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A Finite Extendable Non-linear Elastic Model applied to simulations of some complex flows

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Resumo

The Finite Extendable Nonlinear Elastic-Chilcott and Rallison (FENE-CR) constitutive equation introduced by Chilcott and Rallison [1] was derived using a dumbbell theory and it is known to describe Boger type fluids. Herein, the two-dimensional numerical simulations of viscoelastic flows described by the FENE-CR constitutive equation with a Newtonian solvent contribution are presented, specifically for the problems: fully-developed flow in a channel [2], flow in a cross-slot geometry [3], the impacting drop and the jet buckling problems [4]. Firstly, to verify the numerical technique, the analytic solution for fully-developed channel flow is derived and used to confirm the correctness and accuracy of the numerical code employed. The cross-slot geometry has been employed for extensional rheology measurements and, more recently, to investigate purely-elastic flow instabilities of viscoelastic fluids. For this problem, it is discussed whether the observed flow features reported by Rocha et al. [5] can be predicted by the finite difference method adopted here. The time-dependent jet flow originated from a jet impinging on a flat surface is even presented. It is known that when the molecules stretch indefinitely (by letting the extensibility parameter $L \to \infty$) the FENE-CR constitutive equation reduces to the Oldroyd-B model. A sequence of numerical solutions of a free surface flow problem is studied by using the extensional viscosity property and then, the convergence of these solutions from the FENE-CR model to the solution obtained with the Oldroyd-B model is also displayed. Besides presenting a quantitative verification of the numerical methodology applied to the impacting drop problem, the influence of the finite extensibility parameter and of the Reynolds and Weissenberg numbers on the time evolution of the drop width are also presented. Details about these numerical results and the numerical methodology are found in [6, 7].

Referências

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