TRANSPORT, MINING AND CONSTRUCTION ENGINEERING

DOI - 10.32743/UniTech.2021.92.11.12585

EFFICIENCY ASSESSMENT THE BRAKING EQUIPMENT OF FREIGHT CARS ON THE ANGREN-PAP SECTION OF THE RAILWAYS

Kamoliddin Inoyatov
Senior lecturer of the department Wagons and wagon economy,
Tashkent State Transport University,
Uzbekistan, Tashkent
E-mail: ledi.81@mail.ru

Vasila Ergasheva
Senior lecturer of the department "Wagons and wagon economy",
Tashkent State Transport University,
Uzbekistan, Tashkent
E-mail: Kamal 78@list.ru

ОЦЕНКА ЭФФЕКТИВНОСТИ ТОРМОЗНОГО ОБОРУДОВАНИЯ ГРУЗОВЫХ ВАГОНОВ НА УЧАСТКЕ АНГРЕН-ПАП ЖЕЛЕЗНЫХ ДОРОГ

Хуснидинович Иноятов Камолиддин
ст. преподаватель кафедры "Вагоны и вагонное хозяйство",
Ташкентский государственный университет транспорта,
Республика Узбекистан, г. Ташкент

Эргашева Васила Валижоновна
ст. преподаватель кафедры "Вагоны и вагонное хозяйство",
Ташкентский государственный университет транспорта,
Республика Узбекистан, г. Ташкент

ABSTRACT

Based on the study of data on equipment failure at the Angren-Pap section of the railways of the Republic of Uzbekistan, the article systematizes the main malfunctions of the braking equipment of loaded freight cars. Methods of analysis of the scheme and longitudinal profile of the Angren-Pap line are used to identify the most stressed sections in terms of the complexity of the car passage, and to establish the main malfunctions of the brake system. It was stated that the electrified railway line Angren-Pap is an important link not only for railway transport, but also for the entire economy of the Republic of Uzbekistan. It is shown that the main problems are the gross wear of brake shoes and an increase in their temperature. The analysis of malfunctions of the braking equipment of freight cars operated on the Angren-Pap section is performed. The main characteristic problems and malfunctions of the braking equipment of freight cars operating at the Angren-Pap section were identified. The wear of cast iron shoes and the assessment of the dependence of wear on the speed of rolling stock, the wear thickness of the shoes at different heat flux distribution ratios in the shoes and slope ratios were calculated. The critical time of continuous braking was also calculated. Conclusions were drawn on the basis of calculations and damage assessment.

АННОТАЦИЯ

На основе изучения данных об отказе оборудования на участке Ангрен-Пап железных дорог Республики Узбекистан в статье систематизированы основные неисправности тормозного оборудования груженых грузовых вагонов. Методы анализа схемы и продольного профиля линии Ангрен-Пап используются для выявления наиболее напряженных участков с точки зрения сложности проезда автомобиля, а также для установления основных неисправностей тормозной системы. Было заявлено, что электрифицированная железнодорожная линия Ангрен-Пап является важным звеном не только для железнодорожного транспорта, но и для всей экономики Республики Узбекистан. Показано, что основными проблемами являются грубый износ тормозных колодок и повышение их температуры. Проведен анализ неисправностей тормозного оборудования грузовых вагонов, эксплуатируемых на участке Ангрен-Пап. Были выявлены основные характерные проблемы и неисправности тормозного оборудования грузовых вагонов, работающих на участке Ангрен-Пап. Был рассчитан износ чугунных башмаков и оценка зависимости износа от скорости подвижного состава, толщины износа башмаков при различных коэффициентах распределения теплового потока в башмаках и коэффициентах наклона. Также было рассчитано критическое время непрерывного торможения. Выводы были сделаны на основе расчетов и оценки ущерба.

Библиографическое описание: Inoyatov K., Ergasheva V. EFFICIENCY ASSESSMENT THE BRAKING EQUIPMENT OF FREIGHT CARS ON THE ANGREN-PAP SECTION OF THE RAILWAYS // Universum: технические науки : электрон. научн. журн. 2021. 11(92). URL: *https://7universum.com/ru/tech/archive/item/12585*

Keywords: Researchers, network, equipment, railway line, construction**,** rolling stock.
Ключевые слова: Исследователи, сеть, оборудование, железнодорожная линия, строительство, подвижной состав.

1. Introduction

With the acquisition of state independence in the Republic of Uzbekistan, much attention was paid to the development of railway transport [1-3, p.183]. Today railway transport is an integral part of the formation of the country's economy and plays a key role [4,p.101].

To master the increasing volumes of traffic on the railway network of Uzbekistan, it was decided to develop the production of new freight and passenger cars on the basis of existing car-repair enterprises of JSC "O'zbekiston Temir Yullari" [5-10].

Thereby, on the basis of OJSC "Tashkent plant for the repair of passenger cars" (after putting into operation the production of cars, the plant was renamed into OJSC "Tashkent plant for the construction and repair of passenger cars"), serial production of modern compartment-type passenger cars with air conditioning of 68-907 model [11-13] and bogies of a passenger carriage of 68-908 (68-909) model began [14-15]; the design and development of design documentation for these cars were carried out jointly with the specialists from JSC "NVC "Wagons", St. Petersburg, Russia.

On the basis of the Subsidiary Enterprise "Andijan Mechanical Plant", the production of new freight cars of various types was set, at the first stage, tank cars for the transportation of oil products [16], and later the production of tank containers for the transport of dangerous goods [17-19, p.65-78] and tank cars for sulfuric acid [20-22,].

On the basis of the Subsidiary Enterprise "Foundry and Mechanical Plant" (the production base modernized in 2012-2013) [3, p.89], the construction of new models of freight cars: covered train cars of 11-9923 model with widened doorways, with a body volume of 158 m^3 [23-24, p.99], universal gondola cars of 12-9922 model with gate arrangement, with a body volume of 92 m^3 [25-26 , p.145] and hopper cars for cement transportation of 19-9596 model was developed [27-30, p.75].

Researchers from the Tashkent Institute of Railway Engineers have developed containers for the transportation of fruits and vegetables [31-33, p.75]

Today, the development of the transport system in the Republic of Uzbekistan is becoming more and more intensive. Currently, specific measures are being taken to build and reconstruct highways of international importance, upgrade and modernize the railway and motor transport fleet, create integrated logistics centers and improve the regulatory framework, establish a flexible system of tariffs for the transportation of goods, simplify customs procedures, reduce the time required to pass customs checkpoints and electronic exchange of documents [34, 35].

The electrified railway line Angren-Pap was built to create a new China - Central Asia - Europe railway corridor, and to form a unified railway network of Uzbekistan. It is an important railway link affecting the entire economy of the Republic of Uzbekistan [36, p.25].

Due to the difficult conditions of cargo transportation along the Angren-Pap section and the importance of transporting goods along this line, a number of problems must be solved that negatively affect the carrying capacity of the railway section. Such problems include malfunctions of the braking equipment of freight cars and the need to use effective braking systems [37, p. 145].

2. Methods

Description of the scheme and profile of the Angren-Pap section. The electrified railway line Angren-Pap with a length of 124 km consists of 7 sections with a length from 13 to 24 km (Figure 1) [20]. From the point of view of carriage operation, this line is a difficult section with mountainous terrain, where the slope reaches 27 ‰ (Figures 2, 3), which leads to the need for constant braking during downward journey and the friction system operation in a heavy mountain mode.

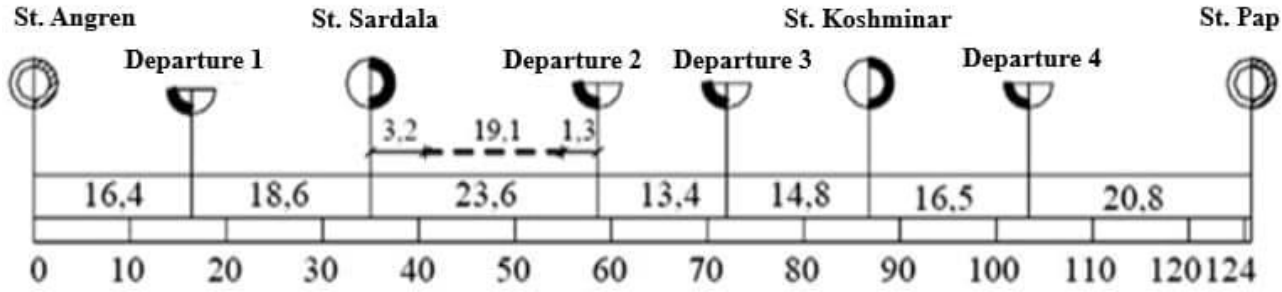

Figure 1. Scheme of the Angren-Pap railway section

Figure 2 shows the longitudinal profile of the Sardala station - Junction 2 section.

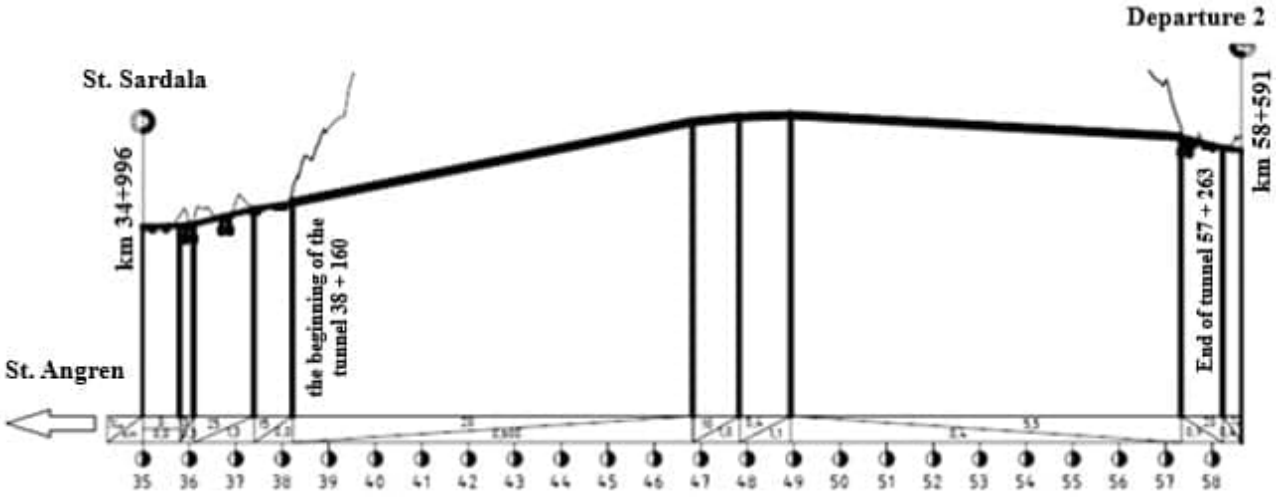

Figure 2. Schematic longitudinal profile of the Sardala station – Junction 2 section

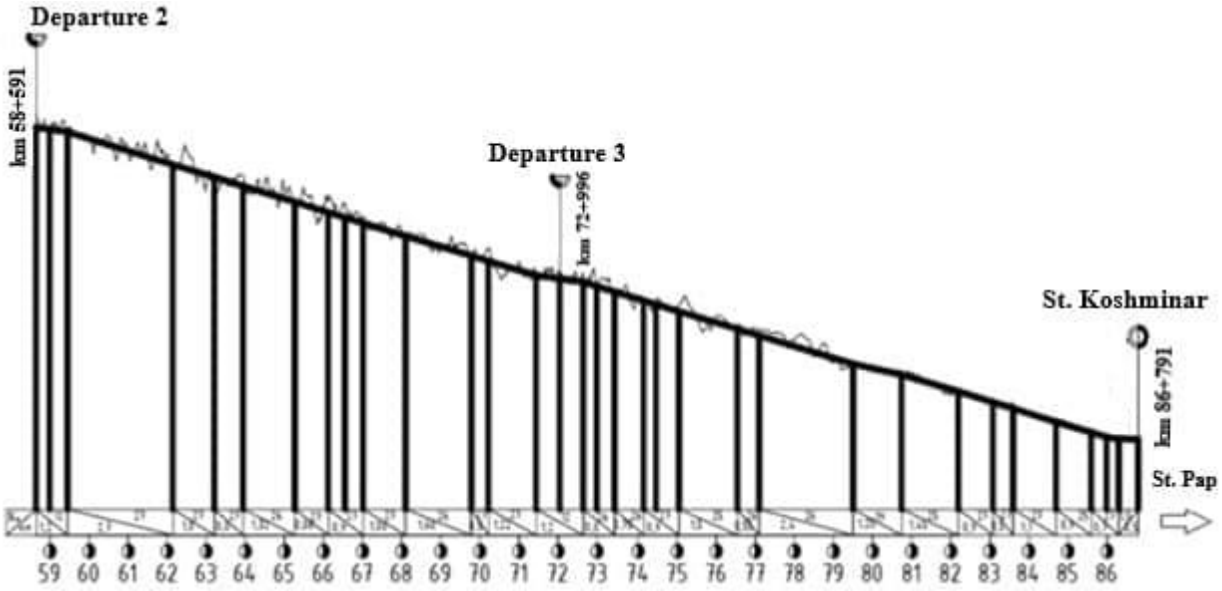

Figure 3. Schematic longitudinal profile of the section Junction 2 - Junction 3 - Koshminor station

The Angren-Pap line belongs to the third category of railway lines (a railway line providing mainly freight and passenger transportation of local significance) and has a length of tracks with a down slope of 34.83 km, in an up slope - 28.4 km. The speed norm for a freight train is 60 km/h, for a passenger train - 70 km/h. The weight norm of freight trains is 2100–2400 tons [18, p.90].

The transportation of goods increases along the Angren-Pap line since this direction reduces the distance of transportation.

3. Results and Discussion

Analysis of malfunctions of the braking equipment of freight cars on the Angren-Pap line. The main problem is the topographic location of the railway line. In particular, the slope, which negatively affects the condition of the braking equipment of cars and creates a number of malfunctions, such as rapid wear of brake shoes, heating of shoes and wheelsets. In addition to the wear of shoes, other malfunctions were identified. So, in 2019, on the Angren-Pap line, the largest number of failures related to the operating conditions of train cars was registered (the total number of faulty cars in terms of brake equipment for the year was 52 pcs.), the reasons were the pressing of shoes - 28%; air distributor failure - 21%; breakage of the feed pipeline 14%; pressure drop in the line - 20%; incorrect adjustment of the BLV incorrect adjustment of the BLV - 17%. Figure 4 shows a diagram of the distribution of the reasons for setting up maintenance of freight cars by types of malfunctions of brake equipment on the Angren-Pap line in 2019.

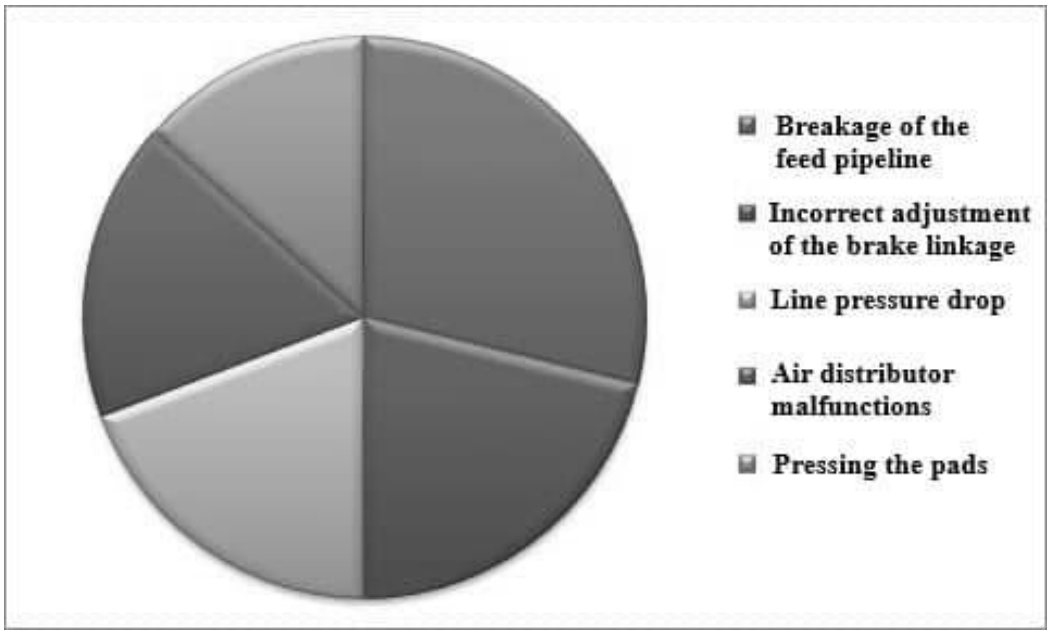

Figure 4. Distribution of reasons for failure of freight cars by types of malfunctions of braking equipment on the Angren-Pap line

The analysis of the main malfunctions of the braking equipment is given. According to [39], the air distributors of freight cars are switched to mountain mode in up trains at Chodak station. In the production of full service brake application, the push rod egress of the air brake cylinders of freight cars with cast iron shoes is adjusted by 75–125 mm, with composite shoes - by 50–100 mm, and in passenger cars - 130–160 mm with cast iron and composite shoes. The charging pressure in the brake line of trains on the Angren-Pap section in freight cars is 0.5–0.6 MPa [20, p.157].

In freight up trains at the Angren station and down trains at the Pap station, the air distributors of the railcars are set to mountain mode with full testing of the brakes with a 10-minute timing in the braked state. When departing up and down freight trains from Angren-Pap stations, the following was established: the thickness of the cast-iron shoes of the cars is no less than 30 mm, the thickness of composite shoes is no less than 25 mm. The installation of brake shoes on one wheelset with a difference in thickness of no more than 5 mm is provided.

It was established that in a mountainous area of the Angren-Pap line, the braking system of the car is subject to accelerated wear of the brake shoes due to constant braking when descending on the tracks with a slope of up to 27 ‰ [19, p.78]. To cool the wheelsets and brake shoes of the rolling stock, it is recommended to make technical stops at the stations: in the down line in Orzu – for 10 minutes; in the up line in Kon and Temiryulobod – for 20 minutes, at the Koshminor station – for 10 minutes [20, p.102]. When parked, the temperature of the brake shoes and wheelsets becomes lower. However, from the point of view of maintenance, such stops lead to excessive consumption of fuel and an increase in the delivery time of the cargo.

The situation is aggravated by the use of composite brake shoes on freight cars, which practically do not remove thermal energy from the shoe-wheel contact area, in contrast to cast iron shoes [17 p.48]. In addition, composite shoes lead to the formation of such a defect as annular wear on the rolling surface of the wheel.

Table 1 shows a cast iron brake shoe with brake shoe wear typical of freight cars. More than 50% of the railcar shoes aimed for repair have a wear area that does not fit into the worn-in area due to normal operation of the brakes and occupies 20–30% of the working surface [11, p.39]. When braking, this area does not participate in the creation of the braking force due to the lack of contact with the wheel. There are shoes with more complex wear. Brake shoes wear depends on pressing force, shoe material, type and adjustment of lever gear.

At a time when uniform wear occurs as a result of continuous braking, wedge wear, sag wear, one-sided wear and fracture of top (bottom) shoe can be considered a consequence of improper adjustment of the BLV the consequences of incorrect adjustment BLV.

Table 1.

Typical wear of the brake shoe of a freight car [7]

Type of wear	Shoe wear characteristics	Amount of wear, %	Longitudinal view
I	Uniform wear across the thickness of the cast iron shoe	64,5	
II	Wedge-shaped wear (tip up, down) of composite shoes	11,7	
III	Wear from sagging of composite shoes	4,5	
IV	Ridge wear (sliding at the bottom, top, along the entire length) of the cast iron shoe	3,3	
V	One-sided wear of the cast iron shoe	3,5	
VI	Fracture of the upper (lower) part of the cast iron shoe	4,5	
VII	Crushing (plastic strain of the cast iron shoe)	4	
VIII	Galling of the composite shoe	4	

The wear of brake shoes under operating conditions substantially depends on the force of pressing, material, type and duration of braking action, adjustment of the lever gear, the position of the shoe relative to the rolling surface of the wheel in both braking and released states and on a number of other factors. The amount of wear *m* for one braking action ΔH can be calculated for cast iron shoes according to the following formula [12, 13]:

$$\Delta H = \frac{0{,}04}{\left(\frac{5\cdot 10^9 F_k}{\alpha_K B_T v t} - \frac{525}{\sqrt{t}}\right) Y}, м \qquad (1)$$

where F_k is the geometric friction area of the shoe acting on the wheel, m^2; $\alpha_к$ is the coefficient of heat flux distribution in the shoe (taken as 0.2–0.3 under one-sided pressing); *t* is the duration of braking action, s; $B_т$ is the average braking force acting from the shoe on the wheel during the braking time, N; *v* – is the average velocity of motion, m/s; *Y* is the quality factor of the shoes (when meeting the standard requirements *Y* = 1).

The duration of braking action for a given length of braking and average speed is easy to find. The average force with a known axle load, kN, and long-term braking on the downward journey can be calculated by the following expression (taking into account the average specific resistance to motion):

$$B_T = 0.5 \cdot \left(i_c - w''_{cp}\right) \cdot q_0, \ H, \qquad (2)$$

where $w''_{ср}$ is the average specific resistance to motion (taken as 2 N/kN).

Substituting the indices of the initial condition (see Table 2), we obtain the following indices of wear of cast iron shoes (Table 3).

Table 2.

Indices of the initial conditions for calculating the wear of cast iron shoes

Parameter	Value
Geometric area of the cast-iron shoe F_K, m^2	0,0305
Axle load q_0, т	20
Track slope i_c, ‰	20
	25
	27
Average braking force B_T, N	1800
	2300
	2500
Heat flow distribution coefficient in the shoe α_K	0,2
	0,3
Shoe quality factor Y	1
Maximum track length at slopes S, km	10,850
	10,408
	12,06

Table 3.

Indices of wear of cast iron shoes

Railcar speed v, km/h	Duration of braking action t, h			Wear of a cast iron shoe in thickness (ΔH), mm (for α_K=0,2)			Wear of a cast iron shoe in thickness (ΔH), mm (for α_K=0,3)		
	i=20‰	i=25‰	i=27‰	i=20‰	i=25‰	i=27	i=20‰	i=25‰	i=27‰
10	1,08	1,04	1,21	1,3	1,7	2,3	2,1	3,2	4,5
20	0,54	0,52	0,60	1,5	2,0	2,9	2,8	4,4	7,14
30	0,36	0,35	0,40	1,6	2,4	3,5	3,5	6,3	13,1
40	0,27	0,26	0,30	1,8	2,7	4,3	4,3	9,8	42,6
50	0,22	0,21	0,24	1,9	3,1	5,3	5,5	19	-

The greater wear of the brake shoes at a higher velocity of the downward journey is explained by the fact that in this case, more heat is focused in the friction area, the temperature of the shoe increases and the wear of the shoe accelerates. The heat flux distribution coefficient in the shoe α_K and the slope i proportionally affect the wear of the shoes. At the maximum track length of the Angren-Pap section with a slope of 27‰ (S_T = 12.06 km), the speed of 50 km/h is not acceptable due to the wear above the allowable standard. Figure 5 shows a graph of dependence of the wear of the shoe in thickness on the speed of the rolling stock for different coefficients of heat flux distribution in the shoe α_K and slopes i.

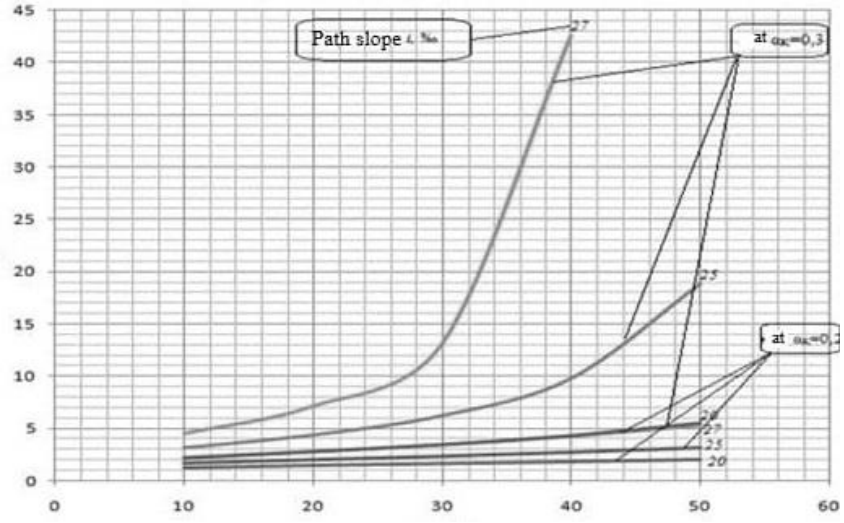

Figure 5. Dependences of the wear of the shoe in thickness on the speed of the rolling stock for different coefficients of heat flow distribution in the shoe α_K and slopes i

The critical time $t_{кр}$ of continuous braking, after which catastrophically rapid wear of the cast-iron brake shoes occurs, is determined by the expression given in [42, 43]. Equating the denominator of formula 1 $\left(\left(\frac{5\cdot10^9\cdot F}{\alpha_к\cdot B_T\cdot vt}-\frac{525}{\sqrt{t}}\right)\cdot Y=0\right)$ to zero, the critical time $t_{кр}$ of continuous braking, after which catastrophic wear of cast iron brake shoes occurs, is

$$t_{кр}=\left(\frac{95\cdot10^5\cdot F_K}{\alpha_K B_T v}\right)^2, c \qquad (3)$$

The critical time of continuous braking depends also on the slope value and the heat flux distribution in the shoe. Calculations of the dependence of the critical time of continuous braking on the speed, slope and heat flux distribution coefficient in the shoe are given in Table 4.

Table 4.

Calculations of the dependence of the critical time of continuous braking on speed, slope and heat flux distribution coefficient in the shoe

Railcar speed v, km/h	Critical time of continuous braking $t_{кр}$, h (for $\alpha_К$= 0,2)			Critical time of continuous braking $t_{кр}$, h (for $\alpha_К$= 0,3)		
	i=20‰	*i*=25‰	*i*=27‰	*i*=20‰	*i*=25‰	*i*=27‰
10	24,6	15,11	12,8	10,36	6,72	5,4
20	5,84	4,95	3,02	2,6	1,59	1,35
30	2,6	1,58	1,34	1,16	0,71	0,6
40	1,5	0,89	0,76	0,65	0,4	0,33
50	0,94	0,58	0,49	0,42	0,26	0,21

Let us plot the graph (Figure 6) based on the calculation data from Table 4.

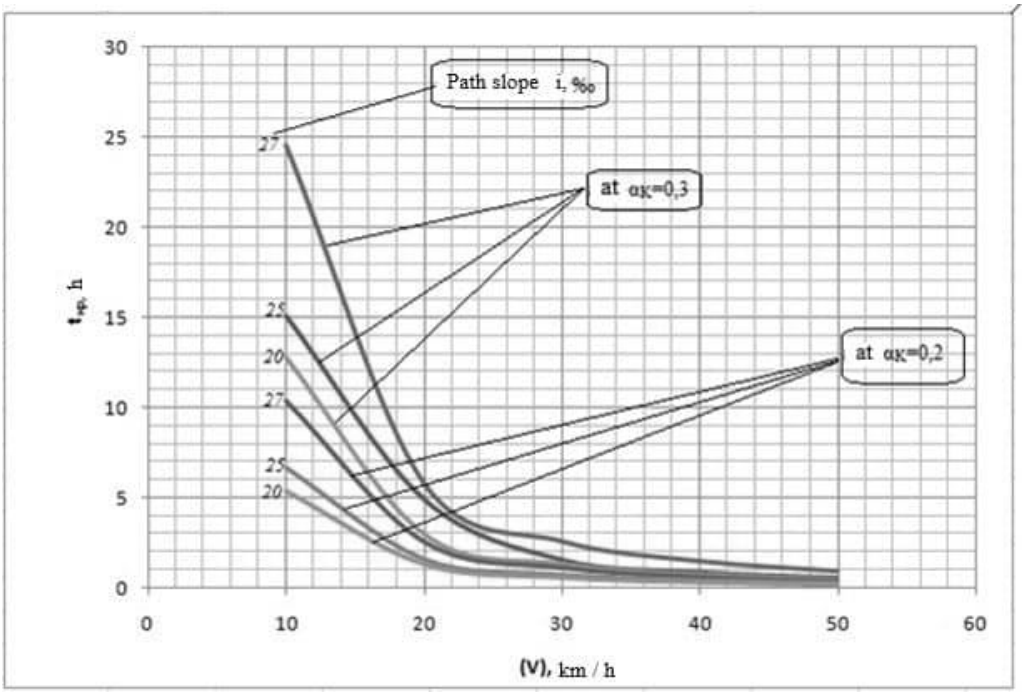

Figure 6. Dependences of the critical time of continuous braking on the speed, slope and distribution coefficient of the heat flux in the shoe during the rolling stock motion

Composite shoes are characterized by other patterns of wear - they practically do not achieve the conditions of catastrophic wear since the working layer formed under the influence of heat at the point of contact between the shoe and the wheel, and the friction mass of the shoe has low thermal conductivity. It prevents the physical and mechanical properties of shoe material from the effect of heat. This explains, in particular, the different ratios of wear resistances of composite and cast iron shoes for operating conditions on a flat track profile and steep long slopes.

Thus, the elimination of nonuniform wear of the brake shoe consists in the correct diagnosis of malfunctions. At the same time, when conducting an external inspection, it must be borne in mind that, despite the relatively simple mechanism of operation of the brake shoes, the malfunctions associated with them can be the consequences of improper operation of other parts of the brake equipment.

4. Conclusions

Thus, the study shows that the main delays of freight cars for the Angren-Pap line of Uzbek Railways are associated with malfunctions of brake equipment and friction units; the most typical of them are wear and an increase in the temperature of the shoes. In addition, on the basis of the results obtained, an assessment of the main characteristic problems and malfunctions of the brake equipment of freight cars was done, depending on the operating conditions in mountainous conditions. It was established that in 2019 on the Angren-Pap line, the largest number of failures was associated with a decrease in the pressing force of the shoes; failure of the air distributor; breakage of the feed pipeline; pressure drop in the line and incorrect adjustment of the BLV. incorrect adjustment of the BLV. The studies carried out show that further work is required to eliminate the cause of failures associated with the difficult operating conditions of freight cars on the Angren-Pap section of Uzbekistan railways. The calculation of the wear of cast iron brake shoes showed that an increase in the speed of a freight car leads to an increase in the wear thickness and reduces the critical time of continuous braking, after which catastrophic wear of the cast iron brake shoe sets in. We also determined that the value of the slope, speed and distribution coefficient of the heat flux in the shoe is proportional to the values of the wear thickness of the cast iron shoe and the critical time of constant braking.

References:

1. Rasulov M.Kh. Problems of increasing the competitiveness of domestic railway corridors / M.Kh. Rasulov, U.N. Ibragimov, R.V. Rakhimov // Proc. of the Republican scientific and technical conference with the participation of foreign scientists "Resource-saving technologies in railway transport". - Tashkent: TashIIT, 2013. - P. 14 - 17.
2. Resolution of the President of the Republic of Uzbekistan dated February 11, 2015 No. PP-2298. Localization program for the production of finished products, components and materials for 2015-2019.
3. Resolution of the President of the Republic of Uzbekistan dated June 28, 2012 No. PP-1780. On measures to implement the investment project "Development of the rolling stock repair base, organization of railcar building and reconstruction of the foundry at the subsidiary enterprise "Quyuv-mexanika zavodi".
4. Decree of the President of the Republic of Uzbekistan dated February 7, 2017 No. UP-4947 "On the strategy of actions for the further development of the Republic of Uzbekistan."
5. Boronenko Yu.P. Assessment of the need for new passenger cars for the railways of Uzbekistan and the main directions of their improvement / Yu.P. Boronenko, R.V. Rakhimov // Bulletin of TashIIT. - Tashkent, 2009. - No. 2. - P. 88 - 91.
6. Rakhimov R.V. Development of a new passenger car for the railways of Uzbekistan / R.V. Rakhimov // Proc. of the VI International Scientific and Technical Conference "Rolling stock of the XXI century: ideas, requirements, projects". - SPb.: PGUPS, 2009. - P. 150 - 153.
7. Ruzmetov Ya.O. Prospects for the development of car building in the Republic of Uzbekistan / Ya.O. Ruzmetov, R.V. Rakhimov // Proc. of the VIII All-Russian scientific-practical conference "Problems and prospects for the development of railcar building." - Bryansk: BSTU, 2019. - P. 147 - 150.
8. Rakhimov R.V. Choice of directions for the development of the railway wagon fleet in Uzbekistan / R.V. Rakhimov // Transport of the Russian Federation. - 2018. - No. 1 (74). - P. 71 - 74.
9. Rakhimov R.V. Analysis of the state and prospects of the development of the freight wagon fleet of the Republic of Uzbekistan / R.V. Rakhimov, Ya.O. Ruzmetov // Non-Ferrous Metals. - 2018. - No. 1 (vol. 44). - P. 7 - 11.
10. Rakhimov R.V. State and prospects for the development of the wagon fleet of railways in Uzbekistan / R.V. Rakhimov // Proc. of the XIII International Scientific and Technical Conference "Rolling stock of the XXI century: ideas, requirements, projects". - SPb.: FGBOU VO PGUPS, 2018. - P. 124 - 128.
11. Rakhimov R.V. The first Uzbek long-distance passenger carriage / R.V. Rakhimov // Heavy Engineering. - 2010. - No. 6. - P. 34 - 35.
12. Rakhimov R.V. New compartment-type passenger carriage for the railways of Uzbekistan / R.V. Rakhimov // Proc. of PGUPS. - 2010. - No. 2. - P. 286 - 295.
13. Minovarov R.M. Passenger cars built in the Republic of Uzbekistan / R.M. Minovarov, R.V. Rakhimov // Bulletin of TashIIT. - Tashkent, 2009. - No. 3. - P. 40 - 45.
14. Rakhimov R.V. Improvement of the design of a passenger bogie with swing link for models 68-909 and 68-908 / R.V. Rakhimov, S.V. Khokhlov // Proc. of the VI International Scientific and Technical Conference "Rolling stock of the XXI century: ideas, requirements, projects". - SPb.: PGUPS, 2009. - P. 204 - 205.
15. Rakhimov R.V. New bogies for passenger cars produced in the Tashkent plant for the construction and repair of passenger cars / R.V. Rakhimov, S.V. Khokhlov // Proc. of PGUPS. - 2010, - No. 3. - P. 157 - 165.

16. TU 3182-014-04868285-00. Tank for light oil products. Model 15-9721. Technical conditions. - Andijan: subsidiary enterprise "AMZ", 2000.
17. Rakhimov R.V. New multimodal vehicle manufactured in the Republic of Uzbekistan / R.V. Rakhimov // Proc. of the Republican scientific and technical conference with the participation of foreign scientists "Transport logistics, multimodal transportation". - Tashkent: TashIIT, 2012. - P. 134 - 136.
18. .Rakhimov R.V. Selection of parameters and calculation of structural elements of a tank container / R.V. Rakhimov // Bulletin of TashIIT. - 2012. - No. 1. – P. 37 - 41.
19. Ibragimov N.N. Development of a container design for transportation of fruits and vegetables / N.N. Ibragimov, R.V. Rakhimov, M.A. Khadzhimukhametova // Young Scientist. - 2015. - No. 21. - P. 168 - 173.
20. TSh 32-09-029: 2011. Sulfuric acid tank. Model 15-9724. Technical conditions. - Andijan: DP "AMZ", 2011.