VOF-CSF methods for solving viscoelastic multiphase flows in microfluidics

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ABSTRACT

Phenomena involving viscous forces, surface effects and capillarity become ever more important and may, at the micro-scale, dominate over gravitational and inertial effects which are often predominant in macroscopic flows. This is particularly significant for multiphase flows, where representing and tracking an interface with complex shape and dynamics, that can develop large deformations, singularities and topological change, is a numerical challenge. In this work, we describe recent progress of numerical methods constructed using volume-of-fluid method (VOF) to interface representation and continuum surface force algorithm (CSF) for the balance of forces in the interface for solving complex fluid-flows in microfluidics. The first method used in this work was recently proposed by Figueiredo et al. [1] while the second methodology was implemented in the opensource OpenFOAM® toolbox. The former code used a piecewise linear interface construction method (PLIC) to reconstruct the interface and a least squares VOF interface reconstruction algorithm (ELVIRA). The latter is based on an algebraic VOF algorithm, where the interface is advected using a Multidimensional Universal Limiter with Explicit Solution (MULES), with interface compression [2]. In order to enhance the stability of the formulations when critical Weissenberg numbers are found due to the famous high Weissenberg number problem (HWNP), a generic kernel-conformation tensor transformation [3] was implemented in the VOF-CSF methods. The ability of the codes is verified in the solution of benchmark test problems of viscoelastic multiphase flows in microfluidics, as for instance, the simulation of break-up of filaments.

REFERENCES

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