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THE SPECIFIC FEATURES AND FIELDS OF APPLICATION OF FILLED POLYMER COMPOSITE MATERIALS

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Abstract. *This article reveals a scientifically relevant and practically important task of developing a methodology for selecting the optimal composition and values of the parameters of technological regimes for the synthesis of particulate-filled polymer composite materials. As a result of the system analysis, the main scientific and technical tasks of developing a methodology for selecting the optimal structure of filled polymer composite materials, taking into account their physical and mechanical characteristics, were identified. The considered analytical approaches to modeling the mechanical properties of polymer composite materials have a significant drawback - the appearance of a gross error during modeling associated with incorrect determination of the type of structure of the materials. This limits the use of these models for predicting the mechanical characteristics of polymer composite materials.*

Key words: *polymer composite materials, filler, modifier, degree of hydrophobization, dispersion, mechanochemical processing, elasticity, hardness, physical and mechanical characteristics, wear resistance, thermal conductivity, thermal insulation.*

Introduction. The problem of improving the quality of protection from electromagnetic radiation of electronic units of products for various purposes is inextricably linked with the level of applied materials, their composition and properties. Dispersed-filled polymer composite materials can act as such materials. The study of quality indicators of disperse-filled polymer composite materials is largely determined by the need to obtain such materials with the most important properties for consumers. In this case, there is a need to determine the relationship between quality indicators and influencing factors (primarily, the composition of the material and technological modes of its synthesis), which can be represented in the form of mathematical models, which allows to optimize the properties of the resulting polymer composite materials (PCM). The properties of these materials are mainly determined by the filler (trivalent iron oxide, carbon black, ferrites, carbonyl iron, nickel, cobalt, aluminum oxides). The filler affects the mechanical properties (hardness, tensile strength and relative elongation at break) of PCM, which determine the possibility of using PCM to protect electronic units under increased mechanical loads. Thus, in modern conditions with the wide use of PCM in various industries, the relevance of the development of an automated decision support system for the composition and values of parameters of technological modes of PCM synthesis depending on the required mechanical properties is growing.

Polymer composite materials can be referred to the class of functional materials. These materials find application in many areas of industry. Their properties have a wide range due to the large nomenclature of polymers and fillers from which they are synthesized, which makes it possible to obtain composites based on them with different properties. This determines the use of composite materials in various industries. A wide variety of design solutions for protection, as well as a wide range of electromagnetic and mechanical effects, require the creation of functional materials for specific operating conditions.

The quality of protection from electromagnetic radiation of electronic units of aircraft control systems is inextricably linked with the level of applied materials, which is determined by the functional properties of radio-absorbing filled polymer composite materials. In order to reduce the time of creation of new radio-absorbing filled polymer composite materials specialists need a tool that allows to model the properties of materials depending on the composition with subsequent multi-criteria optimization. It should be taken into account that the reflection coefficient of electromagnetic waves is determined by the amount of filler of radio-absorbing filled polymer composites, and its value can not change during the optimization process. Thus, the mechanical characteristics of the created materials should be optimized.

Research methodology. The technology of obtaining radio-absorbing filled polymer composite materials is based on the principles of physical interaction of polymer binder, filler and modifiers. At reception of radio-absorbing filled polymeric composite materials the temperature factor is important. Thus, composite materials can be obtained by curing at room temperature (cold curing) and elevated temperature (hot curing), as well as by injection molding, mixing of components and subsequent curing of the mixture [1].

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Obtaining radio-absorbing filled polymer composite materials proceeds in several steps:

1. Selection of polymer, fillers and curing compound (selection of combined components and quantitative ratios of ingredients).

2. Preparation of the polymer containing base, weighing in the mixing vessel.

3. Adding a modifier (which allows to increase the volume of filler, makes the material elastic) and thorough mixing with polymer.

Application of modifiers in quantities below a certain fixed value for each type of materials is ineffective, as it does not lead to the required effect. Application of modifiers in quantities exceeding a certain level may adversely affect the thermal stability of the sealant and lead to their partial release from the volume of vulcanizates of thermally conductive sealant during heating.

4. Storage of the resulting suspension in closed form until the filler is introduced into contact.

5. Mechanochemical processing of the filler.

The initial product is subjected to mechanical activation with the use of grinding equipment at significant shear forces, then the activated product is transferred to the mixing device, moistened, after which the product is dried, deagglomerated (crushed) and subjected to heat treatment for the required time, the finished product is captured and packaged. The obtained product has the required degree of hydrophobization, which is not less than 95%, combines the functions of active filler and flame retardant for use in filled polymeric materials [1].

6. Obtaining a mixture (polymer, modifier, powder filler) in liquid state.

7. Adding solidifier (curing stage) and mixing it with the composite mixture.

When obtaining radio-absorbing filled polymer composite materials it is necessary to solve the problems of selecting binder components with optimal rheological characteristics and good combination with well-dispersed fillers, which are responsible for ensuring the main functional characteristics, namely radio absorption, strength in the required temperature ranges, elasticity, toughness, preventing mechanical damage and providing a given uniformity over the entire surface. Thus, the work requires the realization of the following main stages:

- Selection and testing of polymer binder components, among which should be considered binders based on epoxy resins, polyester resins, liquid polyurethanes, liquid and viscous silicone rubbers, with the inclusion of silicone oligomers, polyvinyl acetate emulsions and pentaphthalic varnishes of different initial viscosity.

– Selection and testing of fillers having selective radio absorption in given frequency ranges, among which carbonyl metals, carbon materials of different dispersity and structure,

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alsiferous fractions and ferrite components of different composition and structure should be considered.

- Development and research of composite structures on the basis of selected polymeric binder components and fillers according to the principle of mutual compatibility of constituent parts, determination of qualitative and quantitative ratios of components, including step-by-step measurement of basic parameters for the purpose of operative adjustment of compositions.

- Development of technological conditions of target application of compositions by means of experimental applications on vertical surfaces of different materials, determination of conditions of exposure of coatings and their complete curing.

- Determination of the possibilities of combining functional coatings with decorative anti-vandal layers and layers with fire retardant properties applied on top of them, provided that the main functional radio-absorbing load of coatings is preserved.

- Refinement of the technology of covering application and drying.

- Selection and testing of fillaers providing minimum flammability of the main covering possessing selective radio absorption in given frequency ranges, among which aluminum compounds, in particular aluminum hydroxide, aluminum oxide, aluminum oxide-hydroxide, as well as these compounds treated with amidophosphate components should be considered [2, 3].

Results and their discussion. Currently, there are increasing demands on the physical and mechanical characteristics of polymer composite materials (PCMs). Physical and mechanical characteristics of PCMs are interrelated, i.e. improvement of some can negatively affect others. For this reason, there is a need to predict the properties of newly created materials.

The heterogeneity of the structure of PCMs, including dispersion-filled ones, determines the distinctive features of their study. It follows that the physical and mechanical properties of materials depend on the structure of the filling (except for the properties of the components themselves), namely:

– Geometry of the reinforcing elements;

– Density of their placement;

– Volume content of reinforcing elements.

The development of methods for modeling the mechanical behavior of PCM is of practical importance. It is determined by the presence of random structure and its role in the formation and formation of effective properties of composite material. When comparing composite materials with homogeneous ones, their significant advantages are emphasized, which are worth paying attention to.

These include high value of strength and stiffness, fatigue life. In the manufacture of composite materials it is possible to improve such characteristics as wear resistance, thermal conductivity, thermal insulation, etc. Conditionally composite materials (CM) are divided into materials reinforced by dispersed particles and reinforced by fibers. When fiber reinforced materials are considered, the main part of the load is carried by rigid and strong fibers. The matrix in this case is a support and protection for the fibers and acts as a stress transmitter to the fibers [4]. Recently, fiber-reinforced plastics and metals have become widespread in the manufacture of automotive parts, pipelines, and aircraft structures. However, there are also disadvantages, which include failure to take into account the specifics of the structure of the material under study. Prediction based on the mentioned approaches leads to inconsistencies, which may be the reason for the resulting errors in prediction. The considered analytical approaches to modeling of mechanical properties of PCM have a significant disadvantage - the appearance of gross errors in modeling, associated with incorrect definition of the type of structure of materials. This limits the application of these models for predicting the mechanical properties of PCM. The task of taking into account the interaction of components of composite materials remains fully relevant, despite the presence of many solved issues in statistical mechanics. The disadvantage of such methods is the necessity to solve a complex system of equations. For this reason, the value of computational procedures to determine the actual properties of composite material increases. The application of methods used in the evaluation of physical and mechanical characteristics of a heterogeneous medium, while applying the results of numerical simulation of the behavior of a narrow fragment of the medium with the property of representativeness is considered to be one of the known ways to solve this problem.

Considering the issues of modeling of regular structures the periodicity cell in the role of representative volume of the medium is noted. The present structure of quite a number of materials is chaotic, that is why the priority task becomes the choice of a certain size of material in such a meso-volume so that its properties could meet the requirement of representativeness.

Conclusions. On the basis of the conducted analysis the following results were obtained:

– the necessity of optimization of ranked quality indicators of filled polymer composite materials and determination of material composition and technological modes of synthesis has been established;

– on the basis of the method of quality function deployment the quality indicators of synthesized filled polymer composite materials were ranked: toughness (according to Shore), tensile strength, relative elongation at break.

– as a result of the conducted comparative analysis the shortcomings in the forecasting of properties of composite materials are revealed, among which the following are emphasized: significant errors of the obtained forecast, application of the hypothesis in private cases, failure to take into account the peculiarities of the structure of the investigated material, limitedness of the put forward assumptions.

– as a result of the system analysis the main scientific and technical tasks of development of the methodology for selecting the optimal structure of radio-absorbing filled polymer composite materials taking into account their physical and mechanical characteristics have been determined.

To solve the set tasks we propose to develop a methodology for selecting the composition and parameters of technological modes of synthesis of filled polymer composite materials for protection of electronic units from unauthorized electromagnetic impact with risk assessment in multi-criteria optimization. To automate the process, the proposed methodology should be implemented in special software program

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