The nanostate factor in the technology of polymer nanocomposites

Avdeychik Sergey 1, Goldade Victor 2, Antonov Alexander 3, Struk Vasily 3, Klochko Pavel 3
Molder Ltd 1 – Grodno, Belarus, Francisk Skorina Gomel State University 2 – Gomel, Belarus, Yanka Kupala Grodno State University 3 – Grodno, Belarus,
E-mail: antonov.science@gmail.com

Abstract: Methodological approaches to the implementation of the nanostate phenomenon in the formation of the optimal structure of composite materials and metal-polymer systems at different levels of organization have been developed. The concept of energy and technological compliance of functional composite materials and systems components, which determines the optimal parameters of stress-strain, adhesion and tribological properties under technological influences on the components in the process of obtaining composite and its processing, is proposed.

KEYWORDS: NANOPIRATE, NANOSTATE, METHODOLOGICAL PRINCIPLES, STRUCTURE, ENERGY AND TECHNOLOGICAL COMPLIANCE

1. Introduction
Modern scientific views on the structure of multicomponent materials (plastics, composites, alloys), products and constructions made on its basis have its foundations in the understanding them as systems whose parameters of characteristics (stress-strain, tribological, thermophysical, adhesive, etc.) depend on the intensity interphase interactions, characterized by the flow of certain physical and chemical processes at a given rate and leading to the formation of boundary (separating) layers with certain composition and structure [1–3]. These processes lead to the transformation of the initial state of the system components and determine the parameters of its performance characteristics.

2. Discussion
In the interfacial region of a multicomponent system, a complex of physical and physicochemical reactions occurs simultaneously with the dominant of one or several, for which the most favorable conditions are realized, determined by the value of the activation energy parameter (Fig. 1). This dominant reaction in the interfacial region, the kinetics of which corresponds to the conditions of formation and operation of the system, determines the resistance of an element made of a composite or a structure to the influence of technological or operational factors.

Methodological approaches to the creation of composite materials based on polymer matrices in the presence of general regularities are characterized by a number of specific features determined by the modes of operation of the product, requirements for manufacturability and recycling, economic parameters that affect its competitiveness when compared with analogues.

In [4], the directions of targeted modification of polymer materials to improve the tribological characteristics are presented (Fig. 2).
It seems to us that the proposed modification methods are effective not only when creating tribological ("antifriction" according to [4]) materials, but also other types of composites for manufacturing products with specified performance parameters with appropriate adjustments to methodological approaches. Analysis of numerous methods of targeted modification of high-molecular-weight matrices to obtain functional materials with specified parameters of characteristics, ensuring the effective use of products from them in the structures of machines, mechanisms of technological equipment, not only emphasizes their diversity, but also allows formulating methodological principles for the implementation of functional materials science in accordance with strategy of innovative development of various branches of the economic complex. When developing such principles (Fig. 3), we took into account the current trends in the development of the industrial sphere and the sphere of life support of social-minds of various levels, based on the permanent renewal of industrial products, increasing the level of its consumer characteristics, including ergonomic ones, in the concept of an ecological imperative in the process production and consumption of industrial products, the concepts of reasonable sufficiency and life cycle. The application of these trends in the practical functional materials science of composites for mechanical engineering made it possible to identify the main requirements, the implementation of which ensures the achievement of optimal technical and social effects:

- optimization of parameters of deformation and strength characteristics;
- increasing the parameters of tribological characteristics in the given operating conditions;
- increasing the parameters of protective characteristics in certain operating conditions.

The formed requirements mainly relate to the field of functional materials science for mechanical engineering and do not consider the features of special materials science, the objects of which are used in the field of housing and communal services, medicine, agricultural production, sports and other areas of the functioning of industrial and special structures.

In our opinion, the formed requirements for functional composite engineering materials based on thermoplastics can be ensured by implementing the basic methodological principles, which include:

- formation of a structure with optimal ordering at a certain level of the organization;
- increasing resistance to tribo-thermal cracking;
- increasing resistance to the effects of thermo-oxidizing environments and aging.

The proposed principles are based on modern approaches to controlling the structural characteristics of composite materials at the molecular, supramolecular, intermolecular and interfacial levels using various materials science and technological solutions, which are systematized by directions:
regenerated ones, the use of which currently does not correspond to its requirements potential opportunities. The developed methodological principles are implemented in practical applications in the form of functional nanomaterials based on industrial thermoplastics and technologies for their manufacture and processing into products [5–8].

Methodological approaches to the implementation of the nanostate phenomenon in the formation of the optimal structure of composite materials and metal-polymer systems at different levels of organization have been developed. The concept of energy and technological compliance of functional composite materials and systems components, which consists in ensuring the parameters of their energy characteristics are adequate to the value of the activation energy of the prevailing structural process is proposed. This concept determines the optimal parameters of stress-strain, adhesion and tribological properties under technological influences on the components in the process of obtaining composite and its processing. The concept was tested in the development of nanocomposites based on polymer matrices of industrial production, which surpass analogues in service characteristics.

3. Conclusion
Methodological approaches to the implementation of the nanostate phenomenon in the formation of the optimal structure of composite materials and metal-polymer systems at different levels of organization have been developed. The concept of energy and technological compliance of functional composite materials and systems components, which consists in ensuring the parameters of their energy characteristics are adequate to the value of the activation energy of the prevailing structural process is proposed. This concept determines the optimal parameters of stress-strain, adhesion and tribological properties under technological influences on the components in the process of obtaining composite and its processing. The concept was tested in the development of nanocomposites based on polymer matrices of industrial production, which surpass analogues in service characteristics.

4. Acknowledgements
The given research was carried out within the framework of integrated assignment 8.4.1.4 “Mechanisms of directed structure formation of functional thermoplastic composites under energy and mechanical influences” of R&D “Investigation of the multilevel structuring mechanisms of functional nanocomposites based on thermoplastics under conditions of the realization of physicochemical synergistic effects” and R&D “Investigate the structure formation mechanisms of regenerated thermoplastics and develop methods for increasing the parameters of stress-strain and rheological characteristics of functional composites based on its inclusion in the subprogram “Multifunctional and composite materials” of the State programs for scientific research “Materials science, new materials and technologies” in 2021-2025. Also the given research was carried out within the framework of integrated assignment 5.6 “Research of the processes of creation and use of polymer packaging materials to ensure the quality and safety of food products” of R&D “Investigation of the processes of structure formation of thermoplastic nanocomposites for obtaining film semifinished products with increased parameters of characteristics” included in the subprogram “Food security” of the State programs for scientific research “Agricultural technologies and Food security” in 2021-2025.

5. References
4. Struk V.A. Tribokhimicheskaia konsepsiia sozdania antifrictionnykh materialov na osnove mnogotonnazhno vypuskaemykh...


