Development of methods for increasing the performance of rubber cord shells of pneumatic shock absorbers

O V Chemisenko, Y S Gnoyevykh, N A Levochkina, E N Eremin and A V Lyamtsev

1 Federal State Budgetary Educational Institution of Higher Education “Moscow State University of Technology and Management named after K.G. Razumovsky (First Cossack University) ”, Moscow, Russia
2 Omsk State Technical University, Omsk, Russia

E-mail: natnaukaomsk@mail.ru

Abstract. The article examines the effect of temperature on the change in the characteristics of tribotechnical properties in a pair of friction "rubber - metal". The reasons for the decrease in the efficiency and durability of rubber-cord casings and pneumatic shock absorbers are analyzed.

Currently, there is a rapid growth in the production of polymers and materials based on them. Polymer materials are successfully replacing many traditional materials - metals, ceramics, glass, wood, etc. [1].

Polymer composite materials for tribotechnical purposes are among the most promising materials for metal-polymer tribosystems. The use of antifriction self-lubricating PCMs in friction units of machines (sliding bearings, roller bearing cages, sealing devices, gearing, etc.) can significantly increase the reliability and durability of technical systems while reducing energy costs for their manufacture, as well as improve the environmental situation when using them [ 2-3].

Friction problems of the developers of new equipment have been worked out and studied in a fairly wide range, using various types of lubricants and antifriction components.

Recently, polymers and elastomers have found wide application in friction units, operating in various tribo-couplings, such as: "metal-polymer", "polymer-polymer", "metal-elastomer", "polymer-elastomer" without lubricant and providing reliable sealing of mating elements.

It is important to note that metals, especially ST 3 steel, in frictional interaction with elastomers, in comparison with polymers, have a high coefficient of friction. An increase and a constant rise in temperature in the contact zone has negative and destructive consequences on the process of material wear. Products made of elastomers, especially those reinforced with synthetic fibers, have a more complex technology for manufacturing parts, and besides, their cost is much higher.

The development and use of shock absorbers of various designs is a strategic direction in the field of maintaining the reliability and durability of equipment. Currently, in various branches of the military and civil industry, rubber-cord casings (RCC) have found application in the design of pneumatic shocklocks (figure 1). For damping vibrations, absorbing the energy of shocks and shocks of moving elements, shock absorbers of various types are widely used: pneumatic, hydraulic, vacuum, the performance of
which is associated with reliable protection of mechanisms from the effects of various types of deformations and stresses.

![Air shock absorber](image)

**Figure 1.** Air shock absorber.

RCC are used to increase noise insulation in units and mechanisms. With their help, the smooth operation of the aggregates is increased, their protection from various overloads, the reduction of dynamic loads under shock impacts, as well as reliable damping of oil and gas pipelines [4]. Compared to traditional spring or rubber-metal elastic elements, shock-absorbing structures based on pneumatic RCC have a number of undeniable advantages. The main ones are: a high degree of vibration isolation due to the absence of direct contact through a metal or rubber mass, the possibility of creating almost any elastic characteristic (linear, nonlinear, with a given nonlinearity in the area), the possibility of implementing the same elastic element for various operating conditions (loads, frequencies, displacements), low frequency of natural vibrations, the ability to perceive significant external influences at relatively large displacements, damping of oscillations in a wide amplitude-frequency range [5].

With significant dynamic loads, the warranty resource of many missile defense systems in the composition of the PA is significantly limited, since the rubber-cord casing has an unsatisfactory ability to dissipate heat energy from the contact zone with the metal parts of the pneumatic shock-absorber.

Antifriction is a characteristic property of the materials of the tribological system (TS), capable of providing insignificant resistance to the relative movement of the system elements and is estimated by the coefficient of friction ($f$). In a complete analysis of tribological processes, such an important parameter as the coefficient of friction must be taken into account among the output parameters of the vehicle. It is the result of a complex of physicochemical processes accompanying the friction of two bodies, therefore it cannot be attributed to any one detail, one material [6].

There are many reasons for the decrease in the RCC's performance, but one of the main ones is a high friction coefficient and a significant increase in temperature in the contact zone of the RCC rubber cover layer with the metal parts of the pneumatic shock absorber. Figure 2 shows that mechanical damage to the RCC in the rubber-metal tribo-interface is associated with thermal destruction of the surface layer of the RCC, they have characteristic destruction. Such destruction of the working surface leads to a loss of tightness, a decrease in the reliability and durability of the entire PA.
To eliminate these damages and extend the life of the pneumatic shock absorber, lubricants based on polydimethylseloxane are used. Silicone fluids represent an extensive group of highly effective oligomeric substances with a set of properties inherent only in this class of polymeric compounds and not repeated in any other currently known natural or synthetic materials.

They have low glass transition temperatures and loss of fluidity (-60 °C ... -130 °C) and at the same time high thermal stability (200 °C ... 350 °C) [7]. However, this solution to the problem is temporary.

A study of the wear surfaces of rubber vulcanizates based on a combination of various rubbers (SKI and SKD) and various vulcanizing systems showed that chloroprene rubber has the greatest wear resistance with an increase in temperature in the friction zone [8].

In order to determine the effect of temperature and friction coefficient on the performance of the RKO during frictional interaction with a metal counterbody, samples were made from a rubber compound based on chloroprene rubber in the form of cylinders with a diameter of Ø = 10 mm and a height of h = 10 mm. The samples were tested on a friction machine “UMT 2168” at a contact pressure of 3.2 MPa and a sliding speed of 0.15 m / s according to the “finger-disk” friction scheme [9]. As a counterbody, a metal disk 320 mm in diameter was used, made of steel grade ST45 with a surface roughness of Ra толщина0.32 μm, disk thickness t = 10 mm. Figure 3 shows a graph of the dependence of the coefficient of friction and temperature in the contact zone on the duration of the tribosystem “rubber-metal”.

Figure 2. Mechanical damage of RCC after operation.

Figure 3. Dependence of the coefficient of friction and temperature on the duration of frictional interaction: 1- coefficient of friction; 2- sample temperature in the contact zone.
As can be seen from figure 3, with an increase in the duration of the tribosystem "rubber-metal", there is an almost linear increase in the coefficient of friction and temperature in the contact zone.

To investigate the possibility of reducing the friction coefficient, the method of applying a polymer film based on polytetrafluoroethylene (PTFE) on a metal counterbody was used. The fixing of the film was carried out by the glue method by means of epoxy resin, figure (4a).

![Figure 4. Surface of the friction zone of the counterbody with glued polymer film: a - before the start of the test; b - after testing.](image)

The results of the tests showed that with prolonged operation of the tribosystem "polymer-elastomer" in the friction zone, an increase in temperature is observed, which has a negative effect on the adhesive composition located between the metal of the counterbody and the polytetrafluoroethylene –foam. Thermal heating of the epoxy resin adhesive composition during the tribosystem test and its crystallization after the termination of operation has a destructive effect on the inner surface of the PTFE film (figure 4b). It should also be noted that rubber and PTFE films have a low coefficient of thermal conductivity compared to metals, which leads to a significant increase in temperature in the contact zone and to the destruction of rubber and destruction of the PTFE foam. Further, fragments of the destroyed PTFE film act as an abrasive. These processes negatively affect the reliability and durability of the tribosystem.

One of the reasons for the decrease in the efficiency of the RCC in the rubber-metal tribosystem is the high coefficient of friction.

An increase in temperature in the contact zone of the RCC with a metal counterbody leads to the destruction of the rubber surface and its high wear.

Further study of the problem and the development of methods for increasing the reliability and durability of missile defense and wear-resistant types of antifriction materials are required.

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