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Development of solid anti-friction elements for greasing the ridges of locomotive wheel pairs

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Abstract. Design work was carried out to develop solid anti – friction elements for greasing the ridges of locomotive wheel pairs (hereinafter referred to as TAEL rods). The results of laboratory bench and operational tests of TAEL rods were obtained in accordance with the procedure for admission of lubricants for the wheel-rail contact to use in grebnesmazyvatelyami lo-comotives operated on the Railways of the Russian Federation . Based on the test results, the developed TAEL rods were approved for use on the infrastructure of Russian Railways.

1 Introduction

Wheel-to-rail contact lubrication has become an integral part of the current track maintenance technology, both abroad and on the Russian road network. At the same time, it can be noted that there are a number of unresolved issues of a technical, economic, technological and organizational nature that hinder the effective development of wheel-rail contact lubrication systems and, accordingly, require a scientifically based approach to their solution.

Among the topical issues that will significantly increase the economic efficiency of the use of technical means of lubrication (TSL), we can highlight the issue of optimizing the use of lubricants in technical means of lubrication (TSL) on Russian Railways, by increasing their efficiency.

Considering and analyzing the inventions related to lubricants for the contact of the ridges of wheel pairs with rails, it can be noted that when lubricating the ridges of wheel pairs of locomotives, both liquid lubricants and lubricants in the form of solid lubricants of various geometric shapes are used.

It is relevant to create solid lubricating elements in the form of lubricating rods that are used to reduce wear and increase the service life of rails and wheelset bands of railway and other rail rolling stock, as well as to reduce energy consumption for train traction [1-6].

2 Purpose of work

The aim of this work is to create effective solid antifriction elements for lubricating locomotive wheel ridges that meet the regulatory requirements for wheel-rail contact lubricants.

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3 Materials and methods of research

The objects of testing are samples of TAEL rods developed in accordance with the technical specifica-tion (hereinafter TK) and technical requirements (hereinafter TT) for lubricants for lubricating the contact zone of wheels and rails. The TAEL rod must meet the following characteristics:

- it is easy to apply, does not crumble, does not chip and is held on the crest of the locomotive wheelset when the locomotive is moving;
- do not have a corrosive effect on metals ;
- do not have water in its composition;
- shore hardness – D scale of at least 40 units.
- density of at least – 1.2 g/cm3;
- tribological performance when testing on TBI:
- critical load, N, not less than – 980;
- diameter of the ball wear spot , at a load of 196 N, mm, not more than – 0.6;
- welding load, N, not less than – 980.
- must be manufactured in a category 1 climate version and function normally under the following conditions:
- limit the range of operating temperatures – minus 50 ° C to plus 45 ° C.
- humidity -100% at a temperature of plus 25oC.
- must be stable in composition. It must not change its geo-metric form during storage and use.

For the correct carrying out of design works on development of TAEL bars a matrix was prepared for conducting laboratory, bench and operational tests prescribed in row admission of lubricating materials to the infrastructure of JSC "RZD" was held in accordance with the order of JSC "RZD" on August 19, 2009 № 1735p "On the admission of combustive-lubricating materials to the use of JSC "RZD".

4 The results of research and their discussion

Laboratory tests are carried out in accordance with the program and methodology of laboratory tests TAEL.222929.000 PM-LB. TAEL samples were selected for testing. Samples in the form of six samples of dif-ferent configurations were transferred to the accredited testing laboratory of VNPP LLC in Rostov-on-don [7-9]. The test procedure provided for the use of standardized test methods presented in table 1. The results of laboratory tests of TAEL are presented in table 2.

As a result of the tests, it was found that the actual values of physical and chemical, tribological and climate resistance indicators of TAEL rods correspond to the requirements set out in the technical task TAEL.222929.000 TK and technical requirements for lubricants for lubricating the contact zone of wheels and rails, approved by the order of JSC "Russian Railways" dated 24.02.2010 No. 375r. The results of the first stage of acceptance laboratory tests indicate that TAEL is ready to conduct the second and fourth stages of acceptance tests-bench and operational tests required for new lubricants for the wheel-rail contact.

Bench tests were carried out in accordance with the program and methodology providing for testing in conditions that simulate the real operating modes of TAEL lubricants in comparison with the standard solid lubricant element of SNTS TU 30.20.40-003-70797974-2017, which is used for grebnesmazyvaniya locomotives. Three samples of round cross-Section TAEL rods Ø25×120 and SNTS lubrication rods Ø25×120 were selected and transferred to the tribological laboratory of Gubkin Russian state University of oil and gas (NRU), Moscow.

Table 1. Test procedure and content

No	Type of check	Item TK (TT)	Description of tests	Method of determination
1.	Laboratory tests (TAEL.222929.00PM-LB)			
1.1	Corrosive action	3.2.3 (7.7)	GOST 9.080	Assessment of corrosive effects on metals TAEL
1.2	Water content	3.2.4 (7.7)	GOST 2477	Assessment of the stability of the composition of TAEL
1.3	Hardness	3.2.5	GOST 24621	Assessment of abrasion resistance of TAEL
1.4	Density	3.2.6	GOST 15139	Evaluation of the volume-mass characteristics and composition homogeneity of TAEL
1.5	Physical and chemical indicators	3.2.3 3.2.4 3.2.5 3.2.6	GOST 9.080 GOST 2477 GOST24621 GOST 15139	Verification of physical and chemical parameters obtained at the stage of preliminary tests
1.6	Tribological characteristics on a four-ball friction machine (lubricating properties)	3.2.8 (7.7)	GOST 9490	Evaluation of lubricating properties on a friction machine ChShM: - critical load, Pк, H; - wear scar diameter, Di, at a load of 196 N, mm. - welding load, Pсв, N.
1.7	Resistance to external influences	3.3.1 (7.1.)	GOST 30630.2.1	Assessment of conformity to climatic design U1
2	Bench tests (TAEL.222929.000PM-ST)			
2.1	Simulation of real operating modes of TAEL	3.2.7, 5 (7.1)	Program and test method TAEL.222929.000PM-ST	Checking compliance with the requirements of the influence on the operational reliability and technical and economic indicators of technology
3	Operational tests (TAEL.222929.000PM-EK)			
3.1	Assessment of a new lubricant in the operating conditions of locomotives, establishing the frequency of maintenance, calculating the technical and economic efficiency from the use of TAEL.	3.2.1, 5 (7.1-7.5)	Program and test method TAEL.222929.000PM-EK	Checking the influence of TAEL on the wear of the flanges of wheel pairs and the service life of the TAEL. Checking the functionality of TAEL.

Table 2. Results of laboratory tests

No	Description indicators	Unit measurements	Norm according to TK	Norma by TT	Actual meaning
1.	Corrosion effect on metals (steel 40.45 in accordance with GOST 1050)	-	withstands	withstands	withstands
2.	Water content	%	absence	absence	none
3.	Shore hardness - scale D, not less	N / mm^2	40	not installed	72/65
4.	Density, not less	g/cm^3	1.2	not installed	1.45/1.33
5.	Tribological indicators: • critical load, Pк, not less • wear scar diameter, Di, at a load of 196 N, no more • welding load, Pсв, not less	 N mm N	 980 0.6 2607	 980 0.6 2607	 1098/1098 0.45/0.45 4381/4381
6.	Resistance to climatic influences: - temperature Range; - humidity	 °C %	 -45…+50 100%	 -45…+50 100%	 withstands

Tests were carried out according to the "disk-finger" scheme on a universal friction machine 2168 UMT "Unitrib" designed for testing friction, anti-friction and lubricants for friction and wear in a wide range of modes. During the tests, the friction moment, weight (linear) wear of the rod samples, the speed of rotation were measured and the friction path was calculated with a constant supply of lubricant and a constant specific pressure in the zone of friction interaction.

The average weight (linear) wear rate of the lubricant rod during friction with the disk was taken as the result of evaluating the production of the lubricant rod, determined as the arithmetic mean of the three tests.

Based on the test results, a test report was drawn up and conclusions were drawn when comparing the following indicators:

1. Actual values of the lubricant rod production life.
2. Tribological indicators of contact (moment of friction , coefficient of friction). The results of bench tests of TAEL rods and SNTS lubrication rods are shown in table 3.

As a result of bench tests on the universal friction machine 2168 UMT "Unitrib", conducted under conditions simulating the contact interaction of the wheel with the rail when applying a solid lubricant to the wheel crest, supplied to the contact in the form of round-section lubrication rods, it was found that the actual values of the TAEL production resource are 8 times less than those of standard SNTS lubrication rods with comparable values of friction moments in the model contact of the wheel crest with the rail. TAEL rods have a significantly increased service life (8 times) compared to standard SNTS rods . This improvement in proper-ties makes it possible to carry out routine work on equipping the locomotive grebnesmazyvaniya devices with a significantly increased frequency, which will have a positive impact on the operational reliability and tech-nical and economic performance of locomotives. The results obtained need to be confirmed during the next stage of acceptance tests – operational tests, based on the results of which it is necessary to make economic calculations and evaluate the effectiveness of TAEL application [8-12].

Table 3. Results of bench tests

№	Name of indicators	Unit of measure ment	Actual values		
			TAEL	SNS	Comparison
1.1	Linear wear rate of the lubricant element (average value)	mm/km	0.01	0.08	8 times less
1.2	Moment of friction (spread of values/average)	N m	22..31 /28	21… 27/24	Comparabl e values

Operational tests were carried out in accordance with the program and methodology on a representa-tive number of units of equipment sufficient to assess its reliability indicators with the specified accuracy and reliability in accordance with the requirements of RD 50-690-89 "Methods for evaluating reliability indicators based on experimental data", in real operation.

In accordance with the experience maps agreed with the traction Directorate – a branch of JSC "Russian Railways" (no. ISH-5517/CT from 19.0.2018) , the equipment of regular grebnemazyvatel locomotives of the VL80 series (78 units), 2TE25KM (75 units) and CHME3 (193 units) was carried out with TAEL rods. Refueling was carried out in the conditions of service locomotive depots of the North-Caucasian branch of Locotech-Service LLC. The locomotives were ex-ployed at the ranges of the North Caucasus, South-Eastern and Volga Railways [13-20].

In the course of testing was conducted to check the following indicators:

1. Assessment of the impact of TAEL for wear of the ridges wheelset. We measured the wear of the ridges of wheel pairs and determined the average values of their wear intensity for each locomotive series. The av-erage wear rate of the band ridges in the locomotive section is determined by the formula (1), mm/104 km:

$$I_{sr} = \frac{\sum \Delta a_i \times 10000}{L \times 2 \times n} \quad (1)$$

where: ΣΔai - total amount of wear over the thickness of the ridges of all bandages in the locomotive section for the entire test period, mm;

L – total mileage of the locomotive for the entire test period, km;

n - number of axes in the section.

2. Assessment of the actual resource of TAEL production. TAEL production life was meas-ured and the average production life was determined for each locomotive series. The average in-tensity of TAEL production during friction against the wheel crest is determined by the formula (2), units/104 km:

$$V_{sr} = \frac{\sum N_i \times 10000}{L \times 2 \times n} \quad (2)$$

where $\sum N_i$- total number of TAEL produced in the locomotive section during testing, units;

L – total mileage of the locomotive for the entire test period, km;

n - number of axes in the section.

3.Evaluation of the functional capabilities of TAEL rods, their resistance to mechanical and climatic influences. Visual inspection of the TAEL for cracks, deformations, damages, and assess-ment of the surface condition of the wheel crest was carried out. The test results are shown in table 4.

Table 4. Test results

N	Series	Qty locomotives	Average intensity development of rods, units / 10 thousand. km			Average intensity wear of wheel flanges, mm / 10 thousand. km		
			TAE	SNTS	RAP	TA	SNTS	RAP
1	VL80	78	0.05	do not apply	2.5	0.30	do not use	0.35
2	2TE25	75	0.06	0.5	do not apply	0.7	1.1	do not apply
3	ChME	193	0.03	not applicable	2.5	0.20	not applicable	0.25

Based on the test results, the technical and economic efficiency of TAEL application was calculated.

5 Conclusions

1. The reduction in the wear rate of the ridges of wheel pairs of locomotives equipped with TAEL compared to standard rods averaged from 25 to 57%.
2. The increase in the production of TAEL rods compared to standard rods was from 2 to 15 thousand km (7.5 times compared to SNTS) and from 0.4 to 20...30 thousand km (50...75 times compared to RAPESEED).
3. During the tests, no damage (chips, cracks) of fuel Rods was recorded due to mechanical and climatic influences.
4. Technical and economic efficiency of Tael application is confirmed by the results of calculations.

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