

## JUSTIFICATION THE STRUCTURE OF BRAKE SYSTEM WITH BELLOW BOOTS DRIVE FOR MINE TRAINS

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The reasons for low efficiency of braking devices that are currently used in the mine locomotive are examined. Attention is drawn to the fact that operating experience of braking systems engineering does not have technical decisions for controlling value of frictional force. It is claimed that force of friction in braking system has reverse reactivity. Using bellow boots during development of rolling stock is described. Conclusions are drawn about use of bellow boots mechanism graded structure of braking system with elastic and dissipative forces for handling of frictional force allow fulfill designing of innovative technologies.

Topicality of the work: the main shipping of coal mines is highly uneven. In this regard, the coal industry of a number of the developed countries of the world prefers rail transport, which took over the tasks and performs the averaging storage of cargo flows of the combined mode of transport for the main and auxiliary cargo traffic.

Since 1973 in the mining industry of Ukraine expanded the scope of the locomotive haulage on roadways with inflated profile of track from 5 to 50 ‰. But braking efficiency of mine trains is not increased. Braking is performed with drum and electromagnetic brakes of the locomotive. On serial locomotives rail brakes are not widely used, the standard serial wagons don't have brake equipment. During the history of mining machinery the brake mechanism of mine locomotives was not exposed according to conditions of draft modernization.

When the path slopes 0,065 and more the movement of a single locomotive traction is not possible. When the path slopes more than 0,025 weight of locomotive according to draft condition is reduced to the value of the locomotive mass.

Productivity on a heavy haulage profile path is reduced by limiting the permissible speed on braking shoe-wheel brake of the locomotive. On the slopes 0,020 and more, the train cannot be stopped by brake locomotive system on the braking path of 40m, which requires reducing the weight of the train.

Brakes accommodation on towed of rolling stock allows you to remove restrictions on the braking performance of haulage conditions. Application of rail brakes on the locomotive is a particular solution to the problem of braking trains a small load capacity and allows you to double the braking force of the locomotive and bring the specific value of the braking force to train laden resistivity movement of rolling stock. The development of the brake system for the coupling part of the train braking performance will improve braking efficiency by 6 times, to extend the scope of locomotive haulage ways on slopes from 0,005 to 0,050 without compromising vehicle safety. Modernization of locomotive drum brake enables to increase braking efficiency from 30 to 50 ‰.

The mining machinery in Ukraine, Russia, Kazakhstan and the Czech Republic has a history of designing when braking equipment is placed only on locomotives. At the same time the specific value of the locomotive braking force is less than the resistivity of the freight trains movement.

In the United States, France, England, Sweden are being operated mine wagons with capacity from 0.75 to 50t, which are produced with the brake equipment.

The results of the braking efficiency tests, structural and dynamic analysis of brake have shown that shoe-wheel brake of mine locomotives is inoperable in the working braking modes in terms of parametric reliability. Also it cannot be used as an analogue of the design on the coupling part of the train. Changing the type of drive (hydraulic, pneumatic), excluding workflow of brake mechanism cannot improve brake characteristics. Solution of similar problems has not been completed on the road and rail transport.

Work objective: To increase the productivity of locomotive transport due to the removal of restrictions on the inhibition of rolling stock.

For achieving the objective of the study should be solved next tasks:

- The development of a computational algorithm of traction simulation and controlled movement of mine trains.
- Justification for the implementation of the traction laws and braking forces of the rolling stock running wheels to determine the mass and number of brake train mechanisms;
- Adaptation of the mine locomotive braking system to train traction ability of serial locomotives.

The idea of the work - lift restrictions of train weight and speed of train movement for inhibition by increasing the number of brake units of rolling stock and oblong stiffness.

The object of study is the operating modes of traction and braking of rolling stock locomotives of mine vehicles.

Subject of the research - control the braking forces depending on the weight, braking deceleration and the speed limit of the train.

Scientific novelty of the results:

- implementation laws of the traction and braking forces of the rolling stock road wheels and mine locomotive transport and rationing for increasing the braking force for normal trains and oversized sections of track;
- the technique of computational experiment and the circuit block implementation for simulating traction and controlling movement of mine trains, instead of prototype tests;
- adaptation criteria of the train brake system to the locomotive traction, friction management and speed functions.

The practical significance of the results:

- Justification of the structure, technical solutions and performance the destination of braking system for mine train;
- Method and the power unit control unit of the trailer braking and increase longitudinal stability of the rolling stock of mine trains.

Poltava aggregate plant, together with the IGTM institute work on creation of the braking system, the composition distribution of the mine train has been performed. According to the said Article, this system can be applied to the shaft of freight and passenger trains, trolleys and section serving them in any locomotive, having a compressor unit. The high degree of reliability provides: independence from the actions of the locomotive brakes, the presence of individual receivers with compressed air on each trolley, dim the brakes on each trolley, dim the brakes at low air pressure in the line or in the place of its damage. In the development of this brake system the authors used the serial brake components car ZIL-130 devices. To reduce the response time of the braking device has been taken as a basis for the tracking actuator without slow action. Small operating time of the drive is performed due to the use of relay diffusers with high sensitivity.

This braking system was equipped with 9 cargo trolleys HCG-2.5. System Tests were carried out in a manufacture environment. The pilot consisted of a locomotive train 14KR-2 and 30 wagons loaded with coal HCG-2.5. Each trolley, equipped with a braking system with two receiver capacity of 0.023 m<sup>3</sup>, two relay diffusers, each of which included two work brake chambers.

The reliability of this brake system has been tested as well in the test three passenger trolleys VL-18 while moving down the slope with the development of 65 %. We tested the effectiveness of the brake application in case of interruption of wagons.

The experimental studies have confirmed the effectiveness of the work of the pneumatic brake system, but the authors did not solve the main problem - the structural study of placing of the mine train pneumatic system equipment. Unsettled this problem can be a serious obstacle for using of the pneumatic brake system.

In the Russian Federation Patent №93019011 / 11, 13.04.1993 [1] A.I. Shabanov proposed to improve the braking system of the car. The inventive brake master cylinder is designed as a bellows filled with brake fluid, comprising two main cavity and an auxiliary associated with servo pushrod, with the main cavity communicated by red-copper tubes bellows introduced into the wheel brake cylinders and adapted to interaction with the pistons of said cylinders to transfer pressure from the vacuum amplifier stream.

The invention relates to vehicles, and can be advantageously applied for passenger cars.

Existing hydraulic drives, brake systems are designed to transmit force from the brake pedal to brake shoes through the main working cylinder, pistons and connecting tubes filled with brake fluid.

Their disadvantages are the presence of the seals with rubber cuffs that are worn and begin to miss the brake fluid; Environmental contamination with brake fluid; the necessity to have the filling tank, as well as the need for pumping hydraulic drive to air removing.

The aim of the present invention is to increase the reliability of the brake system by simplifying the design of the hydraulic drive and the elimination of deficiencies.

The peculiarity of the proposed hydraulic drive vehicle brake system is using main and workers bellow boots cylinders, instead of the cylinder and piston seals with rubber connected red and copper pipe to length for each vehicle. Such bellow boots are used in pressure gauges and pressure tested to 100 kgf / cm<sup>2</sup>.

Bellow boots with a tube filled with brake fluid at the factory, sealed by welding and mounted on the vehicle. Primary bellow boots mounted in the auxiliary housing unpressurized. Auxiliary Bellows going welding of three bellows, open on one side and forming a closed cavity filled with brake fluid. Appointment of auxiliary bellows to transmit the same pressure on the rod of the vacuum amplifier on the main branches of the bellows and the hydraulic drive of the front and rear wheels, regardless of varying degrees of wear of the friction linings. Operating bellows and cylinders are mounted in a similar existing structure since piston ring remain, with the exception of the sealing cuffs each branch of the hydraulic drive is filled with brake fluid, together with all the elements, that is such as a branch of the rear wheels is filled with hydraulic valves and pressure reducing junction boxes and so complete, mounted on a motor vehicle.

In the event of damage to any of branches and the outflow of brake fluid under braking damaged the main bellow boots under the influence of the auxiliary bellow boots, folded and its tide closes the switch or signal lamp. With two warning lights will be known which branch of the hydraulic drive is damaged. During installing branches operating bellow boots must be compressed, and the main bellows expand. During braking, the main bellow boots are compressed and expanded working bellow boots, acting on the pistons, spreading the brake pads.

Also, I.S. Pachikov has suggested braking device "Coupling-brake" system [2].

The principle of operation is based on the compression strength of coupling devices (force of inertia) of the moving structure to increase the braking force of the train.

When braking, the electric locomotive coming at the head of the convoy, after reaching trolley equipped with brakes developed design will be pressed against each other and electric locomotives for its automatic coupling. Efforts by pressing the automatic coupling system is transmitted via a linkage adjustment screws, which press the brake pads to the wagon wheels, and this is provided by braking each wagon.

Each subsequent by electric trolley, clinging to the previous one, will be inhibited herself and brake, front and rear trolley running the more power, the greater the mass and speed of the trolley.

Using the brake control device for the security forces of the inertia force of the moving structure can simplify the linkage system of the efforts of the brake pads and reduce braking device weight, the question of the spread braking force over the length of the train.

To test the efficiency of the proposed principle of operation of the brake devices were manufactured pilot batches of automatic couplings and brake devices that are equipped with silo trucks.

The test results showed that trains equipped with this type of brakes, for the same weight and speed parameters are stopping distance in 1,5-2 times less than conventional trolleys without brakes.

The advantages of a braking device:

- Braking is carried out without energy costs;
- A relatively simple design of the braking device;
- Quick operation.

Disadvantages:

- Not automatic brakes - come off the wagon not brake;
- The lack of universality of the brakes, because when it is working in electric push mode or

maneuvers necessary to have additional devices that disable the braking system. Bellow boots are designed with carefully designed rubber which can hold compressed air at a particular load and forces. These products are typically made from two pieces of thread tie fabric layer and of the inner and outer rubber, which is the process of molding and vulcanization. Strand cord layer carries the load. The inner rubber layer provides a seal; the outer rubber layer provides a seal and performs the function of protection. [3]

Bellow boot is very simple in design and does not require maintenance (fig. 1). That is why applying the brake bellow boot eliminated all disadvantages of brake cylinders. Power actuator characteristics meet the requirements for using in the braking system.

During operating bellow boot is recommended to use external mechanical stops to limit the stroke. These devices should not be moved at the maximum possible value, and not allowed to achieve the lower limit of the motion. Bellow boots should not be placed one above each other, they should be used only in a single configuration.



Fig.1. Bellow boot

The operating principle of the bellow boots drive.

The ability of the bellows change their length under the influence of fluid pressure allows their use as a drive for the control valve. The limited size of the bellows and the small effort that can be generated from their use, determine the scope of the bellow boot drives - a fixture of small dimensions and various control (pilot) of the device in the valve, and various relays for control valves, such as positioners. The internal cavity of the bellows is used to control fluid flow when the bellows must be lengthened with increasing pressure. If the bellows pressure increases must be shortened, the medium must operate outside of the bellows.

For valves most characteristic example of the use of pneumatic bellows thermostatic steam trap is provided with a special bellow boots. The bellow boot filled with fast evaporating liquid, which evaporates at temperatures above 100 ° C it creates a vapor pressure inside the bellows, and he lengthened the slide valve located on it closes the opening in the saddle trap.

Bellow boots actuators are always used as single-acting actuators. Return force is generated by using the elastic properties of the bellow boot. If this force is not sufficient, an additional set of return coil spring, which is arranged coaxially with the bellow boot from outside or inside of it. [4]

The main disadvantages of bellow boot actuators are slow speed, low effort and created a limited

cyclic life, inability to repair and unreasonableness of the bellows, and therefore when it fails it is necessary to replace the entire new bellows valve actuator assembly.

Bellows cylinders are always working against the load at the end of the course should have a limit stop to prevent breakage. For return to the position of bellow boots with a minimum height should be accompanied by an external force. Bellow boots are used, if necessary, the application of enormous effort in a limited space.

Pneumatic "Conitech" firm pillows are available in two mounting versions. When the air bag is not friction between its components they do not require lubrication. It is ideal for use in systems with limited space for installation, requiring a short course, but a lot of effort. Have a high level of sealing when using a vibrating machine, easy to install and use.

Rubber bellow boot designed with carefully designed rubber which can hold compressed air at a particular load and forces. This product is also called bellow boot, bellows mechanical seal or air springs. These products are typically made from two pieces of thread cordon layer and of the inner and outer rubber, which is the process of molding and curing. Layer cordon thread carries the load.

Bellow boot mounted in a tight rubber membrane compartment, upper piston, lower piston, isolators, etc. It can be classified by the type of bending, in bellows type bellows type hose-type according to their shapes. And also can be classified according to the following configurations: type of insulation layer, the type of gripper plates, type bead wire and so on.

Bellow boot contains compressed air. By means of the load increases, bellow boot height is reduced. Meanwhile, the volume of the air spring is increased and decreased. This bellow boot has an effective performance. When loading decreases, the height increases, meanwhile, rubber stiffness increases and the load capacity is reduced. Consequently, within the effective range of travel products, capacity can be bellow boot is determined by means of the spring height bellow boot and so on. In addition, increasing pressure inside the bellow boot and increase diameter of bellow boot is effective in production capacity.

Compared with conventional bellow boot, considering bellow boot has the following advantages:

- Variable capacity. As shown working principle, capacity bellow boot is suitable for a wide range of applications;

- Adjustable stiffness coefficient. In air springs can change load without changing the pitch, and without significant changes in the natural frequency;

- Easy control system height. Using the advantages of the air pressure of the compressor, height of bellow boot can be adjusted by means of closed-loop control system. Bellow boot with load leveling and squatting capabilities, having a steel spring is not commercially available;

- Low coefficient of friction. As distinguished from bellow boot steel spring, the bellow boot equipped with flexible rubber, which is attached to the frame and suspension. Therefore the mechanism is free to move without resistance or friction.

Bellow boot widely used in a brake system, the lifting devices in the shock absorbers, the control systems, rail systems and in many other places.

- Use of the brake system. The brake system uses bellow boot, this system is called air suspension. Using facilitates of bellow boot automatic adjustment of vehicle height, thus maintaining a constant vehicle height. The brake system uses bellow boot due to the following benefits, improved system, low natural frequency, a high level of sound insulation and vibration reduction in generated. What makes the process work mild, increases comfort and softness of the seat, bellow boot also has functions to protect electrical devices, precision devices and the vehicle body from the impact, which is produced by means of vibration. Consequently, the air suspension system can effectively reduce the need for additional maintenance and prolong the service life of vehicles. With all these advantages, bellow boot is widely used;

- Use of a lift system. Normal lifting system is hydraulic system and pneumatic lifting system using bellow boot but these systems require more space and but they are easy to use. If you use the lift system of bellow boot, it will have the following advantages, for example, does not require special maintenance, long term use, easy replacement. Due to these advantages, bellow boot widely used in elevators;

- The use of the shock absorber. Due to low natural frequency vibration, high levels of insulation, considering bellow boot widely used in shock absorbers. This product can guarantee a high level of performance equipment gives stability and control system. That is, these products are widely used in shock absorbers of high-speed machines;

- Using computing engine effectively reduces the friction caused by the vibration during operation of the process. This makes it possible to use this type of product for the control of missiles, launchers, and so on.

We propose to install power cylinders bellows instead of the standard brake cylinder in a brake system of the rolling stock on the basis of these technical solutions.

As a result of the bellow boot brake rolling stock is reduced to the dynamic brake model (fig. 2), which has a design scheme: [5]

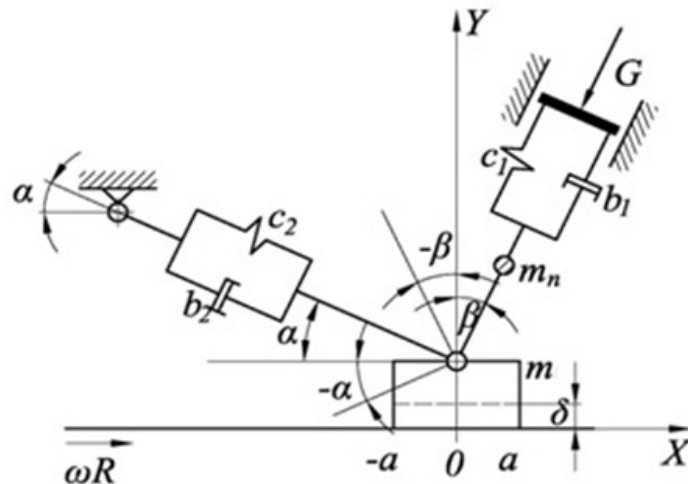


Fig.2. Dynamic brake model

- c - hardness factor
- b - damping factor
- m - mass of the pads
- $m_n$  - mass of the reduced transmission
- G - press brake
- a - the length of pads
- $\alpha$  - angle suspension
- $\omega R$  - speed
- $\delta$  - thickness of the contact layer

### Conclusion

The friction force control in the brake mechanism with the bellow boot application is performed by adjusting the design of the parameters  $c_1$ ,  $b_1$ ,  $c_2$ ,  $b_2$ . Dynamic model of drum-brake wheel of rolling mine rail transport (fig. 3) allows simulating dynamic processes with contact excited frictional vibrations.

The technical level of rolling stock series on the braking efficiency is lower than for the thrust at the rated speed of the train, while on intensive braking modes underutilized to 53% coupling weight of the locomotive, while increasing the braking of loading at the beginning of braking occurs parametric failure of the brakes when slowing down as a result of coupling failure running wheel pairs of the locomotive.

Braking train locomotive of the train head reduces the longitudinal stability of a convoy of cars, with the hitch-free results in the loss of stability and immediately carriages derailed, dynamic forces increase from the train head to tail.

Weight train for any type of rolling stock directly proportional to the coefficient of adhesion of the wheels of the locomotive running rails and is inversely proportional to the slope of the way, at a

value of 0.050 pending to locomotive weight. Therefore, the permissible speed parabolically decreases with increasing bias path for the normative value of braking distance. For the normal profile of the path is the speed exceeds 5 m / s. A computational experiment has been developed to identify the mode parameters for traction and braking.

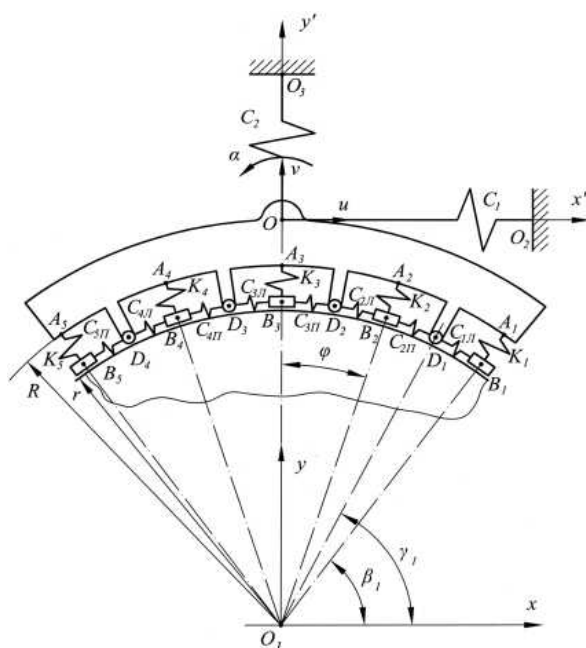


Fig.3. Dynamic model of shoe-wheel brake

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