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APPLICATION OF CARBON PLASTIC BUSHES WITHIN FRICTION KNOTS OF TROLLEY-BUSES

Abstract. *It's well-known that in comparison with metal works, especially made of expensive nonferrous metals, carbon plastic parts have certain advantages both from technical and economical point of view. That's why further implemention of these parts in any subfield of engineering is of a great importance, since it allows possibility of recycling and saving huge industrial and financial funds. The most vivid example - production of carbon plastic bushings for pintles of front shaft instead of bronze ones for different models of trolley-buses: UMZ (Southern machine building factory, Ukraine); ZIU (Uritski's factory, Russia); SKODA (Czech Republic).*

Description of main material. Assortment of details from polymer composites (PC), and from carbon plastics (CP) in particular, is constantly extending and finding greater application in the areas of different directions: chemical industry, engineering, space industry [1]. The constant scientific search, perfection of technologies of producing PC and details from them allow to draw the latter out of the range of expensive specific ones to the range of inexpensive construction materials characterized by good physico-mechanical and tribotechnical properties [2]. This has become the reason for increasing the number of knots and mechanisms in which applying PC instead of traditional antifriction materials (bronze, brass, alluminium alloys) is now possible. Depending on application and working conditions, thermoplastic or thermoreactive linking elements and various fibrous fillers: asbestos, boron, glass fibre, graphite, carbon, etc. are used as PC compounds. Results of the investigations held by the workers at the laboratory of polymer composites in DSAU (LPC) show, that one of the best fillers for thermoplastic and thermoreactive polymers working in the conditions of dry sliding friction is carbon fibres. Applying these fibres as a fillers provides for the greatest increase of wear resistance (by 30…40 times) and for the decrease of the coefficient of friction (by 2,5…4 times) [3]. CP that we have elaborated can work not only in low-and medium-loaded knots and agregates of various application, but can as well be used successfully in responsible friction knots working in hard exploitation conditions. That is why their introduction into any area of engineering is of an important significance, because this allows to realize wasteless ecologically friendly technologies and the same time, to save much at the account of expensive colour metals' exclusion from knots' construction.

High technical and service requirements made towards a car park in general, and to people transportation means in particular must be met not only by technical servicing in the process of exploitation but also by a car construction proper. Regular and qualified work of people transportation means depends to a certain extent on long-life and reliability of knots and agregates of each particular car. Within mobile conjunctions where there is sliding friction, bronze bushes are mainly used. Today this material cannot totally satisfy modern requirements because firstly, bronze in an expensive material; secondly, exploitation recourse of bronze bushes is limited; thirdly, their exploitation needs necessary lubrication with plastic materials. An alternative solution can be connected with exchange of bronze bushes for carbon plastic ones, which don't give way to, and are even advantageous in some indices over the properties of bronze. Some of the best ones in technico-economical and physico-mechanical properties for being applied within sliding friction knots are CP elaborated at LPC on the basis of alyphatic polyamide (TU U 00493675.002-98). Basic properties of CP of CPA-6-40 brand are cited in table 1.

The analysis of work of sliding friction knots and mobile conjunctions of trolley-buses produced by SEP (Southern Engineering Plant, Ukraine), PnU (Plant named after Uritsky, Russia), Shkoda, 14Tr (Czech Republic) has shown that in order to save material consume and to decrease costs of technical servicing, some of the knots in which there would be efficient to change bronze bushes for carbon plastic ones are bushes of front bridge kingbolt.

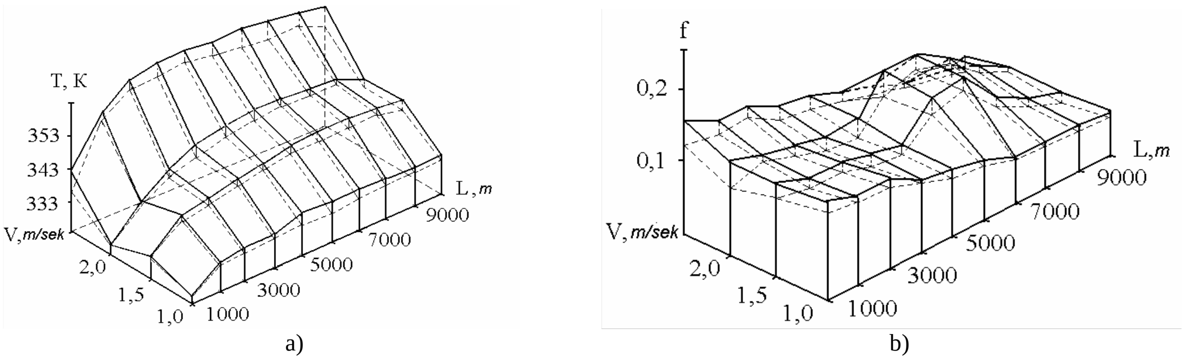
Table 1

Properties of carbon plastic CPA-6-40

Indices	Values
Density of a material, g / cm^3	1,17
Shock viscosity, not lower, kJ / m^2	35
Destructive tension at compression, MPa	166
Intensity of linear wear, 10^{-8}: - dry friction - at oil lubrication	 0,66 0,05
Coefficient of friction: - dry friction - at water lubrication - at oil lubrication	 0,23 0,03 0,01
Contraction at moulding, %	0,04…0,06

Two kingbolts of this knot possess 4 bronze bushes (БРАЖ9-4Л brand) which are in hard exploitation conditions. That is why before setting this CP in industrial testing withing the knot, there have been held its tribotechnical investigation, samples for which were produced by means of pressure moulding at temperature (533K), without further thermo-treatment.

Investigations were held in LPC on a friction disc machine according to the scheme “finger sample-disc”. The disc was made from steel 45 tempered up to the hardness HRC 43…45, surface roughness made R_a = 0,16…0,32. Sliding velocity varied within a range of 1…2,5 m / sec at constant pressure of 0,4 MPa. Analysis of results of tribotechnical testing shows (fig.1), that stable of CP observed at the suggested regimes: no rapid leaps of temperature and coefficient of friction are observed, and, as it goes from the dependence, these indices show good correlation. At maximum sliding velocity (2,5 m / sec), the temperature within the contact zone does not exceed the value of 265 K, while resistance of this material as to Vicat (GOST 15088-69) makes 494 K. It is also necessary to note that friction was realized across the film of transfer, with its periodical removement. Hereby there has been revealed that the temperature within the contact zone at friction across the film is a little higher than that at friction without a film. This is connected with deterioration of heat elimination from the friction zone, for heat conductivity of a film is much lower than that of steel. In its turn, this leads to deterioration of heat dissipation from the contact zone and, consequently, to the growth of temperature within the contact zone, with simultaneous growth of the adhesion component of friction coefficient. However, this implies in no way on CP work in this exploitation regime. At friction track of 5000…7000 m and sliding of 1,5…2 m / sec slight increase coefficient was noticed, but as this phenomenon was short-time, it did not cause the temperature growth, and further the coefficient of friction was stabilized.



a) b)

Fig.1. Dependence of temperature within the contact zone (a) and coefficient of friction (b) of CPA-6-40 across the film (–) and without a film (- - -) of transfer

At the same time at friction there was measured samples' weight on analytical scales VLA-200g-M. The results of weighing the samples show (table 2) that the wear varies within quite a small range and increases along with the growth of sliding velocity.

Table 2

Dynamics of wear of CPA-6-40, mg

Sliding velocity, m / sec	1,0	1,5	2,0	2,5
Value	0,3 / 0,5	0,7 / 0,7	0,86 / 0,33	1,66 / 0,63

Note: On the left of dash – wear across the film, on the right – without a film.

Hereby, it is necessary to concern that each test (at the same velocity and the friction track of 10000 m) was set twice in order to lower the errors, and the values of wear represent the total value for the friction track of 20000 m for each velocity.

In the process of tribotechnical tests there has been stated that CP elaborated at LPC can work at values of factor PV = 1,8 MPa· m/sec [4]. The material has shown good thribotechnical and stability properties satisfying the work within mobile conjunctions of trolley-buses' wheel mechanism.

That is why at the next stage of investigation there have been designed and produced the moulds for making bushes for trolley-buses of the mentioned above brands from CP by means of moulding under pressure. After moulding, bushes' dimensions were made repair ones by means mechanical treatment.

Experimental bushes underwent wide industrial testing in different countries from 1997 to 2000 during 7…11 months. Hereby the track of trolley-buses set with the given details made 26000…35600 km. In the process of exploitation the tested details either worked in the regime of dry friction or were lubricated with plastic lubricant solidole S-13.

The specific trait of investigations lay also in the fact that exploitation of tested details was held in different weather conditions: winter-spring-summer-autumn, which gave the opportunity to test the details at greater range of temperature, humidity, and therefore get more objective results.

Positive results of testing at plain tracks allowed to broaden them and hold them in mountainous regions of Crimea (Ukraine), according to the latest Testing Document from 13.02. 2001 held in "Krymtrolleybus" track of trolley-buses of 14tr brand set with tested bushes made from 23455 to 31349 km. Carbon plastic bushes are still in exploitation. There were no reprooves on the work and technical condition of front bridges' kingbolts' bushes exploitation period.

As to the prior results of investigations there has been stated that long-life of CPA-6-40 carbon plastic bushes in on average 1,2…1,6 times higher, and its cost 2…2,3 times lower in comparison to bronze ones used in serial industry.

This gave an opportunity to start introducing carbon plastic bushes in many trolley-bus depots of Ukraine and Russia.

In the process of long-term resource testing there arose the problem of utilizing the worked-out details. Taking into consideration the fact that the considered CP are thermoplastics and can therefore be retreated many times, it is of use to turn rejected details, as well as flow gates and wastes back for retreatment. Taking it into consideration that – as it has been noted – CPA-6-40 details are set in responsible friction knots, it is necessary to know exactly to which degree their physico-mechanical properties change at further retreatment. If the change of properties insignificant, not only the proper cost of production will become lower, but also one of important problems of realizing resource-saving ecologically friendly wastless technology will be solved. Actually, at introducing such a technology of production only that part of material is lost which is really the product of a detail's wear.

At solving the set task, one of the stages of laboratory investigations was to define shock viscosity as to Sharpy (GOST 4647-80) of the given CP after first, second and third retreatment. Testing samples (dimensions 4×6× 50 mm) were produced by means moulding under pressure, within the temperature range from 513 to 543 K.

Table 3

Influence of temperature on shock viscosity, kJ/m^2

Treatment	Temperature, K			
	513	523	533	543
First	41,6	36,1	42,2	33,6
Second	39,2	33,2	35,7	34,4
Third	43,2	41,6	44,3	42,6

The analysis of obtained data (table 3) testifies to the fact that the highest shock viscosity after the first treatment is observed at the temperature of moulding of 533 K, after the second one 513 K. In the first case shock viscosity of samples after the second treatment turned to be lower than after the first one 15%, and in the second case – by 7,l %. After the third treatment the opposite situation is observed: shock viscosity increases in the range from 41,6 to 44,3 kJ/m^2 and copies dependence curves of CPA shock viscosity after the first and second treatments. It is quite clear that the growth of shock viscosity after the third treatment is connected with “sewing-up” of the linking element, for multiple temperature affects and mechanic destruction cause it to some extent.

At defining heat stability of tested CP as to Vicat is has been revealed that it decreases to 482 K after the second treatment and 452 K after the third one, which is lower in comparison to the first treatment by 2,5 and 8,5 % correspondingly.

The results of thribotechnical testing have shown that after the second treatment the material keeps working at the value of factor PV=1, and after the third one – at PV = 0,8 MPa·m/sec. However, at friction of samples made after the third treatment, there is observed instable material condition revealed in varying of friction coefficient and the temperature within contact zone, as well as in poor correlation between these factors.

So, we can draw to a conclusion that after the second treatment the materials properties decrease on average by 8,5 % which is permissible. That is why it is of use to apply it within the observed friction knot of trolley-buses.

Significant decrease of thermophysical and tribological properties of this CP after the third treatment testify to the possibility of using such a material within low-and medium-loaded friction knots (e.g., glass-care bush, etc.).

Conclusion. Thus, the held laboratory and broad industrial tests of the elaborated CP have shown that this material can work in hard working conditions both with lubricant and without it, going instead of expensive colour metals. Also, introducing this material allows to realize a resource-saving ecologically friendly wastless technology.

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