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Influence of Low Temperature on Heat Transfer in Epoxide NanoComposites

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Abstract
The process of heat transfer in polymer systems and composites due to the variety of factors determining their properties is extremely complex and has been poorly studied practically. Heat transfer in unfilled polymers largely depends on polymer structure in general, on the degree of order of structural elements within one. Infusion of nanofillers into a polymer system leads to significant changes of mechanical, thermal, electrical, and other properties. At infusion of fillers, the heterogeneity of a polymer system at a macroscopic level also increases.
Keywords:-nanofillers **.** polymer **.** heterogeneity **.** intramolecular **.** nanocomposites **.**

Introduction

Nowadays a lot of materials about research and compilation of mechanical and thermal properties of conventional filled polymers have been accumulated. For polymers filled by nanoparticles, there is only fragmentary information, often contradictory, mainly investigating mechanical properties of materials.
Mechanisms of the interaction between polymer and filler for crystallizing amorphous polymers have a different character. Filled to crystalline polymer solid particles can be placed in the middle of supramolecular structures and serve as a basis for growth of conglomerates or to be displaced in the regions between structural elements. At filling of amorphous polymers, with the surface of filler both individual macromolecules and supramolecular structures interact.
It has been found that the main feature in the influential mechanism of fillers on properties of polymers is the nature of the processes at supramolecular levels. The order of supramolecular structure of polymer covers more outlying from filler surface areas than it leads from thermodynamic concepts. Therefore, as a result of the interaction between polymer and filler, rigid structural elements form, permeating the entire volume of polymer and having a significant effect on its mechanical properties. In nanocomposites the entire polymer matrix transforms to the state of an interfacial layer with different from polymer in volume properties. These processes are illustrated by figures (figure 1), made by scanning electron microscope Carl Zeiss Supra^{TM} 55 for epoxide nanocomposites.
Thus, in composites heat transfer processes are caused both by conductivity of individual components and significantly by a boundary layer filler – fixant, its structure and physical –mechanical changes depending on external influences are still poorly researched.
Therefore, experimental data is of particular value for the creation and operation of devices from composite materials.
From a wide variety of polymers, thermoset fixants have been chosen – namely epoxide – as the most widely used in various structural and electroinsulating materials in aeronautics, automotive and electronics industries. Thermosetting epoxides are widely used due to the fact that they combine high strength properties, excellent dimensional stability, heat resistance and resistance to various external environmental influences. However, these highly crosslinked thermoset polymers have inherent fragility, which increases with increasing of crosslinking density. So they are filled by different mineral fillers to eliminate this disadvantage.
Nanocomposites based on polymeric fixants are promising materials from the viewpoint of reinforcement of polymers and imparting them improved properties by infusion of nanoparticles of different materials into a polymer matrix.
With decreasing of particle size, specific surface area of filler, length of the interfaces and boundary layer proportion increase. Boundary layer quantity at the particle size of 0.5 – 5 microns increases up to 50%, and its influence on properties of composite material increases. At the particle size of 10 – 100 nm, composite material can be called nanocomposite. In such materials even with the proportion of filler on the order of parts of a percent, practically the entire polymer transforms into the boundary layer state [1].
Many of promising directions in material sciences, nanotechnology, nanoelectronics and applied chemistry are associated recently with nanotubes and other similar nanostructures which can be called by a general term – carbon skeletal structures. Due to different properties of nanoparticles, such as extended surface, dimensional and quantum effects of nanoepoxide composites exhibit improved mechanical and thermal properties.
But, despite the fact that carbon nanotubes can be considered as heat superconductors (the highest values of thermal conductivity of carbon nanotubes are more than 3000 W/(m·K) [2]), it does not mean that they can have