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Increase of coupling characteristics and profitability of the locomotive modernization of system of supply of sand

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S u m m a r y . The article provides the analysis of inefficiency of the locomotive sand system. A new technical solution is proposed and experimentally confirmed. It will reduce the cost of equipping materials, improve safety, reduce maintenance costs, improve traction quality, and eliminate other system disadvantages of the sand supply.
K e y w o r d s : coefficient of adhesion, sand system, wheel, rail, saving equipping materials.

INTRODUCTION

The tendency to increase the mass and the speed of the train leads to a significant increase in general and specific power of locomotives.

With increasing specific power of rolling stock, there arises the problem of reliable adhesion of wheels with the rails under any weather and climatic conditions, as well as with various kinds of surface pollutions, because traction and braking forces are passed through this node.

One of the most important economic indicators - the cost price of transportations, is mainly determined by the mass of the train, which depends on the parameters of the interaction of the wheel and the rail significantly. In addition, the quality of the work of the «wheel-rail» friction unit has an impact on the speed of movement of trains, traffic safety and a number of other economic and operational characteristics of the work of railway transport [Gorbunov N, Kostyukevich A., Kravchenko K., Kovtanets M., 2011].

THE MAIN OBJECTIVE OF THE ARTICLE

Development of a method and adaptive devices for improvement of interaction in the «wheel-rail» system by supplying sand directly in the zone of contact in one layer.

RESEARCH ANALYSIS

The aim to realize the higher values of the adhesion coefficients led to the emergence of many scientific schools and a number of directions for improvement of adhesion of wheels of a locomotive with rails that can be classyfied into two main groups [Luzhnov U.M., 2003]:

1. Researches aimed at more efficient use of existing properties of the wheels and rails.

2. Researches on the influence on the adhesion coefficient, contributing to the stabilization and improvement of friction properties of wheels and rails.

The second group contains the method of increase the adhesion of the wheel and the rail, which is the most widely spread on the railways of the world and consists of the supply of quartz sand under the wheels of moving locomotive. The detailed examination of the sand locomotive system made it possible to identify its main disadvantages [Lucyk V.S., Kamenskiy V.B., Bashkatova L.V., 2001, Gorbunov N.I., Kovtanets M.V., Gorbunov N.N., Nozhenko V.S., Kravchenko K.A., 2011, Gorbunov N.I., 1987,

Sokolov G.S., 1944, Kovtanets M.V., Naysh N.M., Kravchenko K.A., Kara S.V., 2011]:

– *excessive* and *uncontrolled supply* of sand reduces the efficiency of its use (the maximum effect is achieved when sand is applied in one layer) and contaminating the ballast prism and rail lattice;

– *increase resistance to motion* of the rolling stock which is especially noticeable when passing the curve sections of the track, where the presence of residues of sand on rails makes difficulties in cross movement of train wheels and prevents proper setting of carriages in the direction of the curve and, respectively, increases the consumption of fuel and energy resources (fig. 1);

Fig. 1. Presence of residues of sand on rails

– *sand caking* leads to decrease in reliability of work of the injector and hoppers for storage of sand;

– *increased deterioration or damage* rails and the bandages of the locomotive in the form of defects № 14 (wheel slippage of the rails in the mode of sustainable slippage) and № 40 (wave deformation of the rail head - short waves) shown at fig. 2;

– in case of submission of sand *while passing a railroad switch* the surplus sand fills the gap between wit and side rail, thus violating the normal functioning of the switch mechanism;

– *inability to provide an accurate submission of necessary quantity of sand* in the zone of friction contact, as the pipeline with a nozzle mounted on the car frame, which does not repeat complex trail of movement of a wheel. This causes diversion of sand on the side surfaces of the ridge of the bandage and the rail and acceleration of their wear;

a

b

Fig. 2. Kinds of defects caused by excessive supply of sand a – defect № 14; b – defect № 40

– *clogging of elastic gaskets* between the soles of rails and sleepers that causes them to wear and leads to a change of rigidity of the rail lattice;

– *allocation of the condensate* in snowy, wet weather in the steel pipelines and the ends of the pipes that under negative temperature of ambient air makes it freeze inside, preventing the normal functioning of the sand system;

– *possibility of oscillations* (in case of increased thickness of the layer of sand) in a traction drive during slippage that is inevitably accompanied by significant dynamic and shock loads in the elements of the drive and suspension.

Considering aforementioned issues, the existing (operating) locomotives sand system requires modernization of its main units for the effective use of sand and to increase and control the state of the interaction in the «wheel-rail» system.

PROBLEM SOLUTION

It is known that the general tendency of the development of sand system is its simplification and a gradual switch to systems with the low pour of sand. In [Kamenev N.N., 1968, Osenin U.I.,

1994, Osenin U.I., Shvedchikova I.A., 1997, Kravchenko K.A., 2010] the authors have shown that providing high traction locomotive characteristics to contact of wheel and rail dose-amount of sand should be supplied. The maximum possible coefficient of adhesion of the wheel with the rail is achieved by filling the contact sand saturation 0,6 kg/m^2 [Gorbunov N., Kostyukevich A., Kravchenko K., 2010].

Modernization of locomotive sand system to improve traction-adhesion qualities of a locomotive can be implemented in three stages.

1. Reduce the labor and material consumption of production and operation of new sand system through making the nozzle and pipe, connecting nozzle with injector, of rubber (fig. 3), and reducing the diameter of the pipe and the outlet nozzle comparing to existing design of the sand system.

2. The creation of adaptive, repeating almost all movements of the wheel the sand system [Gorbunov N.I., Kravchenko K.A., Kovtanets M.V., Nozhenko V.S., Garkushin E.A., 2010, Kovtanets M.V., 2012, Gorbunov N.I., Kovtanets M.V., Slashov V.A., Kravchenko K.A., Prosvirova O.V., 2012], by fixing rubber nozzle and pipe with the help of the bracket to the bush for accurate batching of sand (fig. 3, 4). Free run of the wheel set comparing to the upper part is 2 mm, that will allow the nozzle mounted on bush perform the move with smaller amplitude, than when attached to the frame of the carriage, and compensate this movement with angle of the spray sand-air jet.

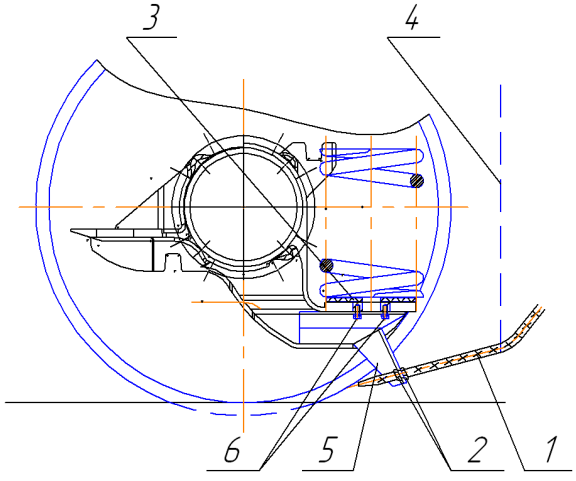
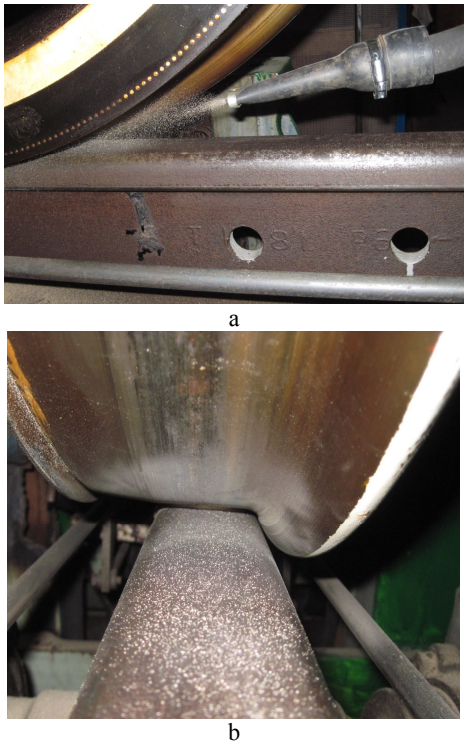


Fig. 3. General view of the upper part of the tri-axial locomotive carriage equipped with a modernized sand system 1 – rubber pipe, 2 – lug nuts, 3 – springs reliance, 4 – safety chain with clip, 5 – bracket, 6 – bracket bolts



a

b

Fig. 4. The operation of the modernized sand system a – the process of submitting the sand directly in contact; b – supply on the surface of the rail

3. Reduction of the consumption of sand by its submission in one layer in the contact of wheel and rail (fig. 4) [Gorbunov N.I., Kravchenko K.A., Popov S.V., Kovtanets M.V., Osenin U.U., 2010,].

To confirm the expediency of application of the modernized sand system of the locomotive, experimental study was carried out on a field stand «Wheel-Rail» (fig. 4), which was built according to the scheme, where the geometrical axis of rotation of the wheel has no longitudinal (along the axis of the road) movement, sliced moves only rail mounted on rollers [Gorbunov N.I., Kashura A.L., Popov S.V., Kravchenko K.A., Osenin U.U., 2008]. The design of the stand allows to create vertical forces to 130 kN, longitudinal - up to 40 kN in the zone of contact. The wheel is revolved special drive, traction force is simulated by the brake force longitudinally moveable rail. The efforts, speed of the wheels and the rails are recorded on an oscilloscope.

For the experiment the standard diesel locomotive wheel was used (diameter 1,05 m and rail brand R65) withdrawn from operation, and therefore has libel and little wear of the tread surface. Parameters of loading and modes of implementation of the tractive force is consistent with the work of the locomotive wheel pairs of locomotive 2TE116.

Physical adhesion coefficient ψ_0 was found by limiting value of longitudinal force P, which should be attached to the rail to move it comparatively the wheel wedged in bush bearings with vertical loading $P_в = 115$ *кН* , *so* $\psi_0 = P/P_в$.

The experiments were carried out for three states of the rail surface: a clean and dry; covered with water; covered with a thin layer of used oil taken from the operated diesel locomotive.

As a result of the performed experimental studies and processing of the results, obtained dependences (fig. 5) of physical coefficient of friction ψ_0 from the sliding speed ε, under different frictional conditions.

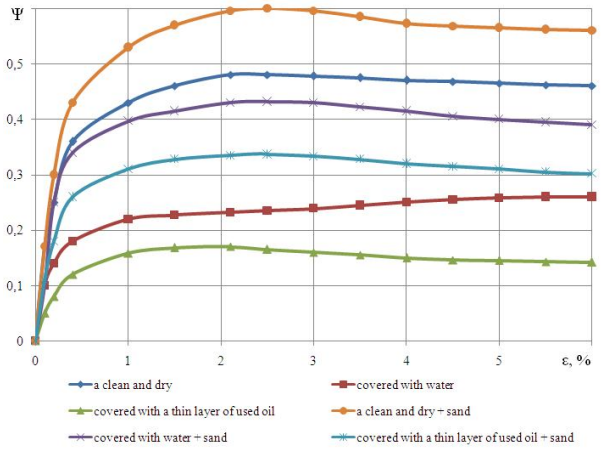


Fig. 5. Dependence of physical coefficient of friction on sliding

Analysis of the results (fig. 5) shows, that the use of the proposed method of submission of sand directly in one layer in the wheel and rail contact allows increasing the physical adhesion coefficient ψ_0 by:

– 20% for a clean and dry rail;
– 39,8% for rail covered with water;
– 49,5% for rail covered with used oil.

To verify the reliability of the upgraded sand system in use, the installation of the design of the system on the shunting locomotive CHME3 №2247 (fig. 6) and the trunk locomotive 2TE116 №1077 (fig. 7) operated in the Kondrashevskaya-Novaya depot.

During the operation installed project sand system showed: the implementation of a high coefficient of friction, lower consumption of sand, the lack of sand on the surface of the rail lattice, the lack of sand get into the gap between the wit and side of the rail, while passing switches, the positive feedback of mechanics in its maintenance in comparison with the sand systems installed on similar models of locomotives.

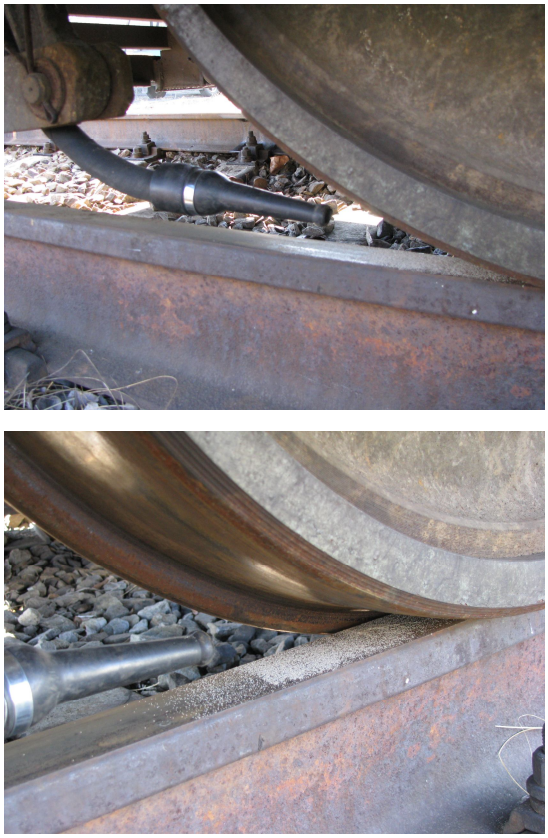


Fig. 6. Installation of the upgraded system on shunting locomotive CHME (№2247)

Fig. 7. Installation of the upgraded system on trunk locomotive 2TE116 (№1077)

As known from [Kravchenko K.A., 2010] the effect of the use one layer of sand will allow to reduce the consumption of sand by 25 times in comparison with the classical supply of sand on the surface of the rails. According to the data of the operation of the locomotive depot Kondrashevskaya-Novaya for the period 2009-2010, the flow of sand Q by the park of locomotives is $389m$ per year, the cost of one ton of sand – $P = 72\ UAH$. The cost of the sand with the account of the expenses connected with cleaning of ballast of the top structure of a way from sand pollution is taken into account by the coefficient $\mu = \left(1 + \frac{32}{26}\right) = 2,23$ according to the data of the operation of diesel locomotives on the railway network.

Complete cost of the sand used in one year by locomotive park of Kondrashevskaya-Novaya depot will be:

$$P_1 = Q \cdot P \cdot \mu = 389 \cdot 72 \cdot 2,23 = 62458\ UAH \quad (1)$$

Cost of the sand used in one year by locomotive park of Kondrashevskaya-Novaya depot using the modernized sand system will be:

$$P_2 = Q \cdot P \cdot \mu = 16 \cdot 72 \cdot 2,23 = 2569\ UAH \quad (2)$$

Consequently, the savings due to the modernization of sand system of the park of locomotives will be:

$$\Delta Э = P_1 - P_2 = 62458 - 2569 = 59889\ UAH \quad (3)$$

As one of the promising solutions for the modernization of locomotive sand system is the completion of the covering of injector from the set of dismountable elements (segments) made of rubber. The proposed nozzle will reduce the cost of its production (having refused from the nozzle made of metal by casting), as well as the complexity of its repairs. Also a set of various number of segments will change the capacity of the mixing chamber the sand-air mixture and consequently the performance of sand system for various types of locomotives.

CONCLUSIONS

It is offered to modernize the existing sand systems used on the locomotives which will allow to achieve the following advantages

– achieve a high and stable coefficient of friction of the wheels of a locomotive and rails;

– reduce the labor intensity and material intensity of production due to the refusal of complex work in the production of metal pipes for the supply of sand, that often break in case of shock loads;

– realization of nozzles and pipes from rubber to eliminate the connections between them and gaskets and reduce the possibility of a moisture penetration conducive to the emergence of clogging of sand in pipelines;

– mounting of pipe and nozzle of sand system on bush reduces labor costs in the production of carriage (abandoning the mounting brackets for sand tubes), improves the use qualities of the locomotive and the terms of its service;

– supply of sand directly in wheel and rail contact in one layer will allow to reduce the consumption of sand in 25 times, increase the coefficient of adhesion of the wheel and rail, which causes the expediency of reduction of discharge nozzle and pipe diameter, and will reduce the capacity of the reservoir for storage of sand in the locomotive, that will reduce time spent on equipping of the sand system with other comparable circumstances and prevent rail lattice pollution;

– eliminates the ingress of sand in the gap between the wit and rail that will reduce the impact loads, enhance safety when driving in switches, so will increase the life expectancy of the elements of the switch and bogie.

According to the proposed modernization of locomotive sand system developed a technical proposal for the drawings 2ТЭ116.30.48.003 СБ. The method [Gorbunov N.I., Kovtanets M.V., Gorbunov N.N., Nozhenko V.S., Kravchenko K.A., 2011] is created and there are reserches on development a system to disable the sand supply in switches, as well as a promising way to improve the adhesion is [Golubenko A.L., Gorbunov N.I., Kashura A.L., Kostyukevich A.I., Kravchenko K.A., Popov S.V., Kovtanets M.V., Krusanov M.A., 2011] using dry ice capsules.

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ПОВЫШЕНИЕ СЦЕПНЫХ ХАРАКТЕРИСТИК И ЭКОНОМИЧНОСТИ ЛОКОМОТИВА МОДЕРНИЗАЦИЕЙ СИСТЕМЫ ПОДАЧИ ПЕСКА

Максим Ковтанец, Николай Горбунов,
Ольга Просвирова, Сергей Сосновенко, Виталий Астахов

Аннотация. Представлен анализ неэффективности работы песочной системы локомотива. Предложено и экспериментально обосновано новое техническое решение, которое позволит снизить затраты экипировочных материалов, повысить безопасность движения, снизить затраты на обслуживание, повысить тягово-сцепные качества локомотива, а также устранить другие присущие песочной системе недостатки.

Ключевые слова: коэффициент сцепления, песочная система, колесо, рельс, экономия экипировочных материалов.