

We study behavior of incompressible non-Newtonian fluids with a relation between the shear stress and the shear rate given by a non-monotone S-shaped curve. These fluids are described with a special class of implicit constitutive relations that may be derived in a thermodynamically consistent manner using the entropy production maximization principle or gradient dynamics. In the latter approach, the constitutive relation is given as the derivative of a non-convex dissipation potential. The concept of dissipation potential allows us to discuss stability of the constitutive relation and explain the experimentally observed response discontinuities. We are also concerned with hydrodynamic stability of flows of implicitly constituted fluids. Finally, we propose a numerical scheme for simulation of transient flows of fluids with a specific non-monotone constitutive relation. We employ the numerical scheme in a simulation of two-dimensional Taylor–Couette flow and the numerical results confirm our theoretical observations concerning the admissible flow states.