Aspects regarding analysis of the work deck from a support vessel

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Abstract. The authors are presenting an analysis of the work deck only for the support vessel, a ship having in its structure among others: deck cranes and helicopter deck. The work deck is one of the most important parts of the support vessel’s hull. We are starting the paper by presenting the role and the importance of the support vessel’s type, by using an original execution drawing carried out using the Unigraphics NX 8.0 Software from Siemens. Further on we can determine the shear, normal and the von Mises stresses pertaining to the work deck by using the finite element method. After determination of these stresses we can assess fatigue life, strength safety factor and fatigue safety factor. In order to determine the fatigue, the loading pattern only with the full unit cycle will be used. As for determining the safety factor only the ultimate strength stress criterion with the stress type von Mises from failure theories, will be used.

1. Introduction
The support vessels are small or medium size ships. They are used for the transportation of various general cargos in the adjacent zones of harbours, as for example the transportation from harbour of materials necessary for the marine platforms, or the cargo loading of the large cargo vessels. From military point of view, they are also used for the transportation of the various missiles or military equipment from harbours to the military vessels in the sea, defending the seacoast. These are only few tasks that can be carried out by the support vessels. Although they are not so usually as for example the crude oil tankers or the cruise ships, their importance cannot be underestimated.

The state of the art support vessels are also foreseen with heliport. The support vessels are continually evolving, mainly in the harbour’s areas of different seas: Black Sea, Baltic Sea, Mediterranean Sea etc., figure 1 [1].

New types of these vessels are equipped with satellite shaving, figure 1.

Goods that are on the deck work are shown in different colours to be seen more easily, figure 1.

The support vessel presented in this paper is designed using the NX 8.0 from Siemens, figure 1 and figure 2.
In order to carry out the drawing were used many dots, lines, circles datum plane, datum axes, extrude, sketch etc., figure 2.[2]

As it can be seen in Part Navigator, 712 commands were used, some of them being ones of great complexity, figure 3.

Although it is a ship of medium size, it is a very complex one from the viewpoint of construction but from the viewpoint of its equipment, such as satellite radars, cranes, a.s.o. Therefore, only for the carrying out of the drawing, based on computer aided design (CAD), many working hours within a team of naval engineers were necessary.

After carrying out the design of the ship (figure 4 and figure 5), in order to achieve a better accuracy of the surfaces, mainly for the ship’s hull, the command Section Analysis with a section placement of uniform type to carry out of some specific diagrams, using the so called needles, has been applied.
Based on the command Trimetric, it may be possible to see this type of vessel from many angles. Since the heliport is optional, in order to see more easily the ship from different positions, the taking out of the heliport together with its fastening system, it is to prefer. The five different view positions are: lateral view, front view, back view, top view and bottom view, as it can be seen in the next 5 figures.
2. Work deck of the support vessel

Work deck is one of the most important parts of the ships of support vessel type. On the work deck it is placed the transported cargo but also the cranes and other special equipment used to place and arrange the cargo on deck, as well, figure 12. [3]

After using the Draft Analysis command it can be remarked the green surface, having the positive draft with limit angle of de 50 (figure 13), representing the work deck of the ship.

Then, we have shown under the work deck the section (storage area) where the cargo is stored. In order to do this, we have preferred to carry out a longitudinal section and a transversal section, figure 14 and figure 15.
Because the surface of the work deck is a very large one (some hundreds of square meters) and the work deck is built out of special steel, in order to resist to very big loads, the building solution is by joint welding and joint board of many steel plates of rectangular shape, to form the area of the work deck, figure 16.

One of the contact areas is representing the contact surface between the crane and the work deck. Since the crane is weighing some tens of tones, and we are additionally adding the maximal load of the crane, then the weight of the crane-load ensemble is rather big. The crane part supported by the work deck is named pedestal base, has the shape of a cylinder and that is why the contact area has the shape of a circle. In conclusion the most stressed area on the work deck is represented by the contact area, figure 16.

In order to determine the stresses, fatigue, and temperature in the contact area the contact area has to be firstly meshed, preferably with elements of 3D Tetrahedral shape. After the border of the contact area is embedded, high contact pressures, normal to the contact area, are applied to this contact area, figure 17 [4].

3. The analysis of the contact surface between the work deck and crane

In order to determine the values of stresses, fatigue and the temperature’s variation in the contact area as well, we are using the finite elements method (FEM) [5].
In the drawings with normal stresses, maximal shear stresses and von Mises stress it can be observed that the extreme values of stresses are lying either in the centre or at the edge of the contact area.

![Figure 18. Max shear stress.](image18)

![Figure 19. Max shear stress diagram.](image19)

At maximal shear stress the values of the strain is higher in the central area and are decreasing towards margins. At the margin of the surface these strains are increasing again, having even maximal values in some marginal areas, figure 18 and figure 19.

![Figure 20. Normal stress.](image20)

![Figure 21. Normal stress diagram.](image21)

Even though the normal stress has medium values in the centre, these are increasing toward margins of the surface, where the maximal values are to be found, figure 20 and figure 21.

![Figure 22. Von Mises stress.](image22)

![Figure 23. Von Mises stress diagram.](image23)
On the other hand the values of the von Mises stresses, which are higher in the centre, are decreasing in the middle of the contact surface and then they are increasing again at the margin of the surface, figure 22 and figure 23.

If the extreme values of the strength safety factor are lying in the centre and at the edge of the contact area, then the extreme values of the fatigue safety factor and fatigue life are lying only at the border of the contact zone, figure 24 and figure 25.

![Figure 24. Fatigue Safety Factor.](image1)

![Figure 25. Fatigue Safety Factor Diagram.](image2)

![Figure 26. Fatigue life.](image3)

![Figure 27. Fatigue Life diagram.](image4)

![Figure 28. Strength Safety Factor.](image5)

![Figure 29. Strength Safety Factor diagram.](image6)
We have chosen in the end of the analysis the analysis of the fatigue of the contact surface because the kind of the fatigue is depending on the values of the stress recorded above.

The values of the fatigue life are rather high, fact which is conducting to the deformation and even the breakage of the analyzed surface over a certain period of time, figure 26 and figure 27.

The values of the strength are low and therefore are indicating a very high value of the safety in exploitation, figure 28 and figure 29.

Figure 30. Temperature.

In order to determine the temperature variation in the contact zone the thermal type analysis solver has been used. As it can be seen in the above temperature diagram, the high temperatures are lying in the centre and are decreasing toward borders, figure 30 and figure 30.

4. Conclusions
During the planed periodical reparation works it is indicated that the physical state of the work deck, subjected to various high loads, is assessed. For example there exists the danger that the cable crane is broken, while a certain load is lifted. That load could fall on work deck and hence deform or even break the work deck, and hence the danger to destroy the cargo rooms of the vessel, putting at risk the safety of the ship when the cargo is, for example, high flammable.

The analysis of the work deck has major importance for the safety of the support vessel, taking into consideration that on one hand the fact that high stresses and deformations during bad sea conditions such as storms on the sea, and on the other hand unappropriated loading of the ware, could deform or even break the work deck of the ship.

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