Simulation Tests of the Constitutive Equation of a Nonlinear Viscoelastic Fluid

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Abstract

The determination of the constitutive equation of a nonlinear viscoelastic fluid is a challenging task, especially if a space-dependent equation is needed [1].

In this contribution, we present simulations of certain rheometry tests of a high-viscosity nonlinear viscoelastic fluid with a rotational rheometer [2]. We compare the measured values with the computed values of a few selected physical quantities, which are suitable to indicate whether the constitutive equation used in the simulation gives a sufficiently accurate material model of the fluid.

We use COMSOL Multiphysics® software and the CFD Module to perform the simulations. Our model is based on the axial symmetric (2D) formulation of the single-phase or two-phase flow (the latter with the level-set method), including swirl velocity. The tested rheological constitutive equations are implemented in general PDE mode, coupled to the flow problem.

Our results show, that a White-Metzner type constitutive equation (with upper-convected derivatives) provides a suitable material model, which is able to simulate e.g. rod-climbing due to the Weissenberg-effect [3].

Reference

[1] F.A. Morrison, "Understanding Rheology", Oxford University Press (2001)

[2] Z. Kőkuti, et al., „High-frequency rheology of a high viscosity silicone oil using diffusing wave spectroscopy”, Applied Rheology 24, 63984 (2014)

[3] S.M. Freeman and K. Weissenberg, Conf. British Rheologists’ Club, 36 K (1946)

Figures used in the abstract

Figure 1

Figure 2

Figure 3

Figure 4