DETERMINATION OF THE LOAD OF A COMPOSITE BRAKE PAD OF A WAGON WITH WEDGE-DUAL WEAR

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Abstract: To improve the efficiency of the operation of freight rolling stock at the present stage of development of the railway industry, it is important to introduce its modern designs. At the same time, special attention should be paid to the rolling stock brakes, as the most important structural unit in terms of traffic safety. According to studies of the technical condition of the brake equipment of freight wagons, it has been established that one of the most damaged units is brake pads. As a result of operating load conditions, they experience uneven wear of the working surface – wedge-dual wear. A study of the load of a composite brake pad of a freight wagon with wedge-dual wear has been carried out. It has been established that the presence of such wear causes an additional load on its structure, including thermal. In this regard, not only the pad destruction, but also a violation of the safety of train traffic can occur.

The conducted studies will contribute to the creation of recommendations for managing the temperature effect on the brake pad, as well as improving the safety of train traffic and a significant reduction in operating costs.

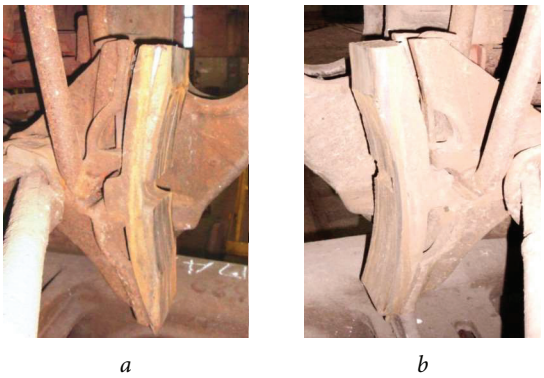
Keywords: brake pad, wedge-dual wear, pad loading, pad strength, train traffic safety.

1. Introduction

The most important value for the railway infrastructure in the conditions of competition in the market of transport services is the reduction of operating costs during freight traffic [1, 2]. This requires improving the quality of work in the organization of maintenance and repair of rolling stock. Therefore, to assess the technical condition of rolling stock units, it is necessary to constantly monitor them, especially those that ensure the safety of train traffic.

One of the most critical units of freight wagons is the tribological pair – "brake pad – wheel" [3–5]. In freight trains, when moving without braking, harmful friction is massively observed by the upper ends of the composite brake pads inclined and pressed against the rolling surface of the wheels (**Fig. 1**). Such friction causes significant operating costs and negatively affects the provision of their movement due to a decrease in braking efficiency.

In addition, due to the presence of wedge-dual wear of the pads, the resistance to the movement of trains increases, to overcome which thousands of kilowatts of electricity are spent, as well as a ton of diesel fuel. Therefore, there is a need for research in this direction.



a *b*

Fig. 1. Wagon pads with wedge-dual wear: *a* – view from the side of the wheel (left pad); *b* – view from the side of the wheel (right pad)

2. Methods

Taking into account the presence of wedge-dual wear of the brake pad, the efficiency of its operation deteriorates [6]. In this case, both an increase in the loading of its structure and an "underuse" of the amount of pressure on it can take place, which leads to an increase in the stopping distance of the train, and, accordingly, to wear of the wheel sets and the superstructure of the track.

To substantiate these hypotheses, the corresponding calculations were carried out.

In order to determine the pressing force on the composite brake pad, the well-known dependence is used [7, 8]

$$\frac{K}{F_K} \le [\Delta p_n], \quad (1)$$

where F_K – the nominal friction area of the brake pad, cm^2;

$[\Delta p_n]$ – allowable specific pressure on the brake pad, N/cm^2.

From here,

$$K \le F_K \cdot [\Delta p_n]. \quad (2)$$

Then, at an allowable specific pressure on the composite brake pad of 0.085 kN/cm^3, which corresponds to its nominal area of 290 cm^2, the pressing force will be equal to 24.65 kN. Taking into account the wear of the brake pad, with the operating force of pressing it, the specific pressure will also increase.

3. Results

In accordance with the collected statistical material regarding the technical condition of the brake pads of wagons, the dependence of the pressure on the brake pad on the mileage of the wagon was determined (**Fig. 2**). The calculation was made on the example of two types of pads – 2TP-11-1 and pads with a steel back. In this case, the pressure on the brake pad is assumed to be constant while ensuring the braking efficiency [7]. From **Fig. 2** it can be seen that the pressure on the brake pads, taking into account the increase in the mileage of the wagon, and, accordingly, the decrease in its area, increases. At the same time, the calculated pressure value for both types of pads exceeds the allowable one already at a mileage of more than 7 thousand km.

Under temperature conditions of loads, the maximum pressing for composite pads is determined [8]

$$K_t^K = \frac{[4\Phi(t) - 2.34 v_0 m_v] + \sqrt{[4\Phi(t) - 2.34 v_0 m_v]^2 + 9.36 v_0 m_v \Phi(t)}}{0.023 v_0 m_v}, \quad (3)$$

where

$$\Phi(t) = \frac{F_{\dot{e}} \Delta\tau_{\max} \alpha_0}{1 - e^{-1.52\alpha_0\sqrt{t}}}, \quad (4)$$

$$\alpha_0 = 0.004\left(1 + 1.33\sqrt{v_0}\right), \quad (5)$$

$$m_v = 0.44 \frac{3.6 v_0 + 150}{7.2 v_0 + 150}. \quad (6)$$

where v_0 the initial braking speed, m/s;

$\Delta\tau_{max}$ – the maximum allowable temperature of the brake pad during braking, °C;

α_0 – the heat transfer coefficient to the environment.

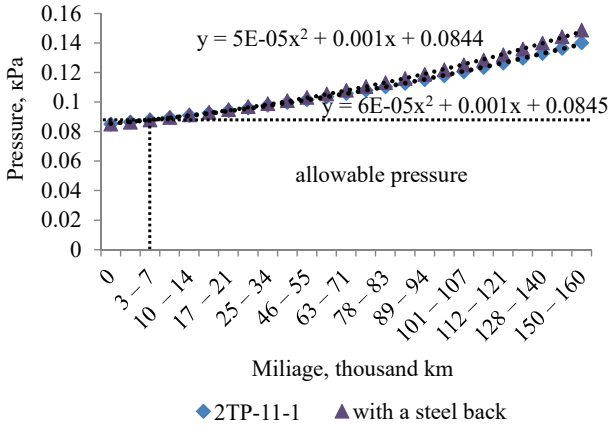


Fig. 2. Dependence of the specific pressure on the brake pad depending on the mileage of the wagon

The amount of pressing on the pad with wear is less by 20.3 % than the one acting on the pad with a nominal value (**Fig. 3**).

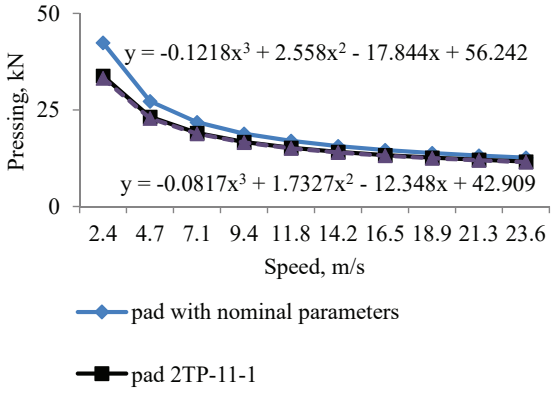


Fig. 3. Dependence of the amount of pressure on the composite pad on the speed of movement

The calculation was made on the example of a brake pad with an area of 0.018 m^2, which is 38 % less than the nominal one. At the same time, under the condition that braking is ensured, the amount of pressure on the wear pad can be equal to that inherent in the pad with nominal parameters. This contributes to damage to the pad and may affect its destruction.

Due to the smaller area, the temperature load of the pad increases. According to the calculations, it is found that the heating temperature of wear-resistant composite pads increases by 17 % compared to the nominal parameters.

4. Discussion

In order to ensure the safety of the movement of freight trains, it is necessary to control the technical condition of its brakes, one of the most important components of which are pads. During operation, due to a change in the angle of inclination of the pad, its wedge-dual wear may occur. This phenomenon has a negative impact not only on the service life of the pad, but also on the safety of train traffic.

As part of the research, the load of wedge-dually worn pads of types 2TP-11-1 and with a metal back was determined. It has been established that in the presence of wedge-dual wear, the amount of pressure on the brake pad increases while ensuring the braking efficiency (**Fig. 3**). In addition, due to the decrease in the usable area of the composite brake pad, its heating temperature increases, which can lead to the appearance of temperature defects not only on its surface, but also on the wheel. In this regard, it is important to create measures aimed at eliminating the wedge-dual wear of the pads.

The advantage of this study compared to the known ones is that until now the issue of determining the load of composite brake pads has not been paid attention. As a disadvantage of the study, it is possible to note the need for an experimental determination of the pad loading. The further direction of this work is to determine the stress state of wedge-dually worn brake pads. In addition, studies aimed at eliminating the wedge-dual wear of pads, as well as the introduction of promising materials for their manufacture, require attention [9, 10].

5. Conclusions

The load of a wedge-dually worn composite brake pad of a freight wagon was determined. It has been established that, taking into account the wear of the pad, the amount of pressure on it decreases by 20.3 % for the one acting on the pad with a nominal value. By reducing the usable area of the pad, its heating temperature increases by 17 %. This can lead not only to the appearance of thermal defects in the pads, but also in the wheel. In addition, damage to the rails may also occur.

The conducted studies will contribute to the creation of recommendations for managing the temperature effect on the brake pad, as well as improving the safety of train traffic and a significant reduction in operating costs.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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The study was performed without financial support.

Data availability

Manuscript has no associated data.

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