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WORKS ON VISCO-PLASTIC MEDIA

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Annotation: This work analyzes the research work carried out on the theory of viscous-plastic media, their rheological properties, and their application in engineering and industry. The behavior of viscous-plastic media in deformation and flow processes, mathematical models describing them (Bingham, Herschel-Bulkley, etc.) are discussed. Special attention is also paid to the results obtained on the basis of modern computational methods and experimental studies. The results of the research are of great importance in optimizing technical and technological processes.

Keywords: Viscoelastic medium, rheology, Bingham model, Herschel–Bulkley model, flow laws, deformation, stress, non-Newtonian fluids, mathematical modeling.

Viscoelastic media play an important role in modern mechanics and technological processes. Such media are fundamentally different from ordinary Newtonian fluids in that they begin to flow after a certain limit stress. They are widely used in the oil and gas industry, building materials technology, chemical industry, and biological systems. Therefore, an in-depth study of the mechanical properties of viscous-plastic media and the development of theoretical and practical models describing them are one of the urgent scientific issues. This work analyzes the research carried out in this area and highlights their scientific and practical significance.

The properties of Newtonian fluids, described by the rheological equation, are common to most liquids, including all gases.[1]

Examples of Newtonian fluids that are remarkable in their properties include thin suspensions, mud solutions, and oil paints. In contrast to Newtonian fluids, the various types of mists in non-Newtonian fluids are explained by molecular motion and the presence of a distinct internal and molecular structure.

"Viscosity-plastic" fluids are of particular interest because they exhibit plastic properties along with viscosity, and as they approach the yield point, some limiting stresses appear. The rheological laws of viscoplastic fluids are attributed to Bingham (1916), although they were studied much earlier (in 1889) by Shvedov F.N.[2]

Starting from the simplest case of a straight-line smooth sliding motion along the Ox axis with a sliding velocity of $\varepsilon = du/dy$, the rheological equation of a viscous-plastic fluid can be presented in the following form:

$$\tau = \tau_0 + \mu' \varepsilon \qquad (\tau > \tau_0) \qquad (1)$$

Here τ^0 is the limiting value of the shear stress, μ' is the coefficient of dynamic viscosity, and when $\tau < \tau^0$, the flow stops, that is, the body behaves like a rigid body.

The viscous-plastic model described above satisfies the behavior of practically encountered media, for example, mud and cement slurries used in oil fields for washing out wells, oil paints, as well as some pastes. This is a physical explanation of the peculiar properties of all liquids, which at rest have some spatial structure, and they are subject to any external influence, which causes It is based on the idea that a fluid can resist the shear stress it generates until it exceeds

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the stress that is compatible with its structure. After that, the structure is completely destroyed and the fluid begins to behave like a simple Newtonian viscous fluid, with the apparent stress being equal to the excess $\tau - \tau^0$, the true stress being equal to the limiting one. When this internal stress is zero, that is, when the true stress reaches its limiting value, the structure of the body is restored.[3]
In other words, the so-called pseudoplastic fluids do not have a shear stress, but are characterized by a viscosity that determines the coefficient of their shear stress. Such "nonlinear" fluids (asymmetric particle suspensions, solutions of high polymers) obey the following law of rheological equations (Ostwald, Reiner).

$$\tau = k\dot{\varepsilon}^n \qquad (2)$$

Here, k and n<1 are constant over a large range of stress and strain rates, and the viscosity coefficient τ/ε =kε ^(n-1) decreases with increasing ε in the equation.
The absence of boundary stress distinguishes pseudoplastic fluids from so-called "dilatant" fluids, whose viscosity increases with increasing stress. (n>1)
This is typical for highly concentrated suspensions of solid particles, as well as starch pastes that are not associated with concentrated suspensions of solid particles.

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