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A unified evolution equation for the Cauchy stress tensor of an isotropic elasto-visco-plastic material. II: Normal stress difference in a viscometric flow, and an unsteady flow with a moving boundary. (English) Zbl 1170.74308

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Summary: This paper continues Part I [ibid. 19, No. 7, 423–440 (2008; Zbl 1170.74308)], in which a unified evolution equation for the Cauchy stress tensor, which takes elastic, viscous, and plastic features of the material simultaneously into account, was proposed. Hypoplasticity in particular was incorporated to account for the plastic characteristics. In the present paper, the stress model is applied to study normal stress differences in the context of viscometric flow, and the unsteady flow characteristics of an elasto-visco-plastic fluid between two infinite parallel plates driven by a sudden motion of the plate, to estimate the performance and limitations of the proposed method. Numerical calculations show that, in the context of viscometric flow, different degrees of plasticity and the associated first and second normal stress differences can be addressed appropriately by the stress model. For the unsteady flow situation the results show that the complex behavior of the fluid, in particular after the start of the driving motion, can be described to some extent by the model. In addition, different relaxation and retardation spectra with plastic characteristics can be simulated by varying the model parameters. These findings suggest the applicability of the proposed stress model, for example, in the fields of granular/debris and polymeric flows.

MSC:

74C15 Large-strain, rate-independent theories of plasticity (including nonlinear plasticity)
76A10 Viscoelastic fluids
76M20 Finite difference methods applied to problems in fluid mechanics

Full Text: DOI

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