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Implementation of Industry 4.0 in Ship Repair Industry: Challenges and Opportunities

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Abstract: : In recent years, the concept of Industry 4.0 has found its way into the industry, particularly heavy machinery manufacturing. This article explores Industry 4.0 in the context of ship repair, which is part of the heavy industry in the Republic of Bulgaria. The characteristic of the ship repair industry is presented by comparing it with that of shipbuilding. The two industries are similar, but despite that, they have differences. The challenges and opportunities in its implementation in the ship repair process are presented and analyzed. Particular attention is paid to ship repair enterprises of the small and medium-sized (SME) type, which are quite numerous in the Republic of Bulgaria. For them, the adaptation and transition to Industry 4.0 are more challenging. There are identified benefits and opportunities for improving energy efficiency in enterprises, especially small and medium-sized ones, enhancing the working environment, reducing waste generation in the production process, and maintaining competitiveness at a relatively high level.

Keywords: Industry 4.0, Ship repair, Challenges, Opportunities, Energy efficiency

Introduction

At the core of the concept of Industry 4.0 lies the implementation of intelligent digital technologies in manufacturing and industry. Industry 4.0 is the fourth stage in the development of techniques and technologies in the industrialization of the world. Its impact is observed in all areas of heavy machinery manufacturing, particularly in shipbuilding and ship repair. Building on the concept of Industry 4.0, the concept of Shipbuilding 4.0 has been introduced, which aligns with the principles of Industry 4.0. Following this logic and considering that shipbuilding and ship repair are closely connected in terms of production capabilities and equipment, it is appropriate to introduce the concept of Ship repair 4.0.

An analysis of the current level of development of Industry 4.0 in the context of shipbuilding has been conducted in (Stanic,2018). Various publications have been summarized, different topics have been analyzed, and levels of production aspects within the industry have been examined. By harnessing the technologies of Industry 4.0, conditions are created for reducing production and operational costs, leading to improvements in manufacturing.

Digitization is one of the directions in industrial development. A branch of digitization is digital twins, which are entering many branches of the industry. A concept for developing a digital twin of the ship design and construction process is presented in (Iwankowicz, 2023). The concept developed in this way has been tested through a shipbuilding process, and practical aspects of its implementation have been highlighted. The development of a digital twin for a shipbuilding enterprise based on statistical and empirical data with the aim of improving competitiveness is presented in (Kunkera, 2022). Digital twins also contribute to environmental protection and workplace safety, making them increasingly applicable in manufacturing.

After the emergence and integration of the Internet of Things, which is a part of Industry 4.0, things in various industries began to change. This led to the maritime industry's interest, resulting in the creation of the Internet of

Ships, which, to some extent, refers to a network of interconnected objects related to ship repair or shipbuilding yards. Through this Internet of Ships technology, the information generated by it can be managed throughout the entire lifecycle of the ship (Sokolov, 2018).

Augmented reality is one of the new technologies that can be useful in shipbuilding and ship repair production. Its use enables operators to receive more and clearer information about the stages of the production process. Potential augmented reality solutions with future applications in ship construction and repair are presented and analyzed in (Fernandez, 2023). The authors have introduced hardware, software, and technological solutions tailored to this industry with their developments.

Ship Repair Industry Overview

The ship repair industry is more dynamic compared to shipbuilding. In shipbuilding, the process takes a long time. Depending on the type of ship, its construction can take anywhere from 6 months to 3 years, while in ship repair, the duration of repairs in modern production, regardless of the type of ship, is around 20 calendar days. The ship repair market is a market characterized by sinusoidal growth and decline. Growth has been observed since 2020, and it is expected to reach approximately 6% by 2028, which corresponds to an increase in profitability (Mark Wide, 2023). The distribution of the market share among the major global regions involved in ship repair, as well as the expected increase in activities across various areas of the ship hull, is presented in the Figure.1.

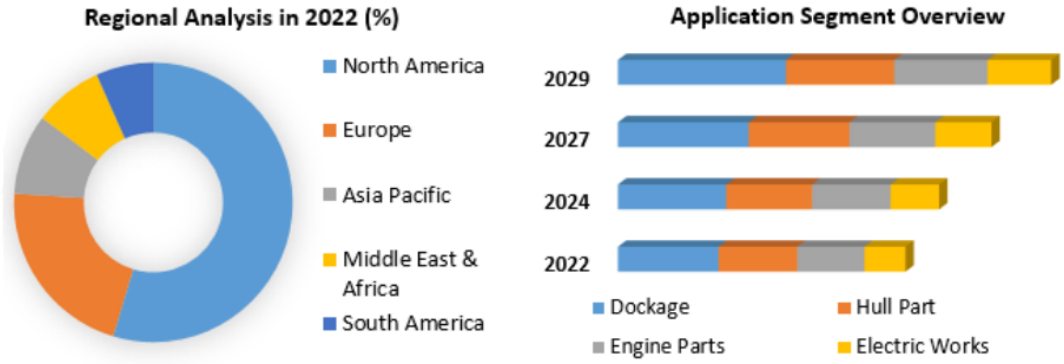

Figure 1. Distribution of ship repair market in major ship repair regions (Ship repair and maintenance, 2023)

Figure 2. Ship repair map in Europe (Trusteddocks, 2023)

From Figure 1, it can be seen that the region with the largest percentage share in ship repair is North America, followed by Europe and Asia. Regarding the different activities related to the ship, the largest share belongs to

ship docking. This is associated with sandblasting and painting of the ship's hull, as well as inspections and repairs of the underwater part. The other three activities, hull repair, machinery, and electrical activities, are almost evenly distributed among themselves. The data indicate that there is an increase in each of these activities by 2029, which will also lead to higher industry profitability. In Europe are located about 150 ship repair yards, Figure 2. Each of these plants is characterized by an index called the ship repair index. It is individual for each plant, but overall for Europe, as of today, it is lower by about 26% compared to the same period in 2022. The types of ships most frequently resorting to repairs are presented in Figure 3.

Figure 3. Ship types most involved in ship repair (Fortune Business, 2023)

It can be seen that the largest percentage share is held by container ships, followed by fishing and passenger ships. Considering the requirements and equipment of these groups of ships, it becomes clear that Industry 4.0 is highly pronounced in them, posing challenges to ship repair plants during dry-docking and class repairs of these ships.

Challenges in Implementation of Industry 4.0 in Ship Repair

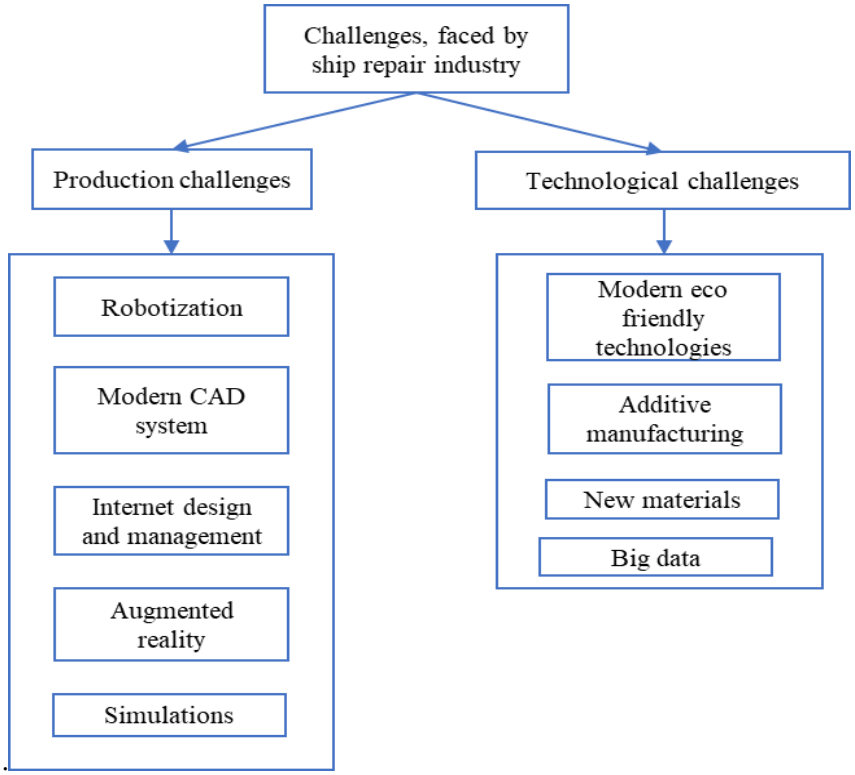

Figure 4. Challenges faced by ship repair industry

The challenges facing ship repair after the entry of Industry 4.0 can be broadly divided into two groups, as presented in Figure 4. The aspects presented in Figure 4 are referred to as challenges because their implementation in the real industry would be costly for the plants, and not all of them would have the capability to adopt these technologies.

The challenges facing the ship repair industry manifest in both production and technological aspects. Each group includes representatives directly corresponding to the impact of modern technologies entering the industry. The use of robots and augmented reality poses challenges to SMEs, as well as to those primarily engaged in ship repair. Significant capital investments are required for their implementation in production, and these investments need to have a return on investment over a certain period of time. Analyzing the current global situation, Europe, and Bulgaria, along with the war in Ukraine and the consequences of COVID-19, the adoption of such industrializations is not very favorable, as there is a ban on the entry of ships flying the Russian flag into our waters, and these are the main clients of many ship repair yards in Bulgaria. This challenge could be addressed through targeted funding from the EU. Challenges such as simulations and internet management are not as directly related to financial investments. They are more oriented as activities that are beneficial to have in the plant for easier production flow and scheduling planning.

The group of technological challenges relates to modern technological aspects that have an impact on the productivity and competitiveness of ship repair enterprises. The use of eco-friendly technologies and additive manufacturing gives a modern look to the plants. Some of these challenges can be easily overcome, as there are European projects and framework agreements for this purpose.

The introduction of new materials in shipbuilding that have an impact on ship repair would be challenging. Examples of such materials include carbon fiber, honeycomb panels, and others. These types of materials require specific processing technology, which also demands specific skills from the personnel. However, with additional training, the desired results can be achieved.

Opportunities in Implementation of Industry 4.0 in Ship Repair

The opportunities resulting from the implementation of Industry 4.0 in ship repair are expressed in two directions: economic and environmental, as shown in Figure 4. They are the result of fully or partially overcome challenge.

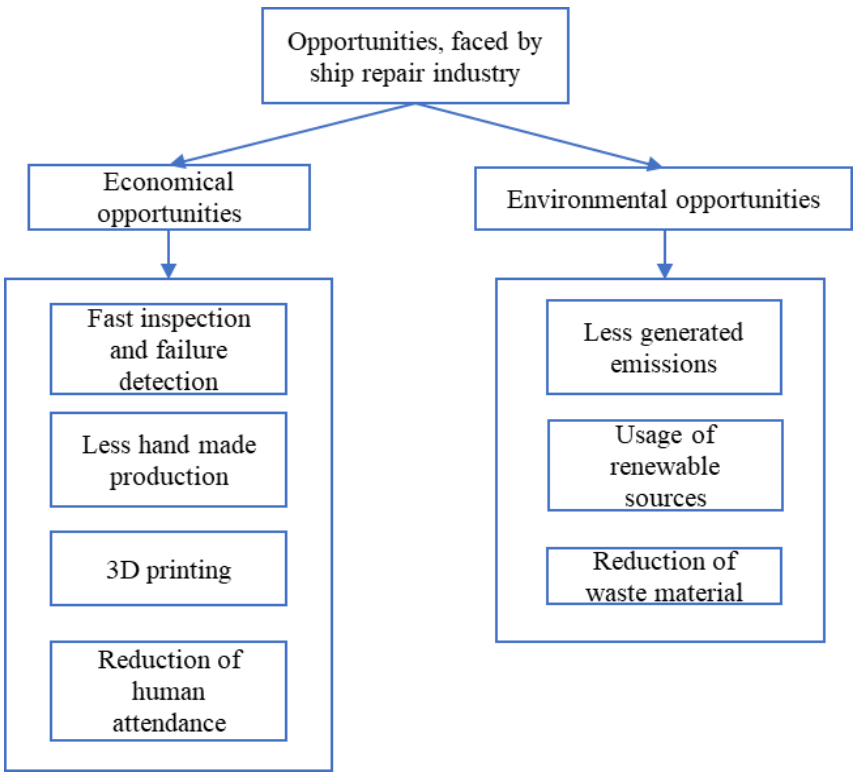

Figure 5. Opportunities in ship repair industry after Industry 4.0 implementation

The rapid inspection and identification of damages resulting from augmented reality and robotics contribute to faster and more accurate planning of work teams in the plant, as well as a reduction in manual labor. The benefit of implementing 3D printing as part of the production process is particularly significant. It can largely replace the long lead times for the delivery of a particular machine, mechanism, or system component. The greatest benefit of the adoption of Industry 4.0 is the reduction of human labor, but not completely, to a certain extent, in order to optimize the process, as there are activities that cannot be performed without human intervention, such as repairing the main engine, diesel generator, etc.

Lately, there is an increasing emphasis on environmental conservation. This applies not only to transportation, which is a small part of the pollutants but also to the industry. The use of renewable energy sources and alternative fuels leads to a reduction in harmful emissions. High-tech CAD systems in production and proper process planning lead to a reduction in technological waste. All these presented possibilities and their gradual implementation lead factories towards so-called Green Manufacturing, which undoubtedly aligns with environmental conservation policies.

Conclusion

The article examines the challenges and opportunities facing the ship repair industry following the introduction of Industry 4.0. The current situation in the global and European ship repair market is presented and analyzed. Special attention is given to the most commonly repaired types of ships, with the largest number being container ships, followed by fishing vessels and passenger ships.

Starting from the current situation in ship repair, the challenges that shipyards face after the widespread adoption of Industry 4.0 are presented and analyzed. These challenges are examined and presented on two levels, production leads to opportunities that reflect the different groups of challenges. The opportunities are presented in two directions, economic and ecological. Both groups of opportunities aim to improve the competitiveness of ship repair yards and respond to national, international, and global measures to combat greenhouse gases.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the author.

Acknowledgements or Notes

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