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APPLICATION OF PLAIN BEARINGS WITH CONTROLLED WEAR ON AUTOMOTIVE VEHICLES

Alexander Novikov[1], Alexey Rodichev[2]*

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RESEARCH ARTICLE

ABSTRACT: The article describes the principle of operation and operating conditions of the balancing suspension of automotive vehicles. An analysis of the wear of the bushings of the balancing suspension was made, on the basis of which an integral normal distribution curve was constructed and the number of plain bearings suitable for operation was determined. The consequences arising from the critical wear of the balancer suspension bushings and their effect on road safety are considered. The article proposes a promising solution for replacing a conventional plain bearing with a plain bearing with controlled wear, made using active parameter control technology. In this design, the emphasis is on controlling the wear of the bearing surface of the sleeve (plain bearing) of the balancing device of the rear suspension of trucks. Special attention is paid to the technological difficulties of applying an antifriction coating in the manufacture of a plain bearing with controlled wear.

KEY WORDS: plain bearing, active control, wear, anti-friction coating, safety

*[1]Alexander Novikov, Doctor of Technical Sciences, Orel State University named after I.S. Turgenev, 302026, Russia, Orel, Moscovskaya str., 77, srmostu@mail.ru (*Corresponding author)*
[2]Alexey Rodichev, Candidate Science Technic, Orel State University named after I.S. Turgenev, 302026, Russia, Orel, Moscovskaya str., 77, rodfox@yandex.ru

PRIMENA KLIZNIH LEŽAJEVA SA KONTROLISANJIM HABANJEM NA AUTOMOBILIMA

REZIME: U radu je opisan princip rada i uslovi rada balansiranog sistema oslanjanja vozila. Urađena je analiza habanja čaura za uravnotežavanje oslanjanja na osnovu koje je konstruisana integralna kriva normalne raspodele i određen potreban broj kliznih ležajeva za rad. Razmatrane su posledice nastale na osnovu kritičnog habanja balansiranog oslanjanja ležaja i njihov uticaj na bezbednost na putevima. U radu je predloženo rešenje za zamenu konvencionalnog kliznog ležaja sa kliznim ležajem sa kontrolisanim habanjem, izvedeno primenom aktivne tehnologije upravljanja parametrima. U ovom dizajnu naglasak je na kontroli habanja nosive površine čaure (klizni ležaj) balansirnog sistema zadnjeg oslanjanja kamiona. Posebna pažnja posvećena je tehnološkim poteškoćama nanošenja antifrikcionog premaza u proizvodnji kliznog ležaja sa kontrolisanim habanjem.

KLJUČNE REČI: klizni ležaj, aktivna kontrola, habanje, premaz protiv trenja, sigurnost

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INTRODUCTION

Most goods for various purposes are transported by road transport. This is primarily affected by the mobility of road transport, the possibility of its use on roads with different surfaces, and in some cases even with complete impassability. Despite all this, the cost of transported goods will remain quite low compared to other types of transport. One of the most common vehicles for transporting goods are KamAZ, KrAZ, MAZ family vehicles. Representatives of these brands of automobile transport work in quarries, on construction sites, in agricultural production, as well as in many industries of our country. They have sufficient carrying capacity, increased cross-country ability and highly maneuverable.

1. PROBLEM FORMULATION

The performance of vehicles on roads with different types of pavement at different speeds during one day of operation is determined by the reliability of the car, that is, the property consisting of reliability, maintainability, durability and persistence. One of the important systems of the car, ensuring the reliability of movement and reliability of the car - is the suspension. According to leading experts in the field of transport operation, working with a faulty suspension reduces the durability of the car by more than 1.5 times. A faulty suspension also causes an increase in vertical and angular accelerations, sharp jolts and bumps on the body of the suspension. Working with malfunctioning suspensions affects the controllability, stability of the car and reduces the safety of its movement. Due to the vibration of the frame, the alignment of the engine and the gearbox of the car is violated, and the mounting of the body parts is also weakened [1]. Failures in the suspension of a vehicle involved in road traffic can lead to road traffic accidents (RTA), the consequences of which are characterized by the death and injury of people, material damage from damage to vehicles, goods, road or other structures, the payment of disability and temporary disability benefits, and etc. From all of the above it follows that the diagnosis of the suspension have great importance in improving the reliability of cars and especially large payloads of the KamAZ, KrAZ, MAZ type [2].

2. THEORETICAL PART

The rear suspension of the KamAZ car (Figure 1) is equipped with a balancing device consisting of two axles pressed into brackets and shoes, into which bushings (sliding bearings) made of antifriction material are pressed [9].

Figure 1 Balance suspension of the KamAZ car

Bushings work under abrasive conditions [1]. These bushings (Figure 2) limit the resource of the rear suspension of vehicles and require restoration or replacement with new of the repair size. One of the most common failures of the balancer suspension is the wear of the balancer bushings. Between the bushings and the axis of the balancer, a clearance of 0.5 ... 0.8 mm is allowed. With such a gap, in fact, large loads act on the bushing, especially during turns. There are four types of bushings from various materials:

- bronze,
- aluminium,
- aluminum with zinc,
- fluoroplastic.

To determine the reliability of the balancing suspension of a KamAZ car, an analysis was made of the wear of the bushings [4] (plain bearings) of the balancing suspension of automotive vehicles. Measurements were carried out on 60 bushings. The car mileage ranged from 46 ... .62 thousand km, the operating life from 8 to 12 months.

Figure 2 Shoe bushings for balancing device of KamAZ car

Worn surfaces of the shoe sleeve were measured in two planes and two mutually perpendicular sections. The location of the planes: A – A - 15 mm from the end face of the sleeve B – B -. 10 mm from the flange of the sleeve. The measurement scheme is shown in Figure 3.

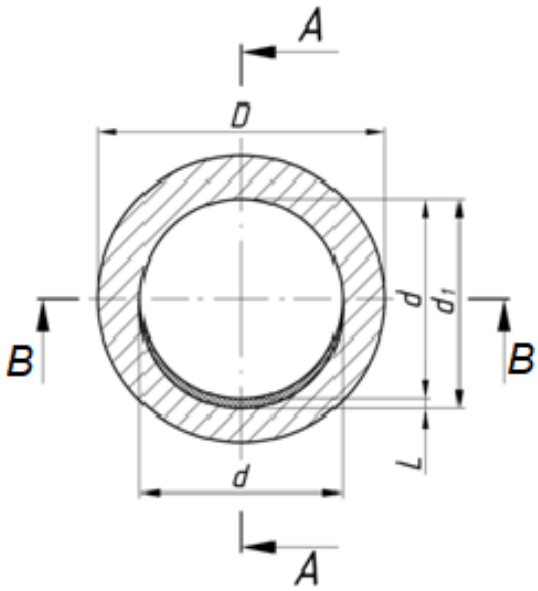

Figure 3 Measurement scheme for worn surfaces

D – bushing outer diameter; d – bushing inner diameter; d_1 – diameter of inner worn surface; L – amount of wear

The measurement of the inner diameter is carried out using the indicator caliper IC 10 GOST 868 - 82 with a division value of 0.01 mm (Figure 4).

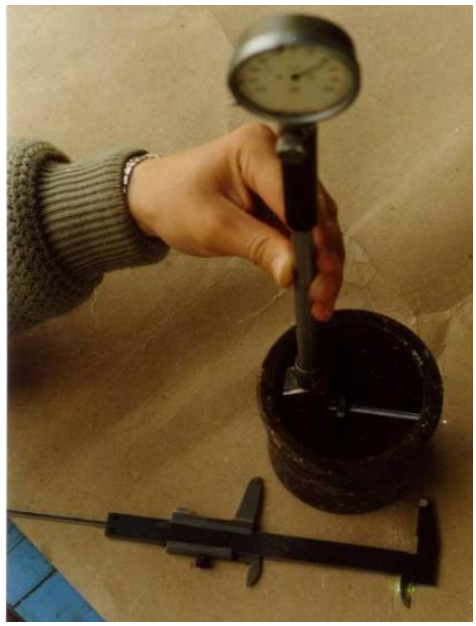

Figure 4 4 Methodology for measuring the shoe sleeve

3. EXPERIMENTAL STUDIES

Wear information was processed using a computer. The results of experimental studies are presented below. As a result of the studies, an integral normal distribution curve was constructed and the number of serviceable bushings without repair was determined (Figures 5 and 6).

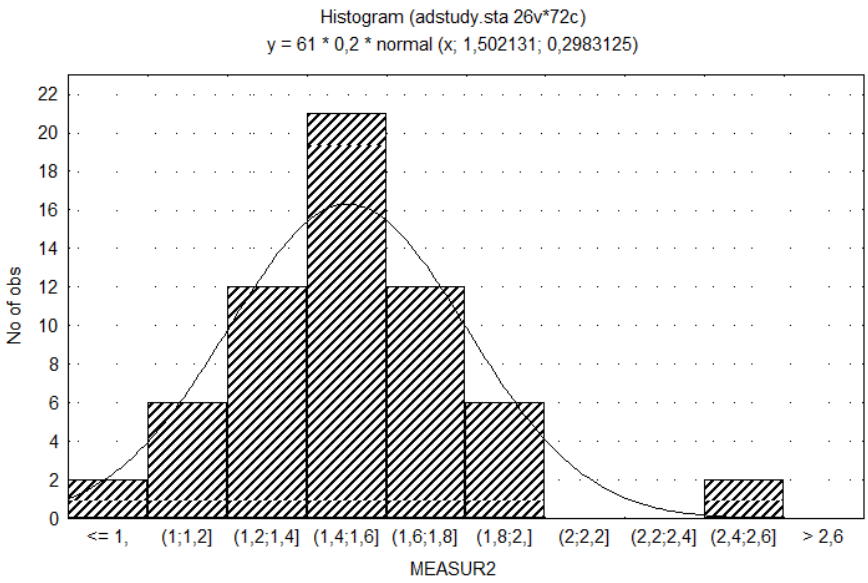

Figure 5 Plane A-A

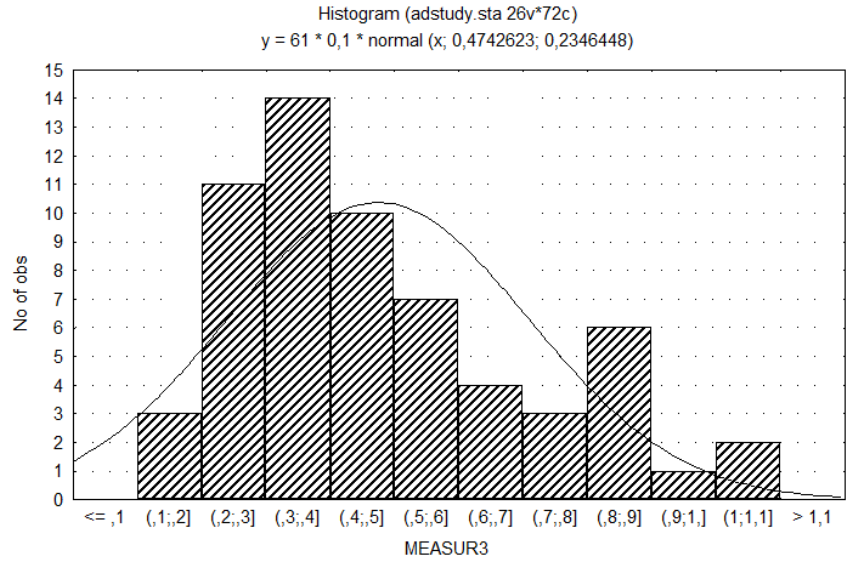

Figure 6 Plane B-B

Analysis of the wear state of plain bearings showed that the inner cylindrical surface of the bronze bushings is outside the range of acceptable operation sizes. Wear of the balancer sleeve by 0.1 mm increases the wear rate by several times, while the sleeve is completely destroyed (Figure 7) [5]. As a result, the load on many nodes of the suspension (springs, spring supports, axle balancer and other elements of the suspension) increases in many

times. In case of deterioration, or breakdown, of which (Figure 8), an emergency may occur with a subsequent traffic accident.

Figure 7 Worn balancer bushings

Figure 8 Battery damage

Reliable operation of the rear balancer suspension of the KamAZ car is impossible without quality control of spare parts, timely maintenance and high-quality repairs. In this case, it is advisable to propose the use of a plain bearing with controlled wear instead of a conventional antifriction sleeve. The analysis of such devices made it possible to choose the invention [6], the essence of which is as follows: a sliding bearing contains a housing and a sleeve made of bimetallic material placed in it (Figure 9). An insulated wire is located in the layer of antifriction material, and the housing is equipped with an electric power element connected to the insulated wire and a signal device, the insulated part of the wire protruding in the layer of antifriction material of the sleeve by an amount equal to the maximum wear, which allows controlling the occurrence of the limiting state of the sliding bearing and, thereby, increase the reliability of the entire bearing assembly.

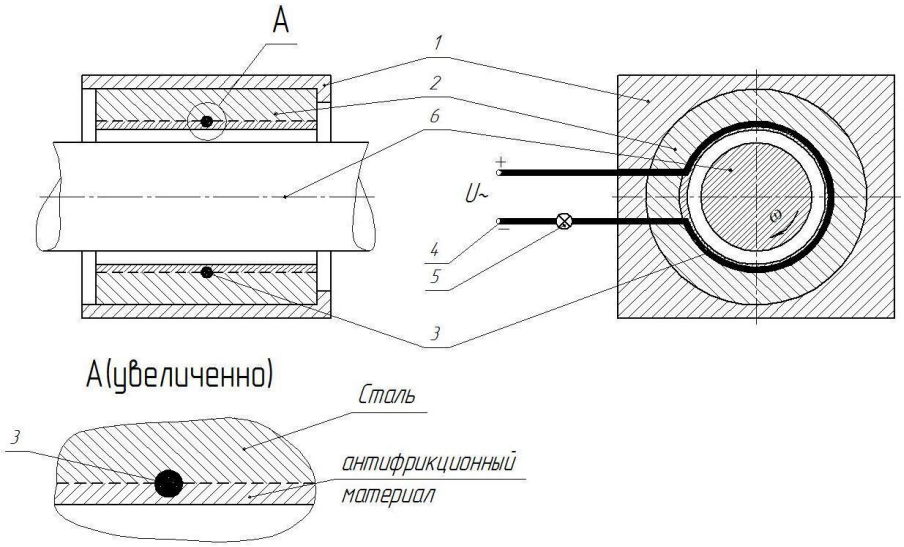

Figure 9 Mechatronic plain bearing (RF patent No. 2398112)
1 – body; 2 – bimetal plain bearing sleeve; 3 – insulated wire; 4 – power supply; 5 – signal device; 6 – shaft

Very often, design decisions are very difficult, and sometimes impossible, to implement due to the lack of technological capabilities to obtain the desired result. The main factor that complicates the manufacture of this sliding bearing is the temperature of applying an antifriction coating to the surface of the steel base of the bimetallic sliding bearing. All processes of thermal spraying are based on one principle - heating of the material (powder or wire) and its acceleration towards the sprayed surface to form a coating. In a collision, the particles are deformed and bonded to the surface, while a huge number of particles stick to one another, a coating is formed, while the particles are bonded to the material through mechanical or metallurgical bonds. Our team solved this problem with the use of film antifriction coatings instead of thermal spraying and a plain bearing with controlled wear was made (Figure109). The technological process includes several operations:

1) The first stage, we take a standard bronze plain bearing.

2) The second step in the manufacturing process of a plain bearing with controlled wear is surface activation.

This is achieved by cleaning and shot blasting (sandblasting). At the same time, grooves for laying wires are grinded on the inner surface.

3) At the third stage, the wire is insulated and laid in special grooves.
4) At the fourth stage, a film of antifriction coating is applied (in the form of a solution) by introducing it into the grooves.
5) In the fifth stage, the applied coating dries.
6) At the sixth stage, the coating is tested for quality by evaluating the mechanical properties and microstructure.
7) At the final stage, the wire is checked for possible damage after applying an antifriction coating.

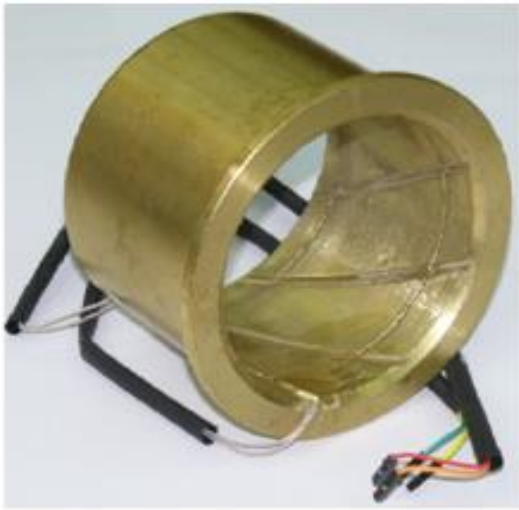

Figure 10 Wear-controlled plain bearing

4. CONCLUSIONS

Monitoring the wear of the bearing surface of the bearings of the most loaded and critical bearing units allows you to prevent the occurrence of a sudden failure of the "shaft-bearing" system, as well as significantly increase the life of the entire machine. A high degree of integration and the absence of additional mechanisms and devices allows, without constructive changes, to upgrade already proven designs by introducing the function of monitoring and preventing emergency situations into them. Overcoming the difficulties of applying an antifriction coating to the surface of a sliding bearing, as well as testing all the nuances of the design at real facilities, is the logical conclusion to the development of a promising sliding bearing with controlled wear before it is directly introduced into production.

REFERENCES

[1] Gavrilov, V.: "Improving the reliability of vehicles when used in agriculture due to the diagnosis of suspension (as example, KAMAZ car)", Volgograd, 2010, p. 20.

[2] Shelofast, V.: "Machine design basics", Moscow, 2005, p. 472.

[3] Chichinadze, A.: "Friction and wear", Moscow, 2003, p. 576.

[4] Kragelsky, I., Dobychin, M., Kombalov, V.: "Basics of friction and wear calculations", Moscow, 1977, p. 526.

[5] Drozdov, Yu., Yudin, E., Belov, A.: "Applied tribology (friction, wear, lubrication)", Moscow, 2010, p. 604.

[6] Savin, A., Popikov, A., Shutin, A.: "Mechatronic bearing units design and calculation principles", Lambert Academic Publishing, 2012, p. 116.