for each question, students had only 1.2 minutes to provide the correct answer, the results are not a subject of doubt.

The explanation might be that the quiz solving was done on their personal devices, in a friendly environment.

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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.10

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

NUMERICAL ANALYSIS OF THE BEHAVIOR OF PRESSURE VESSEL SUBJECT TO VARIABLE REQUESTS USING THE FINITE ELEMENT METHOD

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Abstract: The behaviour of a metallic material subjected to the action of a variable stress (which generates mechanical stresses in the material with variable intensities over time) differs significantly from that corresponding to the action of constant or monotonically increasing stresses which do not change in intensity over time or which increase continuously in intensity as time passes), its rupture may occur even if the intensity of the mechanical stresses generated during the stress σ is less than the tensile strength of the material Rm. The article studied the static and dynamic behaviour (fatigue) of an equipment consisting of a jacket and two semi-helical lids.
Key words: finite element, fatigue, pressure, equipment, tension, FEM

1. INTRODUCTION

If we analyse the operating regime of the equipment (static devices) that make up the petrochemical and refining installations (and other similar technological installations, in the chemical, energy industry, etc.) it can be seen that there are premises for most of them to be included. in the category of metal constructions with variable stresses in operation, which degrades due to the phenomenon of fatigue. A statistic compiled by the European Pressure Equipment Research Council - EPERC, the conclusions of which were summarized in the histogram in Figure 1, shows the share of equipment (metal constructions such as pressure vessels, tanks, pipes, platforms, etc.) subject to variable in-use demands (in total used equipment) in various industrial fields (installations).

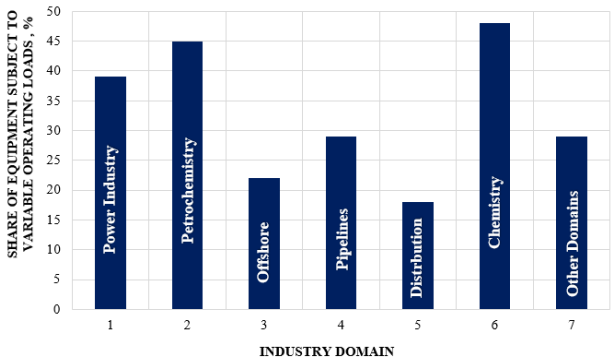


Figure 1 Share of equipment subject to variable operating loads (total equipment used) in various industrial areas (installations)

Proper in-service behaviour of stable metal Pressure vessel that make up petrochemical and refining technological installations is ensured if the following mechanical actions are taken into account when designing this equipment [1,2,3,4]:

- Internal and / or external pressure of fluids or working environments;
- Own weight of Pressure vessel;
- The maximum weight of the contents of the Pressure vessel under the operating conditions;
- Weight of water or liquid used in mechanical strength tests of Pressure vessel;
- Wind and loads of snow, frost or ice;
- Stress due to earth movements (earthquakes);
- Other mechanical loads or loads borne by Pressure vessel, including those acting on them during transport or installation.

Given the multitude of mechanical actions (charges, loads) to which pressure vessels are subjected, various cases of mechanical stress must be considered in their design, which can be classified as follows [5,6,7,8]:

- Cases of normal loading, operation, in which the charges and loads acting during the operation of pressure vessels under normal (normal) conditions are considered, including during the periods of shutdown and / or start of the technological installation of which these vessels are part;
- Cases of exceptional loading, which consider mechanical stresses that could act during events (with low probability of occurrence), such as earthquakes, explosions inside Pressure vessel, etc., which require rapid unloading of Pressure

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.10
ISSN (Print): 1844-6116
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vessel and rigorous verification of their technical condition before re-commissioning.

- Cases of loading to verifications, in which the loads and loads acting during the tests to which the Pressure vessel are subjected after manufacture and / or after carrying out corrective maintenance work are considered.

2. STATIC ANALYSIS OF AN EQUIPMENT USING FINITE ELEMENTS METHOD

The stress analysis method is based on the behaviour of pressure vessels considered as thin-walled coatings, in which case the classification of stresses into membrane stresses and bending stresses, as they are identified in theory, is easy to do. Difficulties arise when the primary analysis, in which the pressure vessel is considered as a thin coating, is not used, and the finite element analysis of the Equipment uses axially symmetrical or three-dimensional elements.

In a first step, a statically pressurized Equipment was analysed. The equipment (Figure 2) consists of a jacket (diameter Ø406 mm, 5 mm thick and 1000 mm long), 2 blind flanges (DN60 and DN 50), 2 semi-ellipsoidal bottoms 8 mm thick and 2supports.

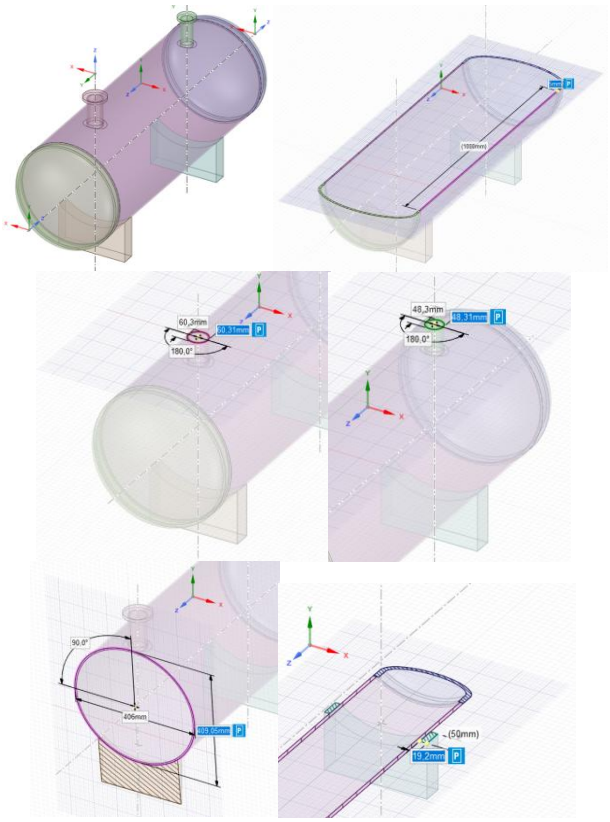


Figure 2 Equipment under analysis

Numerical analyses were performed taking into account that the pressure inside the Equipment is applied in steps of 10 bar up to 50 bar (figure 3).

	Steps	Time [s]	Pressure [MPa]
1	1	0,	0,
2	1	1,	1,
3	2	2,	2,
4	3	3,	3,
5	4	4,	4,
6	5	5,	5,
*			

Figure 3 Successive application of pressure

The results of the static analysis are presented in the sequence of images in Figures 4 ... 6.

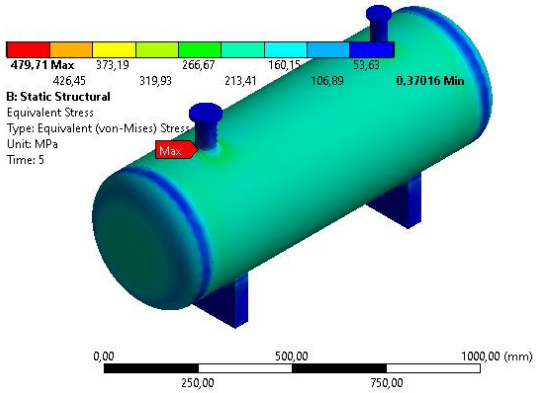


Figure 4 The state of tension in the equipment

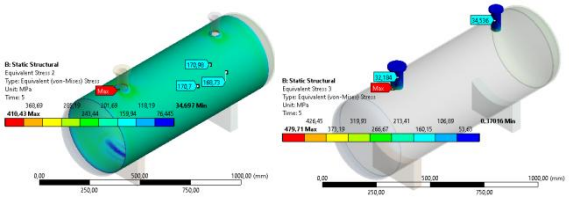


Figure 5 The state of tension in the jacket and connections

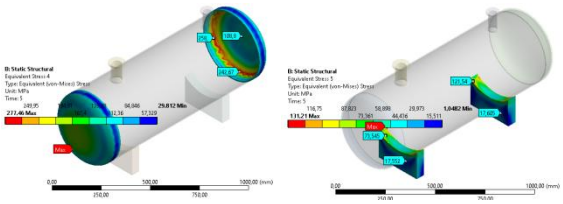


Figure 6 The state of tension in the jacket and connections

The mechanical stresses that are taken into account when evaluating the static behaviour of a pressure vessel are determined (calculated) by a stress analysis on the vessel considered to be free from defects.

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Technology and Environment
DOI: 10.53464/JMTE.01.2022.10
ISSN (Print): 1844-6116
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3. ANALYSIS OF FATIGUE BEHAVIOR OF AEQUIPMENT USING FEM

When evaluating the fatigue behaviour of pressure vessel, special attention shall be paid to determining the states of mechanical stress and specific deformations which are generated during each of the stresses to which they are subjected. When establishing them, the method of stress classification recommended in modern standards (EN13445, BS 5500 etc.) must be applied. This method, also known as "stress analysis", applies to pressure vessels of all categories and consists of determining the states of mechanical stress generated by the elastic domain at all points of a vessel and verifying their admissibility on the basis of appropriate evaluation criteria. Assessment of fatigue behaviour can be done using the finite element method - FEM [5].

The material characteristics used in the fatigue analysis are shown in Figure 7, the data used for the analysis being implemented in the theoretical diagrams presented below.

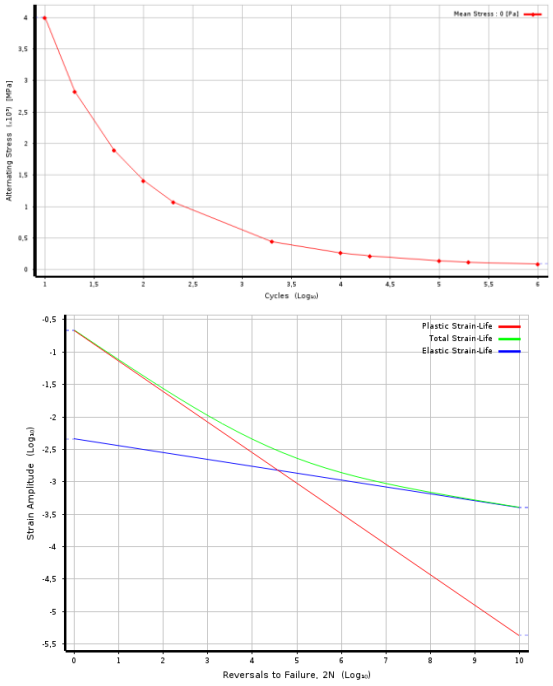


Figure 6 Wöhler theoretical diagram used in numerical analysis

The research was carried out taking into account an alternating stress at which $\sigma_{min}=-\sigma_{max}$ ($R=-1$), an alternating-symmetric stress and an undulating stress at which $\sigma_{min}= 0$ ($R= 0$), as presented in figure 7.

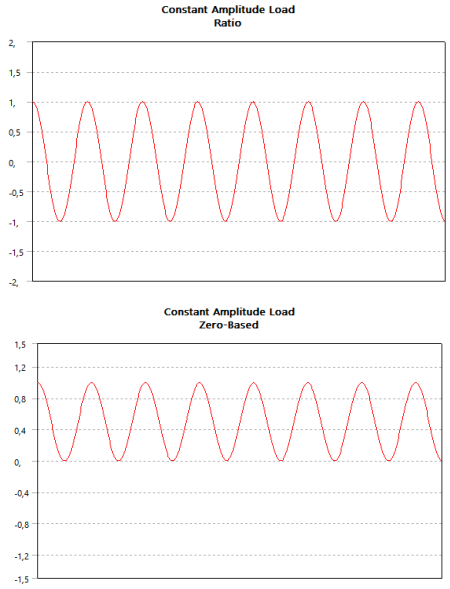


Figure 7 Loaded fatigue stress for Equipment

The analysis of the fatigue phenomenon was performed taking into account the Goodman tension amplitude correction method (see figure 8).

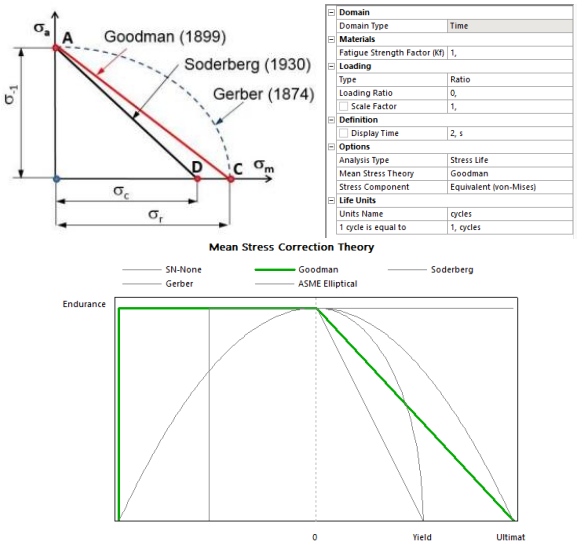
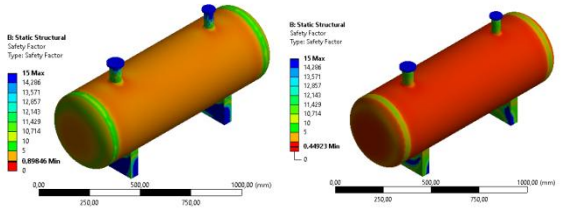
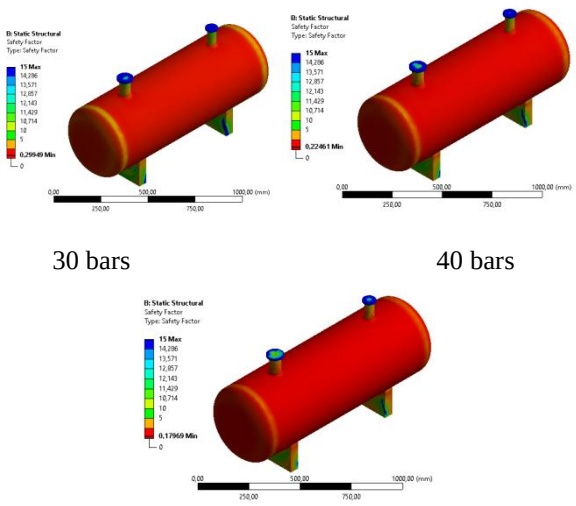


Figure 8 Loaded fatigue stress for Equipment



10 bars 20 bars

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.10
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
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30 bars 40 bars

50 bars

Figure 9 Safety factor for R = -1

The results of the numerical analysis of the fatigue phenomenon (minimum number of cycles to failure, safety factor and diagram of stress cycles) to which the Equipment is subjected, required with internal pressure in 5 steps of 10 bar up to a maximum of 50 bar, are shown suggestively in the sequence of figure 9.

4. CONCLUSIONS

The analysis of the results obtained in the case of static stresses can be used for the optimal choice in terms of load-bearing capacity of the Equipment given that, at a pressure of 50 bar, the maximum stress has a value of ≈ 410 MPa for the jacket in the concentrator area. tension represented by welded joints and ≈ 200 MPa in the body of the jacket. The state of tensions in the bottoms / covers and supports are below the level of the tensions in the jacket.

The phenomenon of fatigue, associated with a variation in pressure (steps of 10 bar, maximum 50 bar), analysed numerically using FEM led to the following general conclusions:

- In the case of a pressure of 10 bar, the number of cycles up to a possible failure is $5{,}7 \times 10^5$ and with a safety factor of ≈ 0,9, the Equipment being able to be operated under operating conditions;

- At a pressure of 20 bar, the number of cycles up to a possible failure varies between 31947 for $R = -1$ and 1.94×10^5 for $R = 0$, and with a safety factor between 0.45 for $R = -1$ and 0.75 for $R = 0$;

- At a pressure of 30 bar, the number of cycles up to a possible fault varies between 7927 for $R = -1$ and 32272 for $R = 0$, and with a safety factor between 0.3 for $R = -1$ and 0, 5 for $R = 0$;

- At a pressure of 40 bar, the number of cycles up to a possible fault varies between 3346 for $R = -1$ and 8005 for $R = 0$, and with a safety factor between 0,2 for $R = -1$ and 0, 4 for $R = 0$;

- At a pressure of 50 bar, the number of cycles up to a possible fault varies between 1735 for $R = -1$ and 2667 for $R = 0$, and with a safety factor between 0.18 for $R = -1$ and 0, 3 for $R = 0$.

Analysing the results obtained, it can be concluded that, for the analysed pressure vessel, the alternating-symmetrical stress type stresses are more dangerous than the undulating stresses.

The numerical results obtained will be verified by making an experimental stand to determine the influence of the fatigue phenomenon on the load-bearing capacity of the respective Equipment.

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DOI: 10.53464/JMTE.01.2022.11

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

PRODUCIBILITY OF FUNCTIONALLY GRADED AlB_2/Al COMPOSITE MATERIAL

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Abstract : This study is intended to investigate producibility of functionally graded AlB_2/Al composites which are used in the manufacture of ship machinery parts. AlB_2 particles have been spontaneously formed in liquid matrix as reinforcement. A semi-solid composite ($Al_{(l)}$ - $AlB_{2(s)}$) prepared at 850°C was solidified under a centrifugal force to grade functionally. The properties of composite materials such as hardness and microstructure have been examined. This research provided the following findings, AlB_2 particles can be successfully synthesized with in situ reaction technique in molten aluminum. It was determined that the hardness value of the composites increases with increasing AlB_2 reinforcement content within matrix. Functionally graded AlB_2/Al composite materials can be successfully produced with centrifugal casting technique. It is also determined that AlB_2 reinforcement ratio of the composite materials ranged from 0 to 7 vol. %. In addition, it was observed that the hardness values of the composites increased with the addition of reinforcement ratio.

Key words : AlB_2, Functionally Graded Composite, Ship Machinery

1. INTRODUCTION

Composite materials are new types of materials formed by the combination of two or more different materials in a macro scale. Generally, these composites occur a ductile matrix and a high-hardness reinforcement material [1-3]. Silicon carbide (SiC) and Alumina (Al_2O_3) are preferred as reinforcing phases due to their high wettability of aluminum and low prices.

With the development of modern production processes, it has been shown that various intermetallic compounds can be used as reinforcing particles in the production of AMCs. Since intermetallic particles are formed spontaneously as a result of exothermic reaction in the matrix, it provides both a cheap and easy production route [4,5].

There are very limited studies on aluminum matrix AlB_2 boride reinforced composites materials [6,7]. Composites can be produced easily and cheaply by in-situ production method.

Commercial Al-B master alloys are used as boron donors in the production of AlB_2 composites [8,9]. Commercial Al-B alloys are widely used as grain refiners in the casting of aluminum alloys and in the production of high conductivity conductor wire [10,11]. At room temperature, boron does not dissolve into aluminum matrix and exists as AlB_2 boride compounds as can be seen from the phase diagram. The Al-B Phase diagram has a pertiectic reaction line at about 1000°C.

AlB_{12} structures are transformed into AlB_2 structures by the peritectic reaction. In the production of Al-B master alloys, unstable AlB_{12} structures are also seen in the structure, since sufficient time is not given for this transformation. In composite production, AlB_{12} boride structures are undesirable because they are unstable and brittle. In order to avoid the formation of AlB_{12} structures, it is necessary to synthesize AlB_2 boride structures without nuclear AlB_{12} structures by crossing the peritectic reaction line quickly [8,9,12].

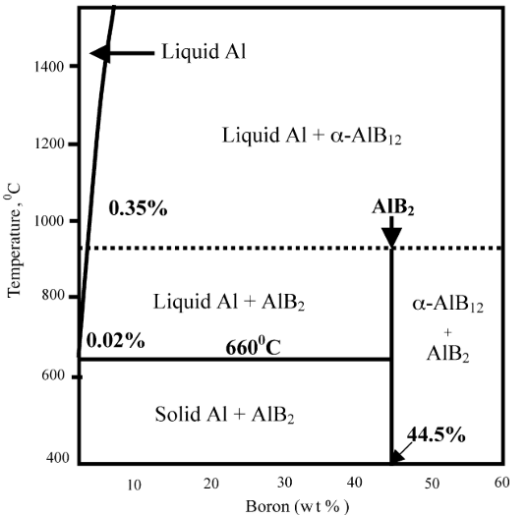


Figure 1 Al–B binary phase diagram

In the literature studies, it is seen that the elastic modulus and wear resistance of the composite materials

Journal of Marine
Technology and Environment
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ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

produced depending on the increasing reinforcement ratio increase.

However, with the increasing reinforcement ratio, it is observed that the composite becomes the fracture toughness decreases significantly. It is observed that the service life of the machine parts, which are exposed to repeated loads, is significantly reduced due to the low fracture toughness. Increasing both fracture toughness and wear resistance can be achieved with functionally graded composite materials [8, 14-16].

There have been studies on the production of AlB_2/Al composites in previous studies [6,7]. However, there is no study that AlB_2/Al composites materials are used in the production of ship machinery parts.

In this study, it was intended to produce functional graded AlB_2 reinforced aluminum matrix composite by centrifugal casting method. After AlB_2 boride structures were synthesized inside liquid aluminum, the semi-solid "$Al_{(l)}$ + AlB_2(s)" solution have been solidified under a centrifugal force to achieve a gradual increase in reinforcement rates. In addition, techniques such as optical microscope, XRD (x-ray diffraction model), scanning electron microscope (SEM) and Brinell Hardness (BHN). has been applied to characterize composites.

2. EXPERIMENTAL WORKS

The production of composites was carried out in 3 stages. In the first stage, Al-B melt was formed at 1200 °C. In the second step, AlB_2 structures were synthesized by crossing the peritechic reaction line quickly. In the last stage, liquid aluminum containing solid AlB_2 structures was solidified under a centrifugal force.

In the first stage, Al-3B master alloys, which are used as grain refiners in the casting of aluminum alloys, were used as a boron source in the formation of the Al-B melt. Considering the Al-B two phase diagrams, it is seen that the boron solubility at 1200 ºC is around 1.5 wt.%. Therefore, the Al-B master alloy was diluted using ETİAL 8 ingots with a purity of 99.6%. Alloys prepared in small ingots were melted in an electric resistance furnace in steel crucibles. In order to synthesize the AlB_2 structures, the Al-B melt in the steel crucible at 1200 ºC was taken from the furnace and solidified by placing it in water in order to quickly cross the peritectic reaction line. Afterwards, the cast ingot was taken into a steel crucible with a diameter of 80mm and a height of 100 mm. The alloy was melted at about 900 ºC to form a semi-solid melt "$Al_{(l)}$ + $AlB_{2(s)}$". The semi-solid was solidified under centrifugal force using a centrifugal casting mechanism so that AlB_2 was functionally graded in centrifugal force.

The composites were characterized by Scanning Electron Microscopy (SEM) using a JEOL JSM6060LV type device and X-ray diffraction (XRD) using Cu -Kα radiation. Reinforcing ratios of the composites were estimated using the peak density ratios of the phases obtained from the XRD studies. The AlB_2 particles were extracted from the composite by dissolving the Al matrix using a 37 %HCI solution to take SEM images. The hardness of the composites was determined using a Brinell hardness tester with a 2.5 mm diameter balls at a load of 31.25 kg for 20 s.

3. RESULTS AND DISCUSSION

It is given that a photographic image of the AlB_2/Al functional graded composite produced by centrifugal casting method in Figure 1. In order to examine the macro scale, the composite material was cut at a certain cross-section with the help of a band saw. The cut surface was etched with HCl solution after metallographic preparation. It is noteworthy that there are two different layers clearly separated from each other in the cross-sectional view of the composite. The outer part of the composite ingots appears to be covered with a dark layer. It is seen in Figure 1 that the layer surrounding the outer part of the composite is dark in color and the layer surrounding the inner part of the composite is light in color. The dark layer on the composite is about 2mm wide, and the light layer is approximately 20mm wide.

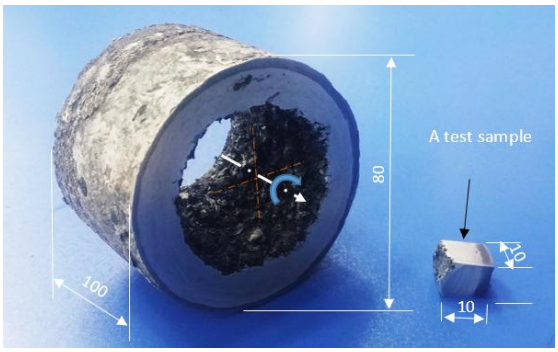


Figure 2 A photography of AlB_2/Al functional graded composite

X-ray diffraction (XRD) analysis results taken from the dark layer and the light layer inner are given in Figure 3a and 3b, respectively. In Figure 2a, it is seen that Al and AlB_2 peaks are present in the XRD pattern taken from the dark layer. However, in Figure 3b, it is seen that only Al peaks are present in the XRD pattern taken from the light layer.

The XRD patterns in Figure 3 show that the composite is composed of only aluminum and AlB_2 phases. According to the XRD peaks above and Ref. [8,9,12], possible chemical reactions in Al-B solution are as follows:

$$B + 3Al \rightarrow AlB_2 \quad (1)$$

This result demonstrates that the Al-B solution nucleates the AlB_2 phases without nucleating the AlB_{12}

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.11
ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

phases by crossing the peritectic reaction line at a sufficient cooling rate. Observation of the AlB_2 phase in the dark layer indicates that the AlB_2 particles are gathered on the outer wall of the composite with the effect of the centrifugal force. According to the peak intensities, it clearly shows that the dark layer contains 8 wt.% AlB_2, and the light layer does not contain AlB_2 particle.

Therefore, the dark and light layer is named as AlB_2-reinforced and non-reinforced layers, respectively.

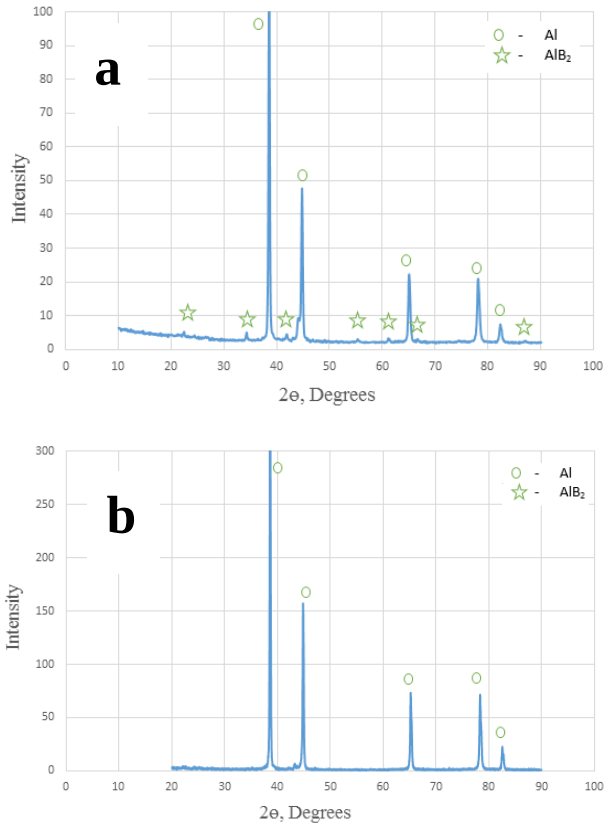


Figure 4 The XRD patterns taken from a) AlB_2-reinforced and b) non-reinforced layers of the composite

Figure 5 shows in the microstructure image taken from the AlB_2-reinforced and non-reinforced layers. Similar to the XRD results, AlB_2 particles are seen in AlB_2-reinforced layer, but there is no AlB_2 particle in non-reinforced layer.

It has been observed that the AlB_2 particles are the appearance of a long bar and exhibit homogeneous distribution in the aluminum matrix. Figure 5 is shown that the width of the AlB_2 particles is approximately 25µm and exhibits a random distribution.

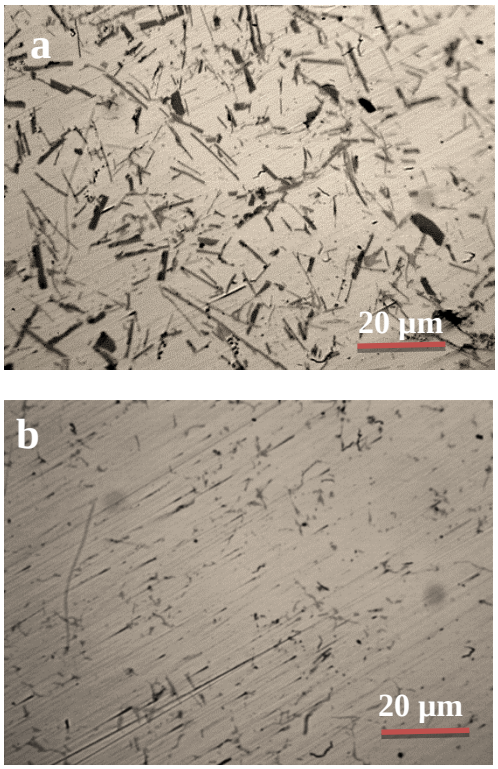


Figure 5 Optical microscope image taken from a) AlB_2-reinforced and b) non-reinforced layers of composite

In order to see the morphology of the AlB_2 particles, a sample taken from the AlB_2-reinforced layer was etched with HCl acid for 60 seconds and SEM images were taken. A SEM image of the rich region is given in Figure 6. It is seen that the AlB_2 particles are hexagonal and plate-shaped. It is seen that the width of the hexagonal plates is about 25 microns and their thickness is less than 1 micron. In addition, although HCl acid dissolved the aluminum matrix easily, it wasn't cause any degeneration of the AlB_2 structures in seen SEM image.

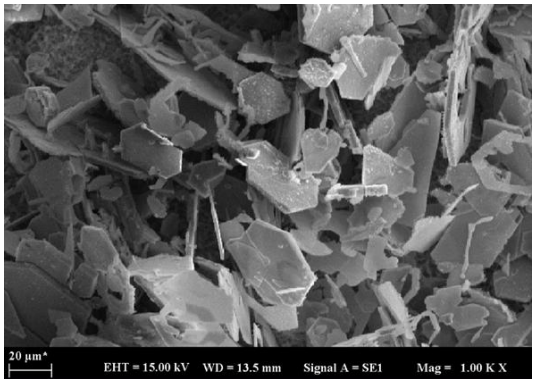


Figure 6 A SEM image of AlB_2 particles

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Technology and Environment
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Table 1. AlB_2-reinforced and non-reinforced layers of composite

Layer of composite	Brinell hardness values (HB)				
	1. Measure	2. Measure	3. Measure	4. Measure	Mean
AlB2-reinforced	77.01	75.15	92.30	84.26	82.25
Non-reinforced	50.01	55.52	52.85	49.17	51.55

Brinell hardness values from AlB_2-reinforced and non-reinforced layers of composite are given in Table 1. It is given the Brinell hardness measurement values taken from AlB_2-reinforced and non-reinforced layers of composite and their averages in Table 1. It is observed that the hardness value of the AlB_2-reinforced layer is higher than the non-reinforced layer. It is further seen that the average hardness value of the non-reinforced layer is 51,5 HB, and the average hardness of the AlB_2-reinforced layer is 82.25 HB. This result shows that the addition of 8wt.% AlB_2 to the aluminum increases its hardness more than 1.5 time.

4. CONCLUSIONS

In this study, production of the AlB_2/Al composites graded functionally by centrifugal casting have been investigated. The results of this study can be summarized as follows:

- The synthesis of AlB_2 particles was achieved by solidifying the Al-B solution prepared at 1200 ºC in water environment. AlB_2 particles were determined to be hexagonal plate-shaped and 25 µm wide.
- It has been shown that functionally graded AlB2 reinforced aluminum matrix composite has been successfully produced by centrifugal casting method. It has been determined that produced composites have two layers reinforced with AlB2 and non-reinforced. It was determined that the AlB2-reinforced layer contained 8wt.% AlB2 particles.
- It was observed that hardness value of AlB2-reinforced layer was higher than non-reinforced layer. It was determined that the hardness value increased from 51.55 HB to 82.25 HB with the addition of 8wt.% AlB_2 in the aluminum matrix.

5. ACKNOWLEDGMENTS

This study was supported by Yildiz Technical University (YTU), Scientific Research Project Coor. (BAP) (project no: FLO-2021-4610). Thanks to YTU BAP for the financial support.

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Technology and Environment
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Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.12

ISSN (Print): 1844-6116
ISSN (Online): 2501-8795
https://www. jmte.eu

ASSESSMENT OF THE PERFORMANCE A VAPOUR COMPORESSION. REFRIGERATION CYCLE WORKING WITH AMMONIA

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Abstract: This paper is a part of the efforts done in order to analyse the performance of vapour compression refrigeration cycles. These technologies are used with a high rate in marine refrigeration and are responsible for important amounts of energy consumptions. The obtained results are indicating the fact that the performance of the cycle is decreased when increasing the condensation temperature and keeping constant the evaporation temperature. Gains in the performance are obtained when degrees of superheating and sub cooling are increased, resulting that the cycle with superheating and sub cooling is superior to the one without these two processes. Ammonia or (R717) is a refrigerant often used on board the ships due to its very good thermodynamic properties. Moreover, the concern regarding the environment and the fact that ammonia is a natural refrigerant, offers to this refrigerant the chance to be adopted in the future plants, on board of new ships. The performance of an ammonia based cycle is discussed in terms of coefficient of performance (COP) and exergy efficiency, the theory of the first and second laws of thermodynamics being fundamental.
Key words: ammonia, cycle, performance, superheating, sub cooling, consumption.

1. INTRODUCTION

Present time refrigeration is, as all other sectors, under the sign of global warming concern and environment protection actions. Expected solutions aim the exploitation of refrigeration systems with no impact on the ozone layer, low contribution to global warming and low energy consumption.

Single or two stage vapour compression refrigeration systems are usually met on board of ships, in order to transport perishables goods overseas or to ensure thermal comfort for crew and passengers [13].

Environmental impacts of refrigerants are given by ODP – measuring the depletion of the ozone layer by some chemical constituents of the refrigerants and by GWP – measuring the global warming effect of the gases [2].

The Montreal Protocol and the amendments that have followed and the Kyoto Protocol as well, forced the replacement of CFCs (chlorofluorocarbons) and of HCFCs (hydrofluorocarbons), with refrigerant presenting null ODP and, even more, with natural refrigerants (such as ammonia) [3].

Natural refrigerants, with a long history in mechanical refrigeration, which were ignored lately because of their toxicity and flammability, are reconsidered, now, on environmental and energetic considerations [4].

Ammonia, or R717, is an attractive solution for vapour compression systems on board, due to its null ODP and GWP, but also to its very good thermodynamic properties [5].

The performance of a single stage vapour compression refrigeration cycle working with ammonia was analysed in terms of COP (Coefficient of Performance) and exergy efficiency.

The theoretical analysis is carried out by considering and by not considering superheating and sub cooling, for a better understanding of the energy efficiency concept.

2. THE CONSIDERED SYSTEM

The main processes encountered in vapour compression refrigeration cycles are: compression, condensation (followed or not by sub cooling), expansion and evaporation (followed or not by superheating), so that the cycle without sub cooling and superheating is as seen in Figure 1.

Journal of Marine
Technology and Environment
DOI: 10.53464/JMTE.01.2022.12
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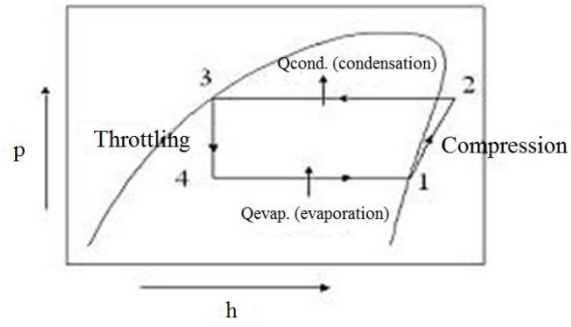


Figure 1 Vapour compression refrigeration cycle without sub cooling and superheating in (p-h) diagram.

The refrigerant, ammonia in our case, changes its phase in the evaporator (where removes heat from the chilled medium) and in the condenser (where releases heat to the environment); vapour refrigerants are compressed in the compressor (with energy consumption) and the refrigerant in liquid state is expanded in the throttling valve [6].
The evaporation and condensation processes occur at constant pressures and temperatures, the lowest pressure and temperature being met during evaporation. Vapours leaving the evaporator can be superheated and liquid produced in the condenser can be subcooled.

The compression process is adiabatic. Before being condensed, superheated vapours are cooled isobaric. Also, sub cooling of the liquid refrigerant is an isobaric process. Expansion occurs isenthalpic and is used to reduce the pressure of the refrigerant.

3. THERMODYNAMIC ANALYS

The performance of the refrigeration cycle is expressed through out COP (Coefficient of Performance) and exergy efficiency, by applying the first and second laws of thermodynamics; COP assessment is based on conservation of energy principle, while exergy efficiency is based on energy degradation law and it considers the irreversibilities of processes [7].

Performance found in COP term is a traditional analysis, COP being the rate between heat absorbed by the refrigerant in the evaporator and the work consumed by the compressor.

Due to the fact that all processes are irreversible and the quality of the energy is degraded, the performance assessment should be oriented towards the irreversibility estimation by applying exergy analysis.

Exergy is the part of energy that can be transformed in any other type of energy.

Such an approach focuses on exergy destruction diminishment, these destructions being caused by irreversibilities.

The equations used in such a type of performance analysis are provided bellow [8], [9], [10].

Specific work consumed in the compressor (w_c), specific thermal load of the condenser (q_{cond}), specific refrigeration load (q_{evap}) are given by specific enthalpies variations:

$$w_c = \Delta h_e \quad (1)$$

$$q_{cond} = \Delta h_{cond} \quad (2)$$

$$q_{evap} = \Delta h_{evap} \quad (3)$$

where:
h – enthalpy
The performance indicators are found as:

$$cop = \frac{q_{evap}}{w_c} \quad (4)$$

$$\eta_{ex} = \frac{Ex_{des.evap}}{W_c} \quad (5)$$

where:
η_{ex} – exergy efficiency
$Ex_{des.evap}$ – exergy destruction in the evaporator.
Generally, exergy destruction is calculated with:

$$Ex_{des} = W_{c\,rev.out} - W_{c\,out} \quad (6)$$

where:
W_{rev} – the reversible work.

4. RESULTS AND DISCUSSION

The analysis is developed by considering two situations: cycle without sub cooling of condensate ammonia and superheated of ammonia vapours and cycle with sub cooling and superheating.

In the first situation, the condensation temperature varies between $(30 \div 60)°C$, while the evaporation temperature is kept constant (at $-40°C$).

In the second situation, the condensation temperature is constant $(55°C)$.

In Figures 2 and 3 are given COP and exergy efficiency values obtained when the condensation temperature varies.

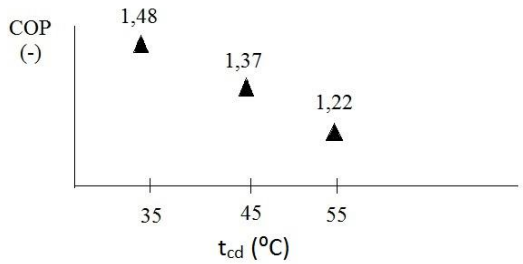


Figure 2 COP versus condensation temperature (evaporation temperature is kept constant)

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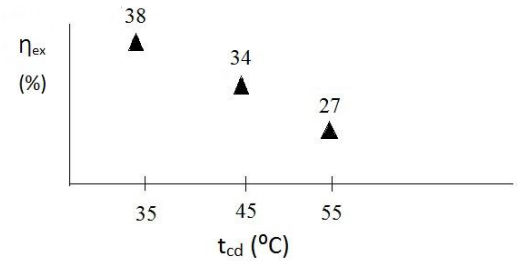


Figure 3 Exergy efficiency versus condensation temperature (evaporation temperature is kept constant)

The performance of the cycle decreases with the increase of the condensation temperature, because of the fact that the difference between the evaporation pressure and the condensation pressure increases, leading to a higher energy consumption at the compressor.

In the next two figures, it is revealed the change in the performance, when the superheating degree varies.

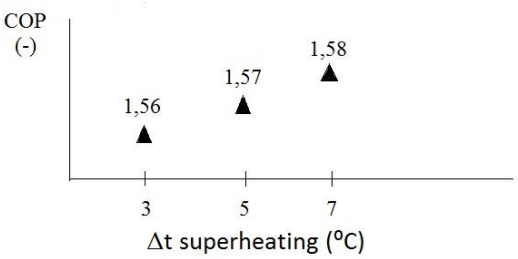


Figure 4 COP versus superheating degree

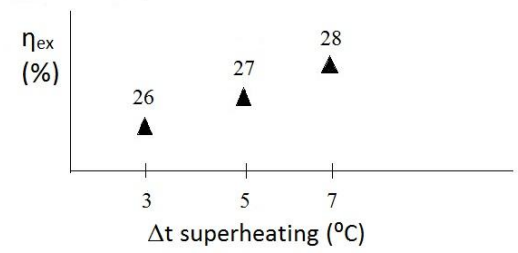


Figure 5 Exergy efficiency versus superheating degree

It is seen that superheating increase has a benefit influence on the performance of the cycle.

Same result it is obtained when we talk about sub cooling increase, as seen in Figures 6 and 7.

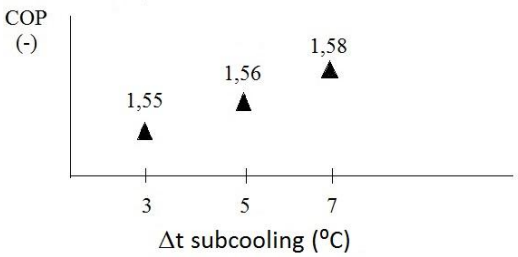


Figure 6 COP versus sub cooling degree

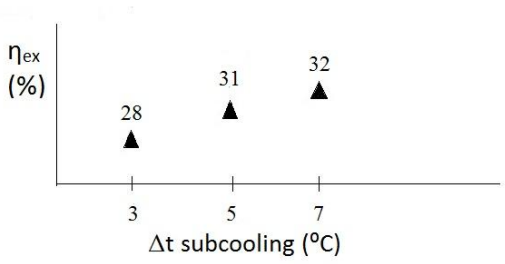


Figure 7 Exergy efficiency versus sub cooling

Best performance of the ammonia cycle results to be obtained for high levels of superheating and sub cooling.

5. CONCLUSIONS

Ammonia is an old refrigerant, successfully used in maritime refrigeration, but showing an increased interest for new refrigeration plants on board the ships.

By taking adequate safety measures, ammonia, as a natural refrigerant, is environment friendly and able to ensure high energy efficiency.

Being recognized the fact that vapour compression refrigeration systems exploitation requires high energy needs, the analysis of these systems is very important.

In this paper, the thermodynamic analysis relies on the first and second laws of thermodynamics.

By considering the both laws, a realistic image of the performance can be revealed; performance indicators were COP and exergy efficiency.

It was found that the cycle is more efficient when the difference between evaporation and condensation temperatures is lower.

Also, for an improved performance, the cycle should contain superheating and sub cooling processes. Higher superheating and sub cooling degrees will lead to higher performances.

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Technology and Environment
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ISSN (Print): 1844-6116
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PUBLISHED SINCE 2008
ISSN:1844-6116
ON LINE SINCE: 2008
PUBLISHED BY: Editura Nautica/ Constanta Maritime University