The mechanism's study of fixing a container on a freight wagon type Rgs

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Abstract. In freight transport is constantly evolving in the world. An important role in development of freight transport is the increasing usually a speed to 180 km/h of freight trains. In multimodal transport, all the goods are transported in containers. Therefore, the freight is mostly containerized. Several containers in freight trains are transported on Rgs freight wagons. On Rgs platforms of freight wagons are bolts of which the containers are fixed. The role of these bolts is very important because when the train takes the curve or brakes ward, containers could leave the wagon's platform. In this paper, we represented a Rgs Wagon loaded with two containers. We have to mention that the dimensions of wagon and containers have been made using original projects. Furthermore, we are approached the theoretical aspects referring to the clamping system. We set out to accomplish a through search of both the used bolt to Rgs wagons and new model of bolt. This research was carried out with the help of finite elements method. The design part and the study with finite elements were made in NX 12 software from Siemens. Because of these bolts types they following stress: normal, shear and von Mises. As a consequence, we deduced that the second bolt type is more reliable.

1. Introduction

The containers transport by railway has increased worldwide especially in the last five years. The goods are carried easier in containers, because the containers are very useful in multimodal transport (ex. maritime, rail and auto).

The goods which are transported in containers, could be: wood, clothing, footwear, electrical and electronic equipment, etc.

The advantages of rail transport for container transport are: safety, cheap transport, carry more containers on a wagon, low transport costs, etc.

The containers are loaded on the freight wagons from container terminal by means of cranes. These cranes are used to lift the or to mount the container on the wagon, [1].

The Rgs wagon series represents: R - open wagon, g - for container transport, s - suitable for use in trains up to a speed of 100 km/h.

Below, with the NX 12 from Siemens software we made a freight wagon of type Rgs with 4 axles.

We have to mention that this wagon is loaded with two containers, which means that the pink container has the height of 20’ (small container) and the orange container has the height of 40’ (big container), figure 1.

Both containers are fixed on wagon platform in bolts to avoid moving during transport.
2. Theoretical aspects of a clamping systems

We consider that a container hits the gripping bolt when it is on the wagon. So, the bolt will be body 1 of length $l_1$ and cross section $A_1$. We mention that the body 1 is the bolt which is resting on a rigid plate (platform). And the bottom of the container that will strike the bolt will be considered in body 2 which acts with weight $G$. The distance between body 1 and body 2 will be distance $l_2$, figure 2, [2].

If the mechanical work made by a force $G$ is equal to the whole kinetic energy of the weight $G$:

$$G(d + l_2) = W$$

(1)

We will use the expression of deformation energy:

$$W = \frac{EA_1d^2}{2l_1}$$

(2)

Where $d$ is the deformation and $E$ is Young's modulus.

From equation (2) we can obtain a grade II equation that has as unknown $d$:

$$EA_1d^2 - 2Gdl_1 - 2Gl_1l_2 = 0$$

(3)

The solutions of the second degree equation are:

$$d_{1,2} = \frac{Gl_1 \pm \sqrt{G^2l_1^2 + 2EA_1Gl_1l_2}}{EA_1}$$

(4)
In our case it is only possible:

\[ d_1 = \frac{Gl_i + \sqrt{G^2l_i^2 + 2EA_1Gl_i}}{EA_1} \]  

(5)

For the static case, the deformation \( d \) becomes static deformation:

\[ d_s = \frac{Gl_i}{EA_1} \]  

(6)

Then we'll simplify the equation (5):

\[ d = d_s + \sqrt{d_s^2 + 2d_2} \]  

(7)

Equation (7) can be written:

\[ d = d_s \left(1 + \sqrt{1 + \frac{2l_2}{d_s}}\right) \]  

(8)

3. Analysis of the container attachment system on the freight wagon

Next we will study the resistance of the container clamping system on the freight wagon using the finite elements methods.

At first, a classic bolt was in 3D in a simplified way, figure 3, [3]. After that, it was proceeded to meshing the bolt in the first case, in which 1534 finite elements were use. The finite elements used are type CTEXTRA with the size of 10 mm. At the bottom we made the recess and at the top the pressure on the bolt acts.

Figure 3. The case 1 - The were use classic bolt.

The extreme values of the shear stresses from the first case are at the top of the bolt. Thus at the element 912 is the minimum shear stress \( \tau_{\text{min}} = 34.846 \) MPa, and at the element 667 is the maximum shear stress \( \tau_{\text{max}} = 2227.443 \) MPa, figure 4.

Figure 4. The case 1 - The shear stresses.
For a drawing up a diagram from this paper, we have chosen the most important finite elements to render the values of the most important stresses.

The shear stress from the element 97 which has a value than 120 MPa. The diagram drops 100 MPa and then rises sharply to 220 MPa. Then it drops again below 80 MPa. But it increases and reaches 165 MPa from the element 1305, figure 4.

The extreme values of normal stresses are only on side of the bolt. Thus the minimum normal stress $\sigma_{\text{min}} = -217.567$ MPa are at the element 23 and the maximum normal stress $\sigma_{\text{max}} = 49.335$ MPa is the element 608, figure 5.

![Figure 5. The case 1 - The normal stresses.](image)

The diagram of normal stresses from the case 1, mostly has negative values. Only in the last part are the values of the normal stresses positive, but their values are below 50 MPa, figure 5.

![Figure 6. The case 1 - The von Mises stresses.](image)

For the case 1 maximum von Mises stress is at the element 667 and has the value $\sigma_{\text{v max}} = 439.359$ MPa. But the minimum von Mises stress at the element 912 is $\sigma_{\text{v min}} = 60.983$ MPa, figure 6, [4].

All the values of von Mises stresses from the diagram in the case 1 are positive. However, all von Mises stresses in the diagram values over 90 MPa, figure 6.

In order for the bolt to resist better shock, we thought of developing a new model as in case 2.

![Figure 7. The case 2 - The new bolt pattern.](image)

The upper part of the new type of bolt is curved. On this case, the container will be placed more easily on the Rgs freight wagon, figure 7. In case 2 the bolt was meshing and 2960 finite elements type CTEXTRA with the size of 10 mm.
In the second case, a uniform pressure is applied at the top of the bolt. But at the bottom of the bolt a embedding a applied.

The extreme values of the normal stresses are: at the element 2677 is the maximum shear stress $\tau_{\text{max}} = 415.726 \, \text{MPa}$ and the element 2829 is the minimum shear stress $\tau_{\text{min}} = 8.671 \, \text{MPa}$, figure 8.

![Figure 8. The case 2 - The shear stresses.](image)

The diagram of shear stresses from the second case has high values. That is, from values above 70 MPa to values of 230 MPa, figure 8. The maximum normal stress is quite low in the case 2, namely $\sigma_{\text{max}} = 5.344 \, \text{MPa}$ and is at the element 907. But the minimum normal stress at the element 406 has the value $\sigma_{\text{min}} = -316.463 \, \text{MPa}$, figure 9.

![Figure 9. The case 2 - The normal stresses.](image)

In the diagram of normal stress from the case 2, there are positive normal stress with very small values. These values are highlighted at the element 1607. In most of the elements in the graph, the values of normal stress are zero, figure 9.

![Figure 10. The case 2 - The von Mises stresses.](image)

For the case 2, the maximum von Mises stress is at the element 2677 and has the value $\sigma_{v\text{ max}} = 814.019 \, \text{MPa}$. But the von Mises minimum stress that is at the element 1206 has the value $\sigma_{v\text{ min}} = 15.265 \, \text{MPa}$, figure 10.

The von Mises stress diagram, it starts from the von Mises stress which is 250 MPa from the element 2960 and reaches a von Mises stress of 460 MPa. After that the diagram decreases to 80 MPa and then increases to a value of over 175 MPa at the element 2759, figure 10.
4. The container on the freight wagon
The freight wagons during transport are subject to different moves during the transport slice: galop, rolling, flexuosity and stick-slip, etc. [5].

The containers could fall out of wagons because of these moves or in exceptional cases when train must to apply the brakes quickly. In this case, the most commonly used clamping system consist of Due to these movements or in exceptional cases when the train has to slow down quickly, container may fall out of wagons. In this case, the most used clamping system consists of eight bolts for Rgs wagon. That is, each bolt will be at each corner of the container.

The four bolts which have a height of 20 mm, can be fixed for setting the container or they can be adjusted to carry a big piece. The bolts from this paper are represented in a simplified way and they are designed to block the movement of the container, figure 11.

![Figure 11. The bolts on the wagon type Rgs](image)

In fact, the bolts are subjected most often to the request for compression by shock because of the container which should be placed on the freight wagon type Rgs.

The breaking of a single bolt can to breakage of the other bolts or even the derailment of the wagon or even train. Therefore, it is better to use as a backup a safety systems on every corner of the wagon. In this case, there's no need installing a side or front wall to freight wagons.

5. Conclusions
Between the two cases, we consider that the bolt of the second case is stronger. Furthermore, the achievement of the second model bolt is cheaper. The bolts are resistant to wear.

With the help of these bolts, the oversize railway transport can be safety performed. Having new types of bolts, the loading and download time of containers on Rgs type wagons become shorter. Moreover, the results obtained from the case 2 are better then those from the case 1. These types of bolts can be fixed if the freight wagons are loaded or reclining of such wagon moves empty.

In the future, it is going to try the achievement of new specific bolts types for every freight wagon, because each freight wagon has a particular construction.

6. References
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