The paper presents a new approach to describe the mechanical behavior of semi-crystalline polymers, plastic deformation of which is determined by their two-phase structure. To describe the plastic behavior of semi-crystalline polymers a two-phase model is used. In the framework of this model, one phase is in a hard (crystalline) state, and the other in a soft (amorphous) state. Two-phase material is modeled by a single-phase homogeneous continuum based on the approximation of the effective medium. It is assumed that two infinitely close material points of the continuum are connected in series by elastic and viscous bonds, what corresponds to the Maxwell model. It is shown that in this case, the Maxwell continuum is a pseudo-Euclidean space. Generalizing the definition of defects from a three-dimensional space to a four-dimensional pseudo-Euclidean space, we obtained a dynamic system of nonlinear, interrelated equations to describe the behavior of translational type defects in the solid phase and dynamic defects in the amorphous phase. As an example of equations application, the phenomenon of creep under uniaxial loading is considered. It is shown that the formalism of the proposed two-phase model makes it possible to describe creep phenomenon regularities, which correspond to both the aging theory and the flow theory.

Studies carried out in the last decade show that many of the key mechanical properties of semi-crystalline polymers are determined by the defect structure, in particular, by the concentration, spatial distribution and defects motion dynamics during the material deformation process. The specific features of the mechanical behavior of semi-crystalline polymers as a two-phase system are determined, among other things, by the specific features of defects in amorphous components and their interaction with defects in crystalline components. This determined the relevance of the development of the approach to the macroscopic description of the inelastic deformation of such materials. This approach takes into account both static (dislocation-type defects) and dynamic (vorticity, acceleration) microscopic mechanisms of plastic deformation of polymers.

The paper formulates the continuum dynamic model of defects arising during deformation in crystalline and amorphous components of semi-crystalline polymers. Within the framework of the model the plastic deformation of the crystalline component, realized by means of crystallographic mechanisms, is described by dislocation motion. Unlike most classical models, the present model also takes into account dynamic defects in a viscous amorphous component. The interaction of crystalline and amorphous components determines the sequence of polymer deformation. The first contribution to deformation is given by elastic deformations of the crystalline components and a "defect-free" (laminar type) viscous flow of amorphous components. The process of inelastic polymer deformation is controlled by the motion of dislocation-type defects (in crystalline components) and dynamic defects (in amorphous components).

On the basis of the proposed assumptions, a physical theory of the deformation of semi-crystalline polymers is built. The theory considers the dynamics of defects of various types (static and dynamic) arising in crystalline and amorphous components during material deformation. This theory naturally takes into account the interaction of defects with each other, as well as the interaction of defects fields with stress fields. In particular, we derived expressions for the interaction force of defects with stress fields from external loading. We note that taking into consideration this interaction is one of the key theory advantages since it allows adequately describing of polymers with high residual internal stresses. Based on the basic relations of the theory, we obtained expressions for the energy, impulse, and mass of defects appearing in the crystalline and amorphous components, which indicate that the defects fields are self-dependent objects. Taking into account the inertial characteristics of defects is also an advantage of this theory and is especially relevant for an adequate description of the polymer mechanical behavior under...
Taking into account the energy, impulse and mass of the defects fields, a system of interconnected nonlinear equations is obtained, and it describes the macroscopic deformation of a semi-crystalline polymer as a result of the defect dynamics and interaction between various types of defects. The numerical or analytical solution of this equations system makes it possible to study and predict the material behavior under complex loading conditions, including hardening, softening and fracture, within the framework of a single (general) formalism, as well as to solve the problems of computer design of the internal structure of composite materials on a polymer basis. Wide capabilities of the developed macroscopic continuum model are illustrated by two simple examples of the analysis of the discrete spectrum of frequencies and energies of natural oscillations of defects in the amorphous phase of the polymer, as well as general features of creep of the polymers with a high degree of crystallinity. The generality of the basic statements and constitutive equations of the developed theory make it possible to describe the inelastic behavior of polymers over a wide range of their crystallinity (from purely amorphous to fully crystalline polymers) under various types of external actions (mechanical, temperature) and different loading regimes (from quasistatic to high strain rate).

**Keywords**

semi-crystalline polymers; two-phase model; continuum defects theory; elasticity; plasticity; viscosity; translational defects; dynamic defects

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