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RESEARCH OF RHEOLOGICAL PARAMETERS AND SELECTION OF COMPOSITIONS FOR APPLICATION ON WORKING SURFACES OF STRUCTURAL MATERIALS OF LARGE TECHNOLOGICAL EQUIPMENT

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Abstract
The effect of rheological properties on the structure formation of heterocomposite polymer coatings obtained by the activation-solar technology has been studied. The influence of the required content of the structure -forming component and the thermal effect of solar energy on the rheological properties of heterocomposite materials and coatings has been established due to a change in the viscosity of the polymer mixture, which contributes to an increase in fluidity, providing a more uniform distribution of the molecules of the structure-forming components and the orientation of their functional groups.

Keywords : kaolin , aggressive environment , corrosion resistance , coatings, composites materials , protective ability .

1. Introduction
There are various types of natural mineral raw materials in the republic, the reserves of which are practically inexhaustible; in this regard, special attention is paid to the processing and use of minerals such as kaolin, wollastonite, bentonite, etc. Along with this, research and applied work is also being intensified, both abroad and in our republic, on the processing and use of mining waste.

Particular attention is paid to nanocomposites. Due to a number of their functionally important properties, they are widely used in various sectors of the world economy.
In the numerous range of components used in materials science and technology of composite materials for functional coatings, a special role is played by nanodispersed fillers and modifiers obtained from various semi-finished products, including natural ones. The relative availability of mineral raw materials, which is often a technological waste from the production of building products, metal structures, mineral fertilizers, etc., along with the effective modifying effect of finely dispersed rock particles, determines its extensive use in practical materials science.
The modern use of the features of the structure, composition and energy state of finely dispersed mineral particles, including nanosized ones, indicates a specific mechanism of their modifying action in matrices of various compositions, especially with polymeric, oligomeric and combined ones.
However, the existing traditional grinding and purification technologies do not fully provide the possibility of obtaining finely dispersed high-quality mineral fillers in the development of multifunctional composite materials. In this regard, the development of an effective technology for obtaining new composite materials based on the study of their chemical, physicochemical, rheological, mechanical, operational properties to obtain high-quality competitive multifunctional composite materials based on local raw materials is relevant.

2.Methods

Based on the analysis of research on the creation and application of polymeric materials and coatings from them, taking into account the purpose and objectives of the dissertation work, polymeric binders and structure-forming components for cold curing were selected for study and further application (Table 1), which ensure the use of the activation-heliotechnological method in modification thin-layer heterocomposite coatings for complex configuration and large-sized technological and machines.

Table 1 Materials selected for research

№	Material name	GOST or TU	Note
1	Epoxy resin (ED-20)	GOST 10587-72	thermosetting binder
2	Dibutyl phthalate (DBP)	GOST 8728-76	plasticizer
3	Gossypol resin (GS)	O zDSt86-38 :2001	Structure builder
4	Polyethylenepolyamine (PEPA)	TU 6-02-594-70	Hardener
5	Kaolin grades: AK F-78, AKC -30, AKT-10)	O'z DST 1056:2004	Filler (d ≤20 μm)

Binder ED-20 is one of the most technologically advanced oligomeric binders for producing potting compounds and coatings from them by cold curing, has fairly high physical and mechanical properties, especially adhesive strength to steel surfaces, which is important to ensure the required operational reliability [1, 2-3]. In this regard, this oligomer was chosen by us for research on the development of heterocomposite materials.

common aliphatic was used as a hardeneraminn - polyethylenepolyamine (PEPA), which allows to reduce the compressive strength of the material.

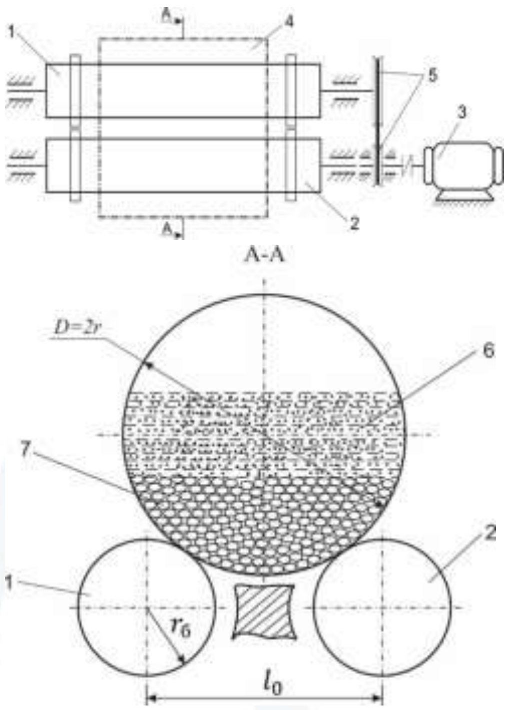
Epoxy resins cured with amines have a dense heterogeneous structure with a globule size of about 100 nm. The size of the globules, depending on the composition of the composition and curing conditions, increases with increasing temperature. The density of the cured compositions decreases with decreasing globule size. The interglobular space is filled with an amorphous phase with a reduced density.

The use of hardeners containing aromatic cycles makes it possible to obtain more heat resistant materials. Curing with aromatic amines is carried out at an elevated temperature, so the final product has a higher glass transition temperature. Compositions cured with aromatic amines are characterized by increased resistance to aggressive media, high modulus of elasticity and compressive strength. However, the need for curing at an elevated temperature complicates the process of manufacturing materials from them (at room temperature, curing lasts 2–3 days, but the products are extremely brittle and have a low softening temperature), and high strength characteristics are offset by brittleness and low fracture toughness. To prevent this phenomenon in our studies, an inert plasticizer-dibutyl phthalate (DBP) was used and a structure -forming agent - gossypol resin (GS) with an equal content of 10 wt.h. relative to binder ED-20

The use of available raw materials - gossypol resin makes it possible to obtain polymers based on epoxy and nitrogen-containing compounds. The gossypol resin molecule contains an aromatic nucleus, which gives it high thermal and chemical stability.

For laboratory studies in control samples, liquid compositions based on ED-20 were applied to the previously degreased surface of the sample using a spray gun, spatula and brush by dipping or pouring. The required amount of resin was heated to 60-80 °C to remove air bubbles from the polymer mass, then at a temperature of 50-60 °C, dibutyl phthalate (DBP) plasticizer or structure-forming gossypol resin (GS) was added with thorough mixing. If necessary, pre-defatted and dried filler was added. At the very end, before application, at room temperature, the hardener - polyethylenepolyamine (PEPA) was added in small portions.

To obtain a high-quality coating, the samples were rotated on a special stand for 0.5 - 1 hour at room temperature. Further, epoxy composites were cured at a temperature of 110-120°C for 1 hour in laboratory studies.
Improving interstructural interactions during the structure formation of materials obtained from different- phase systems is possible using various activation methods, one of which is mechanical activation . (Fig.1) .

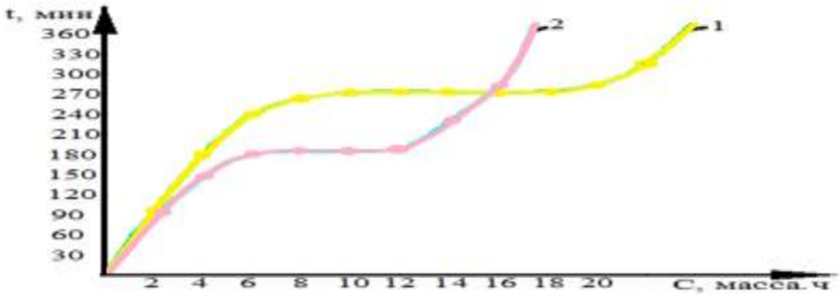


1-leading drum; 2-driven drum; 3-electric motor; 4 – cylindrical vessel; 5-belt transmission; 6-polymer and mineral activated components; 7-ball-like natural mineral stones.

Fig. 1. Scheme of a mechanoactivator using systems of running drums and a cylindrical vessel.

The process of structure formation of coatings is affected by the rheology of polymers, which depends on the gelation process and characterizes the period of viability of the polymer compound . In the manufacture of structures and products or the application of coatings from heterocomposite materials, one of the main technological factors is the time interval from the moment the compound is prepared to its gelation.
Figure 2 shows the results of our studies of the dependence of the gelation time (t, min) from the content of DBP and GS 2) (wt.h). The experiments were carried out in the conditions of the city of Tashkent at an ambient temperature in the shade of 30 ± 2 and in an open area of 42 ± 2 °C. The intensity of natural solar radiation is 710-750 W/m ^{2}.
As can be seen from the figure , the most stable values of the gelation time are observed in compounds containing DBP in the range of 10 ÷ 20 wt.h. at a gelation time of 270 minutes and in compounds containing HS within 6÷12 wt.h. at a gel time

of 180 minutes. A further increase in the content of DBP and HS leads to a decrease in the time of gelation of different intensity and deterioration of the technological properties of the heterocomposite material. In order to study in more detail the effect of rheology on the structure formation of compounds of heterocomposite materials, IR spectroscopic studies were carried out (Fig. 2).



1-DBF, 2-GS

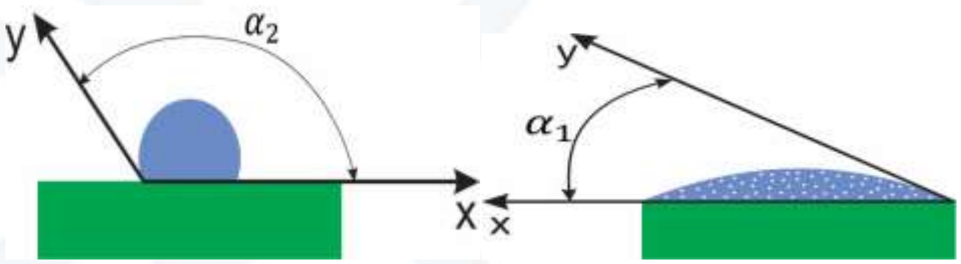
Rice. 2. Gelation time dependence (t, min) on the content of structure-forming components of polymer mixtures.

The study of the process of wetting a mechanically activated filler with a polymer binder showed that the mechanochemical modification of the heterocomposite system "binder-filler" increases the wettability of the filler by 25-30%. The most effective is the content of HS equal to 6-14 wt.h. (Fig. 3).

Improved wetting of kaolin fillers with epoxy resin in the presence of HS is explained by the following reasons:

the modifier reduces the internal energy of the binder and promotes the formation of stable ionic bonds between macromolecules of the epoxy oligomer and metal cations (Fe^{+3}, Al^{+3}, Si^{+4}, etc.) formed during the mechanical activation of the filler;

adsorption interaction is also enhanced due to surface diffusion and migration of molecules of the modified epoxy oligomer and activated kaolin filler. This, apparently, improves the contact at the "filler - binder" - "epoxy resin - kaolin" phase boundary (Fig. 3).



a) b)

a) not modified; b) mechanically activated and modified HS;

Fig. 3. Scheme of the wetting surface of filler particles:

Structural modifier was introduced into the binder in the amount of 6-12 parts by weight , while increasing the viscosity of the heterocomposite mixture, a solvent was used. Acetone was used as a solvent , in which the initial components were well dissolved. The amount of hardeners was 10-12 wt. hours per 100 wt. hours of film former. The curing kinetics was studied by the content of the gel fraction by extracting the sol fraction with acetone.

Based on our research and the experimental data obtained, we applied Newton's formula, which has the following form:

$$P_n(x) = y_0 + \frac{\Delta y_0}{1!h}(x - x_0) + \frac{\Delta^2 y_0}{2!h^2}(x - x_0)(x - x_1) + \ldots + \frac{\Delta^n y}{n!h^n}(x - x_0)(x - x_1)\cdots(x - x_{n-1}) \quad (1)$$

We use this formula as one of the possible forms of writing an interpolation polynomial of the second degree and get

$$P_2(x) = y_0 + \frac{\Delta y_0}{1!h_0}(x - x_0) + \frac{\Delta^2 y_0}{2!h_1^2}(x - x_0)(x - x_1) \quad (2)$$

Based on the results of experimental studies for all compositions, the following regression equation was obtained:

$$P_{i,(i=1\div10)} = 0.625x^4 - 17.06x^3 + 152.1x^2 - 397.7x + 805 \quad (3).$$

Based on the study of factors affecting the rheology of coating formation, we have optimized the compositions of heterocomposite materials .

Table 1 Compositions of heterocomposite materials recommended for use on the working surface of large-sized and complex configuration equipment

Compositions and components of heterocomposite materials										
Components	GKTL-1	GKTL-2	GKTL-3	GKTZ-1	GKTZ-2	GKTZ-3	GKSZ-1	GKSZ-2	GKSZ-3	GKSZ-4
ED-20	100	100	100	100	100	100	100	100	100	100
PEPA	12	12	12	12	12	12	12	12	12	12
HS	6	8	10	8	10	12	6	8	10	12
ACT-10	25	25	25	30	30	30	-	-	-	-
AKS-30	-	-	-	-	-	-	15	15	10	10
Note: GKTL-1 - heterocomposite materials with AKT-10 filler for surface coatings of sheet structural materials, GKTZ - heterocomposite materials with AKT-10 filler for casting materials of complex configuration parts; GKSZ - heterocomposite materials with filler AKS-30 for casting materials of complex configuration parts										

3.Conclusions

On the basis of the study of the rheology of polymer mixtures of HCM (heterocomposite materials), the influence of the required content of the structure-forming component on the viability was revealed to ensure a uniform coating thickness on the working surfaces of complex- configuration and large-sized parts of technological equipment. It is proposed that for anti-friction coatings on working surfaces for complex configuration technological equipment, it is advisable to use the compositions GKTZ-1, GKTZ-2, GKTZ-3 and GKSZ-1, GKSZ-2, GKZS-3, for coatings of sheet materials GKTL-1, GKTL-2, GKTL-3 fluidity is better due to the relatively low viscosity, depending on the type and composition of the components.

It has been established that with an increase in the filler content, the value of both f and δ_0 decreases, which is explained by a decrease in the surface roughness parameters of the coatings and an increase in mechanical properties.

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