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SUBSTANTION OF THE ENVIRONMENTAL EFFICIENCY OF THE DEVICE FOR PARALLEL RETRACTION OF BRAKE SHOES FOR FREIGHT WAGONS

ODÔVODNENIE ENVIRONMENTÁLNEJ ÚČINNOSTI ZAVEDENIA ZARIADENIA NA ROVNOMERNÉ OPOTREBOVANIE KLÁTIKOV NÁKLADNÝCH VOZŇOV

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1 INTRODUCTION

The lower transportation cost is of utmost importance for the railway infrastructure, where the technical condition and reliability of the rolling stock play a major role. The braking equipment is of primary importance for the traffic and environmental safety as well as for energy saving. However, at present there is a critical situation with over-normative wear of brake pads used for freight wagons.

When a freight train moves without braking, the upper edges of brake pads are inclined and pressed to the rolling surface of wheels, therefore, they suffer excessive wear. It causes additional specific resistance to the train movement and increases the consumption of diesel fuel for the train haulage that results in the increased emissions of harmful gases into the environment. Due to the dual wedge-shaped wear, the service life of brake pads does not reach 50 % of its potential. Therefore, they are frequently replaced with new ones due to a threat to the traffic safety despite large residues of the working body; and old pads are sent to landfills (***fig. 1***).

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a) b)

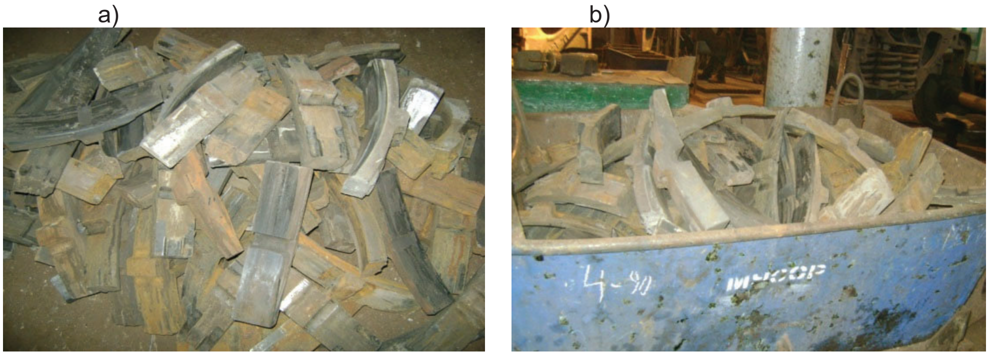

Fig. 1 *Composite brake pads with the dual wedge-shaped wear removed from wagons a) with large residues of the working body; b) prepared for disposal at municipal landfills*

Obr. 1 *Klinové dvojité opotrebované kompozitné brzdové doštičky odstránené z vozňov a) s veľkými zvyškami pracovnej karosérie; b) pripravené na odvoz na mestské skládky*

2 ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Specialists and scientists from many countries including Ukraine have tried to change the difficult situation in the wagon industry regarding the excessive replacement of composite brake pads with the dual wedge-shaped wear by designing special devices to eliminate this wear. Some studies [1] were carried out on full-scale samples of rail vehicles, where the reliability of brake systems of bogies was tested and the values of wear and temperature were measured [2].

Study [3] presents an analysis of the performance indicators of cast-iron and composite brake pads used for various types of the rolling stock. Some negative features of composite brake pads, which can damage the rolling surfaces of wheels of the rolling stock, thus leading to increased costs of freight transportation, were analysed. Moreover, the authors described the negative environmental effect of using composite brake pads.

The research of the design features of innovative brake systems of modern rolling stock is given in [4]. The main factors affecting the braking efficiency were identified. The temperature load on the components of the tribotechnical pair “brake pad-wheel” during the braking of a rail vehicle was calculated. However, the research did not take into account the negative impact of the dual wedge-shaped wear of a composite pad, which frequently occurs in the brake leverage of wagon bogies, on the environment due to the harmful emissions.

Study [5] presents a review of publications and an analysis of the quality performance of cast-iron and composite pads. The authors also described the disadvantages of composite brake pads, such as low thermal conductivity on the rolling surfaces of wagon wheels, which can cause numerous thermal malfunctions. They can cause additional expenditures for the repair of wagon wheelsets. Another significant disadvantage is the environment pollution caused by the harmful substances emitted during the operation of composite brake pads. It worth noting that the authors did not give the operating costs resulting from the dual wedge-shaped wear and higher specific resistance to the train movement, which also negatively affects the environment.

The analysis of literature on the environmental protection has demonstrated that special attention is given to pollutants in the form of suspended particulate matter with various dispersions, which is emitted to the atmosphere by the railway infrastructure. This particulate matter (PM) is formed from brake pads of wagons during their wearing-out.

The most hazardous suspended particulate pollutants are fine particles with a size of 10 μm or less (PM10, PM2.5), which account for about 70% of the total suspended matter. Fine particles are a heterogeneous mixture of organic and inorganic substances. The PM10 is maintained in the air for a long time in the areas where trains run along individual sections with stations or stopping points, and their highest concentration is at an altitude of 1-1.5 m (in the breathing zone). Due to the microscopic sizes, such particles easily penetrate into the human lungs, accumulate there, and subsequently cause various respiratory, oncological and cardiovascular diseases.

The harmful molecular-mechanical wear in the high-temperature environment due to the application of the polymer composite brake pad 2TR-11 is accompanied by the formation of a poisoned environment near each moving train [6].

Unfortunately, the problem related to the dual wedge-shaped wear of composite brake pads for freight wagons cannot be solved when the pads are already in operation, because the design of the brake leverage is very complex and it may increase the weight and the number of parts, which will definitely require higher costs of scheduled repairs of freight wagons.

3 DETERMINATION OF ENVIRONMENTAL EFFICIENCY OF THE DEVICE FOR PARALLEL RETRACTION OF BRAKE SHOE OF FREIGHT WAGONS

The traction rolling stock requires energy and material resources for operation, besides it interacts with the environment. The consumption of these resources and the impact on the environment depend on the technical characteristics of the traction equipment as well as many operational factors.

In recent years, some countries phase in the restrictions on harmful substances in the exhaust gases emitted by diesel locomotives. Thus, Directive 97/68/EC and Standard UIC-624 (E) of the International Union of Railways provide for the tightening of norms of harmful emissions from railway diesel engines. As far as Ukraine must adhere to these environmental standards, there are certain requirements for diesel locomotives regarding the emission of harmful substances (***TABLE. 1***).

TABLE 1 *Environmental requirements for diesel locomotives*

TAB. 1 *Environmentálne požiadavky na dieselové lokomotívy*

Document	Hazardous substances, g/kW·year			
	NOx (nitrogen oxides)	CO (carbon monoxide)	CH (carbohydrates)	PM (particulate matter)
UIC-624-0	9.9	3	0.8	0.25
Directive 97/68/EC	7.4	3.5	0.4	0.2

The environmental effect is determined as the difference between the environmental damage caused by harmful substances in the exhaust gases emitted by diesel locomotives M62 and 2TE116 when they are used for trains with the typical device M 1180.000 and the environmental damage caused by trains with the device for parallel retraction of brake shoes improved with the UkrSURT technology. This difference is the result of the reduced resistance to the train movement and, thus, lower fuel consumption for the train haulage.

Main harmful substances in the exhaust gases emitted by diesel engines are nitrogen oxides (NOx) and carbon monoxide (CO).

The amount of harmful substances emitted by a diesel locomotive to the atmosphere depends on the amount of fuel consumed and the specific consumption of each component formed in the exhaust gases. The research carried out in Germany demonstrated the averaged values (in grams) by harmful substances emitted by diesel locomotives per 1 kg of the diesel fuel consumed [7, 8, 9]: CH – 1.4; CO – 10; NOx – 44; soot – 1.3.

The actual specific emission masses by mainline diesel locomotives according to [7, 8, 9] are: NOx – 52.34 kg/t; CO – 11.25 kg/t; CnHm – 8.78 kg/t; C – 2.83 kg/t.

The emission mass of the n-th component of a harmful substance per one turnover of a mainline diesel locomotive is determined by the formula:

$$m_n = m^f_{nat} \cdot G_f, \tag{1}$$

where m^f_{nat} is the actual specific emission mass of the *n*-th component of a harmful substance emitted by a mainline diesel locomotive, kg/ton of fuel; G_f is the fuel consumed by a mainline diesel locomotive per one turnover, t.

The specific emission mass of the *n*-th component of a harmful substance per one unit of operational work 10^4 gross tkm is determined by the formula:

$$M^f_{nat\,n} = \frac{m_n}{\sum Ql_{gr}} \cdot 10^4 = \frac{m^f_{nat} \cdot G_f}{\sum Ql_{gr}} \cdot 10^4, \tag{2}$$

where $\sum Ql_{gr}$ is the freight turnover performed by a mainline diesel locomotive per one turnover, gross tkm.

Take the traction calculation for the mathematical modelling of the actual specific emission mass of the *n*-th component of a harmful substance emitted by a mainline diesel locomotive when it hauls a freight train along the section. The results of determining the specific emission of a harmful substance emitted by diesel locomotives M62 and 2TE116 by different freight wagons as part of the train are given in ***TABLE 2*** and ***3***.

TABLE 2 *Specific emission factors of a harmful substance emitted by a diesel locomotive M62 according to the traction calculation*

TAB. 2 *Špecifické faktory emisií škodlivých látok do ovzdušia dieselového rušňa M62 podľa výpočtu trakcie*

Factor	Freight wagon	
	Basic	New
1. Direction	Unpaired	
2. Specific emission of a harmful substance, kg/10^4 gross tkm:	-	-
NO	1.24	1.15
CO	0.27	0.25
3. Direction	Paired	
4. Specific emission of a harmful substance, kg/10^4 gross tkm:	-	-
NO	1.27	1.16
CO	0.27	0.25
5. Average per turnover		
6. Specific emission of a harmful substance, kg/10^4 gross tkm:	-	-
NO	1.26	1.15
CO	0.27	0.25

TABLE 3 *Specific emission factors of a harmful substance emitted by a diesel locomotive 2TE116 according to the traction calculation*

TAB. 3 *Špecifické faktory emisií škodlivých látok do ovzdušia dieselovým rušňom 2TE116 podľa výpočtu trakcie*

Factor	Freight wagon	
	Basic	New
1. Direction	Unpaired	
2. Specific emission for a harmful substance, kg/10^4 gross tkm:	-	-
NO	1.61	1.34
CO	0.35	0.29
3. Direction	Paired	
4. Specific emission of a harmful substance, kg/10^4 gross tkm:	-	-
NO	1.62	1.36
CO	0.35	0.29
5. Average per turnover		
6. Specific emission of a harmful substance, kg/10^4 gross tkm:	-	-
NO	1.62	1.35
CO	0.35	0.29

Based on the annual operation and the specific emission of a harmful substance per unit of work, the annual emission by the series of diesel locomotives were determined as follows:

– for M62:

$$M_{n_t}^{M62} = \frac{y_{M62} \cdot m_{nat_n}^{M62} \cdot \sum Ql_{gr}^{lt}}{10^4}, \tag{3}$$

- for 2TE116:

$$M_{n_t}^{2TE116} = \frac{y_{2TE116} \cdot m_{nat_n}^{2TE116} \cdot \sum Ql_{gr}^{lt}}{10^4}, \tag{4}$$

where y_{M62}, y_{2TE116} are part of the freight turnover performed by a diesel locomotives M62 and 2TE116, respectively; $m_{nat_n}^{M62}$, $m_{nat_n}^{2TE116}$ are the specific emission masses of the *n*-th component of a harmful substance per a unit of the work 10^4 gross tkm performed by a diesel locomotives M62 and 2TE116, respectively, kg; $\sum Ql_{gr}^{lt}$ is the annual operation turnover performed by a diesel locomotive, million gross tkm.

The economic evaluation of the damage from gaseous harmful substances emitted by a diesel locomotive per year *t* of the calculation period taking into account the relative aggressiveness of the *n*-th harmful substance is determined by the formula:

$$Y_t = y \cdot \sigma \cdot f \cdot \sum_{n=1}^{n=W} (A_n \cdot M_n), \tag{5}$$

where γ is the regulatory constant that translates the conditional estimate of the emissions into the monetary estimate, the numerical value is determined from the percentage calculated according to the cost of one ton of fuel, UAH; σ is the relative safety of air pollution over the territories of various types, σ=4, it was determined according to [7, 8, 9]; *f* is the correction including the nature of dispersion of the impurities in the atmosphere; A_n is the relative aggressiveness of the *n*-th harmful substance, conditional tonne. According to [7, 8, 9], the following toxic components are taken into account: nitric oxide, carbon monoxide, formaldehyde, acrolein; their numerical values are A_{NO}=41.1 conditional t/t, A_{CO}=1.0 conditional t/t, $A_{form.}$=60 conditional t/t, $A_{acre.}$=20 conditional t/t.

The correction *f* can be determined according to [7, 8, 9] by calculating in advance the correction for the rise in the atmospheric plume according to the formula:

$$\varphi = 1 + \frac{\Delta T}{75}, \tag{6}$$

where ΔT is the average annual temperature difference between the source (diesel locomotive pipe) and the environment at the neck level and take ΔT = 300 ^{0}C.

Then, φ =5.

Under such conditions at the height of the locomotive pipe above the ground *h* = 5 m, then *f* = 0.834.

The initial data for the calculation of the environmental effect are given in ***TABLE 4***.

TABLE 4 *Initial data for the calculation of the environmental effect*

TAB. 4 *Vstupné údaje pre výpočet vplyvu na životné prostredie*

Factor	Value
1. Relative aggressiveness of the *n*-th harmful substance, conditional t/t	
NOx	41.1
CO	1
2. Regulatory constant that translates the conditional estimate of emissions into the monetary estimate (at the rate of 1 % out of the cost of one ton of fuel), UAH	584.3
3. Relative safety of air pollution over the territories of various types	4
4. Correction including the nature of dispersion of impurities in the atmosphere	0.834

The results of the calculation of the annual emissions of harmful substances and the annual damage from harmful substances emitted by diesel locomotives M62 and 2TE116 by freight wagons are given in ***TABLE 5*** and ***6***.

TABLE 5 *The annual emissions of harmful substances and the annual damage from harmful substances emitted by diesel locomotives M62*

TAB.5 *Ročné emisie škodlivých látok a ročné škody z emisií škodlivých látok dieselovými lokomotívami M62*

Factor	Freight wagon	
	Basic	New
1. Specific emission of a harmful substance, gross kg/10^4 tkm:		
NO	1.26	1.15
CO	0.27	0.25
2. Annual freight turnover of a diesel locomotive, million gross tkms	19759	19759
3. Annual emission of a harmful substance, t		
NO	2485	2282
CO	534	491
4. Annual damage from harmful substances, thousand UAH	200085	183784

***TABLE 6** The annual emissions of harmful substances and the annual damage from harmful substances emitted by diesel locomotives 2TE116*

***TAB. 6** Ročné emisie škodlivých látok a ročné škody z emisií škodlivých látok dieselovými lokomotívami 2TE116*

Factor	Freight wagon	
	Basic	New
1. Specific emission of a harmful substance, kg/10^4 gross tkm:		
NO	1.62	1.35
CO	0.35	0.29
2. Annual freight turnover of a diesel locomotive, million gross tkm	19759	19759
3. Annual emission of a harmful substance, t		
NO	3192	2666
CO	686	573
4. Annual damage from harmful substances, thousand UAH	257055	214696

The annual environmental effect is determined as the difference between the annual damage from gaseous pollutants into the atmosphere by a diesel locomotive per year *t* over the calculation period when transporting freight trains with the typical (basic) Y_t^b and the upgraded (new) Y_t^n device for parallel retraction of brake shoes are determined by the formula:

$$\Delta Y_t = Y_t^b - Y_t^n. \qquad (7)$$

The annual environmental effect per one freight wagon of the wagon fleet working on the diesel traction is determined by the formula:

$$\Delta y_t = \frac{y_t^{M62} + y_t^{2TE116}}{n_w^{gr}}, \qquad (8)$$

where y_t^{M62}, y_t^{2TE116} are the annual environmental effect per the freight wagon fleet serviced by diesel locomotives M62 and 2TE116, respectively, UAH; n_w^{gr} is the wagon fleet working on the diesel traction.

The results of the calculation of the annual environmental effect per one freight wagon of the working fleet by diesel locomotive series are given in ***TABLE 7***.

***TABLE 7** The annual environmental effect per one freight wagon of the working diesel locomotive fleet by series*

***TAB. 7** Ročný vplyv na životné prostredie na jeden nákladný vagón prevádzkového parku dieselových lokomotív podľa série*

Factor	Diesel locomotive series	
	M62	2TE116
1. Annual environmental effect by the diesel locomotive series, thousand UAH	16301	42358
2. Annual environmental effect by the diesel traction, thousand UAH	58659	58659
3. Wagon fleet working on the diesel traction	14118	14118
4. Annual environmental effect per one freight wagon of the wagon fleet working on the diesel traction, UAH	4154.84	4154.84

The discounted environmental effect by means of reducing the damage from gaseous harmful substances into the atmosphere emitted by the diesel locomotive fleet over the calculation period is determined by the formula:

$$\Delta Y_t = \sum_{t_n}^{t_{n+T}} (\Delta y_t \cdot n_w^{gr} \cdot \alpha_t), \qquad (9)$$

where α_t is the discount factor; t_n is the year of putting into operation the wagon fleet with upgraded brake systems of bogies using the UkrSURT technology [10, 11]; T is the operating period of the working wagon fleet with upgraded brake systems of bogies using the UkrSURT technology, years.

The results of the calculation of the environmental effect for the working wagon fleet and for one wagon out of the working wagon fleet are shown in Figures 2 and 3 by years of the calculation period.

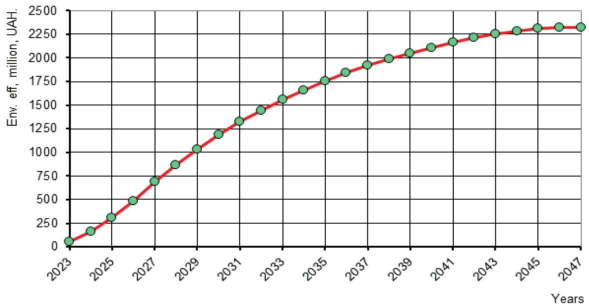

Fig. 2 *The environmental effect for the working freight wagon fleet by years of the calculation period after the introduction of the upgraded device for parallel retraction of brake shoes*

Obr. 2 *Environmentálny vplyv na prevádzkový park nákladných vozňov podľa rokov výpočtového obdobia od zavedenia modernizovaného zariadenia na rovnomerné opotrebovanie brzdových doštičiek*

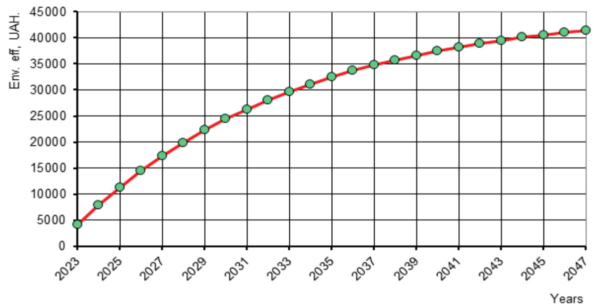

Fig. 3 *The environmental effect for one freight wagon of the working freightwagon fleet by years of the calculation period after the introduction of theupgraded device for parallel retraction of brake shoes*

Obr. 3 *Environmentálny vplyv na nákladný vagón pracovného vozového parku podľa rokov výpočtového obdobia od zavedenia modernizovaného zariadenia*

The calculations carried out allow us to conclude that, unlike the typical device for parallel retraction of brake shoes M 1180.000, the device developed by UkrDUZT provides environmental efficiency.

4 CONCLUSION

1. A methodology for determining the environmental effect of the device for parallel retraction of brake shoes upgraded with the technology developed by UkrSURT over the calculation period for the operating conditions of freight wagons belonging to UZ, which takes into account different types of diesel and electric traction, has been developed.

2. The annual environmental effect of the diesel locomotives M62 and 2TE116 per one freight wagon of the wagon fleet working on the diesel traction with the device for parallel retraction of brake shoes upgraded using the UkrSURT technology is 4155 UAH.

3. The environmental effect of the use of the device for parallel retraction of brake shoes upgraded with the UkrSURT technology over the calculation period (22 years) is: per one freight wagon of the working fleet it amounts to 41,485 UAH and for the working freight wagon fleet it amounts to 2,327,000,000 UAH.

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References

[1] Sarma, K. VS., Vardhan, R. V. Multivariate Statistics Made Simple. A Practical Approach. New York: Chapman and Hall/CRC, 2018. https://doi.org/10.1201/9780429465185 **[2] Sharma, R. C.; Dhingra, M.; Pathak, R. K:** Braking systems in railway vehicles. International Journal of Engineering Research & Technology. 2015. **[3] Мазур, В. Л.; Найдек, В. Л.; Попов, Є. С.:** Порівняння чавунних і композиційних з чавунними вставками гальмових колодок для рухомого складу залізниці. Журнал. «Метал та лиття України». 2021. 2 (29). **[4] Gupta, V.; Saini, K.; Garg, A. K.; Krishan, G.; Parkash, O.:** Comparative Analysis of Disc Brake Model for Different Materials Investigated Under Tragic Situations. Asian Review of Mechanical Engineering. 2016. 5(1). **[5] Мазур, В. Л.; Сіренко, К. А.:** Економічні та екологічні аспекти використання гальмових колодок з чавуну чи композиційного матеріалу для залізничного транспорту. Журнал. «Процеси лиття». 2022. №3 (149). https://doi.org/10.15407/plit2022.03.054 **[6] Равлюк, В. Г.; Равлюк, М. Г.:** Екологічні збитки довкіллю від застосування композиційних гальмівних колодок у вагонах/ Проблеми енергоресурсозбереження в промисловому регіоні. Наука і практика : IV Всеукраїнська наук.–прак. конф. Маріуполь. 2018. **[7] Калабухін, Ю. Є.:** Методологія оцінки екологічних показників функціонування магістральних тепловозів протягом життєвого циклу. Вісник Східноукраїнського національного університету ім. В. Даля. 2009. №4 (134). Ч. 2. **[8] Калабухін, Ю. Є.:** Удосконалення методології визначення техніко-економічних показників функціонування тягового рухомого складу з урахуванням життєвого циклу: дис д-ра техн. наук : 05.22.07. Харків, 2010. **[9] Калабухін, Ю. Є.; Рудковський, О. В.:** Результати дослідження впливу експлуатаційних факторів на екологічні показники використання тепловозної тяги у вантажному русі. Збірник наукових праць Української державної академії залізничного транспорту. 2012. Вип. 129. **[10] Равлюк, В. Г.; Афанасенко, І. М.; Равлюк, М. Г.:** Дослідження геометричних параметрів гальмових колодок вантажних вагонів за шкідливого зносу. *Наука та прогрес транспорту. Вісник Дніпропетровського національного університету залізничного транспорту імені академіка В. Лазаряна*. 2020. 1 (85). https://doi.org/10.15802/stp2020/199515 **[11] Ловська, А. О.; Равлюк, В. Г.:** Дослідження ненормативного зносу гальмових колодок і його вплив на ефективність гальмування вантажних поїздів. Збірник наукових праць «Рейковий рухомий склад». 2022. № 25. С. 30–50. https://doi.org/10.47675/2304-6309-2022-25-30-50

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Summary

When a freight train moves, the harmful friction between the brake pad and the wheel of the wagon occurs and this creates additional specific resistance to the train movement. This may cause the environmental damage because of higher amount of harmful substances in the exhaust gases emitted by the diesel locomotive that transports a train with typical M 1180.000 devices. Moreover, there is a need for unscheduled replacement of composite brake pads as well as their disposal at municipal landfills.

In order to eliminate the harmful friction between the pad and the wheel in motion, it has been proposed to use the device for parallel retraction of brake shoes improved with the technology developed by Ukrainian State University of Railway Transport (UkrSURT). The upgraded device can be estimated with the methodology for determining the environmental effect over the calculation period developed on the example of freight wagons belonging to Ukrzaliznytsia (UZ) according to various types of the diesel traction.

The results of the calculation of the environmental effect, when using the device upgraded by means of the UkrSURT technology over the calculation period, have allowed us to conclude that the improvement proposed has been feasible.

Resumé

Pri pohybe nákladného vlaku dochádza ku škodlivému treniu medzi brzdovým obložením a kolesom vozňa, čo vytvára dodatočný špecifický odpor pohybu vlaku. To môže spôsobiť škody na životnom prostredí z dôvodu vyššieho množstva škodlivých látok vo výfukových plynoch vypúšťaných dieselovou lokomotívou, ktorá prepravuje vlak s typickými zariadeniami M 1180.000. Okrem toho existuje potreba neplánovanej výmeny kompozitných brzdových doštičiek, ako aj ich likvidácie na komunálnych skládkach.

Aby sa eliminovalo škodlivé trenie medzi doštičkou a kolesom pri pohybe, bolo navrhnuté použiť zariadenie na paralelné zaťahovanie brzdových čeľustí vylepšené technológiou vyvinutou Ukrajinskou štátnou univerzitou železničnej dopravy (UkrSURT). Modernizované zariadenie je možné odhadnúť pomocou metodiky stanovenia vplyvu na životné prostredie počas výpočtového obdobia vyvinutej na príklade nákladných vozňov patriacich do Ukrzaliznytsia (UZ) podľa rôznych typov dieselovej trakcie.

Výsledky výpočtu vplyvu na životné prostredie pri použití zariadenia modernizovaného pomocou technológie UkrSURT počas výpočtového obdobia nám umožnili dospieť k záveru, že navrhované zlepšenie bolo realizovateľné.