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Investigation of the Influence of the Type and Quantity of Structure-Forming Modifiers on the Properties of Heterocomposite Polymer Mixtures used in Railway Transport

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Abstract: This article describes the experience of using modern polymer composite materials, as well as the influence of the type and amount of structure-forming modifiers on the properties of heterocomposite mixtures used in the railway industry.

Keywords: heterocomposite polymer materials, epoxy resin, dibutylphtholate, rheology, viscometer, gel formation, kaolin, filler.

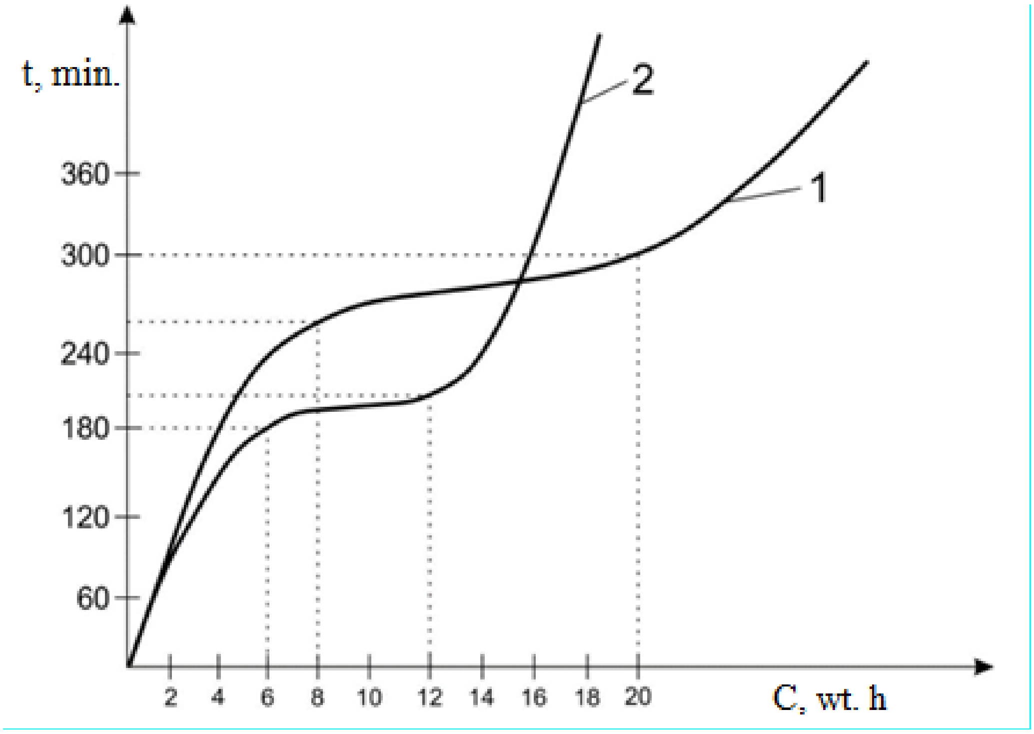
Introduction. Modern polymer composites, as well as structures and products from them, are widely used throughout the world in the construction of transport infrastructure facilities due to a number of advantages compared to traditional materials, the key ones being: high strength, corrosion resistance and low specific gravity. At the same time, at present, on the component parts of machines and devices used in mechanical engineering, aerospace, chemical, oil and gas, and railway industries, to increase reliability, research is being conducted to study the mechanism of the rheological properties of the composition during the formation of interphase structures, as well as the relationship between structural properties and nature of the surface in heterogeneous systems when producing multifunctional heterocomposite coatings from organomineral materials[1-3].

Objects and methods of research. Rheological properties, depending on technological properties, are the deformation properties of melts of polymer materials and the nature of their flow under the influence of external forces, i.e. when large irreversible deformations develop in melts. Rheology is a key characterization technique for developing materials with desired physical properties and for controlling the manufacturing process to ensure proper product quality [4].

Polymer binders and structure-forming components were taken, which do not ensure the use of the activation-solar technology method for modifying heterocomposite coatings for sheet and complex-configuration technological equipment, taking into account their rheological properties [5]. We used the thermosetting oligomer ED-20 as a binder, the choice of which is due to its high manufacturability for producing coatings on the surface of large-sized technological equipment. The most common aliphatic amino polyethylene polyamine (PEPA) was used as a hardener, which makes it possible to reduce the compressive strength of the material [6].

Results and discussion. The use of available raw materials - gossypol resin as a structure former - makes it possible to obtain polymers based on epoxy- and nitrogen-containing compounds. Currently, in Uzbekistan, the Angren-Kaolin LLC enterprise in the Angren district of the Tashkent region produces enriched kaolin of the AKF-78, AKC-30, AKT-10 grades, which are widely used in various economic sectors of the Republic of Uzbekistan (Table 1). The brands of kaolins AKF-78, AKC-30, AKT-10 were chosen for the study. The mineral kaolinite with the general composition $Al_2Si_2O_5(OH)_4$ (or written in terms of oxides: $Al_2O_3\ 2SiO_2\ 2H_2O$) is the main component of kaolin (>98%). The kaolinite mineral is composed of successive alumina octahedral and silicon tetrahedral sheets that form a common plane of oxygen atoms.

Figure 1 shows the dependence of the gelation time (t, min) on the content of DBP and GR (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 open areas of 42 ± 2°C. Intensity of natural solar radiation 710-750 W/m^2.



1-DBP, 2-GR

Fig. 1. Dependence of the gelation time (t, min) depends on the content of structure-forming components of polymer mixtures.

As can be seen from the figure, the most stable values of gelation time are observed in compounds containing DBP in the range of 10–20 parts by weight. with a gelation time of 270 minutes and in compounds containing GR in the range of 6÷12 parts by weight. with a gelation time of 180 minutes. A further increase in the content of DBP and GR leads to a decrease in the gelation time of varying intensity and a deterioration in the technological properties of the heterocomposite material.

A study of the fluidity of heterocomposite mixtures based on various grades of kaolin, which have a significant impact on the rheological and technological properties, is given in Table. 1.

Table 1. Time and confluence variation which characterizes the viscosity of heterocomposite mixtures depending on the type and content of the filler and the number of structures of the GR educator

№	Compositions	Flow time (t, s) with the content of structurant GR (wt. h)				
		Without GR	6	8	10	12
1	ED-20	160	250	265	282	300
2	EDC+10 mah AKT-10	220	2301	235	240	255
3	EDC+20 wt. h AKT-10	334	325	340	354	373
4	EDC+30mh AKT-10	355	365	375	380	383
5	EDC+10 wt. h. AKC-30	465	450	465	479	495
6	EDC+20 wt. h AKC-30	645	535	554	576	695

7	EDC+30mass. h AKC-30	680	790	810	814	820-8
8	EDC+10 mah AKF-78	721	850	895	--	-
9	EDC+20 mah AKF-78	813	-	-	-	-
10	EDC+30 wt. h. AKF-78	910	-	-	-	-
Note: the nozzle diameter is 6 mm, the ambient temperature is T=25ºC						

From the results obtained it is clear that in heterocomposite mixtures containing 20 and 30 parts by weight of AKF-78, when modified with the GR structure-forming agent, the mixture did not pass through the viscometer nozzle due to a sharp increase in viscosity. The expiration time of a heterocomposite mixture containing 10 parts by weight. AKF-78 modified 6-8 wt. h. GR was 850 and 895 s. respectively.

Similar results were obtained with the AKC-30 filler, where at a filler content of 30 wt. h. and a modifier content of 12 wt. h. GS mixture also did not pass through the viscometer nozzle. Change in the fluidity of a heterocomposite mixture containing AKC-30 in amounts of 20 and 30 parts by weight. modified GR in an amount of 6-12 parts by weight. showed high viscosity values exceeding the limit of 700 mm^2/t according to GOST 9070-75.

Thus, based on experimental studies, we can conclude that from a technological point of view of structure formation of heterocomposite mixtures, compositions with AKT-10 fillers in an amount of 10,20,30 parts by weight are suitable. and AKC-30 in the amount of 10 parts by weight of modified GR. Based on the study of factors influencing the rheology of coating formation, we selected the compositions of heterocomposite materials for coatings (Table 2).

Table 2. Compositions of heterocomposite materials recommended for use on the surface of large and complex configuration equipment

Components	Compositions of heterocomposite materials									
	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
PETA	12	12	12	12	12	12	12	12	12	12
GR	6	8	10	8	10	12	6	8	10	12
AKT-10	25	25	25	30	30	30	-	-	-	-
AKC-30	-	-	-	-	-	-	15	15	10	10
Note: GKTL-1 -heterocomposite materials with AKT-10 filler for covering sheet materials, GKTZ - heterocomposite materials with AKT-10 filler. AKT-10 filler for filling materials of complex configuration parts; GKSZ-heterocomposite materials with AKC-30 filler for filling materials of complex configuration parts										

Table 2 shows the results of studies of the main physical and mechanical properties of the developed compositions. It can be seen that the compositions satisfy the basic strength and mechanical properties. In particular, the compositions GKTL-1, GKTL-2, GKTL-3 can be recommended for use on the surfaces of sheet materials for the manufacture of large-sized products, and the compositions GKTZ-1, GKTZ-2, GKTZ-3 and GKSZ-1, GKSZ-2, GKZ-3 are intended as protective multifunctional coatings for complex configuration technological equipment used for transportation of various abrasive and bulk media.

Conclusion. Based on 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 to ensure a uniform coating thickness on the working surfaces of complex and large-sized parts of technological equipment is revealed. It is established that the thermal effect of solar energy allows you to adjust the rheological properties by changing the viscosity of the polymer mixture, contributes to an increase in fluidity, which ensures a more uniform distribution of molecules of structure-forming components and the orientation of their functional groups.

REFERENCES.

1. Ziyamukhamedova, U., Rakhmatov, E., & Nafasov, J. Optimization of the composition and properties of heterocomposite materials for coatings obtained by the activation-heliotechnological method. In Journal of Physics: Conference Series, 2021; 1889(2): 022056. 31.
2. Miradullaeva, G., Rakhmatov, E., Bozorov, O., Ziyamukhamedova, U., & Shodiev, B. Mathematical modeling of rheological properties during structure formation of heterocomposite potting materials and coatings and their application. In International Scientific Conference on Energy, Environmental and Construction Engineering, 2021: 346-355, Springer, Cham
3. Ziyamukhamedova, U.A, Miradullayeva, G.B, Rakhmatov, E.A, Nafasov, J.H, & Inogamova, M. (2021). Development of The Composition of a Composite Material Based On Thermoreactive Binder Ed-20. Chemistry And Chemical Engineering, 2021(3)
4. Ziyamukhamedova, U.a, Rakhmatov, E.A, & Nafasov, J.H. (2021, April). Optimization of the composition and properties of heterocomposite materials for coatings obtained by the activationheliotechnological method. In Journal of Physics: Conference Series (Vol. 1889, No. 2, p. 022056). IOP Publishing.
5. Ziyamuxamedova, U. A., Miradullaeva, G. B., & Nafasov, J. H. (2022). Study of the phase composition of products of mechanochemical interaction in Ta+C systems. Innovative Technologica: Methodical Research Journal, 3(06), 61-67.
6. Reva V.P., Onishchenko D.V., Chakov V.V., Voronov B.A. Mekhanokhimicheskiye protsessy, soprovozhdayushchiye dispergirovaniye metalla v prisutstvii vysokomolekulyarnogo soyedineniya // Doklady Akademii nauk. 2012 T. 445 № 6 S.