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MODERN METHODS OF MODIFICATION OF COMPONENTS USING ENERGY TECHNOLOGIES

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Abstract: The prerequisites for the formation of a special energy state of components of metal-polymer systems and components are considered composite materials based on high-molecular matrices (polymer, oligomeric, combined). The greatest prospects in the creation of functional composite materials and their large-scale production based on high-molecular matrices are dispersed particles obtained on the basis of natural compounds of layered, frame, chain structure and fibrous natural, synthetic and artificial semi-finished products using traditional and special technologies that ensure the formation of the morphology of the surface layer with nanosized components with an optimal level of energy activity.

Key words:values of thermally stimulated current , pulsed laser radiation, polytetrafluoroethylene , structure, mechanical activation of particles, dispersed modifiers.

In the technology of obtaining functional composites based on polymer, oligomeric and mixed matrices and metal-polymer systems based on them, various types of energy impact on components are widely used at the stages of obtaining semi-finished products, dispersion, activation, mixing and processing into products and their target modification - thermal, mechano -chemical, tribotechnical , ionizing, ion-plasma, laser impacts [1].

The choice of a specific type of energy impact and the parameters of its technological implementation is determined not only by the available equipment, but also by the degree of study of the modification mechanisms, the nature of their manifestation in the transformation of the structure, morphology, and activity of components in the processes of interphase interaction.

The most important criteria for a reasonable choice of technology for modifying components of functional materials based on polymers are the availability and efficiency of equipment, the safety of its operation, and the possibility of use in the conditions of an established production process.

Objects and methods of research. The use of laser radiation (LR) in materials science and technology for producing polymer composites and metal-polymer systems allows not only to carry out operations of dimensional cutting and formation of specified geometric parameters of products, but also carry out complex modification of the surface layers of products to give them specified parameters of adsorption, electrophysical, tribotechnical and other characteristics [2].

Results and their discussion. Analysis of literary, patent and commercial sources indicates the predominant use of laser technologies in processing processes characterized by deep transformations of polymer matrices due to melting, thermal-oxidative destruction, ablation, and thermolysis.

These areas of application of LI have made it possible to develop a technology for producing composite coatings for friction units [3, 4], methods for producing ablation products with specified adsorption characteristics, and a technology for modifying the surface layer of carbon fiber (CF) fragments used for filling PTFE in the production of tribological and sealing composites “ Fluvis ”, “ Superfluvis ” [5].

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At the same time, at present there are no unified theoretical concepts that clearly define the experimentally observed changes in the structural and morphological parameters of polymer semi-finished products in the form of films, fibers, fabrics and components used to obtain functional materials when exposed to LR of varying intensity.

Film semi-finished products in the industrial supply condition with a thickness of 120 to 200 μm obtained by blown extrusion or extrusion through a flat-die from low-density polyethylene (HDPE), high-density polyethylene (LDPE), polypropylene (PP), polyethylene terephthalate (PET) were used for the research. Dispersed particles of modifiers widely used in polymer materials science were also modified - particles of clays, silicates, colloidal graphite preparation KGP S-1, etc. To modify samples from polymer materials, a laser installation "Quantum-15" was used , generating laser radiation with a wavelength of $\lambda_o = 1.06$ μm and a pulse duration of $2 \cdot 10^{-3}$ s, and a GOR-100M laser with $\lambda_o = 0.69$ μm and a free-running pulse duration of $1.2 \cdot 10^{-3}$ s. The number of pulses during processing varied from 1 to 10. When using the Quantum-15 installation, the pulse repetition rates varied from 1 Hz to 20 Hz. Both diffusely scattering materials and materials with a graphite coating were used as substrates on which the film samples were placed. The energy of one pulse of the acting radiation varied from 0.6 to 6 J. The diameter of the beam of the acting radiation varied from 4 to 10 mm.

IN as a criterion for The energy state of a polymer material sample was assessed using (TST), which occurs in the sample when it is heated and changes its value when exposed to external factors, in particular, laser radiation and temperature.

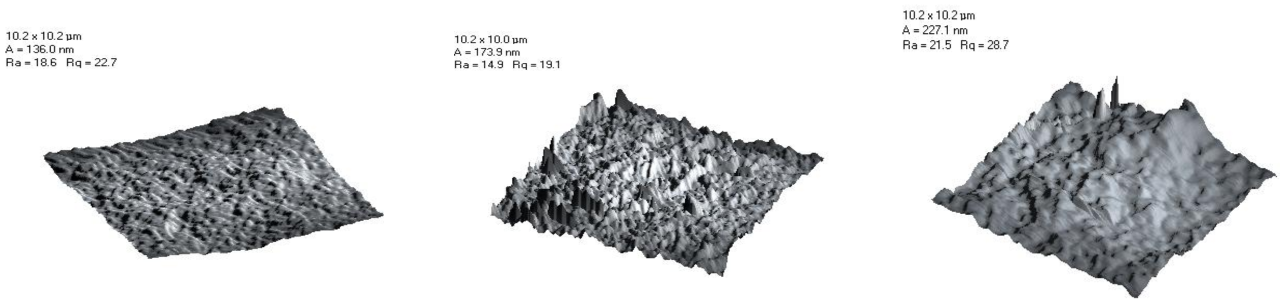
Experimental data indicate an ambiguous effect of LI on the parameters of composites based on PET, HDPE, and PTFE.

the influence of LI have a significant impact on the parameters of the deformation and strength characteristics of composite materials based on thermoplastic matrices .

The complex impact of LI on parameters is manifested in changes in the molecular and supramolecular structure.

Studies were conducted on the morphology of the surface layer of polymer substrates exposed to non-destructive laser radiation.

Exposure to radiation from the GOR-100M laser with a free-generation pulse energy of 0.6 ÷ 30 J leads to the formation of a characteristic relief of the surface layer formed by nanocomponents in the size range of 1 ÷ 100 nm (Fig. 1). It is likely that the formation of such components is due to recrystallization processes under the influence of acoustic waves that arise during the interaction of pulsed laser radiation with a polymer sample.



A) b) V)

Fig. 1. Characteristic morphology of the surface of a film sample made of high-density polyethylene (HDPE) initial (a) and after a single exposure to GOR-100M laser radiation with a free-running pulse energy of 30 J (b) and 2 J (c)

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Similar changes in the morphology of the surface layer are characteristic of other polymer samples – PA, PET, PP [6].

Simultaneously with the change in the morphology of the surface layer during LI processing, a change in the parameters of the energy state of the polymer samples is observed, which is manifested in the appearance of extremes in the TST spectra that are not characteristic of the original samples, as well as a change in the values of the contact angle of wetting with model liquids - water and vaseline oil [6].

Laser exposure of varying intensity changes the morphology of dispersed particles – fragments of carbon fibers (CF), graphite (Fig. 2 and 3).

The surface layer of the CF fragment after LI treatment undergoes a significant transformation, which is characterized by the formation of a large number of nanosized components that change the adsorption and adhesive activity in interphase processes. In addition, as a result of the pulsed effect, the process of fragment degradation occurs with the formation of through cracks, which changes the parameters of the deformation-strength characteristics of the CF and has a favorable effect on the processes of its mechanical dispersion to obtain fractions that ensure the achievement of optimal values of the parameters of the deformation-strength and tribological characteristics of composite materials based on thermoplastics - polyamides, polytetrafluoroethylene [7].

Model studies of the influence of LI on the morphology of dispersed fillers were carried out using a common modifier of polymer, oligomeric and combined matrices, which increases the parameters of tribological and deformation-strength characteristics - colloidal (powdered) graphite grade C-1.

Samples of the colloidal-graphite preparation of the S-1 brand were subjected to two types of energy exposure: thermal at temperatures of 973 ÷ 1273 K for 1 hour and laser at a pulse energy of the Quantum- 15 laser, operating in a pulse-periodic mode, of 140 mJ and an exposure duration of 1 ÷ 2 s.

As follows from the experimental data presented in Fig. 2, the energy impact of both types changes the cluster structure of the colloidal graphite preparation.

Similar results on the change in the structure of a cluster of single particles were obtained with laser modification of other types of fillers, widely used in the materials science of polymer composite materials.

Conclusion: The prerequisites for the formation of a special energy state of components of metal-polymer systems and components are considered. composite materials based on high-molecular matrices (polymer, oligomeric, combined). The factors that determine the manifestation of a special energy state in dispersed particles of materials and components of metal-polymer systems are systematized. It is shown that the factors that determine the nanostate dispersed particles of condensed media are: geometric parameters, structure, composition, morphology surface layer, which determine the choice of technology for the formation of the necessary energy parameters that ensure the manifestation of the optimal mechanism of modifying action.

When selecting a method for activating highly dispersed particles that ensures optimal modification, it is necessary to establish the prevailing mechanism for the formation of a transition (boundary) layer of a given structure and parameters of deformation-strength and adhesion characteristics and the unconditional implementation of the principle of “reasonable sufficiency” in relation to a specific combination of materials science, environmental and economic factors.

The greatest potential in the creation of functional composite materials and their large-scale production based on high-molecular matrices is shown by dispersed particles obtained on the basis of natural compounds of layered, frame, chain structure and fibrous natural, synthetic and artificial semi-

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finished products using traditional and special technologies that ensure the formation of the morphology of the surface layer with nanosized components with an optimal level of energy activity.

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