



TRIBOLOGICAL PROPERTIES OF PHENOL FORMALDEHYDE COMPOSITE MATERIALS CONTAINING POLY(ETHYLENE TEREPHTHALATE)

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Abstract

New polymeric composite materials based on phenol formaldehyde resol binding agent modified with dispersed poly(ethylene terephthalate), reinforced with cotton fabric, were obtained. The resulting composites exhibit lower friction coefficient and wear upon dry friction on steel than tribotechnical cotton textolites widely used in industry. The polymeric composite material based on phenol formaldehyde resol binding agent reinforced with poly(ethylene terephthalate) fabric was obtained and studied for tribological properties.

Key words: phenol formaldehyde composite, poly(ethylene terephthalate), cotton fabric, friction coefficient, wear.



Introduction

Owing to the prominent tribological properties, polymeric composite materials (PCMs) can function effectively in tribocontact with metal counterbodies, which ensures their wide application in the production of friction components for all types of equipment and devices of mechanical engineering [1]. Plain bearings made of PCMs, when used in extreme conditions, have a number of advantages over metal analogs: they have a lower density, are not subject to corrosion, can operate with or without lubrication, and have a longer service interval.

To produce high-load friction components for various mechanisms, it is preferable to use reinforced PCMs based on thermosetting polymers [2], for example, phenol formaldehyde resins, which are available, have a low cost, high load capacity, and enhanced thermal, wear and chemical resistance.

It should be noted that PCMs based on phenol formaldehyde (PF) binding agents reinforced with cotton fabric have been extensively used for many years as tribological materials in mechanical engineering and other industries [3].

The introduction of fillers in the form of dispersed particles of antifriction polymers into a PF matrix is one of the most effective methods for increasing the wear resistance of PCMs based on PF binding agents [4–7].

Poly(ethylene terephthalate) (PET) is one of the most accessible commercial thermoplastic polymers that features high wear resistance. PCMs based on PF resol binding agents reinforced with PET fabric have proven themselves as useful structural materials [8]. However, there are no literature data on the tribological properties of such materials.

To evaluate the possibility of creating new antifriction PCMs based on thermosetting polymers and thermoplastic fillers, this work was aimed at obtaining the PCMs based on a PF resol binding agent reinforced with two types of fabrics

(cotton and PET), using a dispersed binder modifier or without it, and studying the tribological properties of the resulting PCMs under conditions of dry friction on steel.

Experimental section

The work was concerned with LBS-20 (*GOST* (State Standard) 901-2017) PF resol resin used as a thermosetting binding agent and MOST (art. S-M/002-94) and PET (*TU* (Specifications) 8378-004-00319285-96) fabrics of Maltsevoteks production used as reinforcing fillers.

The dispersed PET modifier was obtained by cryogenic grinding of ECOPET-64 granules (EKOPET) in liquid nitrogen.

The prepreps were obtained both by impregnating the PF fabrics with the binding agent without a dispersed modifier and by impregnating the PF fabrics with the binding agent containing the dispersed PET modifier (PET powder was introduced into the PF resin diluted with ethanol).

The PCM samples were manufactured by the direct compression molding of the prepreps ($T = 160\text{ }^{\circ}\text{C}$, $P_1 = 300\text{ kgf/cm}^2$, holding time $\tau = 1\text{ min/mm}$ of sample thickness, binding content 40 wt %).

Three types of the reinforced PCMs based on the PF resol binding agent were obtained: 1) PCM reinforced with cotton fabric (PCM-C-fabric) (for comparative tribological tests); PCM reinforced with PET fabric (PCM-PET-fabric); PCM based on the PF resol binding agent modified with dispersed PET and reinforced with cotton fabric (PCM-PET(d)-C-fabric).

The friction tests of the resulting PCMs were carried out on an I-47 end friction machine (Russia) using a three-ball steel counterbody (CT) at $P_1 = 10.00\text{ MPa}$. The samples were tested at a rotation speed of 0.5 m/s for 60 min. The mass wear of all the samples was determined on an analytical balance with an accuracy of 0.0001 g.

Results and discussion

The investigations of the tribological properties of PCM-PET fabric (Fig. 1, curve 3, Table 1) revealed that the friction coefficient and wear of the material during the steady-state friction (after 35 min of run-in) are significantly lower than those of PCM-C-fabric.

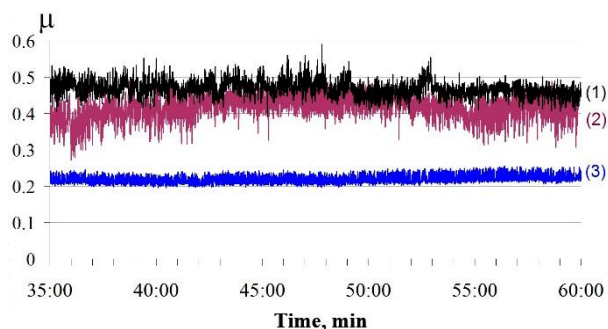


Figure 1. Frictional dependences of PCM-C-fabric (1), PCM-PET(d-10 wt %)-C-fabric (2), and PCM-PET-fabric (3).

The modification of the PF resol binding agent with dispersed PET improved the tribological properties of the PCMs. In the case of PCM-PET(d)-C-fabric, a decrease in the friction coefficient of the samples with an increase in the content of the PET modifier in the binding agent was observed (Table 1).

Table 1. Tribological characteristics of the PF-based PCM samples

PF-based PCM composition	μ_{av}	I, mg
without a modifier, cotton fabric	0.48	8.7
1 wt %, ^a cotton fabric	0.51	7.6
3% wt %, ^a cotton fabric	0.37	6.5
5% wt %, ^a cotton fabric	0.34	8.7
7% wt %, ^a cotton fabric	0.41	5.0
10% wt %, ^a cotton fabric	0.40	3.5
without a modifier, PET fabric	0.22	1.1

^a content of the dispersed PET modifier in the PF binding agent for the resulting PCM samples.

Upon friction of PCM-PET(d)-C-fabric (Fig. 1, curve 2, Table 1), the best tribological characteristics were achieved with a content of the dispersed PET modifier in the PF binding agent of 10 wt %.

Conclusions

The polymeric composite materials based on the PF resol binding agent containing PET as an antifriction modifying dispersed additive and reinforced with cotton fabric were obtained for the first time; the effect of the modifier content on the tribological properties of the resulting PCMs was elucidated.

The tribological tests with a three-ball counterbody showed that the PCM sample reinforced with PET fabric features a minimum value of the friction coefficient. The PCMs obtained in this work surpass the known PCMs based on the PF resol binding agent reinforced with cotton fabric in their tribological properties.

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