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TO THE EMERGENCY STOP OF THE TRAIN IN CASE OF DERAILMENT

The current state of the technical base of Ukrainian railways is characterized by the critical deterioration of the rolling stock. Locomotives and cars of worn-out types lose their initial running properties over time and cause an increased impact on the train structure, thus creating a direct threat to the safety of the trains. In order to maintain the existing rolling stock in a condition that ensures that it meets the requirements of operational safety, technical solutions are required, which are taken on the basis of a scientific substantiation of their effectiveness, first of all from the point of view of ensuring the safety of traffic.

Prospective plans for renewal of the fleet of vehicles involves the supply of traction rolling stock (TRS) and cars with improved technical characteristics. Because of the lack of current system of admission to the operation of new rolling stock, which would meet international standards for the requirements of traffic safety, at the time of renewal of the appropriate regulatory framework. For this purpose it is necessary to develop methods and means of evaluation of the characteristics of the rolling stock with the ultimate goal of ensuring the safety of the trains.

The work is devoted to the further development of methods and means of scientific research aimed at solving the scientific-applied problem of ensuring the technical operation of the vehicle fleet as modernized by scientifically grounded technical solutions, as well as the new generation.

The work presents a technical solution for improvement of the device for emergency stop of the train when the car is derailed by the fact that as a spring two rod magnets are used, one of which is fixed in the body of the pneumatic cylinder and the other on the seismic mass, and the core permanent magnets are directed one on one by one poles, which will ensure increased reliability and speed of the device. The use of the proposed design will increase the reliability and speed of the device for emergency stop of the train when the car is derailed, which contributes to improving the safety of the trains.

Key words: *accidents, operation, traction rolling stock, safety of train operation.*

Statement of the problem. Railway transport is considered to be the safest mode of transport. However, a more substantial analysis shows that in terms of safety of movement the railway transport is the third after the automobile and air transport. This is mainly due to the fact that the current state of the technical base of Ukraine's railways is characterized by the critical deterioration of the rolling stock. Locomotives and cars of aged types over time are losing their initial performance and cause a greater impact on the collinear structure, thereby creating a direct threat to the safety of the train operation. In order to maintain the existing rolling stock in a condition which ensures that it meets the requirements of operational safety, technical solutions are required, which are taken on the basis of a scientific substantiation of their effectiveness, first of all from the point of view of ensuring the safety of traffic. According to long-term plans for renewal of the fleet of vehicles ahead of the supply of traction rolling stock (TRS) and cars with improved technical characteristics. Because of the lack of current system of admission to the operation of new rolling stock, which would meet international standards for the requirements of traffic safety, at the time of renewal of the appropriate regulatory framework. For this purpose it is necessary to develop methods and means of evaluation of the characteristics of the vehicle structure with the ultimate goal of ensuring the safety of the trains. Statistical data indicate a significant number of casualties and fatalities as a result of accidents of passenger trains. Emergency situations during the transportation of hazardous and particularly hazardous materials on the railways lead to significant destruction, contamination of the area and the exposure of large masses of people to toxic substances. At liquidation of consequences of such incidents besides organization of medical aid it is necessary to carry out a complex of nature protection measures.

The number of accidents is constantly increasing from year to year (sometimes by a few percentage points and sometimes by tens of percentage points). For example, the number of accidents on the railway in 2015 increased by 42%, which may have led to the decision to reduce the number of reports on accidents in order not to attract the public's attention. As for the investigation of the events, Ukrzaliznytsia (UZ) conducts them independently, and there is no information in the media about the results of the investigation. It is only known that in 2019 6 employees of UZ were dismissed, another 705 employees were released. Information about criminal prosecution is confidential.

The most frequent incidents include derailment of rolling stock, collisions, crossing obstacles at crossings, fire and explosions in cars. Do not exclude the disruption of railway wheels, collapse, landslide, wreckage. When transporting non-hazardous cargo, gases, easily explosive, flammable, poisonous, poisonous and radioactive substances, there may be explosions, burns of tanks and other carriages. It is very difficult to eliminate such accidents.

According to the "Instruction on the organization of emergency works when eliminating the consequences of transport accidents on the railways of Ukraine" [1] – the failure of the tires of the rolling stock of the railway transport is an accident, which resulted in the loss of interaction of at least one wheel of the railroad vehicle rolling stock as a result of displacement of the wheel from its normal position to the head of the rail.

Emergency situations on railways, which are associated with the descent of units of the rolling stock from the racks, depend on many reasons of both individual and sub-individual nature [2, 3, 4]. The level of operational safety of

the rack units in the mechanical sense is determined mainly by the reserve of their stability in case of derangement from the racks [5]. Therefore, in the field of mechanics of rolling stock, the role of scientific and research work on studying the interaction of the rolling stock and the stake remains highly relevant at all stages of the development of rail transport. In the mechanical sense, the safety conditions of the trains are directly related to the dynamics of the rolling stock, namely to the problems of their lateral wobbles [6, 7, 8].

R. Diomin's scientific works [9, 10] presented the concept of assessment of the risks of the vehicle mating from the racks, which combines the identification of mechanical risks of mating with the technology of computer modeling of the vehicle mating dynamics. It is recommended to use the suggested approach to assess the risk of the rolling stock convergence from the rails for prompt determination of the significance of the convergence factors and formation of the overall normative requirements, which ensure the guaranteed level of safety of the trains' operation.

Work methods. Investigation of ways and solution of scientific-applied problem of ensuring technical operation of the vehicle fleet both modernized by scientifically grounded technical solutions, and the new generation, which will allow to ensure increased reliability and speed of response to emergency situations and contribute to improved safety of the trains.

Definition of the study. In order to achieve the set goal it is necessary to solve the following tasks:

1. To analyze the existing devices and methods of emergency train stopping at car derailment, identify their advantages and disadvantages.

2. On the basis of the obtained data, modify the device for the emergency stop of the train when the car is derailed by using two kilted permanent magnets as a spring.

Main part. As a technical factor contributing to the solution of the train safety problem, the task is to improve the system of emergency train stop at car derailment by using the principally new device for emergency train stop at car derailment [11].

The device for the emergency stop of the train at the derailment of the car (Fig. 1) consists of the body 1 of the pneumocylinder, the crank 2, on the inner surface of which a ring magnet 3 is installed, as well as the button 4 for turning the device to the output position is mounted. In the middle of the body 1 is a stem-valve 5, to the top of which the seismic mass 6 is attached. The torsionally fixed torsion magnets 7, 8 attached to housing 1 and seismic array 6 and facing one another with the same poles, keep the seismic array 6 in a certain position. The core permanent magnets 7, 8 and the seismic mass 6 are located in the chamber 9. Between the body 1 and the stem-valve 5 there are sealing rings 10. In the lower part of the stem-valve 5 there is a cavity 11. The stem-valve 5 is moved in the cavity 12. The device includes a channel 13 which connects the chamber 9 to the lower part of the body 1 and the openings 14 which connect the cavity 11 to the cavity 12. Also in the lower part of the housing 1 there are openings 15, which are used to release air from the pipeline into the atmosphere, i.e. to discharge the pipeline when the device is in operation. A flange 16 is attached to the lower part of the housing 1, which is connected to the gas pipeline. Flange 16 has a valve seat 17. The lower end part of the stem-valve 5 together with the seat 17 creates a pneumatic valve.

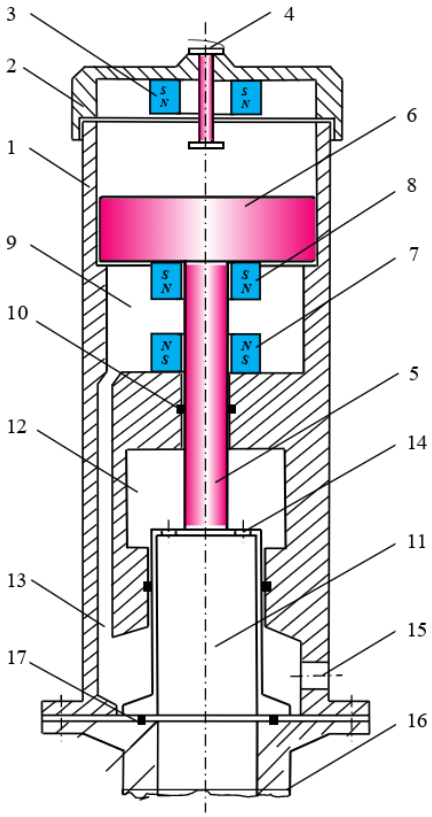

Fig. 1. The device in the output state (vertical section)

In the normal mode of car run, the vertical displacement of the car ends is relatively small, the stem-valve 5 due to the seismic mass 6 is pressed to the seat 17 of the valve, as a result of which the galmoving magistral is isolated from the atmosphere. The air from the gas main is flowing through the flange 16 to the empty stem-valve 5. In this case the pneumatic valve will be closed. The core permanent magnets 7, 8 act upon one another with a force which pushes the seismic mass 6 upwards, this force *F* is a little less than its shaft *P*, therefore the seismic mass 6 is in the output position. As a result, the difference of forces (*P*-*F*) acts on the seismic mass 6 in the vertical direction, by which the pneumatic valve is pressed against the seat 17.

At the moment of movement the end of the car body moves downwards with a certain acceleration. The device mounted on it also moves (Fig. 2). The seismic mass 6 will remain intact for some time due to its inertia, and the housing 1 of the device will move downward relative to this mass, which is tantamount to shifting the seismic mass 6 with respect to the housing 1 above. At the same time the weight of the seismic mass 6 will decrease and the magnetic force will push it upwards. The pneumatic valve starts to open and the air from the gas pipeline flows through the channel 13 into the chamber 9, thus generating an excessive pressure, which is equal to the air pressure in the galmoving magistral, as a result of which the seismic mass 6 will move upwards under the force of the pressure to the contact of the magnet 3 and will be held by it. In this case, the pneumatic valve will be completely open and the air from the magistral through port 15 will enter the atmosphere, as a result of which there will be an extraordinary galumph of the train. The magnitude of the force of the interaction of the stationary ring magnets 7, 8 is set to ensure sufficient pressure on the valve seat 17, and at the same time that the seismic mass 6 in the normal course was at rest. When the seismic mass 6 is shifted upwards, the return button 4 also moves up, signaling that the device is working.

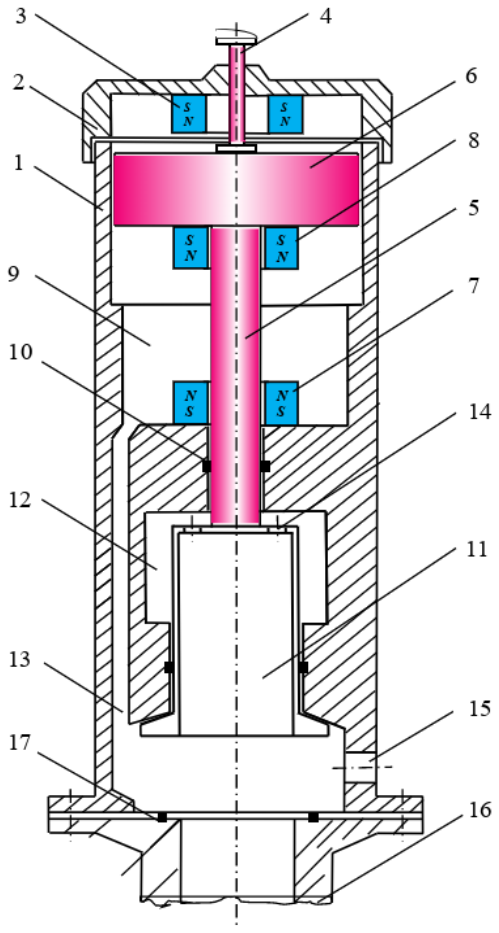

Fig. 2. The device that worked after the wagon wheels came off the rails

Thus, the device will work in the event of large vertical wobbles of the car body, which will cause overheating or simply jeopardize the safety of the journey. Button 4 makes it very easy to find the place in the train where an emergency situation has occurred. To make the device operational, the seismic arm 6 is rotated to the output position by pressing button 4. Thus, the stem-valve 5 with seismic mass 6 and a ring permanent magnet 8 during the movement of the train remain unchanged, and move only in case of a trip. Therefore, wear of elements of the device (for example, the surface of the stem-valve - the wall of the empty, in which it is moved) is practically absent, which in turn increases the guaranteed service life.

Conclusions. The device for emergency stop of the train at the car derailment by using two kilted permanent magnets as a spring is presented, protected by the patent of Ukraine №120252 , the improvement, one of which is fixed in the body of the pneumatic cylinder and the other on the seismic mass, and the core permanent magnets are directed one on one by one poles, which will ensure increased reliability and speed of the device. The use of the proposed design

will increase the reliability and speed of the device for emergency stop of the train when the car is derailed, which contributes to improving the safety of the trains.

References

1. Pro zatverdzhennya Instrukcii z organizacii vidbudovnih robit pri likvidacii naslidkiv transportnih podij na zaliznicyah Ukraïni / Ministerstvo Transportu Ukraïni, Nakaz № 258 vid 27.04.2001, Zareєstrovano v Ministerstvi yusticii Ukraïni 17 travnya 2001 r. za № 422/5613, https://zakon.rada.gov.ua/laws/show/z0422-01#Text
2. Cherniak G. On the study of the rolling stock impact on the track structure / G. Cherniak, R. Domin, O. Nozhenko // Advanced Rail Technologies: 5th International Conference, 9-10.11.2016: Conference Proceedings. – Warsaw, 2016. – P. 31.
3. Chernyak A. The experimental research of the dynamic loading of the railway track / A. Chernyak, Ju. Gerlici, O. Nozhenko, R. Domin, K. Kravchenko, T. Lack // Experimentální a výpočtovémetody v inženýrství: III. Ročník konference pro mladé vědecké pracovníky, 2-3 June 2016, Usti nad Labem, Czech Republic: electronic publishing.
4. Domin Iu. Technical and technological providing of intermodal transportation between ukraine and EU / Iu. Domin, R. Domin // Advanced Rail Technologies: 5th International Conference, 9-10.11.2016: Conference Proceedings. – Warsaw, 2016. – P. 39.
5. Demin R.YU. Rozvitok metodiv i zasobiv doslidzhen' z ubezpechennya tekhnichnoï ekspluatacii zaliznichnogo ruhomogo skladu: dis…d-ra tekhn. nauk: 05.22.07 // Ckhidnoukraïns'kij nacional'nij universitet im. V. Dalya. Sєvєrodonec'k, 2018. – 398 s.
6. Gorbunov M. Innovative risks of introducing advanced technical solutions in transport / M. Gorbunov, V. Nozhenko, M. Kovtanets, O. Porkuyan / Proceedings of 24th International Scientific Conference. Transport Means 2020, September 30 - October 02, Kaunas, Lithuania. 2020. – P. 97-101.
7. Gorbunov M. Reducing the wheel-rail system wear intensity with thermomechanical impact / M. Gorbunov, M. Kovtanets, G. Bureika, T. Kovtanets // Proceedings of the 23nd International Scientific Conference. Transport Means 2019, 02-04 October, Palanga, Lithuania. 2019. – P. 1260-1265.
8. Gorbunov M. Experimental study of temperature stabilization process in tribological contact of brake friction pairs under the impact of forced cooling / M. Gorbunov, O. Prosvirova, M. Kovtanets / Proceedings of 24th International Scientific Conference. Transport Means 2020, September 30 - October 02, Kaunas, Lithuania. 2020. – P. 345-348.
9. Gerlici Ju. Calculated estimate of equivalent conicity influence on critical speed of passenger railway vehicle / Ju. Gerlici, R. Domin, G. Cherniak, T. Lack // Machine Modelling and Simulations: XXII Slovak-Polish Scientific Conference, September 5-8, 2017. Sklené Teplice, Slovakia. – P. 48.
10. Gorbunov M.I. Theoretical foundations for conceptually new rolling stock modules (Part 1) / M.I. Gorbunov, O.V. Fomin, R.Yu. Domin. – Dnipro: Akcept PP, 2017. – 100 p.
11. Patent na korisnu model' № 120252 B61L 3/00, B61L 3/22 (2006.01) Pristrij avarijnoï zupinki poïzda pri skhodi vagona z rejok / Smirnij M.F., Mogila V.I., Gorbunov M.I., Kovtanec' M.V.; zayavnik i vlasnik SNU im. V.Dalya. – u 2017 04395; zayavl. 03.05.2017; opubl. 25.10.2017, Byul. № 20. – 3 s.

Література

1. Про затвердження Інструкції з організації відбудовних робіт при ліквідації наслідків транспортних подій на залізницях України / Міністерство Транспорту України, Наказ № 258 від 27.04.2001, Зареєстровано в Міністерстві юстиції України 17 травня 2001 р. за № 422/5613, https://zakon.rada.gov.ua/laws/show/z0422-01#Text
2. Cherniak G. On the study of the rolling stock impact on the track structure / G. Cherniak, R. Domin, O. Nozhenko // Advanced Rail Technologies: 5th International Conference, 9-10.11.2016: Conference Proceedings. – Warsaw, 2016. – P. 31.
3. Chernyak A. The experimental research of the dynamic loading of the railway track / A. Chernyak, Ju. Gerlici, O. Nozhenko, R. Domin, K. Kravchenko, T. Lack // Experimentální a výpočtovémetody v inženýrství: III. Ročník konference pro mladé vědecké pracovníky, 2-3 June 2016, Usti nad Labem, Czech Republic: electronic publishing.
4. Domin Iu. Technical and technological providing of intermodal transportation between ukraine and EU / Iu. Domin, R. Domin // Advanced Rail Technologies: 5th International Conference, 9-10.11.2016: Conference Proceedings. – Warsaw, 2016. – P. 39.
5. Демин Р.Ю. Розвиток методів і засобів досліджень з убезпечення технічної експлуатації залізничного рухомого складу: дис…д-ра техн. наук: 05.22.07 // Східноукраїнський національній університет ім. В. Даля. Сєвєродонецьк, 2018. – 398 с.
6. Gorbunov M. Innovative risks of introducing advanced technical solutions in transport / M. Gorbunov, V. Nozhenko, M. Kovtanets, O. Porkuyan / Proceedings of 24th International Scientific Conference. Transport Means 2020, September 30 - October 02, Kaunas, Lithuania. 2020. – P. 97-101.
7. Gorbunov M. Reducing the wheel-rail system wear intensity with thermomechanical impact / M. Gorbunov, M. Kovtanets, G. Bureika, T. Kovtanets // Proceedings of the 23nd International Scientific Conference. Transport Means 2019, 02-04 October, Palanga, Lithuania. 2019. – P. 1260-1265.

8. Gorbunov M. Experimental study of temperature stabilization process in tribological contact of brake friction pairs under the impact of forced cooling / M. Gorbunov, O. Prosvirova, M. Kovtanets / Proceedings of 24th International Scientific Conference. Transport Means 2020, September 30 - October 02, Kaunas, Lithuania. 2020. – P. 345-348.
9. Gerlici Ju. Calculated estimate of equivalent conicity influence on critical speed of passenger railway vehicle / Ju. Gerlici, R. Domin, G. Cherniak, T. Lack // Machine Modelling and Simulations: XXII Slovak-Polish Scientific Conference, September 5-8, 2017. Sklené Teplice, Slovakia. – P. 48.
10. Gorbunov M.I. Theoretical foundations for conceptually new rolling stock modules (Part 1) / M.I. Gorbunov, O.V. Fomin, R.Yu. Domin. – Dnipro: Akcept PP, 2017. – 100 p.
11. Патент на корисну модель № 120252 B61L 3/00, B61L 3/22 (2006.01) Пристрій аварійної зупинки поїзда при сході вагона з рейок / Смирний М.Ф., Могила В.І., Горбунов М.І., Ковтанець М.В.; заявник і власник СНУ ім. В.Даля. – u 2017 04395; заявл. 03.05.2017; опубл. 25.10.2017, Бюл. № 20. – 3 с.

Поточний стан технічної бази залізниць України характеризується критичним зносом рухомого складу. Локомотиви і вагони застарілих типів з часом втрачають початкові ходові якості і спричиняють підвищений вплив на колійну структуру, створюючи тим самим пряму загрозу безпеці руху поїздів. Для підтримання наявного рухомого складу у стані, що гарантовано задовольняє вимогам експлуатаційної безпеки, необхідні технічні рішення, що приймаються на основі наукового обґрунтування їх ефективності, перш за все з точки зору забезпечення безпеки руху.

За перспективними планами оновлення парку транспортних засобів передбачається поставка тягового рухомого складу (ТРС) і вагонів з поліпшеними технічними характеристиками. Через відсутність сучасної системи допуску до експлуатації нового рухомого складу, яка б відповідала міжнародним нормам за вимогами безпеки руху, на часі оновлення відповідної нормативної бази. Для цього необхідно розвивати методи і засоби оцінки характеристик рухомого складу з кінцевою метою забезпечення безпеки руху поїздів.

Робота присвячена подальшому розвитку методів і засобів наукових досліджень спрямованих на вирішення науково-прикладної проблеми убезпечення технічної експлуатації рухомого складу як модернізованого за науково обґрунтованими технічними рішеннями, так і нового покоління.

У роботі представлено технічне рішення вдосконалення пристрою аварійної зупинки поїзда при сході вагона з рейок шляхом того, що як пружину застосовано два кільцеві постійні магніти, один з яких закріплений в корпусі пневмоциліндра, а інший на сейсмічній масі, причому кільцеві постійні магніти направлені один на одного однойменними полюсами, що забезпечить підвищення надійності та швидкодії пристрою. Використання запропонованої розробки забезпечить підвищення надійності та швидкодії пристрою аварійної зупинки поїзда при сході вагона з рейок, що сприяє підвищенню безпеки руху поїздів.

Ключові слова: *аварійні ситуації, експлуатація, тяговий рухомий склад, безпека руху поїздів.*

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