Benchmark calculations of viscoelastic flows with a finite-volume method using the Log-conformation approach

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Abstract

A finite-volume method (FVM) is applied to the numerical simulation of two dimensional inertialess viscoelastic flows through a planar 4:1 abrupt contraction and around a confined cylinder in a channel. The upper-convected Maxwell and Oldroyd-B models were selected for this study, in order to allow direct comparison with previous works [1,2]. The numerical method uses general coordinates and is based on the collocated mesh arrangement. In the past, this FVM was implemented to the discretization of the governing equations including various differential rheological constitutive equations for the extra stress tensor [3,4]. In this work we have implemented the log-conformation methodology recently proposed by Fattal and Kupferman [5], which is based on a reformulation of the constitutive laws in terms of the matrix logarithm of the conformation tensor.

Previous research using the log-conformation tensor approach has focused on the stability issue (the high Weissenberg number problem) and has not investigated in the detail issues of numerical accuracy, which is our main motivation here.

Our results show that use of the log conformation approach to solving the stress equation leads to a decrease in accuracy relative to the traditional formulation. The stress profiles near the singularity and along the symmetry plane in the contraction exhibit broader and less intense stress peaks, an indication of higher numerical diffusivity in the simulations obtained with the log conformation formulation.

References

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