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COMPREHENSIVE STUDY OF THE FORCES ACTING ON THE LONGITUDINAL AND TRANSVERSE CONNECTION OF OIL TANKER PROJECT 1598 R AFTER CONVERSION

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ABSTRACT

The article examines the newly installed system of bottom and side sets on the converted tanker "Şamaxı" project 1598 R, and examines the loads acting on the longitudinal and transverse links when the ship is in cargo and empty. The analysis of the vessel hull compression and bending. The loads acting on the outer skin of the hull, longitudinal and transverse beams causing tensile and compressive forces are considered. The system of a set of a double bottom and the second Board, taking into account increase in the General durability of the hull is investigated. Analyzed the main load acting with different forces on the metal plates of the bottom and sides, developed technological methods, the application of which can reduce them to a minimum.

KEYWORDS: Load, tension, bending, corrugations, compression, deflection.

1. INTRODUCTION

The ship hull structure of the tanker is subjected to loads that arise from the construction of the vessel and continue to operate throughout the period of operation in a spontaneously variable form, the direction of the force of impact of which are largely different and cannot be predetermined [1,5]. But to reveal how dangerous and extraordinary loads acting on the hull structure of the tanker, was the analysis of the forces acting on the surface plate and set with different directions and discusses some practical methods of using them are the figures obtained with the characteristic positive values. Construction elements of installed and installation hull structures made of shipbuilding materials of different categories and thicknesses, methods of their welding connection, which have a huge impact on the quality of the product, its strength characteristics, the age of the vessel and the cargo transported, are considered.

2. PROBLEM STATEMENT ANALYSIS

During the movement of the tanker at sea, the bottom and side parts of the hull are subjected to uneven pressure of the cargo from the inside and sea water from the outside (Fig.1). This difference in pressure in the cargo tank – ballast compartment – sea water system can lead to sharp tensile and compressive stresses in the sheet plates of the outer and inner skin, and they in turn to cracks and tears of the bottom and sides skin. Therefore, the transverse and longitudinal set of the ship's hull structure of the bottom, sides and deck installed from the construction should prevent the acting forces from outside, not allowing to compress the bottom and sides of the vessel. But this is not always possible because much depends on the distance of the installed longitudinal and transverse beams, which play a huge role in the movement of the vessel in cargo and empty. Therefore, the conversion of the vessel by the authors were invited to design a double Board and double bottom plating with the same geometric calculations to the load acting from both sides on the plate and on set, are unable to increase the vibration and deformation in the housing, but rather would increase the resistance of the plates and a set of increasing strength Cabinet construction.

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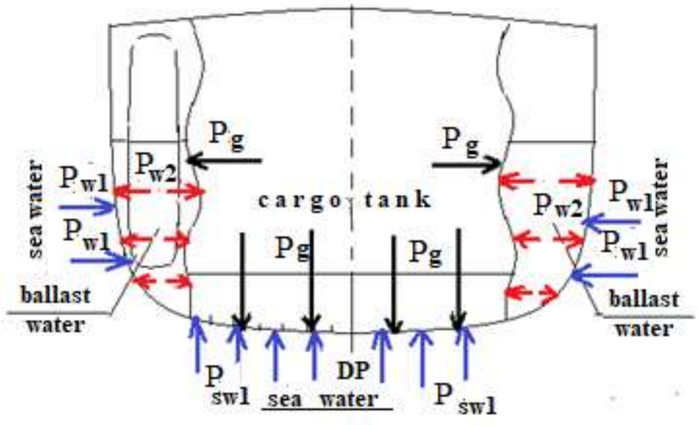

Figure: 1. Diagram of the pressure of cargo (Pg), sea water ($P_{sw}1$), and ballast water (P_w2) on the bottom and side plates prior to conversion.

3. RESULTS AND DISCUSSION

Given that the load acting on the monohulled structures differ in their characteristic features of the two-body where the first have a "flexible" design, under the influence of forces it bending, deformed (Fig.1), and the second has a rigid contour, (due to the constructed second side and double bottom, Fig.2), which divides these forces into several forces, reducing the force of their impact and the direction of movement, longitudinal and transverse links built during the conversion of the tanker.

In order to determine which of the design: double-hull or single-hull have the required characteristic values, it is necessary to investigate the loads and stresses that may occur in the hull after the conversion of the tanker t/x "Şamaxı" from physical and natural factors, as well as the technical condition of the hull structure and the kind of cargo carried and compare them with the characteristics of the equipped tanker that is, with a single-hull design.

In such a study it is necessary to identify the advantages and disadvantages of monohulled and converted structures.

The study converted the tanker showed that the bottom and the double bottom plating, as the overlap must not only perceive the water pressure and weight to the goods, but transfer them to a rigid support circuit – on transverse and longitudinal bulkheads and on Board [1,6], simultaneously causing strength forces in the bottom and creating back pressure from the cargo carried, so as to evenly distribute the loads acting on the vessel's hull without creating stress in the welded joints, which can lead to rupture of metal plates.

In the course of the analysis carried out in the study (1.1), the loads acting summarily on the bottom of the tanker Q_0 were obtained, which are equal to the difference in water pressure Q_1 on the outer skin and the load from the weight of the cargo Q_2 located directly on the bottom [1,2,3]:

$$Q_{0T} = Q_{1_w} - Q_{2_g} \qquad \text{I}$$

Given that the total current load Q_{0T}, acts on the bottom depends on the action of water pressure and back pressure Q_{1w} Q_{2g} cargo, it is possible to identify the load transmission directly on the vessel and on deck [2,5], then if $Q_{2\Gamma}$ is part of the leaving load, which is equal to: $m \cdot Q_{1w}$, then the total load will be equal to Q_{0T}:

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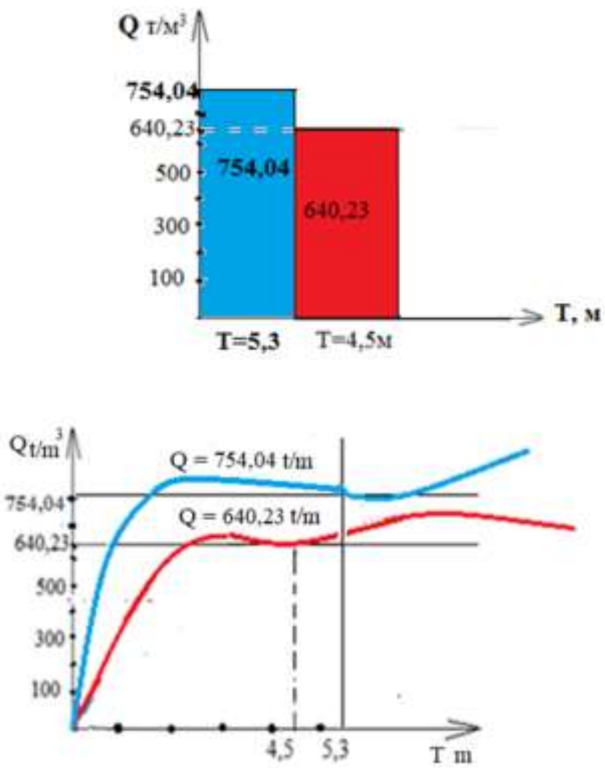
$$Q_{0T} = Q_{2_g} - m \cdot Q_{1_w} = Q_{1_w}(1-m) \qquad \text{II}$$

where: m – is the coefficient equal to 0.4, depending on the type and load of the cargo.
Calculating force of water pressure Q1в, on the bottom of the hold before conversion, when a ship is on normal Tn and a maximum draught Tm, – revealed the following pattern: (figure 2), the less draft less than the water pressure acting on the bottom of the hull. These values are clearly reflected in formula 1.3 and figure 2.

$$Q_{1_w} = B \cdot T_g \cdot l \cdot \gamma = 9{,}95 \cdot 4{,}5 \cdot 13{,}95 \cdot 1{,}025 = 640{,}23 \ \ t/m^3$$
$$Q_{1_w} = B \cdot T_m \cdot l \cdot \gamma = 9{,}95 \cdot 5{,}3 \cdot 13{,}95 \cdot 1{,}025 = 754{,}04 \ t/m^3 \qquad \text{III}$$

where: B – is the width of the bottom in the cargo tank (m); T – is the draught of the vessel (m); γ – is the water density(t/m)^3; *l*- is the distance between the transverse bulkheads (m).



a)

b)

Figure 2. Acting on the hull structure of the bottom of the water pressure force before the conversion of the tanker: a-in volume equivalent; b-graphically.

In this case, the bending and deformation of the bottom and side plates at Tm= 4.5 m is reduced in total, the stresses and loads in the welds are reduced than at Tg=5.3 m.

Based on the calculated data, the result was obtained and a graph was drawn up (figure 2), which characterizes the main parameters of the water pressure acting on the vessel's hull before conversion having certain values at which the hull is subjected to wave resistance and under constant forces the plates are subjected to compression and tension, as a result, deformations of a discontinuous nature are created, leading to metal fatigue [1,4,5].

To the body design of the ship had the highest transverse strength reduces the load acting on the cladding the longitudinal and transverse ties the body of the set [3], the authors have developed a design project for the conversion of the tanker, which took into consideration actually received by the fault detection residual thickness of Cabinet designs (the side of the tanker 13.5 mm, 12.8 mm; the tanker: 15.8 mm, 14.9 mm, 16.0 mm, zygomatic zone of 14.0 mm) and compared them with a valid.

Determined allowable moment of resistance of this set, forces the cross-section of the hull, representing the maximum bending moment at the bend of the longitudinal and bending by transverse set at normal and maximum precipitation, forming a corrugation and should not have an arrow of a deflection of more than $f/a \leq 1/15$ [2, 4.].

Conducted the conversion of a tanker double bottom and the second Board led to a reduction of the voltage (water pressure) in the installed and in the installation sheet of the plates and the applied methodical instructions on the layout, installation and welding of new elements to the building helped to minimize shrinkage stresses in the weld seams and heat affected zone, reducing the residual deformation and torsion [1,2,3].

The analysis revealed that after the conversion, the pressure of water forces from the outer circuit to the outer skin of the tanker was halved, the inertial moment at the wave resistance was minimized and the strength characteristics of the hull structure were increased (figures 3 and 4).

Built the second Board receiving from the external circuit force action has a minimum pressure, as passing the distance between the second boards width = 1000 mm, the water pressure decreases in a few bars, which allows the second Board not to experience any strong-acting stresses and deformation effects on the structure.

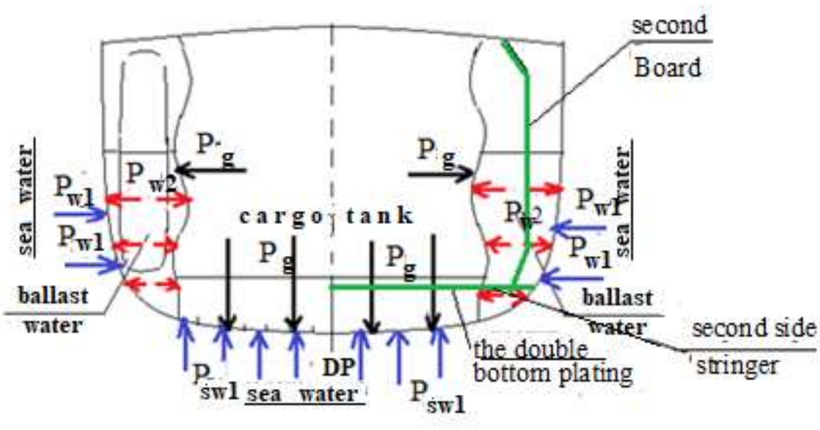


Figure: 3. Scheme pressure cargo (Pg) and water (P_{w1},P_{w2}) on the newly built flooring double bottom and second side after conversion.

Therefore, after the conversion of the tanker, the pressure of forces from the external circuit is reduced, which allows increasing the strength characteristics of the hull structure and reducing the inertial moment of the wave resistance (figures 3 and 4).

It is necessary to take into account not only the static forces arising in the process of moving the ship on the wave, when the ship is empty and, in the cargo, but also from those forces that may arise from the dynamic

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components, primarily from the hull structure itself. Here, dynamically generated forces can deform the hull to a cracking state or lead to twisting and warping of the sheet plates and the set system along the vessel.

These forces are currently poorly understood, and they often play a secondary role in the detection of defects when the vessel has a curvature in the hull structure.

But studying the design of single-hull and double-hull vessels, the authors came to the conclusion that numerous accidents and destruction of the hull is due to the rupture of the outer skin, in areas loaded and having a maximum voltage of metal plates.

Therefore, analysis was conducted of the owned practical and scientific achievements in the study of the forces on the hull and the mathematical model obtained by the authors in the study of the tanker afloat empty in the dream, the wave and the calm. As a result, the acting forces and the forces that the authors investigated when acting on the plates deformed the longitudinal inner set and outer plates.

The occurrence of deformation with pronounced cracks along and at an angle (intersecting cracks), a sign that in the hull structure itself due to some forces formed discontinuous stresses chaotic direction.As a result of the research, a method was developed, installation and installation of structural elements, which is applied to the conversion of the tanker "Şamaxı".

According to the obtained values, the authors justified the results of the study and proposed to use this method not only in the conversion of ships, but also to apply for ships of ship structures, platforms that have become overhaul. The developed method allowed to reduce the deformation, minimized the warping of metal plates, reduced the shrinkage stress.

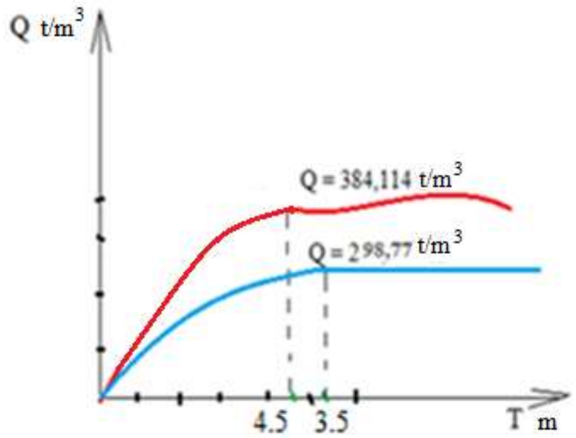

Figure: 4. Graphical representation of the water pressure acting on the structural elements of the bottom of the tanker after conversion and depending on the height of the ship's immersion for normal and maximum draft.

To more accurately determine the loads acting on the hull of the converted vessel, the authors propose to take into account the main indicators that make up the characteristics of the vessel. These are the draught, the width of the vessel, the length of the compartments or tanks and the density of the water.

4. EXECUTION OF WORK

To calculate the force of water pressure on the hull after conversion and draw conclusions, the authors proposed to calculate the water pressure acting on one of the beams of the bottom set to (a) and (b) after conversion (1.4), (figure 4) and the result to determine which option is the most acceptable:

$$Q_{1_w} = B \cdot T_g \cdot l \cdot \gamma = 9{,}95 \cdot 4{,}5 \cdot 13{,}95 \cdot 1{,}025 = 640{,}23 \ \ t/m^3$$
$$Q_{1_w} = B \cdot T_m \cdot l \cdot \gamma = 9{,}95 \cdot 5{,}3 \cdot 13{,}95 \cdot 1{,}025 = 754{,}04 \ t/m^3 \qquad \text{IV}$$

According to the obtained values in the formula 1.4., where the formula $Q_1 = B \cdot T \cdot l \cdot \gamma$ (1-m) was applied allowed to calculate the load acting on any beam of the tanker's bottom and side set, if ***l*** is replaced by ***S***. then the formula 1.4 would look like: $Q_1 = B \cdot T \cdot S \cdot \gamma$ (1-m). Here S is the thickness of the metal plates.

The resulting formula allowed us to calculate the loads acting on the flora at normal draft Tn after conversion:

$$Q_{1_w} = B \cdot T_m \Delta S \cdot \gamma (1-m) = \ 9{,}95 \cdot 4{,}5 \cdot 2{,}325 \cdot 1{,}025 \cdot (1-0{,}4) = 64{,}02 \ \ t/m^3 \qquad \text{V}$$

Where: ΔS- is the distance between the floras.
The load acting on the stringer, which is equal to:

$$Q_s = b \cdot l \cdot T \cdot \gamma (1-m) = 2{,}5 \cdot 13{,}95 \cdot 4{,}5 \cdot 1{,}025 \cdot 0{,}6 = 96{,}52 \ t/m^3 \qquad \text{VI}$$

where: b – is the distance between the bottom stringers.
Calculating the transverse loads of the tanker, the longitudinal bending moments of the vessel in its middle part, which can lead to undesirable technical damage and ruptures, are taken into account and calculated:

$$M_{maks} = LD/k = 141{,}6 \cdot 7900 \ / \ 1{,}065 = 1050{,}36 \ \ t/m^3 \qquad \text{VII}$$

where: L – is the length of the vessel, m; D – vessel displacement, t; k = 1.065-coefficient, which was determined on the basis of a prototype-built tanker.

It is taken into account that when bending the moment of resistance of the beams of the longitudinal and transverse bottom and deck set are bent with different forces, since they are affected by different stresses in nature, the maximum compressive vertical and tangential forces and at minor inertial moments they can bring to the rupture damage of the outer skin.

Therefore, the total permissible value of the moment resistance of the hull, the authors proposed to apply a safety factor to the strength in which to improve the strength characteristics and to reduce the bending and inflection of hull elements and of the plates by the formula: $W_{\eta o}$ = kW d(b),
where: W – is the permissible value of the moment of resistance; in the factor of safety; k – coefficient of bending and inflection reduction;
Wd (b) is the moment of resistance to bending of the deck and bottom for the converted vessel.

In addition, it is necessary to determine the standard wear of the hull structure of the tanker for each element and take the coefficient a1 according to [5, table.1], which should correspond to the formula:
$S_1 = a_1 S_0$.

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The analysis of longitudinal and transverse connections and overlaps in cargo compartments and tanks, which are affected by loads arising in the tanker hull from the transported cargo after conversion [5]. On the basis of which the calculation is carried out:

$$P_g = h \cdot \rho_g \cdot g\left(1 + \frac{a_z}{g}\right) \cdot t \geq 20, \text{kPa} \qquad \text{VIII}$$

where: Pg is the density of the load, t / m [3] and is: $\rho_\Gamma = \frac{1}{\mu}$

Consequently, making a calculation, we get: RG = 0,65 t/m^3; µ - specific loading capacity for General cargo, corresponding to 1.55 m3/ t; h = D – hpp; where D is the height of the Board; RR – the double bottom height; h: the height of the cargo loaded into a cargo tank equal to h = is 7.8 – 1 = 6.8 m

The projection of the calculated acceleration of the hull structure in the vertical direction az: 1st hold; nth hold; cofferdam; MCO [5] where RG is the density of the cargo, t / m 3 and is equal to:

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The projection of the calculated acceleration of the hull structure in the vertical direction az: 1st hold; nth hold; cofferdam; MCO [5.6].

$$a_Z = g \cdot \frac{0{,}9}{\sqrt[3]{L}} \cdot (1 + K_a) / F \qquad \text{IX}$$

where: F- is the load force acting on the hull; As is the projection of the calculated acceleration of the hull structure for the bow of the hull and the first hold:

$$K_a = 1{,}6 \cdot \left(1 - 2{,}5\frac{X_i}{L}\right) \geq 0 \qquad \text{X}$$

K_a - for the aft part of the hull, MKO, cofferdam of the after peak:

$$K_a = 0{,}5 \cdot \left(1 - 3{,}33\frac{X_i}{L}\right) \cdot \mu \qquad \text{XI}$$

K_a – for cargo tanks:

$$K_{an} = 0{,}5 \cdot \left(1 - 3{,}33\frac{Xn}{L}\right) \cdot q_z \qquad \text{XII}$$

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The pressure that is created in cargo compartments and ballast tanks during operation of the tanker on the wave in the cargo and empty, acting on the second bottom of the oil vessel and on the walls of the side cargo compartments is determined:

$$P = \rho \cdot g \cdot Z_i + P_K \qquad \text{XIII}$$

where: ρ-the density of seawater, equal to 1,025 t / m^3; g-9.81 m / sec^2; Zi-is determined by the theoretical drawing of the constructed curves-buttocks; P_k-pressure, kPa, which is adjusted to the safety valve, for load application points located below the summer load waterline.

In the result, the calculated parameters of the found points of contact which allowed to restore the overall strength of the hull in cross-section, where he built a rigid frame members: the bottom-Board-deck and increased the carrying capacity of the ship plates, plastically deformed and fixed, the residual bend from the compressive forces of the elastic model of side slabs. The deflection of the body is reduced by installing new elements of longitudinal links connected in a transverse frame rectangle, which reduces the stretching and deformation of the sheets.

But despite the fact that the design loads acting on the hull with a certain force at the time of conversion were taken into account and the corresponding calculation was applied [4], at the same time it is impossible to predict the secondary stresses that occur on the hull of the tanker. Such loads include natural, secondary and variable-static. These loads can be controlled by applying modern methods of repair during Assembly and welding production, as well as taking into account the structural and architectural features of ships, the material used for their construction and the dimensions of the vessel.

5. CONCLUSION

Used in the conversion of the tanker "Şamaxı" project 1598R technology of construction of double bottom and double sides allowed to increase durability, side and bottom plate Assembly with a system of recruitment, to reduce the deformation of a General curve of the hull from the resonance and oscillation, to reduce wave vibration

to reduce fatigue cracks and residual deformations. The used method of single-stage and multi-stage welding with reverse heating for bending allowed to obtain non-shrinkable welds and reduce cracking in the newly installed plates. The applied technological method of conversion of the tanker allowed to receive wear-resistant to corrosion welded connection which has no porosity. A method of calculating the obtained values of the loads affecting the recovery of the overall strength of the hull in cross section and the modulus of elasticity of the contour, which will reduce the tension plates and fix the longitudinal deformation of character. The main characteristic deformation generators in the hull structure of the inner and outer skin were taken into account, where new structural elements of the double bottom and the second side were built and satisfactory results with the lowest shrinkage rates were obtained.

6. ACKNOWLEDGEMENTS

The article deals with the main problems encountered in the repair and re-equipment of ships of one hull design. The analysis of the vessel hull compression and bending. The main loads affecting the outer skin are considered. Stresses arising in longitudinal and transverse beams of the vessel hull are investigated. The modern technique of installation of the main elements of a set of a double bottom and the second Board, taking into account increase in their General durability is developed. The main loads acting with different forces on the metal plates of the bottom and sides are analyzed, technological processes reducing shrinkage and deformation during welding production are developed. Thanks to a comprehensive study, the authors have developed numerous technological operations that can be used and applied in the repair of ships, ship structures and have a satisfactory quality index with minimal defect-forming components. The experimentally obtained technical developments will help to solve such problems in ship repair and shipbuilding production as minimizing tensile and compressive forces, deformation and shrinkage stresses leading to premature fatigue failure of metal plates and the set system. The

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practical application of the obtained methods leads to an increase in the strength characteristics of the ship's hull, the stability of the plates to the water pressure on the wave. These technologies were applied on the vessels of the oil fleet of the Caspian shipping Company, where they received positive results and proposed to apply them on the vessels of the technical fleet.

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