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Tests to determine the automatic braking systems characteristics of gondola cars of domestic production

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Abstract
Railway transport plays a crucial part in the integrated transport system of the country, considerably influencing economic ties between producers and consumers of products, areas and economic regions of Ukraine with foreign countries. Thus, increasing the speed of movement of both empty and loaded freight cars is an important and relevant scientific and applied problem. The solution of this problem is directly connected with a necessity of ensuring the proper level of security, which largely depends on the characteristics of automated braking systems of gondola cars as the most common type of rolling stock.
The article presents the peculiarities and results of braking tests of gondola cars of PJSC "DMZ" production. In addition, these tests included a stationary and train brake studies with the determination of relevant characteristics.
Key words: TESTING, TRANSPORT MECHANICS, FREIGHT CARS, AUTOMATIC BRAKING SYSTEMS

Introduction

Unified transport system of Ukraine includes the following types of transport: land (rail, road, pipeline), water (sea, inland waterway), air. All modes of transport tend to increase their own effectiveness with the aim of worthy competing in the market of transport services. Railway transport is the most developed transportation network in Ukraine, as in other CIS countries [1-5]. It plays a decisive role in unified transport system of the country significantly affecting economic relations between producers and consumers, regions and economic regions of Ukraine, with foreign countries.

Today more than 90% of the existing rail trunk routes are used both in passenger and cargo transportation; therefore, to create an effective (without downtime waiting for the rail track release) schedule of freight train movement is almost impossible. This leads to an increase in duration of cargo delivery by railway transport and therefore, a dissatisfaction of the requirements of freight traffic and customers' needs. Thus, increasing the speed of movement of both empty and loaded freight cars is an important and relevant scientific and applied problem [2-8]. The solution of this problem is directly connected with a necessity of ensuring the proper level of security [9-13], which largely depends on the characteristics of automated braking systems of gondola cars as the most common type of rolling stock.

The purpose of the paper and main material

The paper presents the main aspects and the results of brake research of relevant automated security systems of gondola cars of PJSC "DMZ" production.

As part of these studies, the characteristics defined by the stationary and train braking methods [3, 7-9] according to modern conventional testing techniques of innovative rolling stock were identified and studied.

When processing the results of stationary brake tests, the average values of the following characteristics were determined [5, 10]:

- density of the main air pipe, brake cylinder and a reserve tank;
- value of the steady pressure in the brake cylinder and reserve tank;
- output value of the brake cylinder shaft for composite and cast iron blocks;
- charging time of braking system;
- time of filling the brake cylinder;
- brake release time;
- brake holding time when braking step without spontaneous release;
- possibility of adjusting the brake rigging and operation of the exhaust valve;
- pressing force of the brake pads on the wheels and calculation of brake coefficients.

Based on the analysis of stationary brake test results, the conclusion on the technical condition, functionality [10, 12] and compliance the actual values of the main characteristics of the brake to requirements of existing regulation documentation, as well as the possibility of performing the train brake tests was made.

The main results of the stationary brake test of gondola car are shown in Table 1.

Table 1. Main results of stationary brake test

Characteristics that are controlled by parameters	Unit of measurement	Parameter value			
		on documentation		actual	
		when composite pads	when cast iron pads	when composite pads	when cast iron pads
1	2	4	5	6	7
Exterior view, completeness of the train braking system		Relevance to drawings, design documentation		Total relevance to drawings, design documentation	
Brake system charging time	s	not less than 360		408	
Charging pressure	kgf/cm^2	5.4±0.1		5.4	

Density of the brake line	kgf/cm^2, s	Air pressure drop over the 300 s should not exceed 0.1		During the 300 s the pressure in the brake line has fallen by 0.04	
The density of the brake cylinder and spare reservoir	kgf/cm^2, s	Drop of steady air pressure after braking during 180 s should not exceed 0.1		During 180 s air pressure in the brake cylinder and a spare reservoir has not decreased	
Settled pressure in the brake cylinder	kgf/cm^2				
- empty car;		1.2-1.6	1.4-2.0	1.43 1.5	1.8 1.8
- loaded car		3.0-3.4	4.0-4.5	3.2 3.2	4.2 4.2
Brake cylinder shaft output [1)]:	mm				
- empty car;		25-65	25-65	36.17 28.75	34.33 59.5
- loaded car		25-65	25-65	37.5 35.83	55.0 64.5
Break holding time without spontaneous release when braking step	s	After lowering the line pressure by (0.5-0.6) kgf/cm^2 the brake should come into action and have not been released for 300 s. After pressure increase to charging the brake must completely release during the time no more than 70 s		After lowering the line pressure by 0.5 kgf/cm^2 brake come into action and have not been released for 300 s. After pressure increase to charging the brake was completely released for 31 s	

Processing of the results of train brake test of test car sample includes decoding and ordering of parameters [5, 8, 9] for the registered inhibitory processes, thus the following characteristics were determined:

- speed of movement at the beginning of braking – by the number of wheel revolutions for one second immediately before the braking;
- braking distance - by the number of wheel revolutions during movement from the beginning of braking to a full stop of the test car.

The regression line was built according to the combination of velocity values at the beginning of braking and corresponding to them braking distances values.

Polynomial of second or third degree regarding the independent variable - V (initial braking speed) is accepted as an analytical dependence of the change in braking distance S from the speed:

$$S(V) = aV^2 + bV, \quad (1)$$

$$S(V) = aV^3 + bV^2 + cV, \quad (2)$$

Alignment of the experimental data according to the equation (1) and (2) was made by the method of least squares:

$$U = \sum_{i=1}^{n} (S_i - (aV_i^2 + bV_i))^2, \quad (3)$$

Where n - the number of investigated speed range intervals,

i - interval number, and the task itself has been reduced to the determination of the coefficient values a, b and c, which minimized the sum of the deviations of empirical values and values that were determined by the formulas (1) and (2). For this purpose partial initial functions (3) were defined according to coefficients a, b, c and equated to zero:

The length of the braking distance of the test train was determined by calculation preparation time of the brake to action, which shall be equal to 3 s:

- for the second-degree polynomial

$$\frac{V_{oi} \cdot t_n}{3{,}6} + a \cdot V_{oi}^2 + b \cdot V_{oi}; \qquad (4)$$

- for third-degree polynomial

$$\frac{V_{oi} \cdot t_n}{3{,}6} + a \cdot V_{oi}^3 + b \cdot V_{oi}^2 + c \cdot V_{oi}, \qquad (5)$$

where t_n - brake preparation time to work, s ;

V_{oi}- speed at the beginning of braking, km / h.

Estimated coefficient of the brake pad pressing force (δ_{pi}) expressed in terms of the train for the initial braking speed V_{oi} was determined from the nomogram (Fig. 1).

Experimental data obtained at train brake tests of gondola car are shown in Table 2.

The graphs of braking distance dependence from the initial braking speed are shown in Figures 2 and 3.

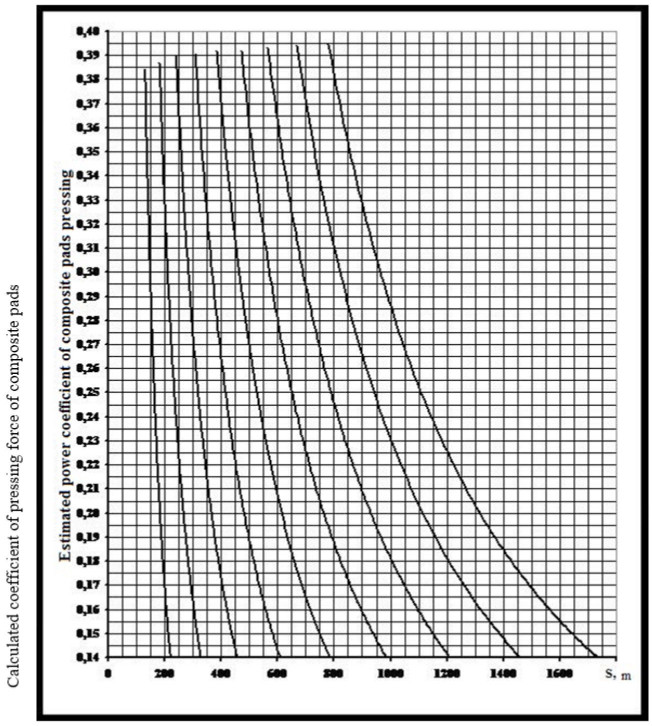

Figure 1. The nomogram for determining the estimated power coefficient of composite pads pressing for freight train

Table 2. Experimental data of train brake tests

Speed at the beginning of braking, km / h	Experimental value of braking path, m	The braking distance of the train loaded with up to 200 axes, m	Calculated brake coefficient	The strength of the composite pad pressing, ts
Empty car				
40	93	127	0.407	2.439
50	132	173	0.417	2.501
60	176	226	0.428	2.566
70	227	285	0.437	2.622
80	284	351	0.446	2.674
90	347	422	0.454	2.724
100	416	499	0.462	2.772
110	491	583	0.470	2.817
120	572	672	0.477	2.861
Average value			0.444	2.664
Loaded car				
40	124	157	0.266	6.193

50	196	237	0.240	5.587
60	283	333	0.228	5.326
70	387	446	0.222	5.168
80	508	574	0.218	5.077
90	644	719	0.215	5.018
100	797	880	0.214	4.989
110	966	1058	0.213	4.967
120	1151	1251	0.213	4.955
Average value			0.225	5.253

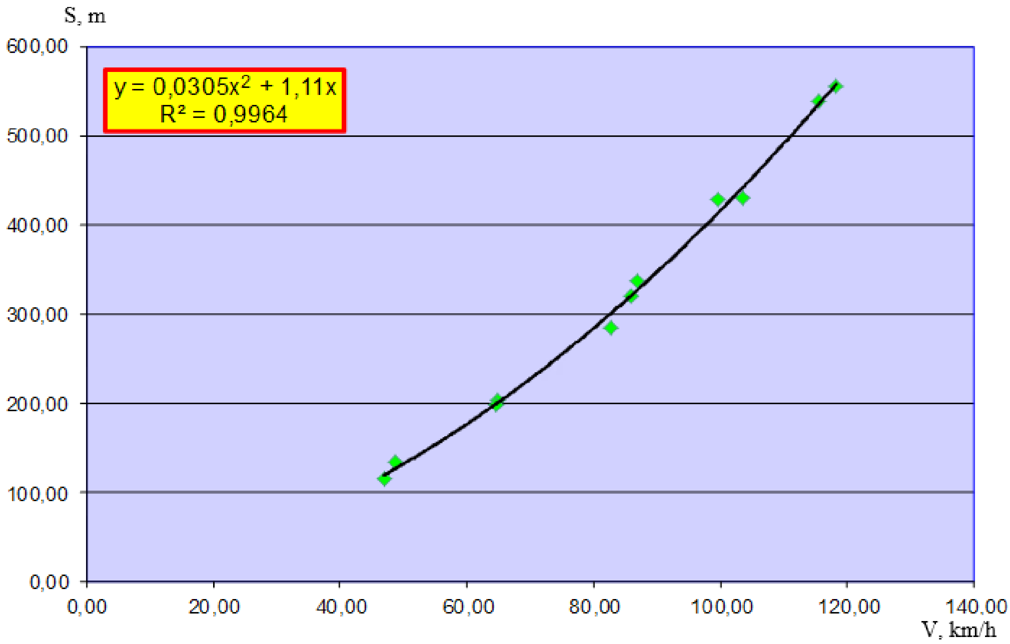

Figure 2. Graph of dependence of empty car braking path from the initial braking speed

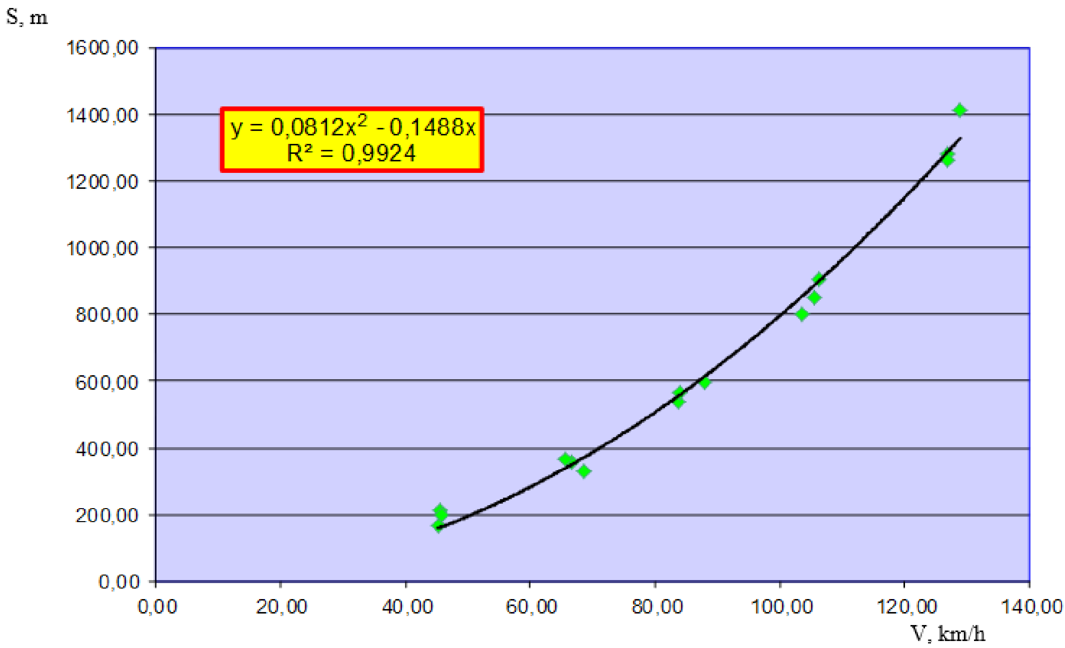

Figure 3. Graph of dependence of loaded car braking path from the initial braking speed

Conclusions and recommendations for future application

After carrying out the stationary and train brake tests it has been established that the characteristics of automated brake system of studied gondola cars indicate that it fully meets the requirements of a modern regulatory documentation and operating instructions.

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