Estimation of the possibility of using anaerobic impregnating compositions to increase frost resistance of rubber suspension elements of road vehicles

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Abstract. The conditions of operation of non-metallic elements of air suspension of road vehicles are analyzed. The influence of negative temperatures on non-metallic (rubber) elements of an air spring has been studied. An assessment of the possibility of using impregnating compositions for servicing the rubber elements of the air suspension of road vehicles in various temperature conditions has been carried out. It is shown that the use of impregnating compositions when servicing rubber elements of an air suspension allows minimizing cracking of the material and, consequently, increasing the durability of the suspension.

1. Introduction

Pneumatic suspensions are currently widely used in the construction of road vehicles (DM). The operating conditions of road vehicles are predominantly severe dynamic modes of loading of parts and suspension assemblies due to severe road conditions. When operating the DM in conditions of exposure to negative temperatures, the pneumocylinder most often fails. It is sensitive to temperature extremes, chemical attack of aggressive media, dirt and dust.

The main defects of the air spring are cracks and cuts through which air can escape. The most dangerous place for dirt and dust to enter is the contact area of the rubber "stocking" with the aluminum cup (in Fig. 1 it is marked with the number 1). When dust and dirt gets into this zone, active wear of the rubber part of the air bellows begins, as a result of which cracks appear, which subsequently lead to rupture of the air bellows [1-3].

Figure 1. Diagram (a) and photo (b) pneumocylinder: 1 - contact area of the rubber "stocking" with the aluminum cup, from which the samples were made.
In most cases, the service life of road vehicles is reduced due to the impact of aggressive environments that negatively affect the components and assemblies of machines. In combination with the moisture and snow of the winter period, road reagents pose a serious danger to the suspension elements of road vehicles. Contact with chemical elements, for example, reagents, on the air bellows can also lead to cracks and damage to the rubber part of the "cushion". At high values of air humidity, conditions are created for intensive corrosion of metals, rapid aging of rubber products, deterioration of the properties of operating materials, primarily due to their destruction (saturation with water), the insulation resistance decreases, fuel and technical fluids are watered, mold grows [3-4]. The addition of a reagent to moisture leads to an increase in the rate of development of all the above consequences.

One of the ways to increase the frost resistance of rubber suspension elements of DM is the use of anaerobic impregnating compounds [3, 5-8].

Anaerobic materials are compositions based on oligoester acrylates of various structures and in the initial state are monomers, which, after curing, are converted into polymers. The composition of anaerobic materials includes many components (stabilizers, initiating systems, plasticizers, etc.), but the consumer receives them in the form of one component, which is very technological and allows the use of these materials in the conditions of repair production [6]. Curing of anaerobic materials occurs by a radical mechanism under the action of redox systems. A distinctive feature of anaerobic compounds is their high penetrating ability, due to which they penetrate into micropores and harden there with the formation of a polymer material.

However, despite a certain similarity in the mechanisms of impregnation and curing with other classes of monomers, oligomers and polymers, standard impregnation technologies are not applicable for anaerobic materials. For them, all those theoretical [9-11] and experimental [12, 13] methods developed for "classically" binders can be used very limitedly. However, modification of standard impregnation technologies [14-18], taking into account the specific properties of anaerobic materials, is possible, as shown by the authors of [3].

**The purpose of this study** is to assess the effect of negative temperatures on the strength characteristics and structure of non-metallic elements of the air suspension of machines when using anaerobic compounds as binders.

2. **Study materials and methods**

The research object of this work is the Airtech pneumatic bellows. Air springs of this company are installed on many trucks of various manufacturers (MAN, Volvo, Mercedes, Scania, etc.). Depending on the brand of the machine, in the design of the air spring, the attachment points to the spar and the lever change, but the design and material of the non-metallic part of the air spring remain unchanged.

To assess the resistance of the material of the pneumatic balloon to the impact of operational factors, samples were made from the part of the rubber "stocking" of the pneumatic balloon most susceptible to cracking, some of which were kept for 30 days at a temperature of -50 °C, another part at a temperature of -30 °C, another) was stored at room temperature [3]. Then mechanical tests were carried out on a machine for testing structural materials "UTS 110M-50", using the temperature test system "STI TS 3". The use of the temperature test system made it possible to carry out destructive tests at the same temperature at which the preliminary holding of the samples was carried out (-30 °C and -50 °C).

The impregnation of the samples was carried out using the anaerobic material Anaterm-1U (AN-1U), the properties of which are considered in [19-21]. The developer and manufacturer of this sealant is the Research Institute of Polymers named after academician V.A. Kargin. The operating temperature range in which the cured anaerobic material retains its performance is -60 ... + 150°C. The pore sizes that can be sealed using anaerobic sealants depend on the composition of the material used. For the AN-1U sealant used in this work, they do not exceed 0.1 mm.

3. **Results and discussion**

Table 1 shows the results of strength tests of samples of the rubber part of the air bellows before and after impregnation.
Table 1. Results of strength tests of samples of the rubber part of the pneumatic cylinder before and after impregnation

| Parameter                              | Sample holding and testing temperature, °C |
|----------------------------------------|-------------------------------------------|
|                                        | +25 | -30 | -50 |
| Without holding in an anti-icing agent |      |     |     |
| Average value of maximum breaking      | 524 | 749 | 1229|
| load, N                                |     |     |     |
| Average value of maximum deformation, mm| 132 | 136 | 111 |
| After impregnation with anaerobic      |      |     |     |
| composition AN-1U                      |     |     |     |
| Average value of maximum breaking      | 456 | 829 | 1075|
| load, N                                |     |     |     |
| Average value of maximum deformation, mm| 109 | 84  | 94  |

Analyzing the test results, it can be noted that after holding the samples at negative temperatures, the maximum breaking load significantly increases. This nature of the change in the mechanical strength is natural, since in the region of negative temperatures above the brittleness temperature of the material under study, the strength increases. At the same time, the impregnated samples show comparable indicators of deformation and strength properties. This allows us to conclude that in the short term, the use of impregnating compositions does not significantly affect the elastic properties of the air spring.

Figure 2 shows the results of strength tests are confirmed by structural analysis. After holding the samples for 10 days at a temperature of -30 °C, structural analysis was performed. Structural tests were performed on a Fenom scanning electron microscope, a distinctive feature of which is a convenient system for placing samples, which did not require their preliminary processing [3].

The above photos clearly show that in the initial state at negative temperatures, even after 10 days of exposure, the number and size of pores increases, which will further lead to a deterioration in the deformation properties and cracking of the material.

The use of an anaerobic impregnating composition does not significantly affect the change in strength properties (see table. 1). But it allows you to fill the pores and thus increase the elasticity of the product during operation in the long term. Figure 3 shows how the anaerobic composition AN-1U fills the pores between the fibers and provides a uniform structure (while the elasticity of the material increases).

If necessary, impregnating compounds can be applied in the field (including at negative temperatures). When applying impregnating compositions at negative temperatures (Fig. 3, b), the pores are not filled throughout the entire depth of the material. This result is explained by the fact that the viscosity and penetration of the impregnating compositions change. Also, an important role is played by the change in the structure of the rubber element itself, which is impregnated at a negative temperature.
Figure 2. Photo of the microstructure of the pneumocylinder in the initial state without impregnation (a) and after holding at a temperature of -30 °C for 10 days (b).

Figure 3. Photo of the structure of samples impregnated with the anaerobic composition AN-1U at room temperature (a) and at a temperature of -25 °C (b).

In this work, the goal was to determine the effectiveness of the impregnating compositions, therefore the material used was applied manually, without the use of special equipment. This method of application is low-tech and cannot be used in the conditions of production and repair enterprises. Therefore, further it is planned to carry out a set of experimental studies to select the most technologically advanced and effective
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method of applying impregnating compositions to rubber elements of the air suspension DM (at the stage of production, maintenance and repair).

4. Conclusions

The impact of negative temperatures significantly increases the rigidity of the rubber part of the air spring, which in turn impairs its elastic properties. The use of impregnating compounds in the operation of air springs is a promising direction for increasing the resource of the air suspension. The use of anaerobic impregnating compounds in the maintenance of the rubber elements of the air suspension of machines allows minimizing the cracking of the material when exposed to negative temperatures and, consequently, increasing the durability of the suspension.

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