Thermomechanical damage to rolling stock wheels

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Abstract. Marshalling yards are a key part of the transportation process. Their precise operation determines the efficiency and safety of the transportation process, which, other things being equal, depend on the durability and safety of cars in real conditions, including during sorting processes on slides. Currently, during the dissolution of trains on low-power slides, shoe braking is used. This is cost-effective, but provokes the formation of thermomechanical damage on the surface of the wheels. These damages are called one-way sliders. The formation of sliders leads to downtime of cars during repairs and to the cost of restoring or manufacturing new wheels. The article presents a study of the effect of wheel sliding on the rail on the nature of thermal and mechanical damage to the wheels of rolling stock.

1. Introduction.
At present, the braking of the cuts on low power slides is controlled manually using the brake shoe technology, the braking effect of which is based on replacing the rolling friction of a wheel on a rail by sliding friction on a shoe and another non-slipped wheel on rails [1]. This sliding is called skidding. The length of the skid, as well as the number of shoes placed under the cut, depends on the speed of the car when it enters the shoe, on the axial load and on weather conditions (moisture on friction surfaces, icing, etc.) [2-5] and depends on the competence of the operator. As a result of sliding friction of a non-shoe wheel with a rail, uneven wear of its rolling circle occurs, which consists in the formation of a straight section on the wheel surface - a one-sided slider, which significantly reduces the service life of the wheelsets themselves, axle boxes, the superstructure of the track as a whole and is the reason for rejection wagons. The problem of the safety of rolling stock has a multi-sided character [6 - 15].

2. Results and Discussions
To determine the effect of the size of the slider on the nature of the destruction of wheel rolling circles, the author together with the Road Chemical and Technical Laboratory of the North Caucasus railway branch of OAO Russian Railways, carried out a survey of wheelsets with characteristic damage on the rolling surface in the form of a slider. The aim of the study was to determine the maximum permissible value of the slider, which does not lead to the destruction of the skating circle during operation. The study of the wheel with the presence of a slide on the rolling surface consisted in the
study of changes in the microstructure and hardness in different parts of the slide and the base metal of the wheel. Sliders with sizes from 0.1 to 0.9 mm and more were studied.

According to the results of laboratory studies, it was found that the formation of sliders larger than 0.7...0.9 mm (Figure 1) directly leads to a change in the structure of the metal and the hardening of the surface layer by 1.5...3 times. When studying the microstructure, it was determined that the surface layer of such a slider was deformed under the combined influence of load and temperature to a depth of about 30 microns, while the perlite structure turned into a reed-bit structure, and the ferrite grid deformed. The hardness of the metal as it approaches the surface of the slider gradually increases from 277 to 404 kg/mm² (Figure 2). The intense heating of the deformed layers in the process of friction and then quenching of the heated volumes due to heat removal into the wheel rim body leads to the formation of thin films on the rolling surface (Figure 3), about 0.3 mm thick, characterized by high with a hardness $H_{200} = 800 \ldots 850$ kg / mm² and having a sharp border with the base metal of the wheel. Heating and hardening to high hardness occurs only in a layer subjected to significant deformation.

The presence of such highly hard layers on the riding circle during the operation of the wheel pair leads to the formation of subsurface cracks (Figure 4) and peeling of the surface layer (Figure 5), and the impact interaction of the slider with the rail leads to the formation of dents and discoloration of the riding circle (Figure 6).

Based on the study, it was found that the leading type of wear in the formation of sliders with a value of more than 0.7 mm is adhesive wear [2] by setting of the second kind. It was also found that during the formation of a slider with a size of no more than 0.15 mm (Figure 7), no change in the initial structure is observed, and an increase in the hardness of the surface layer occurs by only 10...15%, which does not lead to the formation of cracks during operation. The average metal hardness in the zone of such a slider is about 317 kg/mm², with an initial hardness of 270 kg/mm².

The study showed that in this case, abrasive wear is the leading factor. Abrasive wear is mainly caused by the contact of a less solid wheel (HB=270) with a harder rail (HB =300) that has volume hardening, as well as the presence of abrasive on the surface of the rail (sand, fine fragments of ballast, etc.).

Figure 1. Uneven wear of the wheel ride circle.
Figure 2. Changing the microhardness of the wheel rolling circle under the slider, x 100.

Figure 3. Hardening of the surface layer of the wheel as a result of friction with the rail.
Figure 4. Crack formation between the hardened surface layer and the base metal of the wheel, X500.

Figure 5. Peeling of the deformed surface layer under the slider, x 100.
Figure 6. Painting a skating circle when using it wheels with a slider.

Figure 7. Metal structure under the slider size less than 0.1 mm, x 100.

3. Conclusion
The results of the study allowed us to correct the classification of sliders by geometric dimensions, which gives an idea of the degree of their influence on the service life of wheel pairs (table).
Table 1. Classification of sliders by geometric parameters and the nature of their impact on the service life.

| Slide block Type | Size, mm | The nature of the slider effect on the service life of wheel pairs | The number of rejected pairs, in % |
|------------------|----------|------------------------------------------------------------------|---------------------------------|
| 1                | 0.01 – 0.15 | 1. Does not have a significant impact | ___ |
| 2                | 0.2 – 0.4   | 2. The slider “rolls up” during operation restoring the riding circle | 20...30 |
| 3                | 0.4 – 0.8   | 1. If during the repeated skidding this section falls into the contact zone of the wheel – rail, then a rejection slider is formed on it. 2. Can cause the formation of notch | до 50 |
| 4                | 0.9 and more| 1. Rejected slider – is not allowed in use.                      | 100 |

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