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Method of calculation of indicators of durability of the slider of the cart of the car means of the CAD-systems

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Abstract. The technique of the analysis of durability of a cap of a slider of the cart of the car with use of the Russian CAD APMW in Machine, in the conditions of his operation is presented. Computer modeling includes definition of the operating loadings; three-dimensional solid-state modeling of assembly of a side slider; modeling of area of contact in the formed couples of frictions; modeling of the intense deformed condition of a cap and calculation of equivalent tension, and also determination of the specific pressure operating on a cap of a slider.

Keywords: *cap of a slider, durability, tension, system of the automated design*.

1. Introduction

According to statistical data on routine maintenance of freight railway wagons, approximately 34% of bogie failures occur due to the lack of proper clearance monitoring, while around 9% are caused by damage to the sliding components [1]. These sliders play a crucial role in limiting the lateral tilt of the wagon body on the bogies, particularly in curved track sections, where wind loads and off-center forces act upon the system. For freight bogies of the 18-100 model, the slider with clearance serves as a primary functional component. Its modified version is mounted onto the support of the fastening bracket, acting as a cover element (Figure 1).

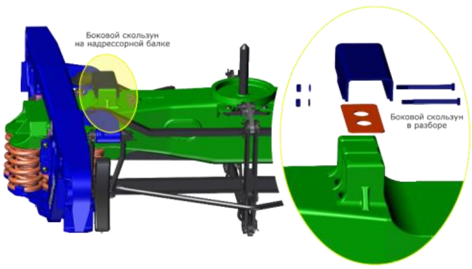

Figure 1. Place the installation of slides

2. Materials and methods

The cover of the slider is influenced by the components of distributed loads with significant force concentration, as determined by established standards [2]. When assessing the structural strength of the cover, the calculation is typically based on its design characteristics without taking into account variable operational conditions. To address this limitation, a methodology has been proposed that involves analyzing the strength of the cover through a 3D model composed of the contact mechanisms of the lateral slider. The application of this design-based approach enables strength assessment under load conditions corresponding to the third computational mode, in accordance with the guidelines outlined in III [2].

Load Calculations. Since the slider cover is an integral part of the press beam assembly, the normative parameters of the loads applied to it are determined through structural load calculations [3]. The schematic representation of the applied forces is shown in Figure 2.

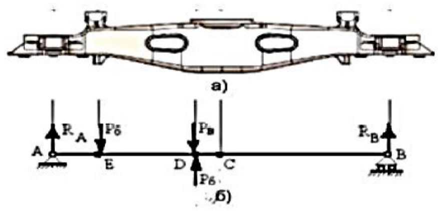

Figure 2. Computer-mechanical scheme

When the wagon enters a curved section of the track, a vertical force denoted as $P = P_g$ begins to act on the slider cover. As a result of the relative rotation between the wagon body and the bogie, a longitudinal friction force H arises due to the frictional interaction.

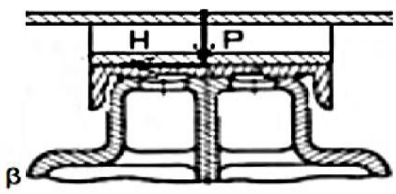

Figure 3. The scheme forces affecting skating

The vertical force P acting on the slider cover is determined based on the calculated values of the vertical component resulting from eccentric forces applied to the press beam of the bogie, denoted as P_6, i.e., $P=P_6$. The longitudinal friction force H is calculated using the following formula:

$$H=\mu * P_б \quad (1)$$

Here, μ - coefficient of friction between the working surfaces of the lateral slider; P - vertical force acting on the cover, measured in newtons (N).

For an axial load of 23.5 tons, the calculated value of the vertical component of the lateral force is $P_б$=84.4 kN. When using a steel cover, the coefficient of friction for a «steel-on-steel» contact is μ=0.18. Accordingly, the longitudinal friction force is calculated as H=μ· $P_б$=0.18·84.4=15.2 kN.

Based on the generated model data, an initial 3D model is constructed using a single-parameter tabular control approach (Figure 4).

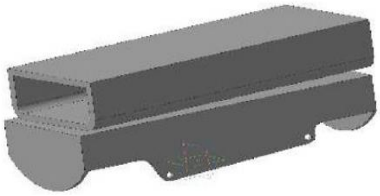

Figure 4. Compass model was built in slides

3. Results and discussion

Parameter determination of the 3D model during the assembly of the lateral slider in the curved track section. During the passage through curved track sections, the angular position β between the bogie and the wagon body is determined according to the relative placement of the contacting elements of the lateral slider. The value of the given angle is calculated as β = 90°−α. The angle α is computed through the solution of the right triangle ΔACO using the following formula:

$$\alpha = \arccos\frac{l}{2*r} \quad (2)$$

Here, l — the wagon base length, in meters; r — the radius of curvature of the track section, in meters.

Stress analysis model for the slider cover. The previously constructed working 3D model of the lateral slider is reprocessed for the given curvature radius of the track to determine the corresponding angle β values. For example, for a radius of r=150 m, the corresponding angle is β=1.95°. The results obtained from solid body modeling (Figure 5) using APMWinMachine [4] form the basis for further detailed research, which is then loaded into the instrumental environment for analysis.

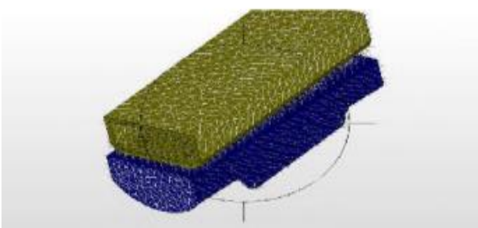

Figure 5. Finite elements of the collection grid

Calculation of equivalent stresses. The computational model for assembling the lateral slider through finite elements includes the strength analysis of the slider cover: calculation of the equivalent stresses (Figure 7a) and the strength safety factor (Figure 7b). The calculated values of the stress across the entire model do not exceed 35 MPa, which satisfies the yield stress requirements [2]. In this case, the safety factor of the strength calculation is 6.

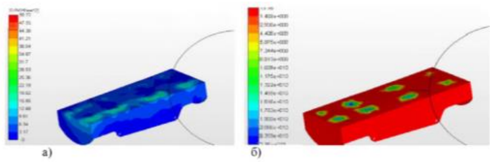

Figure 6. The results of a calculation of the strength) of the power chart; b) strength ratio of the stock chart

Calculation of the contact pressure generated during friction. In the «wagon-body" system, different versions of force closure correspond to various angular configurations. The contact pressure generated during friction is calculated using the following formula:

$$P_{уд} = \frac{P_б}{S} \quad (3)$$

Here, $P_б$ - the load acting on the slider cover (vertical force generated by eccentric effects), in newtons (N); S - the contact area, with the contact area being modeled using APMWinMachine tools, which automatically calculates its area (Figure 7).

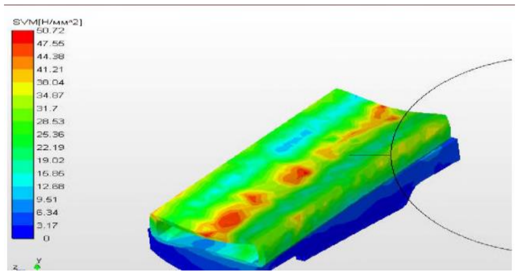

Figure 7. A diagram of the voltage of the collection

The contact area dimensions are $10.18\text{-}10^{-3}м^2$ and when the pressure $P_{уд}$ = 8.3 MPa, this exceeds the specified normative value [2]. In this case, the increase in the contact area is achieved by implementing approved modifications to the bogie and slider frames of the freight wagons, as well as by modifying the design of both the bogie and the slider cover.

4. Conclusions

The developed methodology allows for the study of the main normalized strength indicators of the slider cover of freight wagon bogies under varying operating conditions across all ranges. The engineering analysis results, obtained through solid body modeling, enable the design of an efficient structure starting from the component's structural phase. The most effective application of the developed methodology is ensured when used within an integrated instrumental environment of the CAD/CAE class automated system.

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Автоматтандырылған жобалау жүйелері құралдарымен вагон арбасының сырғанау қақпағының беріктігін есептеу әдістемесі

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Аңдатпа. Пайдалану шарттарын ескере отырып жүк вагондарыньщ қақпақ сырғанағының беріктікке талдау әдістемесі қарастырылған. Әдістемесіне әсер ететін жүктеулерін анықтауы, бүйірлі сырғанақты құрастыруының үш өлшемді қатты денелі модельдеуі, үйкеліс пайда болатын түйісу аумақтарын модельдеуі, қақпақтың кернеулі-деформация күйін модельдеуі және эквивалентті кернеулерін есептеуі, сол сияқты қақпақ сырғанағына әсер ететін меншікті кысымын аныктауы жатады.

Негізгі сөздер: *вагон, сырғанау қақпағы, беріктігі, кернеуі, автоматтандырылған жобалау жүйесі*.

Методика расчета прочности колпака скользуна тележки вагона средствами систем автоматизированного проектирования

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Аннотация. Представлена методика анализа прочности колпака скользуна тележки вагона с использованием российского САПР APMWinMachine, в условиях его эксплуатации. Компьютерное моделирование включает в себя определение действующих нагрузок; трехмерное твердотельное моделирование сборки бокового скользуна; моделирование области контакта в образуемых парах трения; моделирование напряженно-деформированного состояния колпака и расчет эквивалентных напряжений, а также определение удельного давления, действующего на колпак скользуна.

Ключевые слова: *вагон, колпак скользуна, прочность, напряжение, система автоматизированного проектирования*.

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