Flow Properties Inferred from Generalized Maxwell Models

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The generalized Maxwell model is formulated as a nonlinear relaxation equation for the symmetric traceless stress tensor. The relaxation term of the equation involves the derivative of a potential function with respect to the stress tensor. Two special cases for this potential referred to as "isotropic" and "anisotropic" are considered. In the first case, the potential solely depends on the second scalar invariant, viz. the norm of the tensor. In the second case, also a dependence on the third scalar invariant, essentially the determinant, is taken into account in analogy to the Landau-de Gennes potential of nematic liquid crystals. Rheological consequences of the model are presented for a plane Couette flow with an imposed shear rate. The non-Newtonian viscosity and the normal stress differences are analyzed for stationary solutions. The dependence on the model parameters is discussed in detail. In particular, the occurrence of a shear-thickening behaviour is studied. The possibility to describe substances with yield stress and the existence of non-stationary, stick-slip-like solutions are pointed out. The extension of the model to magneto-rheological fluids is indicated.

Key words: Generalized Maxwell Model; Non-Newtonian Viscosity; Normal Stress Differences; Shear-Thinning and Shear-Thickening; Stick-Slip Behaviour; Magneto-Rheological Behaviour