Advanced analysis of the transverse bulkhead of the a general cargo ship

T Axinte[1], C Nutu[1], C Stanca[2], O Cupsa[2], A Carp[2]
[1] Maritime University of Constanta-Romania, Department of General Engineering Sciences, Mircea cel Batran Street, No. 102-104, 900663, Constanta, Romania
[2] Maritime University of Constanta-Romania, Faculty of Navigation and Naval Transportation, Mircea cel Batran Street, No. 102-104, 900663, Constanta, Romania

[1]E-mail tibi_axinte@yahoo.com

Abstract. The paper presents the main strength factors stressing the transverse bulkhead of a cargo ship. The transverse bulkhead is one of the main components of the hull for a general cargo vessel. There are presented the role and the importance of the general cargo vessel's type using an original drawing made in NX 8.0 Software from Siemens. Further on, we are presented the importance of the transverse bulkhead of the general cargo ship's hull. Next there are analysed the formability of the transverse bulkhead's material and then we are determining the shear, normal and von Mises stresses in the traverse bulkhead, using the finite element method. Once the stresses are computed, there are also determined the fatigue life, strength safety factor and fatigue safety factor. The analysis of the transverse bulkhead is important for the safety of the general cargo vessel type because if this component of the ship does not resist to the various stresses and high deformations during bad storms on the sea or if the cargo is stored inappropriately, deformations or even breakage of the transverse bulkhead can occur, thus causing damages of the cargo ship, especially under heavy storm.

1. Introduction

Since the beginnings of the shipbuilding the importance of the strength of the hulls and decks was regarded as a crucial feature and condition which had to be met. A special attention has been dedicated to the fatigue life, strength safety factor and fatigue safety factor, especially after the accident of Titanic. Once the FEM analysis has emerged, the calculus of stresses and fatigues has become more and more accurately, without to much additional calculation.
Since most of the cargo ships on long distances are transporting various general cargos, usually in containers, than the general cargo ship type is mostly used.

These ships are classified after the deadweight tonnage (DWT) as follows:

-Small Handy Size vessels of about 20,000 to 28,000 DWT;
-Handy Size of about 28,000 to 40,000 DWT;
-Handymax Size of about 40,000 to 50,000 DWT.

That is why we firstly considered a 30,000 DWT (handy size) container vessel, designed using the NX 8.0 software from Siemens.

In order that the design is more suggestive, we decided to consider the respective vessel in harbour, for loading/ unloading containers, figure 1 [1].

In general, this type of vessels has its own crane (or cranes), in order to load/unload more easily their cargo, figure 1 [2].

When carrying out the drawing there were used more than 690 commands in the NX software, many of them being complex commands in the part Navigator of NX, figure 2.

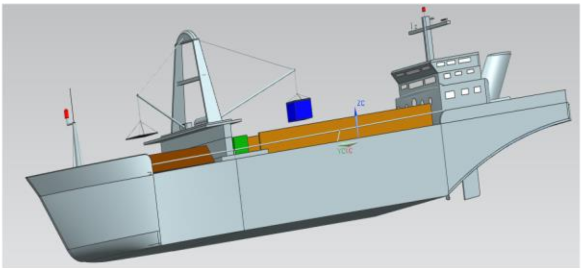

Figure 1. General cargo ship of 30,000 TDW.

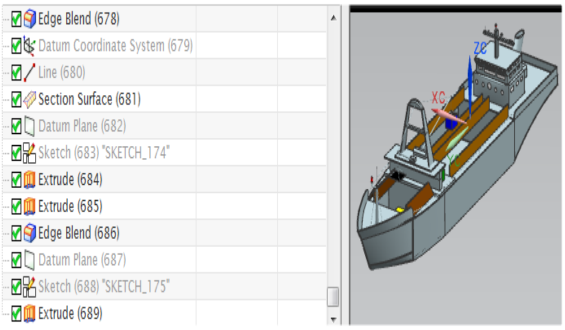

Figure 2. Last commands in Part Navigator.

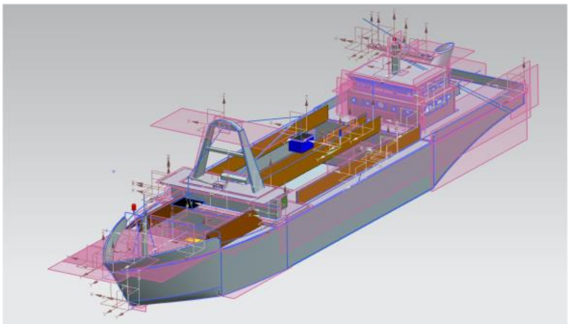

Figure 3. Original drawing of the general cargo ship.

Among these commands there are many sketches, curves and datum planes, which helped us to carry out the respective drawings, figure 3.

The fore of the vessel has been carried out using the command Curve Analysis, especially used in the designing of this part of the ship. Depending on curve analysis we are obtaining a hull with adequate parameters, because the strength of the transverse bulkhead is depending on the shape of the ship, figure 4.

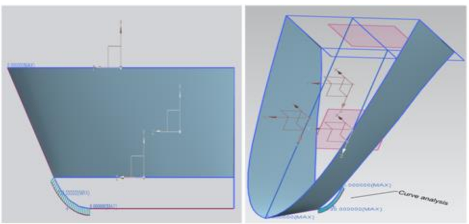

Figure 4. Curve analysis.

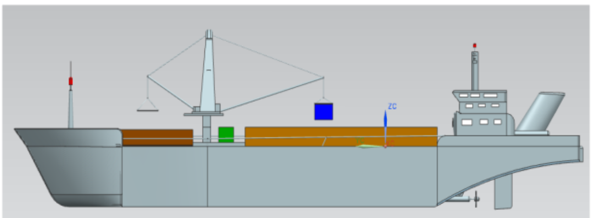

Figure 5. General cargo ship – lateral view.

Since the drawing of this type of vessel is very complex and many working hours, in various teams, have been spent, we have decided to present this vessel in more design views, such as the following five views, below: lateral view, front view, back view, top view and bottom view, because the transverse bulkhead is in the interior of this hull. For its transverse bulkhead we have to analyze the stresses and the fatigue using the FEM analysis.

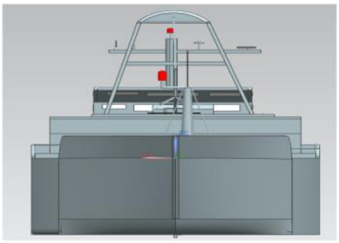

Figure 6. General cargo ship – front view.

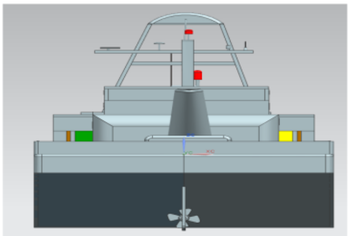

Figure 7. General cargo ship – back view.

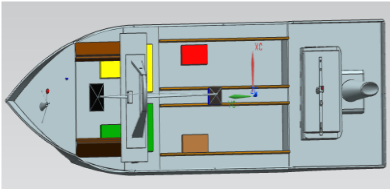

Figure 8. General cargo ship – top view.

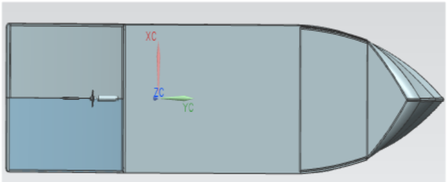

Figure 9. General cargo ship – bottom view.

2. Transverse bulkhead at cargo ship

Transvese bulkhead plays a major role in the strength of the ship's hull of the general cargo vessel. That is why we thought already from the beginning to consider the transverse bulkhead, figure 10.

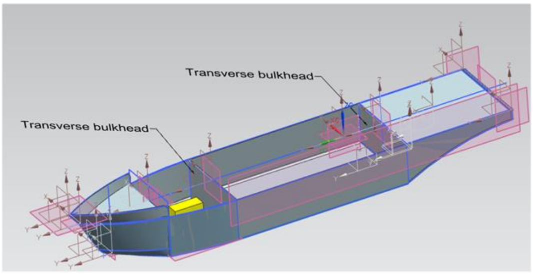

Figure 10. Transverse bulkhead in the ship's hull.

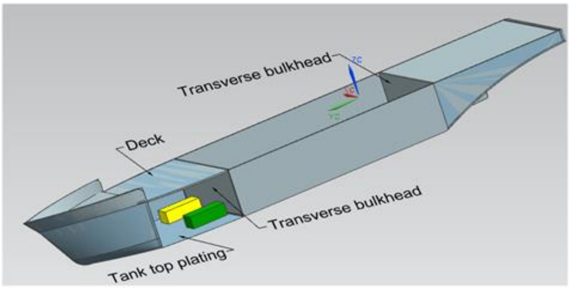

Figure 11. Transverse bulkhead, deck and tank top plating.

In the construction of a general cargo ship, the transverse bulkhead is the link between the portside and starboard and between the deck and top plating, as well, figure 11.

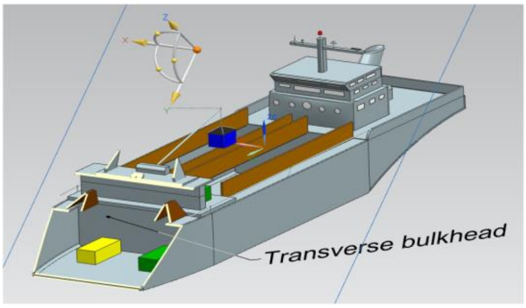

Figure 12. Cross-section of the ship with transverse bulkhead.

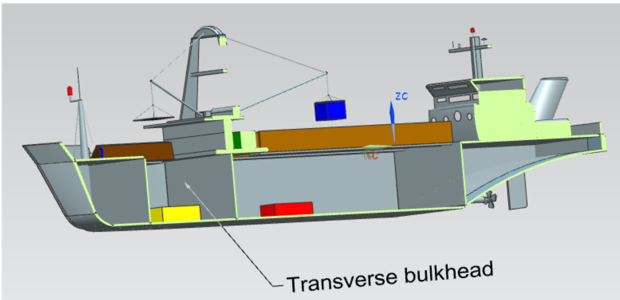

Figure 13. Longitudinal section of the ship with transverse bulkhead.

Moreover, the transverse bulkheads are representing the frontal walls of the storage rooms, where the cargo is stored, figure 12 and figure 13. That is why the storage rooms have to be very resistant in order to maintain the cargo of the ship in good conditions during the transportation [3].

However, during great storms or when the cargo is not fasten properly, then the cargo could hit the transverse bulkhead with a considerable amount of strength. If the transverse bulkhead is hit in the above part then the deck may be deformed, but the safety of the ship shall persist. If the transverse bulkhead is hit in its sides or in the part below, in the edges, figure 14, this can seriously damage the bottom plating or tank top plating, causing thus even the sinking and wreckage of the ship.

The front view of the transverse bulkhead. Since the dimensions as well as the shapes of the transverse bulkhead are depending of the construction of the vessel, we are considering a classic shape of a transverse bulkhead [4].

When having high dimensions, the transverse bulkhead is formed out of many steel plates of considerable thickness, which are all welded together, figure 14.

The most endangered part of the transverse bulkhead, marked with A, is the designated as the dA region.

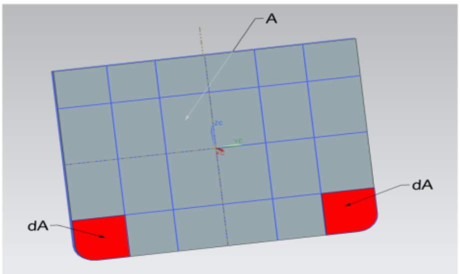

Figure 14. Transverse bulkhead (front view).

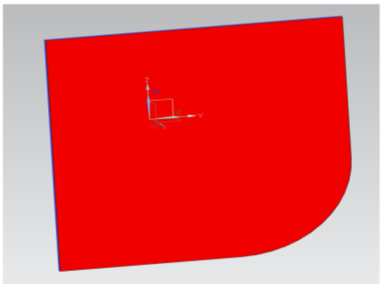

Figure 15. Danger zone in the transverse bulkhead (dA region).

Since the most stressed regions are symmetrical, we shall restrict our analysis only to the right zone, figure 15.

But, since all the material of the bulkhead is made out of steel, for the beginning we will carry out formability one-step analysis. The formability is analyzed in the figure below, as it can be seen in the curving zone. In some yards, before the transverse bulkhead is mounted, an analysis of the formability of the steel plates is required from the producer of the plates, figure 16.

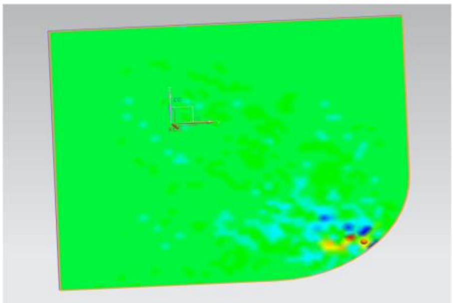

Figure 16. Analysis of the formability – one step.

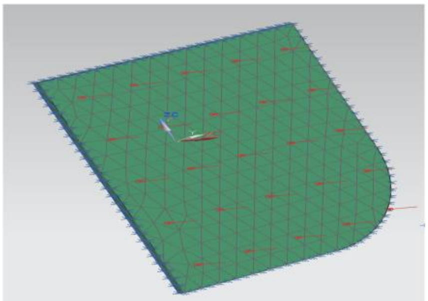

Figure 17. Pressure, embeding and meshing.

In order to analysis the way of behaviour in the endangered zone, then we shall determine the von Mises stress, the maximum shear stress and the normal stresses.

If we are meshing the endangered section by using the finite element method (FEM) we are obtaining 1320 triangle elements of CTETRA (10) type [5].

After meshing the jeopardized zone, on the transversal surface of the plate an uniform pressure of 100 MPA, has been applied. Then, on the contour of the opposite surface of the endangered section, we considered a fixed boundary. Because of this pressure, the dA element plate will be accordingly deformed, figure 17 [6].

3. Results

After the completion of the analysis using the finite element method (FEM), the following facts have been observed:

a) The von Mises stresses are maximal at the edges and minimal in the middle part of the section.

b) The shear stresses have maximal values at the ends and minimal in the middle part of the section.

c) The normal stresses have maximal and minimal values at the boundaries of the plate, which is representing the endangered zone.

Moreover, in order to be more suggestive we have drawn the graphics for each type of stress. These graphics are representing the variation of the stresses depending on the most important nodes pertaining to the meshing of the dA section. The charts corresponding to the stresses are represented below:

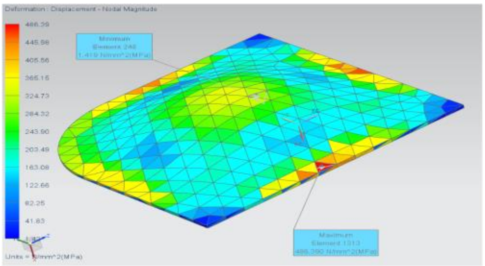

Figure 18. Von Mises stress.

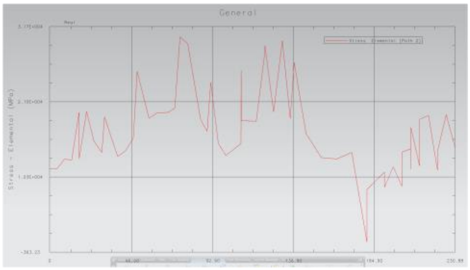

Figure 19. Diagram of the Von Mises stresses.

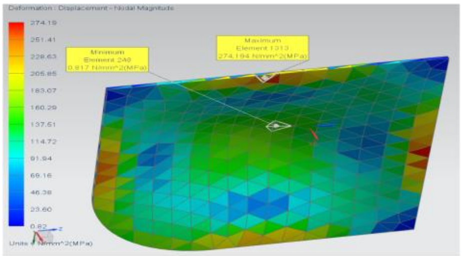

Figure 20. Max shear stress.

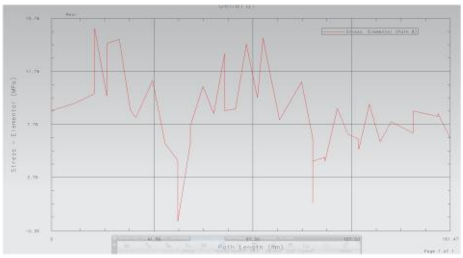

Figure 21. Diagram of the max shear stresses.

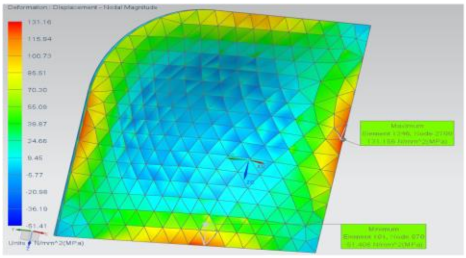

Figure 22. Normal stress.

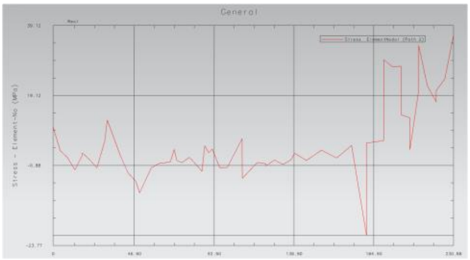

Figure 23. Diagram of the normal stresses.

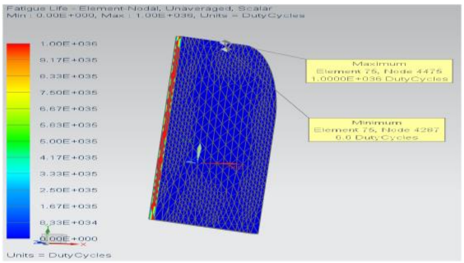

Figure 24. Fatigue life.

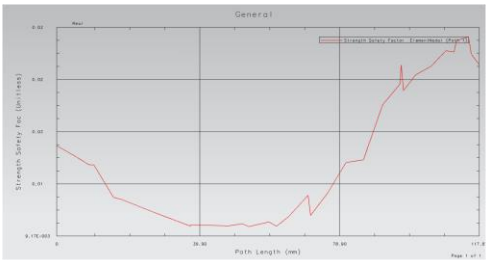

Figure 25. Diagram of the fatigue life.

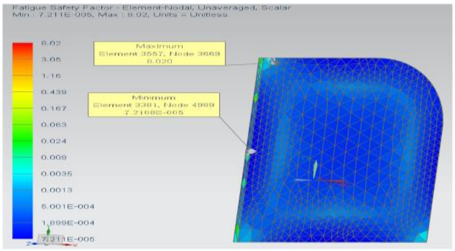

Figure 26. Fatigue safety factor.

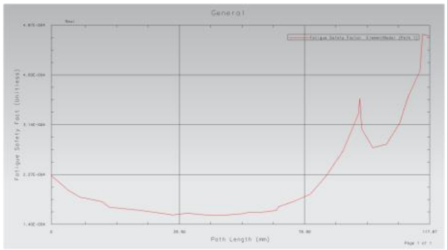

Figure 27. Diagram of the fatigue safety factor.

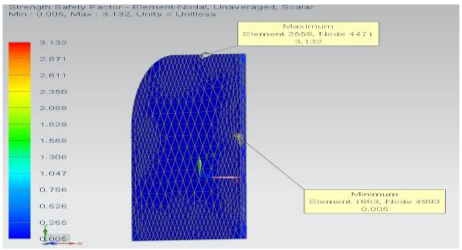

Figure 28. Strength safety factor.

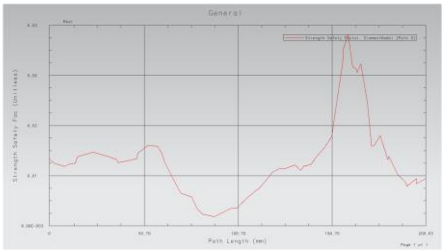

Figure 29. Diagram of the strength safety factor.

4. Conclusions

Based on the values of the stresses the influence of the three fatigue factors on the transverse bulkhead can be analysed. The three fatigue factors are: fatigue life, fatigue safety factor and strength safety factor.

As it can be observed from the graphics pertaining to the fatigue life and fatigue safety factor, the obtained values are good at the ends of the graphics, thus indicating a stability's fatigue of the material in the dA region. As for the last graphic, namely the strength safety factor, the results are rather average toward poor, meaning a poor strength safety.

If the values of the strength safety factor have permanently decreasing results over time, this fact could lead to the breakage of the material in the safety zone dA. That is why we believe that the maintenance of the ship has also to focus on the checking of the strength safety factor.

Because this type of vessel is preferred due to its strength on various seas and oceans, an important problem regards the wearing of the ship's hull and of the component parts of the ship, including the transverse bulkhead, as well. Moreover, there may occur dangerous situations, such as the shocks due to the cargo improperly fasten applied onto the transverse bulkhead, which lead to gradual decreasing of the safety factor and to decreased safety of the ship.

References

[1] Stanca C, Acomi N, Ancuta C and Georgescu S 2015 Comparative analysis of different loading conditions on large container ships from the perspective of the stability requirement, IOP Conference Series: Materials Science and Engineering, 95(1). 012072.
[2] Cupsa O and Martinas G 2015 International Journal on Marine Navigation and Safety of Sea Transportation pp. 243-248
[3] Stanca C 2002 Implementation of quality management systems in Romanian maritime education and training (IAMU) pp. 1-5.
[4] Oanta E, Panait C, Batrinca G and Pescaru A 2011 Computer Based Educational Model of the Bent Hull in the Context of the Maritime Education, Annals of DAAAM, ISBN 978-3901509-83-4, pp. 503-504.
[5] Hadar A, Marin C, Petre C and Voicu A 2004 Metode numerice in inginerie, Politehnica Press Publishing House, Bucharest.
[6] Oanta E and Nita A 2009 An Original Method to Compute the Stresses, Applied Elasticity Journal of Optoelectronics and Advanced Materials pp. 1226-1230.