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INCREASING OF DURABILITY OF SHOCK ABSORBERS OF CAR SUSPENSION BY USING OF AN INNOVATIVE REPAIR KIT OF SILENT BLOCK

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ABSTRACT

Silent blocks are one of the most common and characteristic mates in transport technology, and, in particular, in the design of shock absorbers for car suspensions. The defect such as a “silent block rupture” is characteristed for the rear shock absorbers in operation, Moreover, the silent block often fails much earlier than the shock absorber itself. The shock absorbers restoration by replacement with new silent blocks of standard design does not solve the problem of unsatisfactory durability. The authors consider that the reserve for increasing the durability of shock absorbers is to improve the restoration of silent blocks due to original technical solutions for repair kits. Original technical solution for the silent block repair kits is using a bearing with a movable conical spring insert in it. The design parameters of such an innovative repair kit were previously theoretically substantiated in the authors' works. The silent block repair kit consists of a modified standard silent block and additional elements - a steel sleeve and a conical spring insert. It is presented the developed technological process of manufacturing a repair kit. The validity of the theoretical prerequisites for the development of a repair kit for the silent block of the shock absorber of a vehicle containing a bearing with a tapered spring insert is confirmed by the results of experimental studies using high-precision measuring and control tools, as well as observations under operational conditions. The scientifically substantiated technical and technological development presented in this research is essential for increasing the efficiency of road transport operation by substantiating the principle and developing a technology for restoring the health of vehicle suspension joints using repair kits with movable spring inserts. Summarizing the research results and observations, we can conclude that the developed innovative silent block repair kit has the following important practical advantages; 1. The durability of the node is increased in 1.5 - 2 times due to the presence of such phenomena that are absent in the known designs of bearings, such as the “ratchet effect”, “the effect of oil and thread” and “the effect of wearlessness”; 2. The costs are reduced for the manufacture and assembly of the repair kit by reducing the requirements for the accuracy of the working surfaces of the parts.

Keywords: silent block, repair kit, spring liners, car suspension, shock absorbers.

INTRODUCTION

Ensuring the performance of car suspension in operation is one of the factors of safe and comfortable movement. The front and rear suspension of the car consists of a large number of elements.

A significant proportion of element failures (about 90%) falls on telescopic racks, upper and spherical bearings, rear shock absorbers, and wheel hub bearings (Figure-1), and the share of specific labor for their elimination is about 93% [1].

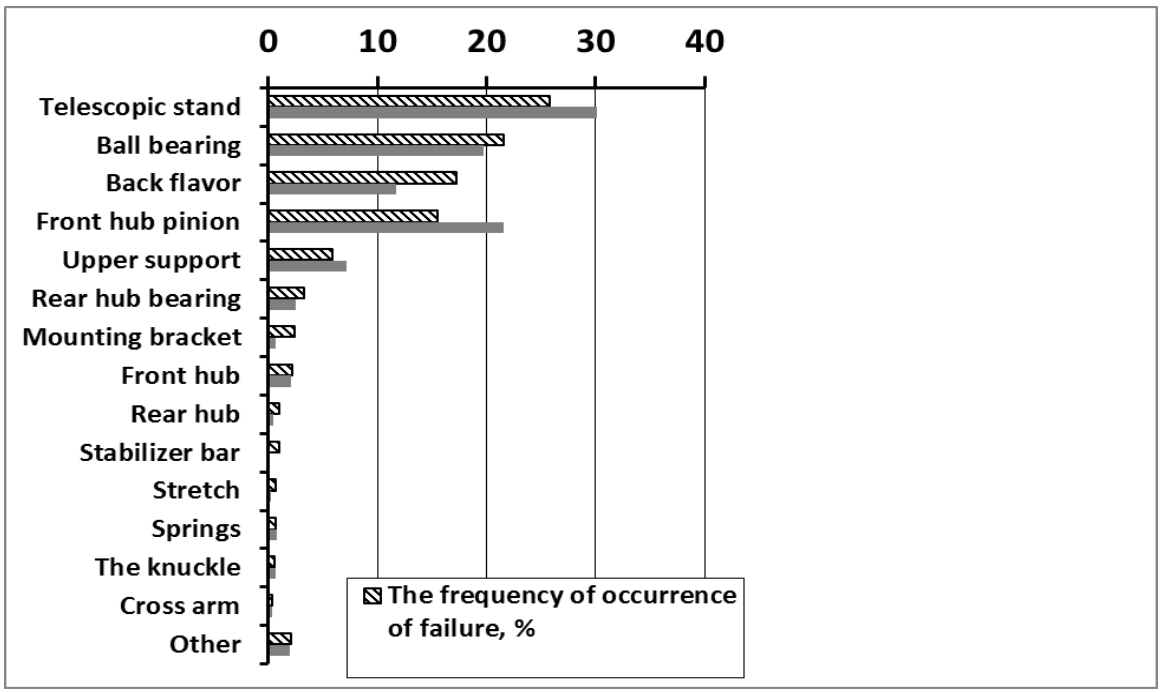

Figure-1. The distribution of failure recurrence of the main suspension elements and the specific complexity of their elimination for cars.

The costly suspension elements - telescopic racks and rear shock absorbers - account for 43% of failures and 42% of the specific laboriousness of eliminating them. The average MTBF of the rear shock absorbers, depending on the operating conditions of the vehicle and the driving style of its owner, is not more than 70 thousand km. For the rear shock absorbers, a defect such as the "silent block rupture" is characteristic. The silent block often fails much earlier than the shock absorber itself.

A silent block is a rubber-metal hinge that consists of two metal bushings between which there is a rubber or polyurethane insert. They serve to connect parts, and due to the elastic insert between the bushings it dampens vibrations transmitted from one assembly to another.

Silent blocks are one of the most common and characteristic mates in transport technology. They are used for mounting levers, anti-roll bar, shock absorbers, gearbox, engine, etc.

Silent blocks work in a tightened state at a certain regulated variable load in a rotary (oscillatory) mode. When increased load (due, for example, to an increased number of passengers or the mass of the cargo being transported, especially in combination with road irregularities), deformations that twist the rubber fibers, which lead to their fatigue failure, arise in them (Figure-2).

Figure-2. Possible deformation of the rubber bush of the silent block and its destruction.

The shock absorbers restoration by replacement with new silent blocks of standard design does not solve this problem, and their longevity remains unsatisfactory. An analysis of methods to ensure the operability of bearing assemblies [2-4] allowed us to conclude that the reserve for increasing the durability of shock absorbers is to improve the restoration of silent blocks due to original technical solutions for repair kits.

METHODS

One of the ways to increase the durability of tribological couplings operating under high loads in the rotary mode is to use the ideas of Professor N.E.

Zhukovskyi "on movement without friction", leading to its decrease in the working body [5, 6]. The idea of rotating an intermediate support without using an external energy source for this is partially realized in a sliding bearing for reciprocating motion developed by A.N. Vinogradov, V.G. Kuranov and others [7-12].

When the bearing operates in oscillatory mode, the spring liner rotates only in one direction, and thereby uniformity of wear and distribution of the lubricant is achieved. In such a bearing, tribological principles are fulfilled that minimize wear processes. The first principle - activation of the working surface by plastic deformation - is realized by installing an elastic spring liner between the outer and inner bushings so that there is a slight interference on the working surfaces of the liner, which changes during the operation of the bearing. The second principle - the suppression of oxidative processes on them - is ensured by the installation of stuffing box seals, which eliminate the access of oxygen and other oxidizing agents to the working surfaces, and the introduction of inhibitors into the lubricant [7].

The bearing with a cylindrical spring liner can be used instead of the propeller shaft needle bearings, suspension silent blocks, steering joints and other hinge assemblies. The experience of using bearings with a movable cylindrical spring insert revealed a significant drawback - to ensure the required fit, it is necessary to use high-precision equipment and expensive tools in the manufacture, and the difficulty in assembly due to the use of the selective method.

To eliminate these shortcomings, it was proposed to make the spring liner conical, and the remaining surfaces of the parts mating with it cylindrical to ensure tight fit on cylindrical surfaces. A patent of the Russian Federation for invention No. 2499920, a Eurasian patent No. 022603 and an innovative patent for the invention of the Republic of Kazakhstan No. 282440 [13-15] were obtained for this bearing.

Thus, the original technical solution for the silent block repair kits is to use a bearing with a movable conical spring insert in it. The design parameters of such an innovative repair kit (Figure-3) are theoretically justified in [16].

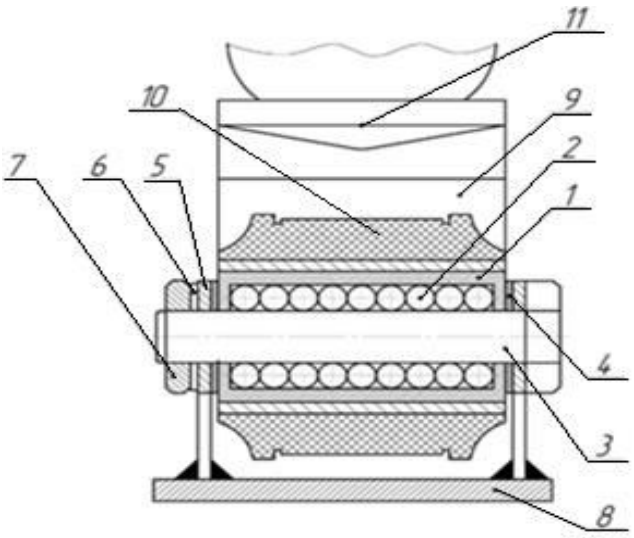

Figure-3. Installation Diagram of the Silent Block of the Shock Absorber with a Movable Conical Spring Insert for Cars of the VAZ Family.
(1-steel sleeve; 2-conical spring insert; 3-bolt; 4-rubber seal; 5-lug; 6-washer; 7-nut; 8-support; 9-silent block aluminum bush; 10-bushes silent block; 11- shock absorber lower housing)

A mathematical model of the process of changing the size of a movable conical spring bearing shell of a shock absorber bush was developed [17]. It is established that the proposed mathematical model, in comparison with a similar model for a cylindrical spring insert [18], is characterized by a more accurate correlation and an extended size range of application. The theoretical calculations of the dimensions of the bearing are carried out on the base on the model.

An innovative silent block repair kit for the of the shock absorber uses a bearing with a conical spring insert installed in the bored hole of the bush of the silent block. The conical spring in the silent block is designed to relieve stresses in the rubber of the silent block that occur when the load on the car changes, as well as as a result of compression-rebound forces that arise on road bumps. Since the silent block is fixed rigidly, stresses appear in its rubber sleeve, which tend to break the rubber. Therefore, when the load changes, the spring liner will turn in the right direction, thereby relieving stresses in the rubber bush of the silent block, which in this design is intended only to absorb stress and does not work on twisting.

The silent block repair kit consists of a modified standard silent block and additional elements - a steel sleeve and a conical spring insert. The manufacture of a shock absorber silent block repair kit includes the following works: an intermediate steel sleeve with a cavity with bumps along the inner diameter is made to install a spring conical liner; a conical spring insert is made; the internal bore of the aluminum bush of the standard silent block is bored to the required diameter; the steel sleeve is pressed into the aluminum sleeve; the conical spring insert is screwed into the steel sleeve.

The manufacturing technology of the spring liner includes standard operations, including heat treatment. A conical spring insert was wound on a model A520 spring-coiling machine from copper-plated 65G wire of square cross section with a square side of 1.4 mm.

The manufacturing process of the repair kit includes the following operations (Table-1).

Table-1. The Manufacturing process of silent block repair kit shock absorber.

Stage	Operation	Equipment	Using, instrument	Works
1. The manufacture of the intermediate sleeve under the spring liner	005 Turning-screw-cutting	Screw-cutting lathe 16K20	Cutter turning through passage, undercutting, boring	1) to install and remove the part; 2) to sharpen the outer surface of the sleeve; 3) to trim the end face; 4) to drill a hole; 5) to bore a hole for the liner; 6) to cut off the sleeve; 7) to trim the end.
2. The manufacture of the spring liner	005 Spring Coiling	Spring-coiling machine model A520	Special mandrel for winding conical spring	1) to install and remove the part; 2) to wind a conical spring.
	010 Surface grinding	Surface grinding machine 3D722	Magnetic plate 7208-0001 (100x250); cassette holder; special grinding wheel 25A40 150x20x32	1) to install and remove the part; 2) to grind the ends of the springs on one side; 3) to reinstall the details; 4) to grind the ends of the springs on the other side
	015 Thermal	Thermal furnace CHO-8.8.6/12	Special cassette holder;	1) to install and remove the part; 2) to harden spring liners to a hardness of 52 ... 56 HRC.
3. Finalization of the silent block	005 Turning screw cutting	Screw-cutting lathe 16K20	Special split mandrel; boring tool	1) to install and remove the part; 2) to bore a hole in the silent block for installing the sleeve.
4. Assembling the silent block repair kit	005 Press	Sorokin tabletop hydraulic press 7.10	Special installation fixture; punch	1) to install and remove the part; 2) to press the sleeve into the silent block.
	010 Locksmith	Bench table	Vice is metalwork	1)to install and remove the part; 2) to screw the spring insert into the sleeve

The silent block repair kit details are shown in (Figure-4).

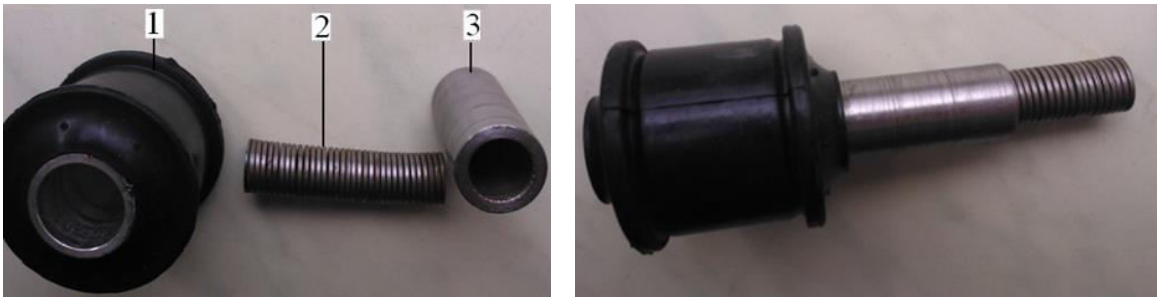

Figure-4. Details of the silent block repair kit (1 - silent block, 2 - conical spring insert, 3 - steel sleeve).

Graphs of the calculated and experimental characteristics of changes in the size of the conical spring bearing bush of the silent block were plotted, which shows that, taking into account the construction of confidence intervals, the mismatch is not more than 10% in the range from 0 to 1.5 mm, which is quite acceptable (Figure-5).

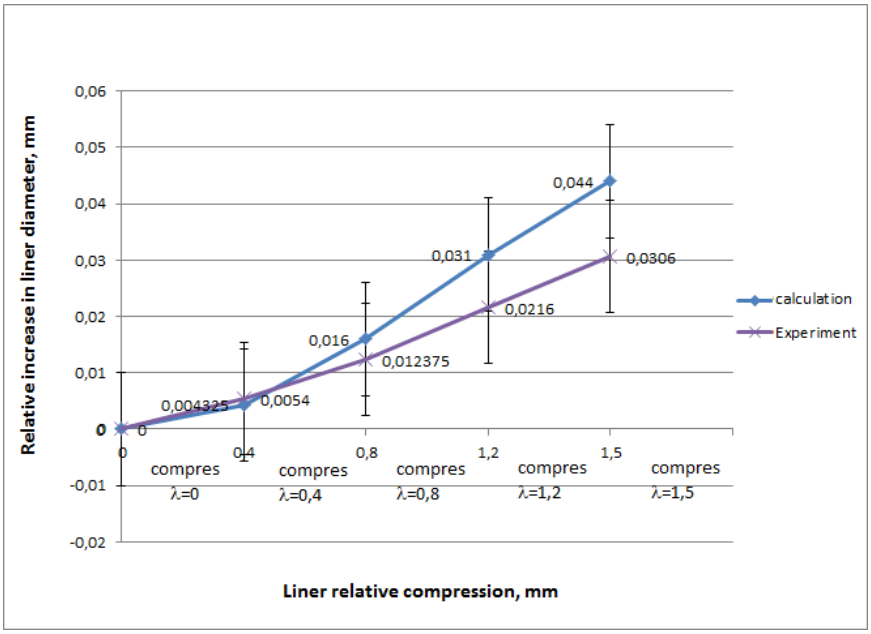

Figure-5. The comparative characteristics of the size change of the conical spring bearing bush of the silent block.

Resource tests of silent block repair kits in the rear shock absorbers of VAZ passenger cars were carried out. Thirty-five cars were involved in the testing. Cars were operated in urban and suburban modes with different conditions of the road surface in winter and summer time.

The change in the technical condition of the standard silent block was assessed by the nature of the destruction of the rubber sleeve, and the innovative repair kit of the silent block by the value of the stroke of the bolt of preloading the metal sleeve to compensate for the resulting clearance in the bearing pair with a specially designed device with a cylindrical probe and micrometer MK 25-1.

The limiting values of the parameters of the technical state of the compared silent blocks are determined by the methods of mathematical statistics from a sample of failed silent blocks. The limited wear in the pair was 1.5 mm, since at this value the rubber sleeve broke.

Seeing the right shock absorber wears out, as a rule, faster than the left shock due to a number of negative factors, such as, for example, transverse roughnesses of the road, the right wheel hitting the curb, etc., the wear of the standard silent block and the silent block repair kit was compared using the right shock absorber.

Graphs of changes in the technical condition of the standard silent block and silent block repair kit for the right rear shock absorbers depending on the vehicle mileage are shown in Figure-6.

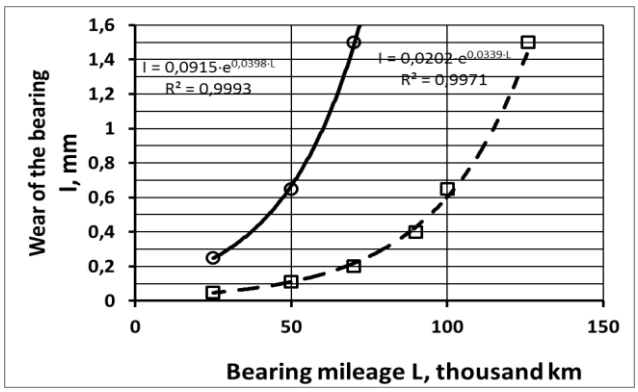

Figure-6. Graphs of changes in the technical condition of the silent blocks of the right shock absorbers from vehicle mileage (1 - standard silent block, 2 - silent block repair kit).

For all silent blocks, the dependence of wear on mileage is exponential; however, the limited wear of the repair kit occurs much later. The standard silent block has an average MTBF of about 68-70 thousand km., and a repair kit - from 115 to 130 thousand km., which is 1.5 - 2 times more.

RESULTS AND DISCUSSIONS

The validity of the theoretical prerequisites for the development of a repair kit for the silent block of an automobile shock absorber containing a bearing with a conical spring insert is confirmed by the results of experimental studies performed using high-precision measuring and control tools, as well as observations under operational conditions [19].

Summarizing the research results and observations, we can conclude that the developed innovative silent block repair kit has the following practical advantages:

- the durability of the node increases in 1.5 - 2 times due to the presence of such phenomena that are absent in the known designs of bearings, such as the “ratchet effect”, “the effect of oil and thread” and “the effect of wearlessness”;
- the costs are reduced for the manufacture and assembly of the repair kit by reducing the requirements for the accuracy of the working surfaces of the parts;
- it is possible to adjust the compression of the spring liner in order to compensate for wear;
- the operability of the rubber sleeve is maintained due to stress relieving in the material.

CONCLUSIONS

The scientifically substantiated technical and technological development presented in the article is essential for increasing the efficiency of operation of automobile transport.

The principle of restoring the operability of vehicle suspension mates using repair kits with movable spring inserts is developed. Original judgments about the functioning of the conical movable spring bush of the shock absorber bush are proposed. Theoretical provisions have been proved that expand the idea of methods for restoring silent blocks of shock absorbers using repair kits with movable spring inserts. A technology has been developed to restore the performance of the silent block of the shock absorber of cars using a repair kit.

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