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ANALYSIS IN SOLIDWORKS SOFTWARE OF THE STRENGTHS GENERATED IN THE UNDERGROUND PART OF THE WAGONS AS A RESULT OF THE IMPACT OF FORCE ON THE ENTIRE WHEELS OF WAGONS

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Abstract:

Objective. The purpose In this article, the vertical and horizontal forces acting on the wheel of a freight car are calculated using formulas, and the calculated forces are determined by placing the wheel on a 3D model using Solidworks software.

Methods. The 3D model of the wheel is drawn using the Solidworks program according to GOST 10791-2011, and the forces calculated through the simulation section are placed on the rolling surface, and the results are tabulated.

Results. When the calculated forces were applied to the wheel through the simulation section of the SolidWorks program, the minimum stress on the bottom part of it was 10 MPa, and the maximum stress was 120 MPa. The stress results were calculated 60 times, that is, the forces were divided into 12 blocks and the wheel was turned five times. Efforts were made after each direction and results were obtained

Summary. The conclusion of the scientific article is that the tension generated in the wheel is related to the thickness of the tread. When the wall thickness was 70 mm, when the operational maximum force was applied to it, a stress of 80 MPa was generated. During the service life, the value of voltages in the calculation field changes in each direction

Keywords. Rolling surface, polzun, uneven rolling, wheel, solidworks, simulation, prosperity, computational area, mises stress.

Introduction. Pairs of wheels are considered the main part of the movement structure, and its durability and reliability are considered the most important issues when the wagon appears. Many scientists have worked on evaluating, analyzing and increasing the durability of the wheel [1,5,9]. The wheel is affected by vertical and horizontal forces (Fig. 1), and these forces are divided into static and dynamic types. When finding these forces, the loaded or unloaded state of the wagon is taken into account 2,3,7,14. The following calculation diagram shows the cross section of the wheel and the direction of the forces falling on the rotating surface and its linear dimensions [4,8,11]. As we all know that there are many types of drivetrain wheel disc, in this work we will only do the calculations by putting the force values according to the calculation diagram below for flat disc all-round wheel. The value of the forces was calculated using the formulas in table 1 given in the norm.

Methods of scientific research. The 3D model of the wheel is drawn in the solidworks program according to GOST 10791-2011 [17], the forces calculated according to the norm are placed on the rolling surface through the simulation section, and the stress level is determined. Determined forces are applied to the minimum thickness of the rim after each direction of the rim [6,10,13].

According to current calculations, the entire rolling wheel rotates five times during its service life. By applying forces calculated on the rolling surface of the pavement after each direction, the stresses generated in the subgrade part of the pavement are transferred and placed according to the columns in Table 2.

This method was implemented using software. There is also a methodology for theoretically calculating the same voltages, and we will cover this in our next scientific articles.

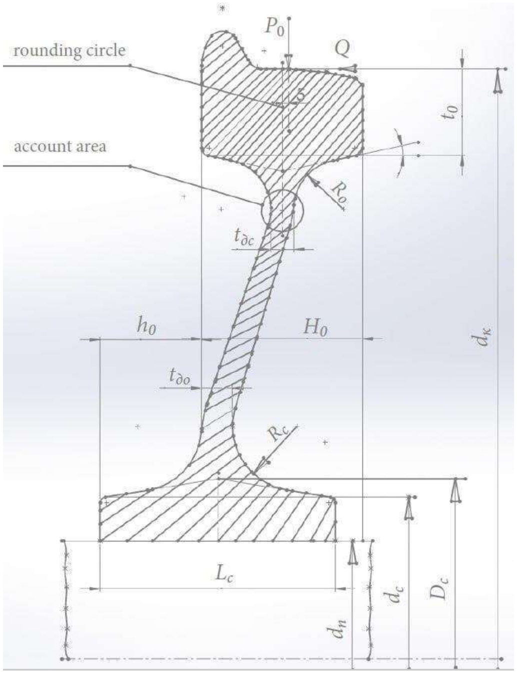

Figure 1. Standard and design wheel view

This drawing shows the vertical P and horizontal Q forces on the wheel, its linear dimensions and the calculation zone. The forces acting on the wheel vary in different values depending on the defects of its rolling surface. When we find the forces, we consider 3 types of failure states of the wheel rolling surface: non-defective, slippery and uneven rolling. The value of the forces acting on this failure is calculated using the formulas given in Table 1 below [12,15].

Table 1

The condition of the washing surface	Formulas for determination	
	Mean square approximation	Mean square approximation
	Vertical force	
Defect free	$\bar{P}_1$=0,621·P	
Polzun	$\bar{P}_2$=0,856·P	
Uneven rolling	$\bar{P}_3$=0,533+14,252·10^2·v·$m^{1/2}$	$\bar{P}_{p3}$=5,915·10^2·v·$m^{1/2}$

	Horizontal force	
In any case	$Q=3,78 \cdot 10^{-3} \upsilon \cdot P$	$S_{Qj}= 2,457 \cdot 10^{-3} \upsilon \cdot P$

* Note: vertical forces acting from the wheel to the rail in a static state, kN
P=Po=230.5 in the loaded state, P=Pn=60 in the unloaded state
mn = 1797 kg – the total weight of the lower parts of the spring acting on the wheel
y = 25 m/s (90 km/(h)) – calculated speed.

When we calculate the forces acting on the wheel, we consider the weight of the axle as 23.5 tons [13,18]. In addition, formulas for root mean square approximation are also presented in this table. The mean square approximation means that we can find a limited amount of variation of the calculated forces, that is, the value of the determined forces is observed in the range of values found by this approximation. We do not calculate the root mean square approximation in this work, but instead calculate the value of the vertical and horizontal forces acting on the wheel by mathematical expectation. Below, we will only do the calculations for the wheels of the freight cars, since the structural speed and the mass of the lower parts of the springs will be needed.

The values of the vertical and horizontal forces acting from the wheel to the rail were calculated using the formulas given in the table for loaded and unloaded wagons [14,20].

These calculated forces were applied to the rolling surface of the wheel drawn according to GOST 10791-2011 in Solidworks using the simulation section (Fig. 2) and stress values in the calculated zone were obtained.

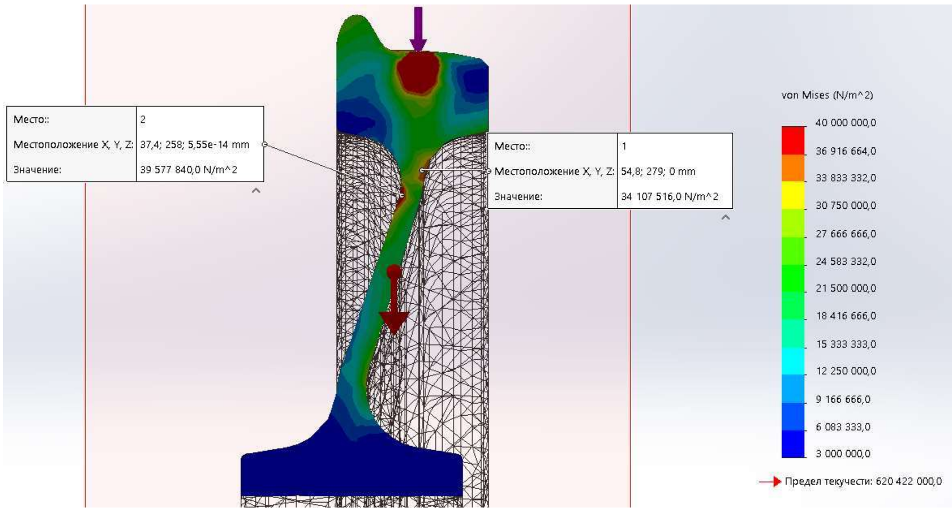

Figure 2. Image of the force applied to the wheel and the stresses in the calculation zone in the Solidworks/simulation program

Calculated forces were applied to the new wheel, resulting in the following image (Figure 2). The results have been moved to column 1 of the table below. On the rest of the columns, the forces calculated after each direction were placed, and the results were copied in sequence. Depending on the types and sizes of faults, the thickness of the rolling stock wheel is changed 5 times during the average service life [15,19]. After each direction, the value of the voltage in the calculation zone increases.

Results. When the calculated forces were applied to the wheel through the simulation section of the SolidWorks program, the minimum stress on the bottom part of it was 10 MPa, and the maximum stress was 120 MPa. The stress results were calculated 60 times, that is, the forces were divided into 12 blocks and the wheel was turned five times. Efforts were made after each direction and results were obtained. From Figure 2 above, we can see that when a force is applied to the rolling surface of the wheel, its high stress areas are represented by red colors.

The obtained results were found to be positive according to the requirements given in the regulatory documents, and we have observed in our previous scientific works that the accuracy level is higher than 95% when the results are obtained by influencing the detail with the help of software [7,11,16].

Table 2

Block number of forces j	Wagon condition	Impact force, kN	Action share λ	The average Mises stress in the calculation area of the wheel is MPa when it is oriented n times				
				n=0	n=1	n=2	n=3	n=4
1	Loaded	$\overline{P}_1$=142,8	0,2514	45	50	55	57	60
2		$\overline{P}_2$=196,9	0,045	55	60	65	72	77
3		$\overline{P}_3$=273,8	0,0036	75	85	90	100	110
4	Not downloaded	$\overline{P}_1$=37,3	0,1676	10	11	12	15	16
5		$\overline{P}_2$=51,4	0,03	15	18	19	21	22
6		$\overline{P}_3$=182,7	0,0024	50	55	60	70	75
7	Loaded	$\overline{P}_1$=142,8 Q=21,7	0,2514	48	53	60	64	69
8		$\overline{P}_2$=196,9 Q=21,7	0,045	60	70	78	82	92
9		$\overline{P}_3$=273,8 Q=21,7	0,0036	80	90	100	110	120
10	Not downloaded	$\overline{P}_1$=37,3 Q=5,67	0,1676	10	12	15	17	18
11		$\overline{P}_2$=51,4 Q=5,67	0,03	15	19	21	22	24
12		$\overline{P}_3$=182,7 Q=5,67	0,0024	55	60	67	73	76

Note: $\overline{P}_1$ – for a defect-free condition of the wheel rolling surface; $\overline{P}_2$ – for wheel slip position; $\overline{P}_3$ – for the condition of uneven rolling of the wheel surface.

The Mises stress in the calculation area was obtained as a result of applying the forces when the wheel is directed to the minimum limit according to GOST and the change of forces.

Conclusion. as a general conclusion, these values increased due to the reduction of the thickness of the wheel part as a result of turning, and the highest value was observed when the wheel was loaded and rolled unevenly. The highest stress value was 120 MPa when calculated according to the Mises stress.

It should also be mentioned that the greatest tension was created after applying a horizontal force of 21.7 kN and a vertical force of 273.8 kN in 9 power blocks after the fifth direction. vertical was formed by applying a force of 37.3 kN and its value was 10 MPa.

These conclusions were given on the basis of the results obtained using the solidworks program of the stresses generated in the lower part of the wheels as a result of operational forces. In our next scientific articles, we will continue the comparison with the results obtained by theoretical calculation and software calculation.

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