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THE USE OF METAL-CONTAINING POLYMERS IN THE AUTOMOTIVE INDUSTRY

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Abstract: *Modern machine building requires expanding the range of wear-resistant materials possessing strong exploitation characteristics. In this respect, obtaining new polymer composite materials is of great interest. Such materials have been developed based on thermo resistant polyamide S-1 by means of introducing powder-like carbonyl nickel. The compositions were prepared by means of mixing the components within the rotating electromagnetic field. According to the obtained data, the characteristics of this system are defined by the filling degree. In this way the impact strength reaches its maximum at nickel content of 15 mass %.As for the hardness, compression strength and thermo physical properties of metal-containing polymers, they all grow with the increase of Ni content, which is provided for by good adhesion between the filler and the binder. The smallest wear in the conditions of dry friction is that of the composition material containing 15 mass % of carbonyl nickel. This system is more than eleven times as wear-resistant as pure S-1.With this regard, developed metal-polymers have been designed from metal-containing polymers for pivot knots and brake systems of ZIU, UMZ, Skoda trolleybuses instead of bronze. These have shown good performance and reliability at exploitation. Due to the proposed bushings dimensions, the entire rangeof sleeves repair can be solved and purchases of new ones can be reduced. Thus, given the reliability and work efficacy of the mentioned bushings, replacing the series parts of trolleybus friction knots made of alloys based on non-ferrous metals with the metal-containing polymers ones becomes profitable.*

Keywords: *polymers comprising a metal, thermal resistant polyamide, S-1, carbonyl nickel, trolley buses, ferrous metals*

1. Introduction

According to the data from Kostetsky [1], only 10 - 15% of machine and mechanism details go out of the machine due to insufficient strength, the rest - from the amount. In the work [2] also it is noted that 30% of all the aviary is made out of the amount, in this case, because of the abrasive amount they are 30%, because of the adhesion - 15, the stabilized - 15, the thermal stability - 12, the contact corrosion - 10, corrosion - 10, because of cavitation - 8%. It is evident that the increase in the amount of hard surfaces is an important scientific and production task. Nowadays she is in the forefront of the problem of increasing the reliability and longevity of modern technology [3, 4]. In connection with this, scientific interest represented the study of the influence of the regime of exploitation on the tribo technical characteristics of metallopolymers.

2. Objects and methods of research

Investigating the metallopolymers on the basis of the aromatic polyamide phenylene S-1 (TU 6-05-221-101-71) - one of the perspective thermostatic polymers, which is capable of working up to 533 K temperature and gives away only the best marks of arculated plastics. (PNK-2K10, GOST 9722-97), medi (PMS-1, GOST 4960-2009), aluminum (PA-1, GOST 6058-73), titanium (PTK-1 (2), TU 14-22-57-92) and bronze (BrO5C5S5, GOST 613-79). The degree of charge was 5-20%. %. The basic properties of press-pots are given in Table 1. Physico-mechanical properties were determined in accordance with GOSTs for plastmass, and tribological characteristics on the disk drive system according to the methodology described in [5].

Table 1. Basic properties of press costs

Символ	Цвет пресс-порошка	Плотность, кг/м^3	Насыпная плотность, кг/м^3	Температура плавления, К	Размер частиц, мкм
С-1	розовый	1350	200 – 300	543*	35 – 50
Ni	серый	8900	1200 и больше	1726	12 – 21
Cu	красный	8960	1250 – 2000	1356	33 – 57
Al	серебристо-белый	2699	960	934	129 – 172
Ti	серебристо-белый	4505	2850	1933	158 – 284
Бр	золотистый	8800	3700 – 4700	1203 – 1373	43 – 90

* Vika's Smudging Temperature

3. Results and their discussion

In the course of the investigations of the physico-mechanical properties of elaborated metallopolymers, it was found that a more plot structure is formed around the metallic particles, which is the result of the comparison of the scales calculated for the law of additivity and obtained experimentally hydrostatic method. This structure leads to the increase of the properties of metallopolymers by comparison with the non-charged polymer (see Table 2).

Table 2. Properties of metallopolymers containing 15 mass% of fillers

Свойства	С-1	Al	Бр	Cu	Ti	Ni
Экспериментальная плотность, кг/м^3	1350,0	1476,0	1549,0	1570,3	1518,2	1550,9
Расчетная плотность, кг/м^3	1350,0	1459,4	1546,4	1546,9	1509,1	1546,8
Твердость, МПа	180	221	230	227	260	241
Предел текучести при сжатии, МПа	228,8	251,3	261,7	267	269	259,5
Предел пропорциональности при сжатии, МПа	152,6	187,5	200,8	210,0	203,0	212,8
Модуль упругости при сжатии, ГПа	2,75	3,31	3,06	2,99	3,35	3,10
Ударная вязкость, кДж/м^2	30,8	34,8	14,1	13,2	35,6	42,0

The appearance of metal precursors in the polymer matrix leads to an increase in hardness to 23-45%, liquidity and proportionality regions at 11-18 and 23-39%, the Yung modulus at 11-25%. The introduction of Al, Ti, Ni increases the impact of the compositions, which is motivated by the better dissipation of the energy of the shock for the increase in the degree of crystallinity and the polarity of the polymer matrix. Tibological investigations of metallopolymers (Figure 1) are associated with decreasing the intensity of the amount with the increase in the content of the filler. At this, the intensity of the amount will reach its minimum content with a content of 15% by weight, which is explained by the greatness of the compositions. In the course of research it was established that changes in contact zone (see Figure 2) occur in the process of

thrusting under mechanical and thermal loads. If for the surface of the phenylon form, not a verified test for the amount, a characteristic globular structure, it is after the tests that the particles and the deformed zones are deformed, which can be considered as the micro-points of the capture.Their formation is due to the discrete contact of the contacting micro protrusions, which leads to their mechanical destruction under the influence of tangential force, with the exposure of the underlying layers.

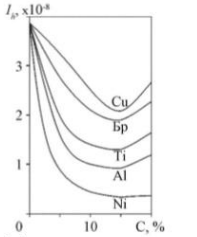

Рис. 1. Зависимость интенсивности износа от содержания наполнителя

Рис. 2. Поверхность фенилона после трения (P = 0,6 МПа, v = 0,3 м/с). Увеличение x12 000

The appearance of dispersed metal powders in a polyamide matrix strengthens the composite material and inhibits the development of deformation processes in the matrix during abrasion, which increases the wear resistance of metal polymers. On the other hand, an increase in the content of the metal filler reduces the temperature at the interface between the composite and the counter body, by increasing the thermal conductivity, which inhibits the development of destructive processes and, as a result, leads to an increase in the wear resistance of the systems. As a consequence, the friction surfaces of the metal polymers (see Figure 3) have a furrowed structure formed as a result of plowing. On the friction surfaces, there are no microcracks, which indicates the plastic destruction of the compositions. Also on the friction surfaces, traces of setting are seen in the form of areas of material displaced in the direction of friction, but they are much less common than in phenylon, and the higher the degree of filling, the less they become [6].

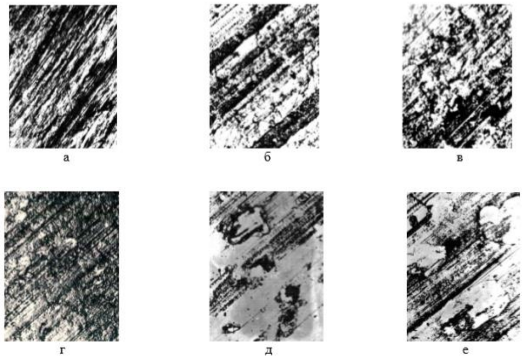

Fig. 3. Friction surfaces of phenylon (a) and metallopolymers based on it, containing 15 wt.% Ni (b), Br (c), Cu (g), Al (d), Ti (e)

Given that the optimal tribological complex properties (minimum coefficient of friction and wear) have metal polymers containing 15 wt. % of the metal filler, further studies of the tribological properties of materials were carried out for metal polymers with the optimum content (Table 3).

From Table. 3 that the introduction of a finely dispersed powder of carbonyl nickel into the aromatic polyamide of phenol improves the wear resistance of phenylon by almost 11 times, and that of copper by 2.

Table 3. Tribological properties of metal polymers

Свойства	С-1	Al	Бр	Cu	Ti	Ni
Интенсивность износа, $\cdot 10^{-8}$	3,95	0,92	1,9	2,08	1,3	0,35
Коэффициент трения	0,52	0,35	0,27	0,39	0,25	0,43

Since the filling of the phenylon with metal particles provides good wear resistance to the polymer, the study of the effect of friction regimes on the properties of metal polymers was of scientific interest (see Fig. 4).

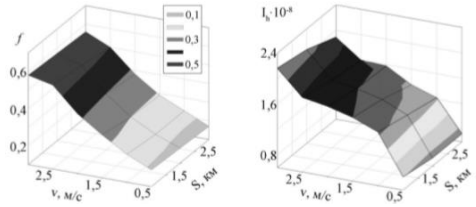

Fig. 4. The effect of operating conditions on the coefficient of friction (f) and the wear rate (Ih) of a metal polymer filled with 15 wt% Ni at a load of 0.6 MPa

As can be seen from Fig. 4, at small and medium slip velocities, the friction coefficient remains practically unchanged, since in this case the friction is mainly due to local adhesion and shear in the transfer film regions.

In the process of wear, fine-dispersed wear products are formed, which are a fine powder, in color close to the original composition. These particles fill the micropropaths on the surface of the counterbody, as a result of which friction is realized not by steel but by wear products. This indicates a pseudoelastic mechanism of abrasion, which ensures the longest service life of the interfaces and minimal growth of joint clearance [7].

The transfer of material from one surface of the sliding pair to the other can be regarded as an integral part of normal wear, at which adhesion at the interface between the MP and the counterpart decreases and, as a consequence, the frictional force decreases.

With an increase in the slip velocity, the interface can not reach a stationary temperature state, which leads to local destruction of the transfer lubricant film and an increase in adhesion, and as a result, the coefficient of friction increases [8].

As for the wear rate, an increase in sliding speed leads to an insignificant increase in the wear of metal polymers, which is due to an increase in adhesion. It is interesting to note that wear and friction coefficient decrease depending on the distance traveled, and this can be explained by an increase in the area of actual contact.

The positive results of laboratory studies of the wear resistance of the developed metal polymers in friction without lubrication made it possible to proceed to the pilot-industrial tests of metal-polymer pivot bushes in passenger electric transport.

In the design of trolleybuses of Ukrainian manufacture, the release of which was established as far back as 1993 - 1994. bronze parts were laid in many bearings and movable joints. The operation of these machines has recently become very expensive, as the increase in the deficit of bronze in the Ukrainian market and the depreciation of the national currency have led to an instant increase in its value. As you know, the friction units made of bronze should work under good lubrication conditions, as they are not working in a dry environment.

The objects of research for the order of the Dnieper depot (Dnepropetrovsk) were the bushings of the kingpin of the front bridge (see Figure 5) of Ukrainian trolley buses (YMZ T-2) and Russian (ZiU-9) production. The introduction of research results should simplify maintenance and reduce the cost of parts.

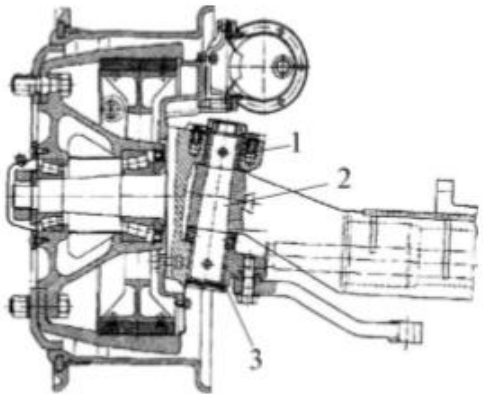

Fig. 5. The front axle of the trolleybus: 1 - the upper pivot sleeve, 2 - the pivot, 3 - the lower pivot sleeve

Analysis of technical maintenance of the rolling stock in the depot of the city of Dnipro noted the low quality and non-compliance of the technical staff with the service regulations. However, even with a high level of maintenance, the cost of the standard bronze bushings and their maintenance is too high for use in this type of transport. In the trolleybus depot number 1 there were cases when the kingpins were self-sharpened in a mechanical shop from pipes or a circular profile. This was a forced production step due to a lack of original spare parts and working capital. However, this did not solve the problem due to the discrepancy of the bronze brand with technical requirements. It should also be noted that the specialists of trolleybus depots used parts made of pure polyamide-6 instead of bronze parts, but it did not give any tangible positive results: they operated under limited lubrication conditions, but after 3200-3,500 kilometers they were required for replacement because of intensive wear. Using the results of

laboratory studies, it can be argued that in these sites, in order to reduce metal consumption and reduce the cost of maintenance, it makes sense to replace the bronze bushings on parts made of a polymer composite material based on aromatic polyamide phenyl-C-1 filled with finely dispersed carbonyl nickel. During the next on-line repair of the trolley buses, metal-polymer experimental parts were installed (see Table 4), which were subsequently operated under normal production conditions. Before testing, the parts were greased with grease. In the future, they did not lubricate. In the process of testing there was not a single failure of the experimental parts, the operation took place in accordance with the regulations.

Table 4. Characteristics of pivot bushes of trolleybuses

№	Марка троллейбуса	Размер, мм			Вес, кг		Количество
		D	d	h	МП	БрАЖ 9-4	
1	ЗИУ	60	46/48	50	0,08	0,38	40
2	ЮМЗ	60	46/48	70	0,10	0,53	24
3	Skoda	60	46/48	57	0,09	0,43	28

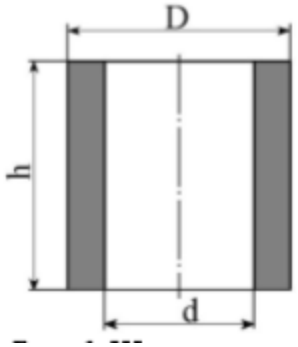

Fig. 6. Pivoting sleeve

According to the test report for the period from 11.04.2016 to 17.10.2016, the run of trolleybuses equipped with experimental details amounted to 21179-23298 km, which is 6 to 7 times the maximum permissible run of bronze bushes. On the day of the technical condition check, it is established that the experimental bushings have little wear: the loopholes in the pivots are insignificant and are within the permissible limits (i.e., less than 0.3 mm). In connection with the technical suitability for operation, the experimental bushings were left to continue testing.

Considering the considerable increase in the durability of metal-polymer pivot bushes, their introduction is able to ensure a saving in the working capital of trolleybus depot No. 1 by at least 2 times, although the cost of these bushings is 3.6 times more than bronze ones. It should be noted that thanks to the offered sizes of bushes it is possible to cover the whole range of repaired ones and to reduce purchases of new pivots. Parts to the repair size are machined using the usual machining methods. Thus, options are offered to replace the serial parts of friction units of trolleybuses from non-ferrous alloys to metal-polymer ones.

4. Conclusions

In the course of research based on heat-resistant polyamide C-1, a number of new metallopolymers with an improved set of characteristics were obtained. It was found that the appearance of metallic fillers in the polymer matrix leads to an increase in hardness by 23-45%, yield strength and proportionality by 11 ± 18 and 23 ± 39%, and Young's modulus by 11 ± 25%. The introduction of Al, Ti, Ni increases the toughness of the compositions. It was found that the least wear in conditions of friction without lubrication is characterized by a metal polymer containing 15 wt. % carbonyl nickel. Industrial tests proved the expediency of using metal-polymer bushes in passenger electric transport instead of bronze ones. It is shown that experimental bushings provide an increase in the range of electric transport in 6 - 7 times.

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THE USE OF RFID TECHNOLOGIES IN PRODUCTION OF POSTAL SERVICE

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Abstract: *RFID is a technology that uses a technique of frequency radio waves to exchange data between the reader (eng. Reader) and a device called tag (eng. Transponder). Tag contains a silicon microchip and an antenna. The antenna emits radio waves and thus sends the data to the microchip that the reader through the entries in the computer. The transponder is on the production and the packaging contains a unique serial number. RFID - technology is mainly used for the identification of packaging products to be transported, stored or periodically enumerated and is a type of electronic 'smart packaging' '(eng. Smart packaging). In order to approach the consideration of the application of RFID in traffic, it is necessary to first see how the system works, which are the basic elements of this technology, and the possibility of application in other systems. This paper presents the basics of RFID technology in terms of product identification in automated postal systems. These are the advantages of this technology as well as disadvantages, with particular emphasis on bar code technology that RFID system needs to succeed in the postal service.*

Keywords: *RFID, Technology, Post, Traffic, Shipment*

1. INTRODUCTION

The idea of introducing the postage stamp is attributed to Lovrenc Kosir, an Austrian clerk (of Slovenian origin) who in 1835 proposed to the Austrian Ministry of Trade the replacement of the postage payment system from the recipient of the shipment by collecting from the sender in order to spread the mail and the possibility of sending the shipment to a wider population.

The idea was also dealt with by James Chalmers, who three years later made the first draft of the postage stamp as we know it today. This proposal was rejected by the Austrian side for the idea to be supported by Sir Rowland Hill, in charge of England's postal reform, which issued the first postage stamp on May 1, 1840, called One Penny Black, which was released on May 6, 1840 (the curiosity is that there is a copy dated May 2, 1840). On the first postage stamp is a portrait of Queen Victoria on a black background and worth one pennies.