6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

MODELING OF VISCOELASTIC TWO-PHASE FLOWS

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Keywords: *Rising bubble, Arbitrary Lagrangian–Eulerian (ALE) approach, Finite elements, Local Projection Stabilization*

Computational modeling of multiphase viscoelastic flows are highly demanded in several scientific, engineering and industrial processes such as enhanced oil recovery, droplet based microfluidics, emulsions and polymer blends. A quantitative understanding of the flow dynamics is essential to predict optimal processing conditions to improve the quality of the final products in various industrial applications. Therefore, it is important to understand the flow dynamics of an individual droplet in a viscoelastic or a Newtonian fluid medium. In this work, we numerically capture remarkable interesting flow dynamics of a buoyancy driven droplet in which either the drop or surrounding fluid is viscoelastic or both are viscoelastic.

The mathematical model of a viscoelastic fluid can be defined by the coupled time-dependent Navier–Stokes equations and a viscoelastic constitutive equation in a time-dependent domain. A finite-element scheme based on arbitrary Lagrangian–Eulerian (ALE) [1] approach is developed for the computations of two-phase viscoelastic flows. In particular, a three-field formulation based on the Local Projection Stabilization (LPS) [2] is proposed for the computations of two-phase viscoelastic flows. The stabilized scheme allows us to use equal order interpolation spaces for the velocity and the viscoelastic stress, whereas inf-sup stable finite elements are used for the velocity and the pressure. The interface-resolved moving meshes allow the accurate incorporation of the surface force and jumps in the material parameters. Further, the spurious velocities can be successfully suppressed using isoparametric finite elements, discontinuous pressure approximations and the tangential gradient operator technique for representing the curvature. The governing equations are solved in a monolithic approach with 3D-axisymmetric configuration.

The proposed numerical scheme is implemented in the finite element code ParMooN [3]. A parametric study is performed with various non-dimensional numbers demonstrating the effects of viscoelasticity on the flow dynamics of a buoyancy driven droplet in two-phase flows. We observe that a Newtonian drop immersed in a viscoelastic fluid experiences an extending trailing edge while a viscoelastic drop in a Newtonian fluid develops an indentation around the rear stagnation point.

REFERENCES

[1] S. Ganesan, L. Tobiska, Arbitrary Lagrangian–Eulerian finite-element method for computation of two-phase flows with soluble surfactants, *Journal of Computational Physics*, 231 (2012), 3685–3702.

[2] J. Venkatesan, S. Ganesan, A three-field local projection stabilized formulation for computations of Oldroyd-B viscoelastic fluid flows, *Journal of Non-Newtonian Fluid Mechanics*, 247 (2017), 90–106.

[3] U. Wilbrandt, C. Bartsch, N. Ahmed, N. Alia, F. Anker, L. Blank, A. Caiazzo, S. Ganesan, S. Giere, G. Matthies, R. Meesala, A. Shamim, J. Venkatesan, V. John, ParMooN - A modernized program package based on mapped finite elements, *Computers and Mathematics with Applications*, 74 (2017), 74–88.