Hydrodynamic Instabilities in Viscoplastic Fluids

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Modeling of the Richtmyer-Meshkov instability with a yield stress in the 2D and 3D cases shows a presence of the threshold w_0^{crit} of the velocity w_0. It is related to the limiting value of the yield stress τ_0. Below threshold value surface displacements can be neglected, because incipient stresses are less, than τ_0 and the velocity field rapidly damps because of "model" ($\mu_0 = \tau_0 / \dot{\gamma}_{\min}$) viscosity. Essential plastic motion begins above a threshold. The Richtmyer-Meshkov instability is a surface instability - velocity and stress fields decay into bulk. Therefore the region of motion is near surface. This region grows with increase of exceed of w_0 above threshold. For fixed w_0 above threshold velocity decays with time and region of motion gradually shrinks. The fluids come to rest in a finite amount of time. This amount grows as the value $w_0 - w_0^{crit} > 0$ increases.

Critical amplitudes have been evaluated at least for two values of a yield stress. At various thresholds of stress τ_0, the velocity thresholds w_0^{crit} are different. The assumption of scalability of the critical amplitude for two variants of a threshold stress τ_0 has been confirmed.

Considering the Rayleigh-Taylor instability of viscoplastic fluids it can be noted that yield stress plays an important role in the development. As well as in the Richtmyer-Meshkov instability the major role is played by the critical amplitude of initial perturbation w_0^{crit}. However, due to a gravity force, the value Rayleigh-Taylor critical amplitude is less than the critical amplitude of the Richtmyer-Meshkov instability. At amplitude above threshold $w_0 > w_0^{crit}$ instability of the Bingham fluids develops as if fluids were Newtonian.

Numerical modeling of mixture of two fluids both with the Newtonian and non-Newtonian rheology has been carried out. The initial disturbance field of velocity has been specified as a superposition of five modes with a random phase displacement, and with wave vectors $\vec{k}_x^i$ and $\vec{k}_y^i$ ($i = 1 \div 5$). In this case breadths of intermixing zones and coefficients of turbulent mixing α for fluids with different rheological dependences have been gained.