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СИСТЕМИ РОЗРОБЛЕННЯ ТА ПОСТАНОВЛЕННЯ ПРОДУКЦІЇ НА ВИРОБНИЦТВО. ІНДУСТРІЯ 4.0. СУЧАСНИЙ НАПРЯМОК АВТОМАТИЗАЦІЇ ТА ОБМІНУ ДАНИМИ У ВИРОБНИЧИХ ТЕХНОЛОГІЯХ

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HIGH-PERFORMANCE COMPOSITE MATERIALS BASED ON POLYTETRAFLUOROETHYLENE TECHNOLOGY FOR AUTOMOTIVE AND INDUSTRIAL APPLICATIONS

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There is tremendous pressure to innovate in the automotive industry nowadays and the technological requirements are becoming increasingly complex.

The materials for sealing elements have special requirements, especially considering the conditions of operation of such equipment assuming a long production cycle without service, reverse nature of movement, lack of special lubricant environments, influence of hostile environment and increased temperatures.

Widespread use of polytetrafluoroethylene (PTFE) composites in friction units and seals of various kinds of machinery and equipment is conditioned by features of molecular and supramolecular structure of polytetrafluoroethylene which ensure the implementation of a unique combination of deformation and strength, tribotechnical, anticorrosive, thermophysical and other service characteristics and determine the field of efficient use of these products.

Among the PTFE-based composites, applied to production of pressurizing and sealing elements of static and movable interfaces, the wide circulation was gained by materials of a series Flubon and Fluvis which use the dispersed carbon fiber (CF) as a multipurpose filling agent. These materials surpass domestic and foreign analogs in a complex of service characteristics. However, due to the specific characteristics of structure and morphology of macromolecules and disperse particles of PTFE and CF, potential opportunities of PTFE-based composites' components are not realized fully. It leads to a noticeable drop of load and speed range of application of products manufactured from composite materials on the basis of PTFE, reduces a resource of their effective operation and increases production and processing cost.

Good basic adaptability of the gaskets and exceptionally high temperature resistance coupled with good media resistance are the special properties of this proven material.

Scientifically substantiated and practically proved that effective way to improve physical-mechanical and tribotechnical properties of PTFE is its mechanical activation in which the supramolecular structure of PTFE undergoes significant changes - from lamellar disordered in the structure with higher ordering until the spherulitic. As a result of energy-active mechanical impact is chemical mechanical destruction of macromolecules of polytetrafluoroethylene with the formation of radical fragments and formation of inter-fractional elements of PTFE which that form the structures that more actively resist wear and provide higher physical and

mechanical properties.

By IR spectroscopy method it was found that in case of the PTFE modification as a result of mechanical activation, a transition of the polymer into dispersed, nanodispersed and other structural states occurs. In the IR spectra of these formations, the bands that characterize the vibrations of individual fragments and whole chain even under intense energy impact are preserved. This allows assuming that the external mechanical influence does not result in noticeable destruction of polytetrafluoroethylene molecular chain, but in some cases, certain changes occur at the molecular level, which leads to enhanced physical, mechanical and service properties of the polymer and reveals the possibility to use activated PTFE as a matrix of fluoropolymer composites of various applications.

The mechanical properties of PTFE depend strongly on its crystallinity, crystalline phase, and crystalline morphology, all of which may be strongly influenced by interactions at the polymer/nanoparticle interface. PTFE has a unique crystalline structure that is often described as banded, and this banded structure contains intermittent bands of crystalline polymer and amorphous polymer; the viscoelastic properties of this banded structure are related to its friction and wear responses. Within crystalline regions, lamellar slices are composed of folded PTFE chains. An individual chain is a fully fluorinated carbon backbone in a helical conformation, the twist of which dictates the phase. The influence of the nanoparticles on the polymer is limited by how well the particles have been dispersed. High surface area per unit volume, the very property that makes nanoparticles special, also encourages them to stick or agglomerate. This behavior results in a competition between the potential for mechanical enhancement and difficulty of dispersion.

There are significant efforts dedicated to the research and development of low friction, low-wear solid lubricants with traditional particle and fiber fillers, many of which have successfully transferred to application. In this particular composite, a soft PTFE film is preferentially drawn from the composite to separate the surfaces, protecting the relatively soft polymeric material from direct asperity contact, and providing a low shear friction reducing film to accommodate the sliding motion. This is called a transfer film. Friction coefficients for unfilled PEEK were relatively high and noisy with average values of $\mu = 0.37$. The addition of PTFE reduced the friction coefficient for all loading conditions. In the context of polymer tribology and in particular the tribology of polytetrafluoroethylene (PTFE) films, molecular dynamics (MD) simulations have been used to investigate atomic-scale friction at interfaces of self-mated PTFE constructs. Sliding of chains oriented parallel to the chain backbones resulted in low friction forces and in low barriers to interfacial slip and molecular reorganization at the surface. In contrast, sliding of chains oriented perpendicular to the chain backbones resulted in high friction forces and wear in the form of molecular reorientation and chain scission. These predictions were examined and validated by complementary experiments on oriented transfer films of PTFE.