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DEVELOPMENT OF COMPOSITIONS AND RESEARCH OF METHODS FOR INCREASING THE STRENGTH PROPERTIES OF ORGANOMINERAL THERMOPLASTICS

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Abstract. *In this article presented the results of a study on improving the mechanical properties of composite materials based on polyethylene. A composition materials filled with a thermoplastic polymer - polyethylene modified with a kaolin-graphite filler is proposed, which will allow obtaining high-quality products based on local raw materials, simplifying the material composition, and expanding their performance due to improved strength and tribotechnical properties. On the basis of the studies carried out, pipes for the branch parts of oil collection tanks were obtained, which were tested under production conditions.*

Keywords: *polyethylene, organo-mineral material, filler, kaolin, graphite, coefficient of friction.*

Annotatsiya. *Ushbu maqolada polietilen asosidagi kompozit materiallarning mexanik xususiyatlarini yaxshilash bo'yicha tadqiqot natijalari keltirilgan. Termoplastik polimer – kaolin-grafit plomba moddasi bilan modifikatsiyalangan polietilen bilan to'ldirilgan kompozitsion materiallar taklif etilmoqda, bu mahalliy xomashyo asosida yuqori sifatli mahsulotlar olish, material tarkibini soddalashtirish va mustahkamligi va tribotexnika xususiyatlarini yaxshilash hisobiga ularning ish faoliyatini kengaytirish imkonini beradi. . O'tkazilgan tadqiqotlar asosida ishlab chiqarish sharoitida sinovdan o'tgan neft yig'ish tanklarining filial qismlari uchun quvurlar olindi.*

Kalit so'zlar: *polietilen, organo-mineral material, plomba, kaolin, grafit, ishqalanish koeffitsienti.*

Introduction. Nowadays using of materials based on thermoplastics is becoming increasingly important due to the development and growth of the industry for the synthesis of hydrocarbon raw materials. Here it is important to emphasize that polymer-based materials are also used in the petrochemical industry for various purposes. The use of various transport pipes made of composite materials quite satisfactorily replaces steel pipes, which are currently the main transport type for the delivery of hydrocarbon raw materials. It is important that when transporting hydrocarbons through steel pipelines, there are problems associated with corrosion of both the internal and external walls of pipelines that occur under the action of hydrogen sulfide, salt water, carbon dioxide and various acids, which lead to significant capital costs due to corrosion.

The use of pipes based on polymeric materials is relevant due to the low cost, lower operating costs, as well as environmental friendliness, which is relevant in the oil and gas industry.
Currently, research is being developed in the field of developing compositions of polymer reinforced pipelines [1-5], these developments have found wide application in foreign and domestic practice.

During the operation of pipes made of thermoplastics, a number of problems arise as a result of dynamic loads that cause pipe deformation. One of the solutions to this problem is to enhance their mechanical properties in order to provide the required performance characteristics, which is achieved in many cases by developing compositions of polymeric materials using mechano-chemically modified dispersed and reinforcing fillers. [6-8].

As filler can be used mica, carbon black, graphite, silica gel, tuff, calcite, cement, basalt, oxide or hydroxide. Relevant is research aimed at the use of electrically conductive dispersed fillers obtained from industrial waste, which are used in other materials [9-14], where research is conducted at more fundamental levels. [11-13].

One of the problems in obtaining composite materials is the creation of materials with an optimal structure that provides a balance between hardness and durability. Modern methods of modification in the production of composite materials make it possible to obtain the desired compositions, taking into account their performance characteristics.

Methods and materials. To obtain a modified filler, in addition to kaolin, natural minerals such as talc, mica, quartz, etc. can be used, which makes it possible to reduce the cost of the composite material. Kaolin is a light-colored clay rock, oily to the touch, with a bulk density of 1.8-2.2 g/cm. By its properties, it is a filler. Traditionally used to increase chemical resistance and strength. We propose the use of Angren kaolin grade AKS-30, fineness up to 100 microns. The studies carried out in this direction have shown the relevance of choosing the type and amount of this filler, depending on the purpose and operational characteristics of technological equipment. [6-9, 15,16]

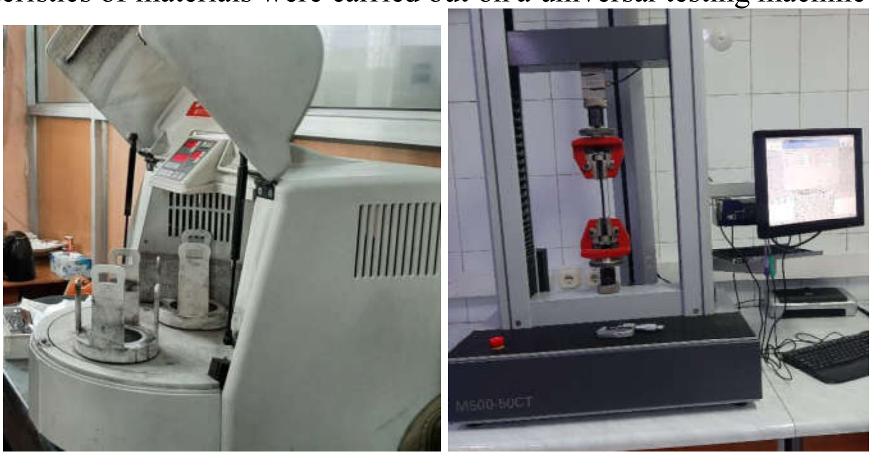
Silver scaly graphite (GOST 558-82) has the form of plates or leaves that have a metallic sheen, greasy, stains hands, specific weight 1.9-2.6 g/cm3. Chemically inert. It has high tensile strength and modulus of elasticity. In mechanical engineering, it is used as an antifriction material for friction units.

Polyethylene is used as a plastic material, high density HDPE grade P-Y342 according to Ts 17642168 -05:2014, while polyethylene grade I- 0525 is used for plasticizing soot in order to ensure homogenization of the process.

Modification of the crushed natural mineral together with silver flake graphite is carried out within 3-5 minutes on modern ultradispersion plants, providing particle size from several nanometers to 1-2 m/km. The thus obtained modified mineral-graphite filler is introduced into the polymer matrix in a given ratio and a filled polymer with desired properties is obtained.

A thermoplastic polymer, polyethylene, is used as a polymeric binder, and a modified filler is used in an amount of 15-19 wt. % mixture consisting of a calculated amount in relation to the polymer matrix, silver flake graphite (1-5 wt.%) and kaolin (13-15 wt.%), processed in a simpler and less energy-intensive way - mechanical activation, that is, simultaneous mixing and grinding to nanoparticles of components, in which there is an enhanced synergistic effect, leading to improved structure formation.

To obtain a modified filler, the natural mineral kaolin from the Angren deposit was taken with a dispersion of up to -100 m / km, and preliminary dispersion was carried out in standard mechanical mills or modern productive ultra-dispersant activators. In our case, mechanical activation in the laboratory was carried out on a planetary ball mill (Fig. 1.). Studies of the mechanical characteristics of materials were carried out on a universal testing machine (Fig. 2).



a b

Fig.1. Instruments for research: a-High speed planetary mill; b-Universal testing machine M500-CT50

Results and discussion

The aim of our research was to improve the physical mechanical and operational properties of polymer compositions, such as strength and relaxation stability, by improving structure formation in the process of their preparation and to reduce the cost of composite materials through the use of local raw materials.

Our use of a thermoplastic polymer as a matrix in the composition, in combination with the introduction of a mechanically activated composition of kaolin and graphite, led to the performance of a new function, i.e., obtaining a new set of features - an increase in strength and relaxation stability, by increasing the rigidity of the material due to improved intermolecular interaction "filler-matrix", providing a minimum and stable value of the friction coefficient, which is one of the main performance indicators, expanding the scope of structural materials from organic mineral components operated in various [7,8], including abrasive conditions, which made it possible to obtain new the quality of the composite material, which corresponds to the task and may be sufficient to state the significant difference between the proposed solution and the known one.

Depending on the properties of the natural mineral and the fineness of its particles, dispersion can also be carried out in several stages with different dispersion times, until a nanosized mineral mass is obtained. After that, the required amount of ultradispersed mineral mass is taken and dried in laboratory ovens with a heating temperature of 150–200°C until moisture is completely removed from the dispersed mass according to the procedure [17] using measuring instruments of a given accuracy according to [18].

At the same time, the higher the content of nanosized particles in the crushed product, the better for the structure formation of the modified filler [13, 16].

The finely dispersed mass obtained in this way was sent for further modification by mechanical activation together with silver flake graphite in specified mass ratios to a high-speed planetary mill, where particles are split, abraded and mixed for 30 min with full structure formation and an increased synergistic effect.

To modify the above mineral colin, the most effective was the use of flake silver graphite [19], which, due to its lamellar structure, is very well crushed and mixed with a natural filler - kaolin, thus creating a homogeneous, crushed to nanosize, mixture during mechanical activation. Then, the above kaolin-graphite modified filler is introduced in a given ratio into a polymer matrix, for example, polyethylene, and a filled polymer is obtained in an injection molding machine or by another acceptable known method.

In the case of using high density polyethylene (HDPE), the modified kaolin-graphite filler was mixed with polyethylene powder, then homogenized and fed into the injection machine.

Under laboratory conditions, the mineral-graphite filler modified in a high-speed planetary mill (Fig. 1) together with a polyethylene matrix is mixed in microrollers at a temperature of 120±5°C in the case of low-density polyethylene (LDPE) or at a temperature of 135±5°C in the case of HDPE (high density). Photos of the obtained samples for mechanical properties test tests are shown in Figure 2.

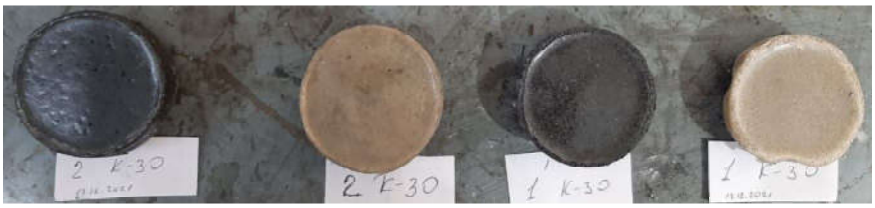


Fig.2. HDPE samples: 1-with graphite filler, 2-with kaolin filler, 3-graphite+kaolin+modified fibrous filler, 4-fibrous filler

Preparation of samples of filled polyethylene composites for testing and determination of their physical and mechanical properties was carried out according to the procedure [20]. We took the mineral filler kaolin brand AKS-30, in the amount of 15 wt.%, and silver flake graphite in the amount of 1.0 wt.%, in relation to the amount of polyethylene in the composition, i.e. the mixture in total is 16 wt.%, which were jointly loaded into the mechanical activator where the mixture is simultaneously crushed and mixed. Mechanical activation was carried out for 10 min until a mixture with particle sizes from several nanometers to 1–2 m/km was obtained. As a result, a nanosized kaolin filler modified with graphite was obtained. The resulting mixture - a modified kaolin-graphite filler, the amount of which was 16 wt.% (graphite - 1 wt.% + kaolin - 15 wt.%), was introduced into a polymer matrix containing 84 wt.% LDPE (low density) polyethylene manufactured by Shurtan Gas Chemical Complex (SGCC) brand I-0525TSh39.2-231:2011, Filling was carried out by a mixed method, both in laboratory and in production conditions, at a temperature of 125 ± 5 ° C for 5 minutes.

The compositions of polymer compositions, physical-mechanical and performance indicators are given in Table 1.

Table 1

Physical-mechanical and operational parameters depending on the composition of the polymer composition

Composition				Composition properties				
wt.% Polyethylene + modified filler (mixture of mechanically activated graphite and kaolin)				breaking strength σp, MPa	Relaxation strength σ∞1MPa	Relative elongation at break (50mm/min) not less than, %	Volumetric electrical resistance ρv ×10¹⁰OMsm	Friction coefficient f
Control soot-filled composition				14,2	10,2	300-400	2,2-2,6	0,20-0,21
LDPE: graphite: kaolin: modified filler								
84	1	15	16	23,5	20,4	30-60	0,9- 1,1	0,18-0,20
85	2	13	15	20,8	18,3	40-70	1,2- 1,4	0,16-0,18
83	3	14	17	19,4	15,6	50-100	4,5- 5,6	0,15-0,16
81	4	15	19	18,2	14,5	60- 120	6,2- 7,1	0,12-0,14
82	5	13	18	16,5	11,5	65-110	9,6- 10,1	0,10-0,12
LDPE: graphite: kaolin: modified filler								
84	1	15	16	18,2	16,1	40-75	2,0-2,4	0,14-0,18
85	2	13	15	17,2	15,2	60-100	1,5-1,8	0,12-0,16
81	4	15	19	16,3	14,5	75-100	6,4- 6,9	0,10-0,14
82	5	13	18	14,5	12,4	100-125	7,0-7,6	0,15-0,18

HDPE - high-density polyethylene, LDPE - low-density polyethylene, mod.nap. in the mixture - modified filler in the mixture.

Note:

- the magnitude of the relaxing voltage obtained during t - 30 minutes under constant load.
- friction coefficient f (the ratio of friction forces to normal load) is determined according to GOST 23.223-97, a metal disk made of structural steel St 65KhGS is used as a counterbody.

As follows from the table, a positive effect is achieved through the use of a thermoplastic polymer as a binder, into which a modified filler is introduced in the form of a mixture in an amount of 15-19 wt.% of kaolin and silver flake graphite, mechanically activated to nanosized particles. The content of the components within the specified quantitative limits makes it possible to optimally combine the strength and tribometric properties of materials, including relaxation stability. Going beyond the specified parameters does not provide further improvement in physical and mechanical properties.

From the data given in the table it follows that the filling of polyethylene with the proposed mixture of modified kaolin-graphite filler, in comparison with the control sample, leads to an increase in relaxation (σр) stability and mechanical (tensile) strength by 1.2-1.6 times, a decrease in volume resistance and friction coefficient (f), when compared with the analogue, a higher strength of the samples we proposed is also observed. Information about the relaxation stability of composite materials in analogs was not found, however, by the value of relative elongation (50-300%) and mechanical strength (10-12 MPa) displayed in the tables of analogs, one can judge their low relaxation resistance to mechanical loads. This indicates that we have received a new technical result corresponding to the task. The mechanism of structural phenomena in this case can be compared with the results of studies of materials obtained by the method of mechanochemical modification of mineral fillers in the preparation of composite heterocomposite materials [6,7].

Conclusion. The use of the proposed composition with the filling of a thermoplastic polymer - polyethylene with the proposed modified kaolin-graphite filler will allow, on the basis of local raw materials, to produce cheaper and at the same time high-quality products, simplifying the composition of the composition, expand, due to improved strength and tribometric properties, the range and scope manufactured products, while increasing the economic effect, both by increasing the service life of products due to their strength, and by using cheap regional raw materials. Samples of the proposed composition were tested at the Karshitermoplast enterprise, JSC of the Shurtan gas chemical complex.

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