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# Increase the resource and reduce the life cycle cost locomotive wheelset

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**Abstract.** The paper presents the results of research on the analysisy of modern technical means and technologies to increase the service life and reduce the cost of the life cycle of a locomotive wheelset. Calculations are performed and the results of technical and economic efficiency of the use of modern innovative comb-smearing devices lubrication (USGL) and plasma hardening devices (SCR) for locomotive wheel pairs, as well as clutch activation devices (UATL), are presented. The practice of operating USGL and UPU devices has shown that the most effective is their joint use with the achievement of a consolidatedого effect on increasing the service life of locomotive wheel bands. Technical and economic calculation of the efficiency of using UATL friction activation devices has shown the economic feasibility of using locomotive coupling activation systems которые обеспечиваю, which provide an increase in the mileage of locomotives between equipment in the conditions of field operation of the locomotive fleet and reduce the cost of building additional points for equipping locomotives with sand. Keywords: friction activator, tests, friction activation system, locomotive traction characteristics, project stages, methodology, feasibility study.

## 1 Introduction

The strategy of organizing locomotive repairs under the conditions of traction resource management technology at the landfill should be aimed at improving the efficiency of locomotive operation, which currently remains low.

One of the constraints to improving the performance of locomotives is the low life cycle of a freight locomotive's wheelset. It is known that the resource characteristics of the cargo locomotive's brace are significantly lower than planned indicators and established inter-repair runs. For electric locomotives, the average actual life of wheelset bandages over the past three years remains at the level of 500 thousand km, for diesel locomotives, this indicator is at the level of 380 thousand km. What is the reason for changing wheels' bandages it is carried out during the inter-repair period, and then again on planned types of repairs. This imbalance leads to the rejection of wheelsets that have not reached the maximum wear limit, a decrease

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in the technical readiness coefficient due to downtime of locomotives in the TO-4 and to enormous unproductive losses.

The reasons for this are well known, the main one is the lack of systematic work on the use of resource-saving technologies as a result of high operational wear of the ridges, the use of irrational turning technologies, insufficient hardening of the wheelset, and a low level of forecasting the state of the wheel geometry.

## 2 Materials and methods of research

The object of this research is resource-saving technologies aimed at increasing the resource and reducing the cost of the wheelset life cycle. One of the factors that increase the service life of the wheelset is the formation of optimal conditions for friction contact in the "wheel-rail" system. The effective use of modern technologies for controlling the friction state of the wheel-rail contact makes it possible to reduce the cost of the wheelset life cycle, increase the traction and coupling characteristics of the locomotive, the duration of the uncoupled run of locomotives, and manage the interval for replacing the wheelset brace.

In the course of the work, analytical methods of research, methods of systematization in information processing, patent research, as well as analysis of the work of scientists and specialists in the field under consideration were used.

**The purpose of the work** is to analyze modern technical means and technologies for increasing the service life and reducing the cost of the life cycle of a locomotive wheelset, and to evaluate their effectiveness in their application.

## 3 Results

The issues under consideration are increasing the service life and reducing the cost of the wheelset life cycle, especially for freight locomotives operating in difficult operating conditions of heavy traffic on the landfill and in mountainous areas. The practice of operating such locomotives shows that the costs associated with the low life cycle of wheelsets are very significant.

The tools that can significantly affect the state of contact interaction of the wheel with the rail include lubrication systems, hardening, activation of adhesion, turning and forecasting methods. In the short term, the use of modern technical means and innovative resource-saving technologies can increase the resource of the bandage to the planned indicators and solve this problem. The key condition for success here is a comprehensive consolidated approach to using all these technologies under a single management, with strict monitoring of the effectiveness of activities.

In the long term, it is necessary to develop existing technologies to the level where they will provide conditions where all elements of the wheelset from the bearing and axles to the brace will have an equal service life, which will allow a complete change of the wheelset with all its elements once during the inter-repair run from 1200 thousand km and above.

In the course of the research, the issues of technical and economic efficiency of the use of modern innovative comb-smearing devices (USGL) and plasma hardening devices (SCR) for locomotive wheel pairs, as well as clutch activation devices (UATL)were considered. The practice of operating USGL and SCP devices has shown that their joint use is the most effective. At the first stage, it is necessary to turn the wheelset along the profile, which provides a ridge thickness of 29…31 mm. Then the wheel is subjected to hardening. After that, the wheelset is put into operation, where the USGL devices installed on each wheel throughout the entire life cycle are contact-fed to the ridge of the reinforced wheel with a solid anti-friction lubricant (TAEL). This technology of joint application gives a consolidated effect, with мan increase of two or three times the mileage between the turns of locomotive wheelsets, with an increase in the life of the bandage by more than 1.5,times.

Calculations of the economic efficiency from the use of SCR on the example of strengthening the ridges of wheel pairs of freight electric locomotives and mainline diesel locomotives with the subsequent use of USGL devices and TAEL lubricants show that the combined use of hardening and lubrication technologies provides a cumulative cost reduction (Fig. 1) Traction directorates to maintain the life cycle of the wheelset 29.1%, respectively, for freight electric locomotives and 30.8% for mainline diesel locomotives. For Service companies, the cost reduction will be 29.0 % and 29.4%, respectively, for electric and diesel locomotives , this is without taking into account downtime in repairs, risks of fines for non-compliance with the technical readiness coefficient, unscheduled repairs, downtime and downtime in repairs and waiting for repairs.

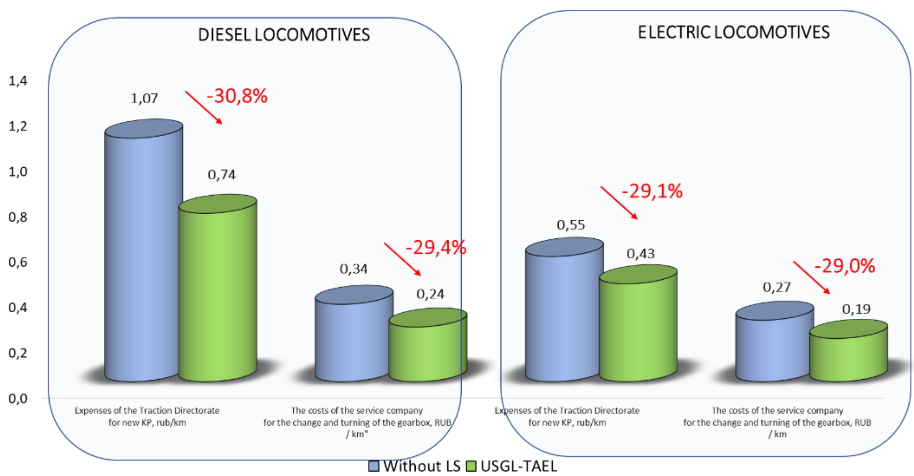


**Fig. 1.** Reducing the cost of maintaining the life cycle of a wheelset.

One of the important aspects of increasing the lifeого cycle of a wheelset is the introduction of locomotive clutch activation systems, which will reduce to a minimum or completely abandon the use of sand feeding to improve the coupling properties of the locomotive. Analysis of world experience shows that the use of modern means of activating the coupling of locomotive wheels is a promising means of improving the coupling properties of locomotives and reducing wear on the rubbing surfaces of the wheel.

The use of clutch activation systems reduces the wear of wheel pairs, improves the traction and speed capabilities of locomotives and reduces the negative impact of sand on the upper structure of the track, the characteristics of the ballast prism, and the operation of rail chains of the SCB.

Traction of the locomotive to the rail depends to a large extent on the current climatic conditions, which determine the condition of the traction surfaces of the wheel and rail. In such unstable conditions, the coupling coefficient in the contact zone can vary widely and quickly over time [1-44]. Therefore, it is almost impossible to ensure stable values of the ko coefficient of adhesion required for driving without boxing. In connection with it, experts and scientists around the world are offered to prevent to use as a traditional means in the form of sand, and a variety of mechanical, chemical methods of activation of the clutch by cleaning the rails [5-7], assessment methods slipping wheel sets [8], the use of abrasive powders [9,10], friction modifiers [11-15].

As part of the work on creating innovative technical means in the field of improving the traction and coupling characteristics of locomotives, the Novocherkassk Locomotive

Building Plant in 2020 began implementing a project to equip new 3ES5K series electric locomotives with resource- saving technical means developed by scientists of the Federal State Budgetary Educational Institution of Higher Professional Education RSUPS and specialists of Transintech LLC. These are the properties of friction activation of the locomotive wheel surface area (UATL) and devices for greasing the ridges of the USGL locomotive under a joint project with PC NEVZ LLC.

Electric locomotive 3ES5K No. 1147 produced by PC NEVZ LLC in 2021 was manufactured in a complete set with axial traction control and motor-axial rolling bearings and was equipped with UATL and USGL devices. The test run of the 3ES5K electric locomotive No. 1147 was carried out in the form of controlled operation нat the North Caucasus Railway test site on the Bataysk-Likhaya-Bataysk, Bataysk-Taganrog-Bataysk, Bataysk-Rossosh-Bataysk sections during the period from 09.02.2021 to 04.03.2021 with участием trains weighing from 7000 to 7300 tons. Tests of UATL and USGL devices were carried out according to the Program and methodology of preliminary tests and technical solutions for the implementation of the UATL and USGL installation project on a newly manufactured 3ES5K electric locomotive using a traction and power laboratory.

The scheme of forming an experimental train on the Bataysk – Taganrog section without a trailer load is shown in Figure 2.

Tests are carried out using the following scheme of the test train: a locomotive equipped with a UATL system is located at the head of the test train; a dynamometer car equipped with a measuring complex for traction and energy tests is located in the coupling with it; an auxiliary electric locomotive with an electric braking system is installed in the tail of the experimental train to create an additional load on the head electric locomotive. The electric locomotive's traction was realized by one head section, two bogies, and four 3ES5K traction motors.

To simulate the trailed load, rheostatic braking was performed by the auxiliary locomotive VL80S at the command of the test manager.

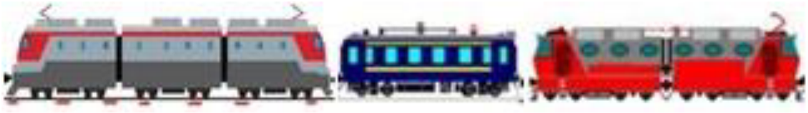

**Fig. 2.** Scheme for forming an experimental train without a trailer load.

General conclusion on the Bataysk – Taganrog test site:

Based on the results of traction and power tests of a 3ES5K series locomotive No. 1147 equipped with UATL devices with an experimental train on the Bataysk - Taganrog section:

- the use of UATL devices in extremely unfavorable coupling conditions leads to equalization of traction motor currents, reduction of boxing rings and increase in traction characteristics by 5-15% with the implementation of the coupling coefficient up to 0.283 at a speed of 37 km / h;

- the combined use of UATL devices of an automatic sand feeding system leads to equalization of traction motor currents, reduction of boxing operations and increase in traction characteristics by 9-30% with the implementation of the coupling coefficient up to 0.295 at a speed of 45 km / h;

- the use of UATL devices in favorable coupling conditions creates conditions for the complete elimination of boxing without the use of sand due to the formation of a friction layer on the rolling surfaces of locomotive wheels with the implementation of a coupling coefficient of up to 0.335 at a speed of 42 km/h.

The scheme of formation of an experimental train on the section Sulin-Lesostep nudging from the tail of the train is shown in Fig.3. Tests are carried out using the following scheme of the test train: at the head of the test train there is a head locomotive, which is coupled to freight cars, behind the cars there is a dynamometer car equipped with a measuring complex for traction and energy tests; in the coupling with it, an experienced electric locomotive equipped with the UATL system, which works as a pusher, is installed in the tail of the experimental train.

**Fig. 3.** Scheme of formation of an experimental train with a trailer load.

Based on the results of traction and power tests of a 3ES5K series locomotive No. 1147 equipped with UATL devices with a freight train on the Sulin-Lesostep section:

- when using UATL devices, no unacceptable slippage (SW) of wheel pairs was recorded in the traction and regenerative braking modes, overheating of traction engines, current and traction characteristics corresponded to those specified in the operating manual of the locomotive of this series, on the basis of the above, it is possible to drive freight trains with a critical mass rate of 7 100 tons. 3ES5K series locomotives;
- without the use of UATL devices, minor boxings of wheel pairs were recorded throughout the entire test area. Short-term boxings were accompanied by an increase in currents on the TED anchors (with the automatic sand feeding mode constantly turned on). Based on the test results, the Russian Railways acceptance Commission recommended that UATL devices be operated under controlled control in the autumn-winter period at the Eastern Test Site. Currently, the electric locomotive is undergoing controlled operation on the Bolshoy Lug-Slyudyanka section of the East Siberian Traction Directorate.

A feasibility study of the use of UATL friction activation devices performed by specialists of the Federal State Budgetary Educational Institution of Higher Professional Education RSUPS, as part of the development of technical requirements for friction activation devices, showed the economic feasibility of developing and implementing the technology. Comparison of the indicators with the variant of the scenario of construction of equipment positions with sand without the use of a locomotive traction stabilization system showed that the variant with the use of locomotive traction stabilization systems has a technical and economic perspective, since the calculation of technical and economic indicators proves the economic feasibility of developing and implementing the technology.

## 4 Discussion

The question remains debatable: what are the prospects for solving the problem of overstatingя the service life and reducing the life cycle cost of a locomotive's wheelset in conditions when the use of resource-saving technologies is managed by private service companies that provide locomotive maintenance under service contracts? The priority of such companies is to reduce the direct costs of locomotive maintenance, and the use of resource-saving technologiesг can achieve a significant effect in the short term, but a priori increases the current direct costs of these companies.

## 5 Conclusion

The conducted research made провести it possible to analyze modern technical means and technologies to increase the service life and reduce the cost of the life cycle of a locomotive wheelset. Evaluation of the efficiency of their application has shown that the best results can be obtained with an integrated approach that provides a consolidated effect of reducing the cost of the life cycle because of the joint use of technologies of rational turning, plasma hardening, and cantate combing.

The use of locomotive coupling activation systems provides an increase in the mileage of locomotives between equipment in the conditions of field operation of the locomotive fleet and allows us to abandon the use of sand supply systems that reducesя the negative impact of sand on the upper structure of the track, the characteristics of the ballast prism.

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