The change in physical and mechanical properties of technical fabric by means of plasma treatment

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Abstract. The properties of a technical cushion fabric modified by a low-temperature plasma are studied. It established that the treatment with plasma of low pressure allows us to give anti-adhesive properties of technical fabrics with improvement of physical and mechanical properties.

1. Introduction
The manufacturing of technical products is the fastest growing in the textile industries in the world's leading countries. The basis for intense increase in volumes of production of technical textiles and expansion of spheres of its application is active in researching activities, which are directed considerable for financial resources and in which appears numerous innovative developments [1].

Technical fabrics are widely used in various sectors of the economy. In contrast to fabrics of a household purpose, they are characterized by higher breaking load, surface density and thickness. The performance of technical textiles is due to their purposes. These properties include water - and air permeability, conductivity and electrified, thermo-, light - and chemical resistance, bond strength with the coating, the linear shrinkage from the effects of temperature stability of the relaxation properties when working under stress not exceeding above 10% of the breaking loads, and others [2].

However, it should be noted that the appearance of industrial fabrics does not impose such strict requirements compared to that of household fabrics. Technical fabrics are widely used for production of conveyor belts, rubber hoses, flat and V-belts; soft furnishings of the seats and the interior lining of cars; for awnings and covers, materials, shells, balloons and inflatable hangars, folding garages, tourist tents, automobile and aviation tires; as a filter partitions. Technical fabrics coated with rubber
or polyvinyl chloride, used in manufacturing of containers for storage and transportation of liquids and
bulk goods, inflatable boats, life jackets and rafts on ships, flexible fences (skirts) air-cushion vessels,
straps for lowering and lifting of pipes of large diameter for construction of oil and gas pipelines, pipes
for air supply in mines [2].

A significant proportion of fabrics for technical purposes used as cushioning materials for storage
of uncured rubbers preform, rubber profiles and tire cord prior to assemble and vulcanize.

During operation of the cushioning materials, experience various static and dynamic effects: the
dynamic stretching and bending at the seam and rolling, abrasion surface material, and static
electricity. The main reason for the decline is the life of the strip is the loss of its dimensional stability.
Consequently, in the process of multiple seaming raw rubber blanks on their surface scarring. In
addition, increased abrasion of the surface of the cushioning material leads to the penetration of
oxygen to the uncured rubbers and reducing their consumer properties.

2. The objective of study
As the cushioning materials used cotton and combined fabrics: calico, muslin, percale, chafer and
chafer containing lavsan and cotton fibers, To reduce the adhesion of cushioning materials to the raw
rubber blanks require additional processing costly release formulations or develop completely new
reliable materials.

In this case, to regulate adhesion, physical and mechanical characteristics, and reduce the cost of
technical fabrics for mechanical rubber goods are urgently use to develop new formulations of
technical fabrics or the modification of their surface.

Non-equilibrium low-temperature plasma changes the adhesive properties of the material surface
depending on the parameters of the modification. In connection with this interest, the impact on non-
equilibrium low-temperature plasma on the fabrics for technical purposes, containing natural and
synthetic fibers.

The surface and strength properties of technical fabrics can be adjust by changing the parameters of
low-temperature plasma treatment [3].

The objective of the study selected technical cushioning fabric ChLH containing cotton and polyester
fibers (51% cotton, 49% polyester), manufactured by company "Krez", Elabuga. Insulating fabric
 cushioning ChLH used in the tire industry between steel cord and rubber, therefore, is to make the
necessary anti adhesive properties of the technical fabrics to the rubber.

3. Methods and means of research
Processing of technical fabrics was performed in an industrial plasma installation, the process
parameters that were changed within the following limits: the voltage of the anode (Ua) from 3 to 7.5
kV; anode current (Ia) from 0.3 to 0.7 A; the processing time (t) from 1 to 10 minutes. The Plasma
gas: gas mixture argon / propane-butane in the ratio of 70%÷30%. The value of plasma gas flow and
pressure in the vacuum chamber was G=0.04 g/s and P=26.6 Pa, respectively, and installed in the early
works [4, 5] as optimal for the processing of chemical fiber materials.

To evaluate the surface properties of the fabric selected standard methods for determination of
capillarity, water absorption and contact angle of wetting.

4. Results of experiments and discussion
The experiment dependence on the values of the capillary modes plasma treatment of tissue ChLH
presented in Table 1.

According to table 1, the lowest elevation of tissue fluid after the plasma-forming gas treatment in
argon / propane-butane (70% ÷ 30%) was observed for the parameters: Ia = 0.5 A, Ua = 4.5 kV,
t = 3 min, P = 26.6 Pa.

Then, we carried out experimental evaluation of the contact angle of the wettability of the surface of
the fabric. The result of the measurement of the equilibrium-wetting angle was considered to be the
arithmetical average values of wetting angle six drops of water. Therefore, found that after processing
the cushioning tissue in the environment of argon/propane-butane wetting angle is increased by 46% compared to a control sample.

**Table 1.** The influence of non-equilibrium low-temperature plasma processing on tissue capillarity (t = 3 min, P = 26.6 Pa; G = 0.04 g/s, argon / propane-butane (70%÷30%)).

| Processing modes | Ia, A | Ua, kV | Capillarity, mm |
|------------------|-------|--------|-----------------|
|                  | 0.2   | 4.5    | 86              |
|                  | 0.3   | 3      | 77              |
|                  | 0.3   | 6      | 63              |
|                  | 0.5   | 2.5    | 102             |
|                  | 0.5   | 4.5    | 5               |
|                  | 0.5   | 6.5    | 89              |
|                  | 0.7   | 3      | 70              |
|                  | 0.7   | 6      | 83              |
|                  | 0.8   | 4.5    | 8               |
|                  | Not treated |  | 105            |

In the next phase of the research was determined water absorption capacity of technical fabrics, after plasma modification, the cushioning tissue water absorption decreased by 20%.

The decrease in the water absorption of technical fabric after the action of the plasma flow of a high-frequency capacitive discharge of reduced pressure can occur both due to splitting and changes in the internal structure of the processed materials, both by changing the free energy of the surface of the pores and capillaries, and by restructuring the nature of the functional bonds [6, 7].

Due to the fact that the textile material is exposed to temperature during the manufacturing of rubber products, the effect of the plasma modification on the thermal shrinkage of the technical fabric was determined. The results of the experimental data showed that after the modification of the technical fabric in a high-frequency capacitive discharge of reduced pressure, the values of thermal shrinkage in hot air are reduced by 28%.

Reducing the shrinkage of the tested materials when exposed to the plasma stream of the high-frequency capacitive discharge of low pressure occurs, firstly, due to the shrinkage effect of the plasma: recombination of ions and bombardment of the surface with them, and secondly, the thermal effect of the plasma leads to increased kinetic energy of molecules and atoms and weakening of intermolecular bonds, which contributes to the resumption of the relaxation process. Defects caused by the formation of a “buried” layer of a plasma-forming gas atoms, give rise to stretching stresses, which prevent shrinkage.

Study of changes in the adhesive properties of technical fabrics after plasma modification was performed by the method of determining the bond strength rubber-cord (H-method).

Tests to determine the strength of the bond between the rubber and the cloth consisted in pulling the cord from a rubber sample, which, when placed on a flat surface, was shaped like the letter H. Samples were cured at 150 ° C for 20 minutes in a mold. The mold has mutually perpendicular channels, into which strips of rubber compound and threads of textile cord laid. Then samples were determined under normal conditions for 24 hours, and then tested for bond strength on a breaker RM-50.

According to the experimental data, after the plasma treatment, the strength of bonding with the rubber for the lining fabrics, the bond strength decreased by 1.5 times.

Investigation of the strength properties of the cushion fabric showed some improvement in strength characteristics. In Figure 1 is a graph of the fracture curves of samples of technical fabric.

**Figure 1.** The nature of the destruction curve of the cushion fabric:
1 - without plasma exposure;
2 - the sample modified in an optimum mode.
From figure 1 it is seen that after plasma modification in optimum conditions, the breaking load for cushioning fabric increased by 33%.

This can be explained by the fact that in the case of processing in the environment of argon-propane-butane, there is a probability of grafting of monomeric units and fragments of the molecules of propane-butane to the resulting free radicals, the formation of additional bridges and cross-links, which greatly reduces the number of free radicals after processing, results in a significant increase in strength and impart anti-adhesion properties.

5. Conclusion
Thus, a study of surface properties showed that for the cushion fabric in the optimal mode (Ia = 0.5 A, Ua = 4.5 kV, t = 3 min, P = 26.6 Pa argon / propane-butane in the ratio 70% ÷ 30%) drop in capillarity by 10 times, water absorption by 20%, wetting angle increased by 46%, thermal shrinkage decreased by 28%, breaking load increased by 33%, and bond strength with rubber decreased by 1.5 times.

Analyzing the obtained results, it can be concluded that plasma treatment of technical cushioning fabric in the plasma-forming medium argon / propane-butane allows increasing the strength and anti-adhesion properties of the fabric.

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