Influence of wear of friction wedges of model 18-100 trolleys on the lifetime of the comb

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Abstract. The issue of the influence of wear of friction wedges on the wear of the flange thickness of wheel pairs of freight cars operating on the railways of the Republic of Uzbekistan is considered. An analysis of freight car uncouplings during current uncoupling repairs is presented based on malfunctions of the thin flange of the wheel pairs and overestimation/underestimation of the friction wedge relative to the supporting surface of the bolster more than normal. Methods of combinatorial and statistical analysis of source data were used. The parameters of freight car bogies that most influence the wear of the flange of wheel pairs have been studied. Ways to reduce wear on the flange of wheel pairs in operation are considered by tightening the regulatory requirements established when releasing bogies from repair based on the condition of the friction wedges. The results obtained indicate a decrease in wear on the flanges of wheel pairs and an increase in the service life of the wheels of bogies of 18-100 freight cars when following the recommendations of the article on the repair of bogies.

1 Introduction

The ever-increasing demand for safer and faster surface transportation, such as rail, creates many challenges when inspecting critical components such as train axles and wheels. These components, mainly during operation, are subject to very complex dynamic loads, and their defects can lead to catastrophic failures, possibly resulting in loss of life. Therefore, wheel pair elements require a specific manufacturing process to ensure the necessary conditions for durability and high reliability [1-3]. These issues are relevant for the newly created research center for railway transport, which solves many issues to ensure the safety, reliability, increased service life of cars, their parts, assemblies, including, among other things, the use of modern lightweight materials and technologies for their processing in car construction, wear phenomena [4-10], improving the thermal characteristics of cars of all types [11-15] and many others.

The important problem of identifying the causes of wear on the flanges of wheel pairs in bogies of the 18-100 model was dealt with by I.I. Chelnokov, Yu.P. Boronenko, M.M. Sokolov, B.E. Glyuzberg, A.M. Orlov, it was shown (based on experimental and theoretical

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studies) the mechanisms of interaction between the rubbing elements of freight car bogies [16-20].

Some modern technologies and materials are already successfully used in the production and operation of railway rolling stock, for example, in the field of train traffic management, safety, traction and infrastructure. Traction substations use modern power and switching equipment. The traction power supply system of the Uzbek railways includes five traction substations and four sectioning posts located on a double-track section of the railway. The graph of the electrical load of traction substations has two areas of maximum values, corresponding to the peaks of passenger traffic. However, the analysis shows that the expanding network of existing rail transport lines primarily consumes excessive energy from the city grid and makes a negative contribution to the global sustainable development agenda. Therefore, the last questions are the short-term scientific work of the TSTU research team.

The main goal of this work is to reduce wear on the flange of wheel pairs in operation by tightening the regulatory requirements established when releasing bogies from repair based on the condition of the friction wedges.

2 Materials and methods of research

Like any transport system, railway transport poses a potential danger to humans.

The main features of railway transport are:

- concentration of a large number of passengers on commuter and long-distance trains;
- high speeds of passenger and cargo transportation on main lines;
- vulnerability to terrorist attacks on tracks, rolling stock, passenger and cargo stations;
- large volumes of transportation and high concentration of dangerous goods at junction stations (flammable gases, flammable liquids, toxic and highly toxic substances, oxidizing substances, explosives, radioactive substances, ammunition and weapons, etc.);
- the presence of a large number of intersections with highways at one level;
- huge length of main lines, the remoteness of a significant part of them from populated areas and roads.

The listed features cause a particular severity of the consequences of accidents, catastrophes and natural disasters in railway transport, which is due to the poor predictability of the places of their occurrence, the complex nature of the consequences and the presence of secondary risk factors, the difficulty and long time of access of forces and means of liquidation of consequences to the source of an emergency situation.

Currently, in the context of the increasing intensity of various types of threats and a sharp change in the economic mechanism of functioning of railway transport facilities and the entire system as a whole, the development of conceptual and methodological foundations for analyzing and increasing the efficiency of systems for ensuring the safe functioning of railway transport, including also friction wedges of bogies, is becoming particularly relevant.

The analysis of the regulatory and legal support for the processes of managing the operational safety of railway transport facilities showed that currently one of its main shortcomings is the lack of recommendations for the development of models and methods for analyzing the processes of occurrence of emergency, abnormal and emergency situations, as well as the choice of ways to reduce the negative consequences of them the emergence and provision of the necessary levels of fault tolerance, survivability and general safety of the functioning of railway transport.

The methodology for solving the problems under consideration should be based on advanced scenario analysis of alternative ways of developing the situation and key risk factors that carry various types of security threats. For the purposes of further analysis, these

factors can be grouped into a number of levels, with the factors of the upper level being generative for the factors of the subsequent level. The use of this methodology ensured the reliability of the results of this study.

3 Results and discussion

Statistical analysis showed that the number of uncouplings of freight cars for routine repairs due to a thin ridge (Table 1) increased on the railways of the Republic of Uzbekistan by 63%. At the same time, the number of uncouplings increased due to overestimation/underestimation of the friction wedge by 30%.

Table 1. Number of uncoupling's of freight cars for current repairs

Malfunction	Number of uncouplings by year (vag)				
	2016	2017	2018	2019	2020
Fine comb	2047	2672	2791	3076	3338
Overestimation/underestimation of the friction wedge relative to the supporting surface of the bolster more than normal	1224	1205	1269	1396	1591

The technical increase in the indicator for uncoupling's for routine repairs due to a thin flange (Figure 1) is due to the increased rate of wear of the wheel flanges (the wheels do not reach the next planned type of repair), which, in turn, is associated with a weakening of the standards for the release of trolleys from planned types of repairs, the use of spring suspension components and parts in them that have insufficient wear resistance for the period between planned types of repairs. Thus, wear of the friction wedges during operation leads to insufficient coupling of the side frames when driving in curves, the formation of runaway side frames and, as a consequence, increased wear of the wheel flanges.

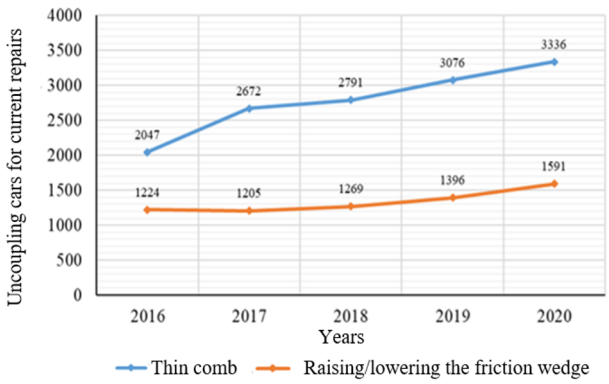


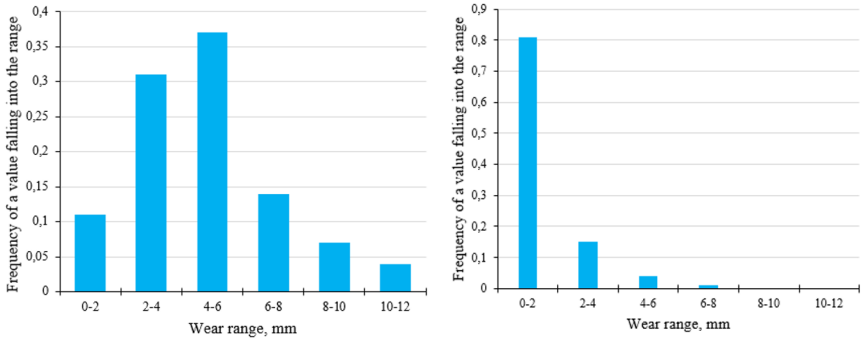
Fig. 1. Dynamics of uncoupling's during unscheduled repairs of freight cars due to defects (thin ridge and over-/under-inflated friction wedges)

Based on the results of a survey of the wear rate and analysis of the technical condition of the components of model 18-100 bogies during the overhaul run of 160 thousand km, it was found that friction wedges made of SCh-25 cast iron had an insufficient service life (Figure 2).

Wedge vibration dampers made from SCh-25 grade after a run of 100 thousand km have wear that exceeds the permissible values. In most cases, for all wedges, the wear of the inclined surface exceeds 2 mm, in some cases this figure reaches 10-12 mm, with wear of the

vertical surface no more than 2 mm (Figure 3). In our opinion, such a wedge does not ensure normal operation of the bogie in operation with a turnaround time of 160 thousand km, since the wear of the inclined surface affects the amount of overestimation of the wedge relative to the bolster, which leads to a violation of the geometry of the bogie and, accordingly, negative dynamic behavior of the car with an increase in lateral forces, acting on the flanges of the wheels and their increased wear.

The constructed statistical model of wear growth in a wedge vibration damper (Figure 4) showed that friction wedges made of SCh-25 cast iron have a 99.8% probability of wear resistance for a mileage of 60 thousand km. Reducing the rate of wear of wheel flanges and increasing the service life of wheel pairs in this case can be achieved by reducing the overhaul mileage of model 18-100 bogies with friction wedges made of SCh-25 cast iron (and lower) to 60 thousand km with the replacement of friction wedges with new ones as planned repair. When turning wheelsets along a thin ridge during routine repairs, it is recommended to proactively replace the friction wedges with new ones.



(a) (b)

Fig. 2. Distribution of wear on the surfaces of friction wedges made of SCh-25 in operation: (a) – inclined surface; (b) – vertical surface

(a) (b)

Fig. 3. Wear of friction wedges

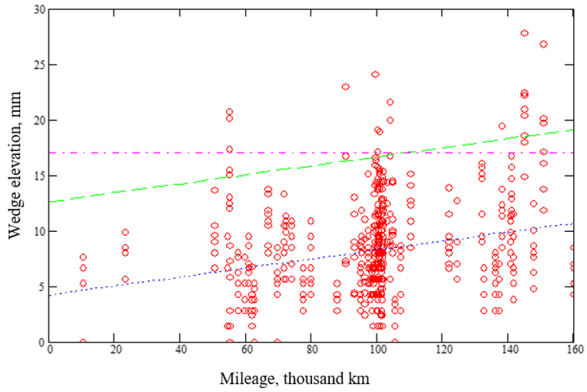


Fig. 4. Graph of the dependence of the wedge overestimation on the car mileage: red marks – overestimation of the wedge; green line – maximum overestimation value; blue line – average value of overestimation; purple line – permissible (normative) value of overestimation

The studies carried out on a friction machine confirm a significant increase in the wear resistance of the "wedge-friction bar" friction pair when using only VCh-120 cast iron (Figure 5).

To ensure a 99.8% probability between overhauls of 110 thousand km (and even more so 160 thousand km), it is necessary to make changes to the bogie repair technology, namely:

- use cast iron material with increased wear resistance for the wedge (SCh-35, VC-70, VC-120) and with a polymer lining for VC-70 or VC-120 cast iron on an inclined surface to prevent wear of the bolster pocket;
- when exiting a planned or routine repair, do not allow the wedges to be lowered by less than 10 mm, wear of the bolster and friction strip;
- tighten the requirements for the geometry of side frames and axle boxes (see justification below).

Based on the conducted research, the following conclusions can be drawn.

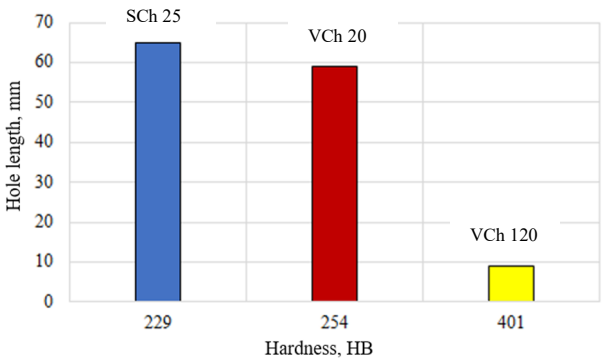


Fig. 5. Dependence of wear on the hardness of friction wedges according to test results on an MTSh-1 friction machine

4 Conclusion

In relation to bogies of the 18-100 model, in order to increase the service life of the flanges of wheel pairs, the most effective measure should be the tightening of regulatory

requirements established when releasing bogies from repair on the condition of friction wedges and other elements of the bogies.

Reducing wear of wheel flanges and increasing the service life of wheel pairs can be achieved:

- reducing the overhaul mileage of model 18-100 bogies with friction wedges made of SCh-25 cast iron and below to 60 thousand km with the replacement of friction wedges with new ones during scheduled repairs and ensuring improved bogie geometry. When turning wheelsets along a thin ridge during routine repairs, it is recommended to preventively replace the friction wedges with new ones;
- installation of friction wedges of increased wear resistance (cast iron grade SCh-35 and higher) in the repair and provision of improved bogie geometry while maintaining the overhaul mileage of 160 thousand km.
- exclude the overestimation of the friction wedges relative to the lower supporting surface of the bolster, prevent a longitudinal gap in the axle box opening of no more than 10 mm, the difference in the bases of the side frames should be no more than 2 mm. The difference in clearances in the axle box openings of one wheel pair should be no more than 4 mm, in the bogie slides - no more than 3 mm;

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