Technological support for the durability of the balancing suspension of the car

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Abstract. The article presents an analysis of vehicle suspension failures. One of the main malfunctions is the wear of the rear axle balancer. Dimensional chains are shown that describe the working clearance in a sliding bearing for various types of repairs. Describes how to repair the balancer of the car suspension. The dependence of the wear of sliding bearings on the gap in the pair "sliding bearing - the axis of the balancer" is obtained. A promising method is proposed for reducing the working clearance in the sliding bearing of the balancer of the automobile suspension by applying film antifriction coatings.

1. 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.

2. Problem formulation
The performance of vehicles on roads with various types of pavement under varying speed conditions during one day of operation is determined by the reliability of the car. Reliability is characterized by 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.

The car suspension reduces the dynamic loads transmitted by the car when driving on a rough road surface, and ensures the transmission of all power factors acting between the wheels and the frame. 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 [1]. Working with malfunctioning suspensions affects the handling, 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 attachment of the body parts is loosened [1, 2].

Failures in the suspension of a car 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 the foregoing, it follows that monitoring the condition of the suspension is of great importance in improving the reliability of heavy-duty vehicles of the KamAZ, KrAZ, MAZ type [2, 3].

3. Theoretical part
One of the features of cargo vehicles is the use of plain bearings in the design of their suspension. Such bearings have high antifriction properties, corrosion resistance, withstand significant specific loads, as well as high speed modes. Most often it is the bronze plain bearings of the "sleeve" type.

The rear suspension of the KamAZ, MAZ, KrAZ car has a different structural solution to the balancing device. The balancing device includes bushings (plain bearings) made of antifriction material. These plain bearings limit the resource of the rear suspension of trucks, and require replacement with new ones. New bearings have repair dimensions. The wear of anti-friction bushings (plain bearings) is one of the main defects in the balancing suspension of a truck [4, 5].

Each balancing device has two plain bearings. There are two balancing devices on the truck, one on each side. When disassembling (Figure 1), in the event of wear of the axles 1 and bushings 2 and 3 (plain bearings) of the balancing device 4 is higher than the permissible, the axes are grinded to eliminate any signs of wear and repair (reduced in inner diameter) bushings are installed. There are four main types of bushings that are made of different materials (Figure 2): bronze bushings, aluminum with zinc, just aluminum and plastic. The permissible clearance between the axle and the balancer bushings according to the manufacturer’s passport is 1 mm [6]. During operation with such a gap, the sleeve has enormous loads, especially when turning the freight transport. A malfunctioning suspension causes an increase in vertical and angular accelerations, sharp jolts and body bumps on the suspension.

**Figure 1.** Scheme of installation of plain bearings in a balancing suspension.

**Figure 2.** Photo of the plain bearing sleeves.
During the repair and maintenance of the balancer suspension, the question often arises of ensuring alignment when pressing sliding bearings into the balancer. There are two ways. The first method consists in boring the internal sliding bearing to the required diameter, followed by pressing it into the balancer. The second method consists in pressing bushings, followed by boring two bushings in one pass to the required size [7].

A theoretical calculation of the dimension chains of the connection [8, 9] shows that the coupling “balancer body - sliding bearing” at Ø100мм with a fit of H7/r6 gives the following deviations:

\[ \Omega_{100}^{H9_{0}, 0.087} + \Omega_{100}^{r6_{0}, 0.051} \] (Figure 3).

In this way, \( S_{min} = 0 - (0,073) = -0,073 \text{ mm} = -73 \mu m; \)
\( S_{max} = +0,087 - (-0,051) = 0,036 \text{ mm} = -36 \mu m. \)

![Figure 3. Deviation scheme "balancer body - sliding bearing".](image)

It should be noted that the seat of the balancer under the sliding bearing usually has the shape of a cone or ellipse. The above allows us to conclude that in the first installation method, the alignment of the two plain bearings will not be observed.

Consider the pair "sliding bearing - the axis of the balancer", it should have a guaranteed clearance, which will ensure the health of the node. The theoretical calculation with a fit of \( H11/c8 \) on Ø88мм gives the following deviations: \( \Omega_{88}^{H11_{0}, 0.220} \) and \( \Omega_{88}^{c8_{0}, 0.224} \), presented in Figure 4.

![Figure 4. Deviation scheme "sliding bearing - balancer axis".](image)

In this way, \( S_{min} = 0 - (-0,170) = 0,170 \text{ mm} = 17 \mu m; \)
\( S_{max} = +0,220 - (-0,224) = 0,444 \text{ mm} = 444 \mu m. \)

This shows that during assembly we get a guaranteed clearance. However, the gap has a large size variation in the coupling «sliding bearing-the axis of the balancer». 
4. Experimental studies
To determine the influence of the gap in the pair “sliding bearing - balancer axis”, a full-scale experiment was conducted. When repairing the balancer suspension of trucks (Figure 5), the clearance between the axle of the balancer and the balancer was measured. Measurements were carried out using two methods:

1. Theoretical (by measuring the diameter of the sliding bearing and the diameter of the axis of the balancer);
2. Practical (using test probes)

![Figure 5. Repair of the balancing suspension of the KamAZ car.](image)

After mounting and installation of all parts of the balancer suspension, we measure using the test probes, inserting the probe plates in turn into the gap between the sliding bearing and the axis of the balancer in its upper part. Measurements were carried out in five cars on the outer sliding bearing. The discrepancy between theoretical and practical measurements was no more than 2%.

Checking the condition of the vehicle balancers was carried out after 1.5 years of operation. Car mileage ranged from 64 ... 84 thousand km. Shoe bushings of the balancing device are shown in Figure 6.

![Figure 6. Shoe bushings for balancing device of KamAZ car.](image)

In some cases, in the absence of proper diagnosis of the balancers, uncontrolled wear occurs, which can lead to the complete destruction of the sliding bearing (Figure 7, 8).
An analysis of the results of the studies made it possible to identify a graph of the dependence of the wear of plain bearings on the clearance $S$ in conjunction, shown in Figure 9.

One of the promising ways to reduce the gap between the axis of the balancer and bearings is the boring of the bearings, followed by the application of film antifriction coatings [10, 11]. For the application of these coatings, no additional complicated equipment is required, and their thickness of 40-60 microns will reduce the clearance in conjunction between the balancer axis and the sliding bearing, and add the effect of “additional lubrication” to the repaired assembly (Figure 10, 11).
5. Conclusions

The material presented above allows us to draw the following conclusions that in order to ensure the safe movement of heavily loaded vehicles, it is necessary to diagnose the working clearance of the balancer suspension of the car. The smaller the gap between the balancer axis and the plain bearings, the longer it will take until it wears to a critical size. With every tenth of a millimeter of wear of a sliding bearing, wear increases many times, since an increase in the gap between the axis of the balancer and the plain bearings allows the balancer to make amplitude movements in different planes, thus wearing out the axis and the bushings themselves.

Thus, the easiest way to reduce the working gap is to apply a film of antifriction coatings on the surface of the sliding bearing of the balancer. This method allows you to increase the life of the balancer suspension of the car.

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