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Comparative Analysis of Measures to Reduce Wear on Ship Hull Structures in Areas Around Ballast System Suction Pipes

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Abstract: During the operation of a ship, it is necessary to take in and discharge ballast water. This is carried out with the help of the ship's ballast system. When the system is in operation, ulcers form in the areas beneath the suction pipes. This phenomenon is due to cavitation erosion, which is common in this type of system. The article examines measures to increase the wear resistance of the ship hull structure, most often the bottom plating of the ship hull in these areas. Criteria for evaluating two types of measures with the same purpose are proposed. It has been proven that by installing additional wear-resistant plates beneath the suction pipes of the ballast system, the wear problem is eliminated. On one hand, this measure helps reduce the time needed for hull repairs during docking and class repairs. On the other hand, it saves a significant amount of money for the shipowner, as additional activities related to providing repair conditions are not necessary.

Keywords: Wear, Suction pipes, Ship ballast system, Cost, Repair

Introduction

The wear and tear on ship structures around the suction and ballast tank pipes is a widely known and very common problem in ship repair practice. It occurs in relatively older ships of the world commercial fleet. In many cases, this wear leads to a breach in the watertight integrity of the ship's hull or the watertightness between ballast tanks.

Corrosion in ship ballast tanks is a phenomenon that cannot be completely restricted during the operation of the ship. It is caused by various factors such as microorganisms, among others, but fundamentally steel can interact with the environment when the corrosion protection is compromised. Intensive corrosion in these areas of the ship's hull causes serious damage to the ship's structural integrity. A study on the effects of microbiologically influenced corrosion as a serious problem in the shipping industry was conducted in Heyer et al. (2013). There, the authors thoroughly examine the construction and purpose of ballast tanks, summarize the mechanism of corrosion from an electrochemical perspective, and discuss surface treatment and coating applications. A significant aspect is the outlined measures to reduce microbiological corrosion. Some of these measures include excellent application of anti-corrosion coatings, structural changes to reduce sediment in the water, treating the water with nitrogen, and more. Part of these measures are already being implemented with the so-called ballast water treatment systems.

With the introduction of ballast water treatment systems, various installations and mechanisms for their treatment have also emerged. Some of them do not cause damage to the ship's hull structure in the areas around the suction pipes, while others do. One such method is the developed counter-rotating hydrodynamic device (Ren et al., 2023). Its purpose is to mechanically treat the ballast water on board the ship. It has been found that at a certain range of rotational speeds, cavitation bubbles form, which develop cavitation in later stages.

The accumulated sediments in ballast tanks lead to intense corrosion and wear in certain areas of the tanks. To reduce this undesirable phenomenon, a modification to the design of ships has been proposed in (Prange, 2013).

The proposed modification involves the creation of scuppers on the floors and stringers, allowing easier passage of water to the suction points of the ballast system. This modification is also applicable to already constructed ships.

Non-ballast onboard (NOBOB) ships pose a significant environmental risk because even a small amount of residual ballast water can support the survival of benthic and planktonic organisms in the bottom of the tanks (Drake et al., 2005). These organisms were responsible for several invasive species outbreaks in both Chesapeake Bay and the Great Lakes during the 1980s, a time when regulations for residual sediments in tank bottoms were inadequate (Drake et al., 2007). With this type of ship, problems with wear under the suction and measuring pipes are absent, which somewhat facilitates their maintenance and repair.

For all types of corrosive and erosive wear, there are suitable methods for prevention and repair. Most commonly, these methods include welding and the installation of corrosion- and erosion-resistant plates. Additionally, it is important to analyze both methods in terms of the time required for making the improvement or repair.

Criteria for a Comparative Analysis Between the Measures for Wear Reduction

The proposed comparison criteria are adapted and fully comply with real ship repair practices. The two comparison options are as follows. Option one is when the erosion resistance plate is installed during the ship hull repair stages, and option two is when the erosion resistance plate is installed during the ship hull building stage.

The comparison and evaluation criteria are follows: opening and closing of the manhole, tank ventilation, cleaning before work, cleaning after work, and repair area preparation. As proposed, they are directly related to the technological time required for the ship's repair. Each one of them is described in the next paragraphs.

Figure 1. Option one without installed plate

Figure 2. Option two with installed plate

Manhole Opening/ Closing

The opening and closing of manholes on the ballast tanks of the hull is a routine procedure during repairs. They are not opened and closed if emergency repairs are being carried out and the respective tank is not affected. Besides providing easy access to the tank, they also play a role in its ventilation, however minimal that may be. It is unacceptable to enter a ballast tank without it being ventilated.

The manhole cover is closed using a threaded connection. During the opening process, the threads of some bolts become damaged, necessitating their re-threading or replacement with new ones. Replacing them with new bolts is a critical task because the welded joint must be watertight after the repair. If these activities are not accounted for in the ship's repair schedule, they can sometimes lead to an increase in the repair time. When closing the manholes, new gaskets must be installed. In most cases, these are rubber gaskets cut to the shape of the manhole.

Tank Ventilation

Ventilation of ballast tanks is a mandatory process before starting any work in them or gaining access for inspection. After opening the manholes of all ballast tanks, the quantity and composition of the air in them are determined. This is done using special devices called gas analyzers, after which specific protocols are filled out. Permission to work or inspect the tank is granted when the air is within the permissible limits. The main consideration is the minimum oxygen level, which must be no less than 21% (International Chamber of Shipping). If it is below the allowable limit, intensive ventilation of the tank is initiated. In practice, a pressure ventilation system is often installed on one manhole of the tank, and a suction ventilation system, usually centrifugal fans, is installed on the other.

Cleaning Before Repair

The cleaning of the work areas begins after the tank is fully ventilated and a gas-free certificate is issued. Cleaning before starting repair activities is an important step. It can be carried out in two ways: partial cleaning for access or complete cleaning of the tank. Primarily, it involves cleaning out water that was not discharged overboard and mud settled during the ship's ballast operations. Proper cleaning ensures safe work and quick completion of repair activities in the ballast tank. The working time depends on the size of the tank, the type of construction, and the degree of contamination.

Cleaning After Repair

Cleaning after completing the repair is an important stage following the completion of the repair. It involves the removal of all technological waste generated during the repair process. Most often, these are remnants of electrodes, pieces of cut metal, electric bulbs, household waste such as water bottles, dust masks, and others. This process is mandatory because some of this waste can end up in the ballast system pipelines and disrupt their normal operation.

Repair Area Preparation

Preparing the area consists of a series of operations to ensure the smooth execution of the repair. The main operations performed are directly related to the cutting and welding processes. Their quality largely depends on the cleaning done before starting the repair and entering the tank in general.

The surface preparation for repair in option one consists of burning off the paint around and under the suction pipe, welding, grinding the welded areas, installing, and welding the anti-erosion plate. The peculiarity here is that all these activities cannot be performed by two people simultaneously. This is precisely why the repair takes a longer time to complete.

Evaluation Criteria Validation and Comparative Analysis

The preliminary developed criteria for evaluating the reduction of wear in the areas around the ballast pipeline suction pipes have to be validated. Validation consists of assigning each criterion to the corresponding option. In this case, whether a specific activity will be carried out in a particular option for reducing wear is defined by the number 1, and if it will not be done, by the number 0 Table1.

Table 1. Criteria validation

Criteria	Variant 1	Variant 2
Manhole opening/ closing	1	0
Tank ventilation	1	1
Cleaning before repair	1	0
Cleaning after repair	1	1
Repair area preparation	1	0

From the criteria presented in Table.1 and their validation for each of the two methods, it can be seen that all activities are applicable in option one. While in option two, only two of them are applicable. This is mainly due to the fact that such work to improve the wear resistance of these areas is much easier to perform when access to them is significantly easier and does not require much additional equipment.

In shipbuilding and ship repair practice, for easier quoting and pricing, it is customary to measure the work done in man-hours. For example, in Burler (2000), the number of man-hours for various types of activities related to the overall repair of the ship is presented. The required number of man-hours for the various activities related to the analysis and evaluation of two methods for reducing the wear of the hull structure around the ballast pipeline suction points is presented in Table 2.

Table 2. Man hours for different criteria

Criteria	Variant1, mh	Variant 2, mh
Manhole opening/ closing	2	0
Tank ventilation	10	10
Cleaning before working	5	0
Cleaning after working	2	2
Repair area preparation	6	0

The values of the man-hours presented in Table 2 for each criterion are based on experience from the ship repair practice of a small to medium-sized ship repair enterprise. The man-hour values include all activities from preparation to final completion, including working with crane equipment for activities related to tank cleaning. The cleaning work before and after the repair is carried out by several people, most often three or four. It should be noted that the specified values pertain to the repair in a single ballast tank. It is assumed that the cleaning covers 80% of the bottom area of the respective tank and there is 10 mm of water in the tank, which is the distance from the suction point to the bottom lining or the double bottom of the ship.

The comparative analysis shows that the total number of man-hours in option one is relatively higher than in option two, figure 3. This is partly due to not only the different types of additional work related to the repair but also to factors such as poor-quality materials, non-standard operating conditions of the ballast pumps, and other circumstances without which the ships would not be able to perform their functional purpose.

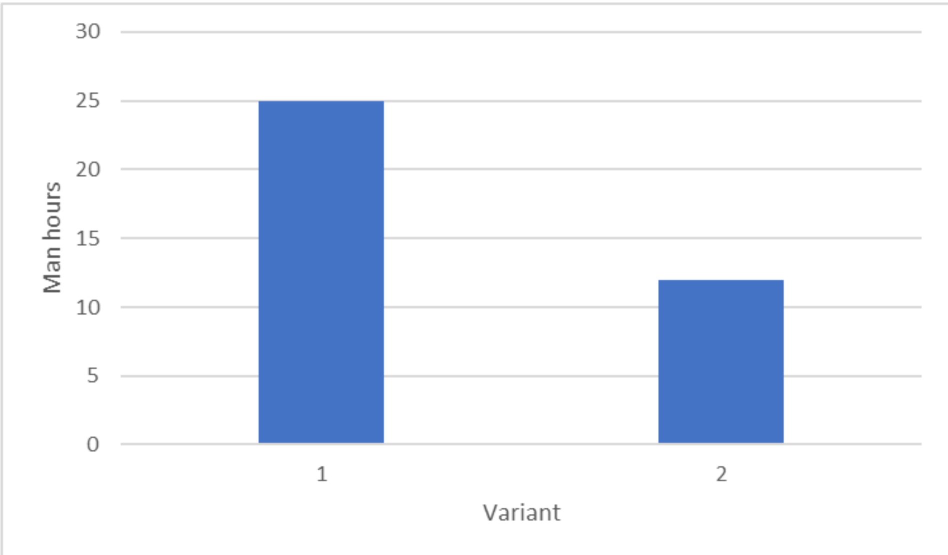

Figure 3. Comparative analysis between the variants

The results presented in fig.3 make it clear that with pre-installed wear-resistant plates under the ballast system suction points, significant savings are achieved in the ship repair time, and thus costs, which in most cases are not anticipated. The difference in man-hours, measured in percentages, is approximately 50% more time required to repair the worn areas around and under the suction pipes of the ship's ballast system when no wear-resistant plates were installed during the construction stages.

Conclusion

The wear of the ship's hull structure in the areas around the ballast system intakes is a common issue. In many cases, it is observed in relatively older ships and those with a non-stationary operating mode of elements (pumps) in the ballast system. Two possible solutions to this problem are presented. Option one is when the erosion resistance plate is installed during the ship hull repair stages, and option two is when the erosion resistance plate is installed during the ship hull building stage.

Criteria for evaluating each of the methods have been proposed. The proposed criteria are directly related to the time required for the construction or repair in these areas. The criteria include opening the manhole, tank ventilation cleaning before repair, cleaning after repair, and surface preparation in the area for performing hull work. The proposed criteria have been validated for each of the two methods. Average man-hours for the work of each method have been presented. It has been found that the method based on installing a wear-resistant plate during the ship's construction stage takes about 50% less time for repairs compared to installing such a plate during dock repairs. The results obtained from the analysis provide a clear argument for implementing the installation of corrosion-resistant plates under the intakes of ballast systems on all ships in the global commercial fleet.

Scientific Ethics Declaration

* The author declare that the scientific ethical and legal responsibility of this article published in EPSTEM Journal belongs to the author.

Conflict of Interest

* The authors declare that they have no conflicts of interest

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References

Bulter, G. (2000). *Guide to ship repair estimates (in man-hours).* Butterworth-Heinemann.

Drake, L. A., Jenkins, P. T., & Dobbs, F. C. (2005). Domestic and international arrivals of NOBOB (no ballast on board) vessels to lower Chesapeake Bay. *Marine Pollution Bulletin*, *50*(5), 560-565.

Heyer, A., D'Souza, F., Leon Morales, C.F., Ferrari, G., Mol, J.M.C., & de Wit, J.H.W. (2013). Ship ballast tanks a review from microbial corrosion and electrochemical point of view. *Ocean Engineering, 70*, 188-200.

Prange, G., & Pereira, N. (2013). Ship ballast tank sediment reduction methods. *Naval Engineers Journal, 125*(2), 127-134.

Ren, W., Bie, H., Liu, G., Guo, C., & Hao, Z. (2023). Research of a novel counter rotating hydrodynamic cavitation device applied for ballast water treatment. *Ocean Engineering, 288.*

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