Development of Cast Iron Brake Pads That Exclude the Working Surfaces of Locomotive Wheel Pairs

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Abstract. It is known that ensuring the safe movement of locomotives in the locomotive fleet of JSC "Uzbekistan temir yo'llari" plays an important role. Because the correctness and reliability of the brake system, which is an important part of the safe arrival of cargo and passenger trains to their destination, is of great importance. If we look at it from this point of view, the reliability of the brake system of locomotives depends on the strength, degree of wear and hardness of the brake pads. In this article, scientifically based solutions to the problem of ensuring the reliability of the braking system of the rolling stock are offered, while increasing the strength of these brake pads of locomotives.

1 Introduction

The coefficient of friction of the brake pad to the bandage. The size of φ_k depends on the material from which it is made, the speed of the train, its specific force on the bandage, the condition of the friction surfaces of the pads and bandage surfaces, its shape and the method of preparation.

One of the most important characteristics in railway operating conditions is the dependence of φ_k on the speed of movement and the force exerted by the pad on the band. Interdependence φ_k, V and N_T are determined by experiments in laboratory or operating conditions [1-2]. It is found that the magnitude $\varphi_k$decreases as the speed V increases and the force of the pad on the bandage N_T increases.

One of the most important tasks for railway rolling stock is to increase the reliability and service life of brake systems, and this issue is related to improving the strength of the brake unit of the pad type and providing increased resistance to wear. In the developed countries of the world, such as the USA, England, France, Spain, Germany, Japan, China, Russia, attention and interest in the problem of brakes is increasing, and in this regard, research is being conducted in research institutes and industrial enterprises aimed at improving the friction performance of rolling stock brake units [3-5]. New constructions of elements of brake systems and effective technological processes of production are being developed.

For many years, gray frictional cast iron has been used as a traditional material for rolling stock brake pads, and it has proven itself as a relatively reliable material in friction conditions

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against steel without lubricating oil [6]. At the same time, recently more resistant materials - metal-ceramics and polymers [9-10], as well as from various combinations of cast iron [11] made pads also appeared. Despite the above, cast iron is still a promising material with a number of serious advantages: a much lower level of production, the material is cheap, it is relatively simple to manufacture, the effectiveness of braking does not depend on weather conditions, etc.

2 Objects and methods of research

Today, railways of the CIS (Commonwealth of Independent States) countries mainly use cast iron brake pads specified in GOST 30249-97 for locomotives [7-8].

Many experimental studies [12-14.] determined based on the results, the friction coefficient values of cast iron pads can be calculated according to the following formula.

$$\varphi_{кч} = 0{,}6\frac{16N_T+100}{80N_T+100}\cdot\frac{V+100}{5V+100}. \quad (1)$$

The results of foreign research experiments also lead to the same or close relationships with formula (1).

Fig.1 shows the dependence of the friction coefficient $\varphi_{кч}$ of cast-iron pads on the bandage on the change in speed V, where the speed varies from 0 to V_K = 100 km/h (V_K = 27,778 m/s). It is known that the friction coefficient of cast iron pads decreases from 0,153 to 0,082 as the movement speed V increases.

$V =$	$\varphi_{кч} =$
0	0.153
1.852	0.143
3.704	0.134
5.556	0.127
7.407	0.12
9.259	0.115
11.111	0.11
12.963	0.105
14.815	0.101
16.667	0.098
18.519	0.094
20.37	0.091
22.222	0.089
24.074	0.086
25.926	0.084
27.778	0.082

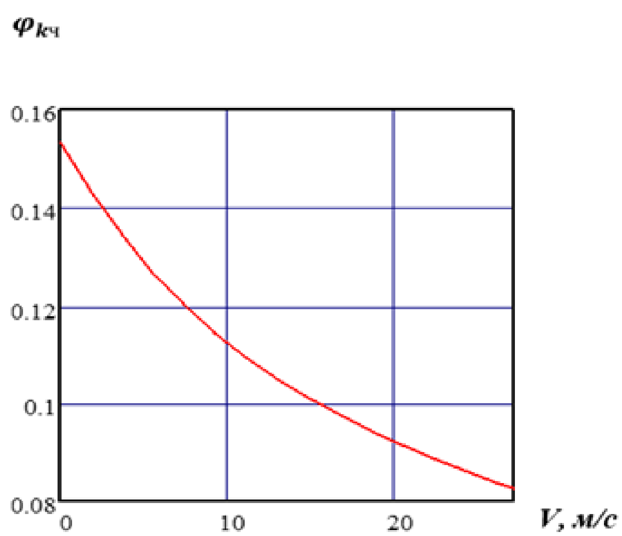

Fig.1. – Dependence of friction coefficient $\varphi_{кч}$ of cast-iron blocks on bandage on change of movement speed V.

The reduction of the coefficient of friction of cast iron pads with the increase in speed can be explained by the fact that during the braking of the rotating wheel, the protruding particles of the friction surface of the pad sticking to it are subjected to elastic and plastic deformations in the form of crushing, cutting, breaking, and then are crushed and come out in the form of metal dust. In this case, a large amount of heat is released. As the movement speed V and the increasing force of the pad to the bandage N_T increases, the amount of heat released per unit of time increases, and therefore the thin layer (microlayer) of the metal of the rubbing surfaces heats up more and more. As a result of the increase in temperature, the metal microlayer softens, becomes plastic and melts, and turns into lubricating oil, which lies between the deeper, relatively cold hard metal layers of the pad and bandage.

Operating practice shows that standard cast-iron pads are more resistant especially at high braking speeds and high specific forces [15-17].

Phosphorus content in order to increase resistance to melting while improving frictional aspects 1.0-1.4% cast iron pads are used. For such blocks, according to scientific works, it was determined that the values of the coefficient of friction of cast iron pads (with the addition of 1.0-1.4% phosphorus) can be calculated according to the following formula.

$$\varphi_{k\text{фч}} = 0{,}5\,\frac{16N_T+100}{52N_T+100}\cdot\frac{V+100}{5V+100} \qquad (2)$$

Fig.2 shows the dependence of the coefficient of friction on $\varphi_{k\text{ч}}$ of cast-iron pads (with 1,0-1,4% phosphorus addition) at a change in speed V, where the speed is from 0 to V_K =100 km/h (V_K =27,778 m/s) varies in the interval. From the analysis of Figures 1 and 2, it is known that the coefficient of friction of cast iron pads (with the addition of 1,0-1,4% phosphorus) $\varphi_{k\text{ч}}$ with the addition of phosphorus, respectively, the indicator $\varphi_{k\text{ч}}$ now decreases from 0,153 to 0,082 compared to 0,19 to 0,101 for standard cast iron pads changes up to and increases, that is, their resistance to damage increases.

$V =$	$\varphi_{k\text{фч}} =$
0	0.19
1.852	0.177
3.704	0.166
5.556	0.157
7.407	0.149
9.259	0.142
11.111	0.135
12.963	0.13
14.815	0.125
16.667	0.121
18.519	0.117
20.37	0.113
22.222	0.11
24.074	0.107
25.926	0.104
27.778	0.101

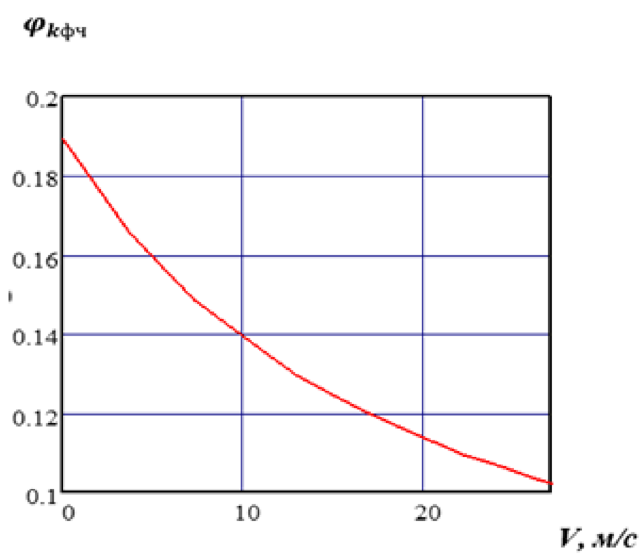

Fig.2. Dependence of the friction coefficient $\varphi_{k\text{ч}}$ of cast-iron bearings (with the addition of 1,0-1,4% phosphorus) at a change in speed V.

Fig.3 shows a graph of the comparative analysis of changes in the friction coefficient $\varphi_{k\text{ч}}$ of standard cast-iron pads and the friction coefficient $\varphi_{k\text{ч}}$ of cast-iron pads (with the addition of 1,0-1,4% phosphorus) when the speed V changes.

3 Results and their Discussion

In order to improve the resistance to melting, composite pads are widely used. Composite bearings have approximately three times the wear resistance of standard cast iron bearings. In particular, made of 6KV-10 material experiments conducted for composite pads with a friction coefficient almost independent of speed showed that the friction coefficient of the pads $\varphi_{kk\text{п}}$ can be determined according to the following formula:

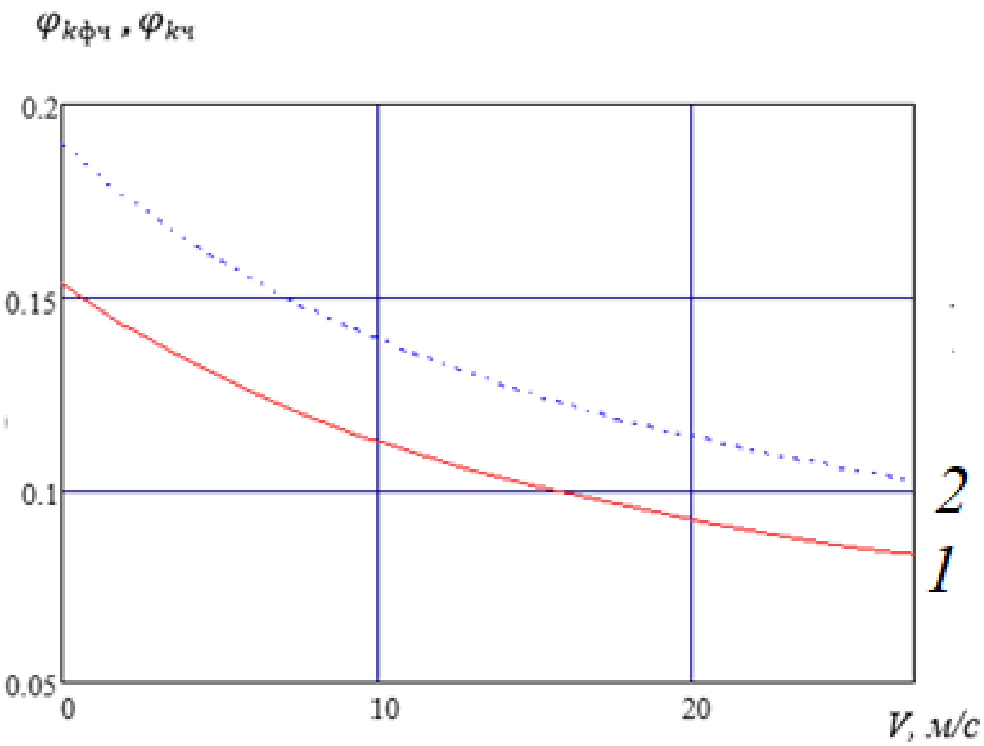

Fig.3. A graph of the comparative analysis of changes in the friction coefficient $\boldsymbol{\varphi}_{\boldsymbol{k}\text{ч}}$ of standard cast-iron bearings and the friction coefficient $\boldsymbol{\varphi}_{\boldsymbol{k}\text{ч}}$ of cast-iron bearings (with the addition of 1,0-1,4% phosphorus) as the speed V changes.
1 − $\varphi_{k\text{ч}}$ - coefficient of friction of standard cast iron pads;
2 − $\varphi_{k\text{ч}}$ -1-1,4% phosphorus added cast iron pads friction coefficient.

$$\varphi_{kk\text{п}} = 0{,}44\frac{N_T+20}{4N_T+100}\cdot\frac{V+150}{2V+150} \quad (3)$$

Fig.4 shows the friction coefficient of composite pads made of 6KV-10 material with changes in speed [21; 12-15 b,] the dependence graph of $\varphi_{kk\text{п}}$ is shown.

$V =$	$\varphi_{kk\text{п}} =$
0	0.21
1.852	0.195
3.704	0.183
5.556	0.173
7.407	0.164
9.259	0.157
11.111	0.15
12.963	0.144
14.815	0.138
16.667	0.133
18.519	0.129
20.37	0.125
22.222	0.121
24.074	0.118
25.926	0.115
27.778	0.112

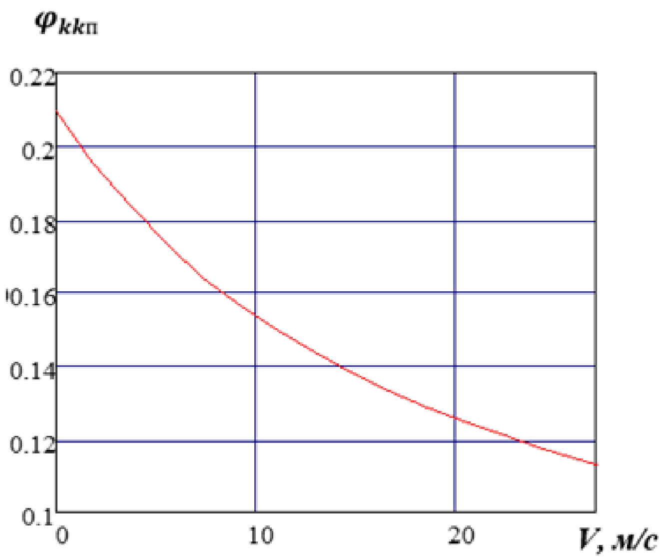

Fig.4. Friction coefficient of composite pads made of 6KV-10 material with change of movement speed V, m/s [18-19] The dependence graph of $\varphi_{kk\text{п}}$.

The most important indicators that determine the level of normal performance of the tribological pair "Bandage-brake pad" are the stiffness of the brake the stability of this indicator on the section of the pad and the small spread of the hardness level indicators on individual pads. It determines the size (value) of the hardness of the pad, the change of the hardness on the cross-section leads to a qualitative change of the friction processes, and the wide dispersion of the hardness on the pads leads to the poor use of the material of a part of the pads.

The hardness of cast iron brake pads depends on their internal structure. The main constituents of this structure are ferrite, pearlite, graphite, cementite, and other impurities present in cast iron form carbides, and phosphorus forms phosphide eutectics.

GOST 30249-97 in M-type locomotive pads, deviations (deviations) of carbon content from 2,7 to 3,4% are allowed, in which pearlite has a stable hardness, and changes in material hardness are mainly due to free cementite and phosphide eutectics. is determined. An increase in the amount of carbon also affects the amount of free cementite. The hardness of the locomotive brake pad must correspond to 229 – 302 NV according to the same standard for "M" cast iron.

On the basis of a gross inspection of the hardness of new and used pads on the Krasnoyarsk railway, it was determined that their degree of hardness in terms of hardness reached 25%, of which about 4%.

4 Conclusions

It has a hardness of up to 600 NV at a depth of 2 mm. In the process of using such pads, the sliding surface of the tire is accelerated, and during braking, it experiences a strong spark. In the process of operation, the metal is highly cracked and corroded. Their structure consists of white or pale cast iron, which indicates a violation of the technological process of casting.

In order to reduce the production of bandages, new materials made of expensive chrome-plated steel are being introduced. The fact that bandages with a curved surface are made in more than one level causes the need for alignment [20], which further shortens the service life of bandages.

Based on the preliminary theoretical developments, it was determined that stable hardness can be achieved only by changing the bearing structure to a ferrite-graphite type, without changing the chemical composition of the initial cast iron and the production technology. In this case, ferrite has a stable hardness, and changes in the amount of carbon lead to changes in the quantity of the graphitic component due to the transformation of free cementite and cementite into free graphite in pearlite.

Due to the alloying of this matrix, the content of existing silicon, ferrite metal matrix can reach NV230, and the amount of manganese and phosphorus can reach NV230, which is in line with the lower limit of the standard hardness.

References

1. Mamayev, S., Fayzibayev, S., Djanikulov, A., & Kasimov, O. (2022, June). Method of selection of mainline locomotives in the unloaded state according to the speed characteristics affecting the electromechanical vibrations of the WMB. In *AIP Conference Proceedings* (Vol. 2432, No. 1). AIP Publishing.
2. Khamidov, O. R., Kamalov, I. S., & Kasimov, O. T. (2023, March). Diagnosis of traction electric motors of modern rolling staff using artificial intelligence. In *AIP Conference Proceedings* (Vol. 2612, No. 1). AIP Publishing.
3. Khamidov, O. R., Kamalov, I. S., & Kasimov, O. T. (2023, March). Heat calculation of pads during locomotive braking. In *AIP Conference Proceedings* (Vol. 2612, No. 1). AIP Publishing.
4. Kasimov, O., Fayzibayev, S., Djanikulov, A., & Mamayev, S. (2022, June). Numerical studies for estimation of temperature fields in bandage material during locomotive braking. In *AIP Conference Proceedings* (Vol. 2432, No. 1, p. 030025). AIP Publishing LLC.
5. Kasimov, O. T., Djanikulov, A. T., & Mamayev, S. I. (2021, November). Modeling the bending of the tire surface by pads during braking. In *AIP Conference Proceedings* (Vol. 2402, No. 1). AIP Publishing.
6. Djanikulov, A. T., Mamayev, S. I., & Kasimov, O. T. (2021, April). Modeling of rotational oscillations in a diesel locomotive wheel-motor block. In *Journal of Physics: Conference Series* (Vol. 1889, No. 2, p. 022017). IOP Publishing.
7. Djanikulov, A. T., & Safarov, U. I. (2023). Correction of ted field weakening switching diagram for mainline diesel locomotives of te type. In *E3S Web of Conferences* (Vol. 401, p. 01071). EDP Sciences.
8. Djanikulov, A. T., & Abdulatipov, U. I. (2023). Torsional oscillations of armature shaft of generator of main diesel locomotive in diesel start-up mode. In E3S Web of Conferences (Vol. 401, p. 01072). EDP Sciences.

9. Jamilov, S., Ergashev, O., Abduvaxobov, M., Azimov, S., & Abdurasulov, S. (2023). Improving the temperature resistance of traction electric motors using a microprocessor control system for modern locomotives. In *E3S Web of Conferences* (Vol. 401, p. 03030). EDP Sciences.
10. Abdurasulov, S., Zayniddinov, N., Yusufov, A., & Jamilov, S. (2023). Analysis of stress-strain state of bogie frame of PE2U and PE2M industrial traction unit. In *E3S Web of Conferences* (Vol. 401, p. 04022). EDP Sciences.
11. Khamidov, O., Yusufov, A., Jamilov, S., & Kudratov, S. (2023). Remaining life of main frame and extension of service life of shunting Locomotives on railways of Republic of Uzbekistan. In *E3S Web of Conferences* (Vol. 365, p. 05008). EDP Sciences.
12. Yusufov, A., Khamidov, O., Zayniddinov, N., & Abdurasulov, S. (2023). Prediction of the stress-strain state of the bogie frames of shunting locomotives using the finite element method. In *E3S Web of Conferences* (Vol. 401, p. 03041). EDP Sciences.
13. Khamidov, O., & Udalova, D. (2021, May). Technical and Economic Efficiency of Intelligent Data Analysis on the Railways of the Uzbekistan Republic. In *International Scientific Siberian Transport Forum* (pp. 230-239). Cham: Springer International Publishing.
14. Abdurasulov, S., Zayniddinov, N., Yusufov, A., & Jamilov, S. (2023). Analysis of stress-strain state of bogie frame of PE2U and PE2M industrial traction unit. In *E3S Web of Conferences* (Vol. 401, p. 04022). EDP Sciences.
15. Ergashev, O. E., Abduvakhabov, M. E., Khamidov, O. R., Tursunov, N. K., & Toirov, O. T. (2022). INCREASING THE DURABILITY OF GEAR TRANSMISSIONS OF ASYNCHRONOUS TORSION ELECTRIC MOTORS. *Web of Scientist: International Scientific Research Journal*, *3*(10), 1030-1036.
16. Xamidov O., Ergashev O., Abduvahobov M., & Nematova S. (2022). “O‘ZBEKISTON” ELEKTROVOZI VA TE10M TEPLOVOZINING TORTUV REDUKTORI TEXNIK HOLATINI BAHOLASH. Current approaches and new research in modern sciences, 1(4), 37-42.
17. Safarov, U., Ergashev, O., & Saidivaliev, S. (2023). The Essence of Explaining the Emergence of Briefly Braking Modes of Diesel Locomotives with Direct Current Electric Transmission (No. 10038). EasyChair.
18. Ablyalimov, O., & Julenev, N. (2023). Logistic indicators of locomotives of diesel traction on high-speed section of the railway. In *E3S Web of Conferences* (Vol. 401, p. 05023). EDP Sciences.
19. Ablyalimov, O. (2023). Indicators of transport logistics of locomotives of diesel traction on Kattakurgan-Navoi section in operation. In *E3S Web of Conferences* (Vol. 401, p. 05022). EDP Sciences.
20. Ablyalimov, O., & Avdeyeva, A. (2023). Operation of locomotives of diesel traction on hilly section of railway. In *E3S Web of Conferences* (Vol. 401, p. 01058). EDP Sciences.