The optimization of container transport on a ship type PSV

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Abstract. In this paper, we studied how containers need to be transported on a PSV ship. The deterioration of the containers during the transport can get a result in the destruction on the goods. All the drawings were made by us in the NX 12 software from Siemens. Furthermore, the analysis of the container clamping system was performed by the finite element method using the NX 12 Siemens software. Structural dimensions following an original project, were used to the achievement of a PSV (Platform Supply Vessel) ship in design. Although, PSV ships are relatively small, they have a complex design. The purpose of these ships types is to transport freight and weights bigger and bigger. This is the reason why we close to present in this work only the optimization of containers on PSV ships.

1. Introduction
Maritime platforms are large metal constructions, which are used in seas or oceans for the extraction of oil and natural gas. Because maritime platforms are generally far from the shore, the PSV (Platform Supply Vessel) ships are used for material supply or personal exchange.

Although PSV vessels are small in size, that means between 50 and 100 m, these vessels must travel across areas of the seas or oceans with large waves (ex. North Sea).

Figure 1. The PSV ship with two containers.

The PSV type ships that are Offshore Vessels (OSV) type, which means, these vessels are only single deck. In the drawing presented below we have a PSV type ship loaded with two containers. This PSV type ship is shown in figure 1.
In fact, the PSV ships are considered with the simplest types of vessels from a technical point of view, used for maritime platforms.

But offshore vessels can also be equipped with one or more cranes. And these ships are called crane vessel (C/V).

In addition, modern PSV ships are also equipped with ROV (Remotely Operated Vehicle), [1].

2. Gripping of the container system on the ships type PSV

The logistical support of offshore platforms is provided safety if all the goods are transported in containers.

Depute the fact that PSV ships have a roller or a pitch motion, because of the waves, all the containers should be fixed to avoid toppling over. In fact, several containers are placed on the ship's platform.

Then a new method would be the installation of special fastening systems that are on the deck, on which the 20' and 40' containers can be safely mounted. But if large pieces that can't fit into the conventional containers have to be transported, then those large pieces can be attached more easily to the metal frame made for transport of the containers, in a figure 2.

![Figure 2. PSV type ship with a container catching system.](image)

During storms, if this container clamping system is not used, water which is on the platform and possibly enter in the containers and damage the cargo. Generally, the goods transported in containers by PSV ships are: foods, spare parts, etc., which can be damaged by moisture, [2].

By the way, the shear stress is as in equation (1):

\[
\tau_{xy} = \tau_{yx} = \frac{dM \cdot A}{dx \cdot b \cdot I_z}
\]  

(1)

In which the shear force T is as in equation (2):

\[
T = \frac{dM}{dx}
\]  

(2)

And according to Juravski's formula it's:

\[
\tau_{xy} = \tau_{yx} = \frac{T \cdot A}{l \cdot I_z}
\]  

(3)

In which: M - the bending moment, A - the section surface, l - the section width, I_z - the axial inertia module, as in equation (3).
Figure 3. The volume element with the shear stresses.

It should be noted that the shear stress $\tau_{xy}$ is parallel to the axis $O_x$ and perpendicular to the axis $O_y$. Analog the shear stress $\tau_{yx}$ is parallel to the axis $O_y$ and perpendicular to the axis $O_x$, as it can be seen in figure 3, [3].

The container holder may deform when it can be loaded with a container. This can happen due to the movement of the ship, strong wind, high waves or crane.

But to perform a more developed analysis on the clamping system, then we can determine with the finite element method the shear stresses.

Figure 4. The case 1 - The container support.

So, in the first case we have a fixed support. This bracket is fixed to the deck, as figure 4.

The container holder in this case is a fixed fastening system. The container support was meshing and 8409 finite elements type CTETRA(10).

The maximum shear stress at the element 3862 has the value $\tau_{\text{max}} = 496.208\text{MPa}$. But the minimum value of the shear stress at element 453 has the value $\tau_{\text{min}} = 0.192\text{MPa}$. These values are shown in figure 5. The diagram from figure 5, after the finite element 6685 in the care of shear stresses is $\tau=120\text{MPa}$. All shear stresses values are tangible. Although this diagram is variable with shear stresses, it can reach a maximum stress up to a value of almost 230MPa.
Figure 5. The case 1 - The extreme values of shear stresses $\tau$.

Furthermore, adjusting strips are used to improve the strength of system, especially in container's transport. These adjusting strips are also used to improve of the gripping device, as in figure 6.

Figure 6. The case 2 - Improvement of the fixed clamping system.

After the clamping system from the case 2 was meshed, resulted 11400 the finite elements type CTETRA(10), [4].

In figure 7, it's observed that the values of the extreme stresses of the shear stresses are located in the middle of the clamping system. So we have in element 6105 a shear stress value $\tau_{\text{max}} = 608.281$ MPa and in the element 9771 we have a minimum shear stress value of $\tau_{\text{min}} = 0.040$ MPa.

The values of the shear stresses in the diagram from figure 10, starts at $\tau = 280$ MPa and ends at finite element 693 with the shear stress value of $\tau = 40$ MPa, [5].

The clamping systems can be fixed or mobile. The PSV ships can be loaded with the clamping mechanism together with the container.

The mobile clamping system is much more advantageous than fixed one, because the system can be easily disassembled and the deck is released.

In general, it's possible to mobilize in four formats care devices are fixed in the document. The container shall be fixed until it's available. The maintenance of the devices is mounted side and in front empty.
Figure 7. The case 2 - The extreme values of shear stresses $\tau$.

Usually the mobile clamping system consists of four devices that are fixed on the dock. On these devices the container is fixed. Between the devices are mounted both side a lateral and frontal connecting rods, figure 8.

Figure 8. The case 3 - The mobile clamping system.

As in the other cases, in case 3 the vertical pressures act, like placing a container on the clamping system. In this case, we obtain 14629 finite elements type CTETRA(10). Before mounting the mobile device, each device must be fixed to the dock, [6].

The case 3 can't be reliable, because at a strong shock, the front bars from the middle of the clamping device can be broken, as shown in figure 10. The extreme values in case 3 are: at the element 7481 there is the minimum shear stress which has a very small value $\tau_{\text{min}} = 0.000799$ MPa. But the maximum shear stress at element 8297 is $\tau_{\text{max}} = 981.381$ MPa. So in case 3, the difference between the maximum of the shear stresses is very large, figure 9.

Figure 9. The case 3 - The extreme values of shear stresses $\tau$. 
It's very interesting how the extreme values of the shear stresses from case 4 are presented. So the minimum shear stress is in the right-hand corner of the device at the finite element 5779 has the value τ_{min} = 0.000168 MPa. At the bottom of the newly mounted device which is at the center of the system on the left side the maximum shear stress value τ_{max} = 472.703 MPa. As in case 3, the difference between the extreme values of the shear stresses is large, in figure 10, [7].

![Figure 10. The case 4 - The extreme values of the improved system.](image)

The diagram of figure 10 starts from a null value in element 4747 and if ends at the finite element 6346 to a value of almost 20MPa. As in the order previous cases, the values from the last diagram of the shear stresses are positive.

3. Conclusions
In general, the PSV type deck is heavily loaded with containers or large parts needed at oil rigs. Then we need to improve or find another model for the mobile container grab system, as in figure 10.

Note that the four mounted devices don't deform even if a container can fall freely and hit the clamping system.

In conclusion, the last case is the attachment system which is the best. It can be easily mounted or dismantled by personnel authorized to work on the deck.

In the future, in-depth studies can be done to modernize this system of catching containers and other types of ships.

4. References
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