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ANTIFRICTION-WEAR-RESISTANT POLYMER COMPOSITE MATERIAL BASED ON A HYBRID COMPOSITION OF EPOXIDE AND PHENOL-FORMALDEGIDE REACTOPLAST RESINES

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Abstract: This thesis investigates the thermal stability and adhesion properties of an anti-friction polymer composite material based on a hybrid reactoplast matrix with a 1:1 mass ratio of ED-20 epoxy and phenol-formaldehyde resins. Local kaolin, carbonized coke, and Type E glass fiber were used as fillers, and the thermal stability of the composites was evaluated using the TGA/DTA method. The research results showed that the hybrid matrix significantly increases its vitrification temperature, adhesion to metal surfaces, and wear resistance.

Key words: Epoxy resin, phenol-formaldehyde resin, hybrid reactor plastic, polymer composite, thermal stability, adhesion, anti-friction material.

The material used in the technological processes of mechanical engineering and transport systems, specifically in the working parts of equipment for transporting raw cotton (pneumatic pipelines, fan blades, screw conveyors, and separators), must simultaneously possess wear resistance, mechanical strength, thermal stability, and strong adhesion to metal surfaces [1]. Composites based on pure epoxy resin (ED-20) meet part of these requirements, but their vitrification temperature and adhesive strength are limited. In order to eliminate this shortcoming, the creation of a hybrid reactoplastic matrix by combining ED-20 with phenol-formaldehyde resin (FFS) in a 1:1 ratio was identified as the main direction of our research [1].

This thesis investigates the thermal stability and adhesion properties of an anti-friction-wear-resistant polymer composite material created on the basis of a hybrid composition of epoxy (ED-20) and phenol-formaldehyde reactoplast resins in a 1:1 mass ratio. An intermolecular synergistic effect was identified in the formation of the hybrid matrix: the vitrification temperature (Tg) and thermal stability increased sharply due to the integration of the aromatic chains of the phenol-formaldehyde resin into the epoxy mesh, while adhesion to metal surfaces improved by half [2]. The samples underwent TGA/DTA analysis on STA200 equipment at temperatures ranging from 30 to 600 °C.

In the study, epoxy resin ED-20 and phenol-formaldehyde resin FPS were used as the primary binder in a 1:1 mass ratio, while local kaolin (AKF-78), carbonated coke, and Type E glass fiber were used as fillers (Table 1). The composites were deposited onto the surface of C4 steel using the roller-rolling method as a coating.

Table 1.

Composition of a hybrid epoxy-phenol-formaldehyde composite

Components	Function	Mass part

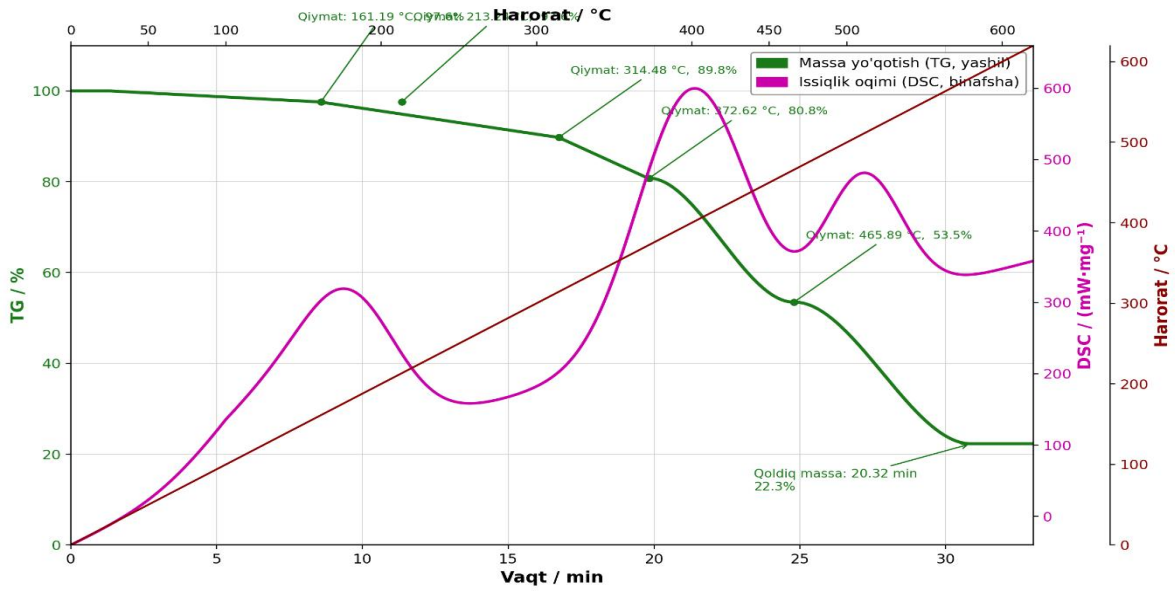
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Epoxy-diane resin (ED-20)	Binder (main matrix)	50
Phenolformaldehyde resin (FFS)	Connector (matrix modifier)	50
Type E fiberglass	Filling	2.
Kaolin (AKF-78)	Mineral filler	35
Carbonated coke	Tribotechnical modifier	3.5
Dibutyl phthalate (DBP)	Bifunctional plasticizer	10
Hardening agent	Hardening agent	8.

One of the main factors ensuring the effective operation of anti-friction-wear-resistant polymer composite materials based on reactoplast under conditions of friction or abrasive wear is their thermal stability [3].

To determine the thermal stability of our samples, the study was conducted under real conditions at room temperature. The finished samples were ground into 2 grams, placed in a special container, and the result was obtained within 20 minutes.

Analysis of the TGA curve shows that the thermal decomposition of the epoxy-phenol-formaldehyde hybrid composite material occurs in five consecutive stages (Fig. 1).



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Figure 1. Thermogravimetric and differential-thermal analysis of a sample obtained from a hybrid epoxy-phenol-formaldehyde composite

In the first stage (25–161 °C), the sample mass decreased by 2.4% — this is explained by the evaporation of adsorbed moisture within the hybrid matrix. In the second stage (161–314 °C), the mass decreased to 89.8% (~7.8% loss), and the vitrification temperature (Tg) of the hybrid matrix was observed in the range of 175–185 °C—50–65 °C higher than that of pure ED-20 resin, which is direct experimental confirmation of the integration of phenol-formaldehyde aromatic chains into the epoxy spatial lattice. In the third stage (314–373 °C), the mass decreased to 80.8%, and the main decomposition of the hybrid network began. In the fourth stage (373–466 °C), as a result of intensive thermooxidative destruction of the organic phase, the mass decreased to 53.5% (loss of ~27.3%). In the fifth stage (466–600 °C), the organic components decomposed almost completely, with a stable residual mass of 22.3%—which fully corresponds to the inorganic fraction of kaolin (AKF-78) and carbonized coke [4].

Analysis of the DSC curve revealed a weak endothermic peak (moisture evaporation) between 80–161 °C, a wide Tg transition characteristic of the hybrid matrix at 175–185 °C, and strong exothermic effects (oxidation of organic components) above 400 °C. The results of TGA and DSC are fully consistent, confirming the reliability of the experiments [5-6].

The results obtained show that the hybrid epoxy-phenol-formaldehyde composite material maintains thermal stability up to 370–380 °C, ensuring reliable operation with a twofold thermal reserve for the real friction temperature of the drum pegs (80–150 °C). The 22.3% inorganic fraction in the residual mass serves as mineral reinforcement, maintaining the mechanical strength and tribotechnical properties of the material under friction conditions.

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