

Finite Element Computations of Free surface and Multiphase flows with Surfactants

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ABSTRACT

Computations of free surface and two-phase flows are very challenging, in particular, when surface-active agents (surfactants) present in the fluid [1,2,3]. Surfactants on the interface lower the surface tension, and surfactants' nonuniform distributions induce Marangoni forces. The adsorption and desorption of surfactants between the interface and the bulk phase may occur when the surfactant is soluble. Thus, the existence of surfactants in fluids influences the dynamics of the flow strongly.

A finite-element scheme based on a coupled arbitrary Lagrangian-Eulerian and Lagrangian approach will be presented to compute free surface and interface flows with soluble surfactants. The numerical method is designed to solve the time-dependent incompressible Navier–Stokes equations and an evolution equation for the bulk phase's surfactant concentration. Simultaneously, a surface evolution equation for the surfactant concentration on the interface. Second-order isoparametric finite elements on moving meshes are used to discretize these equations. The interface-resolved moving meshes allow the accurate incorporation of surface forces, Marangoni forces, and jumps in the material parameters. The lower-dimensional finite-element meshes for solving the surface evolution equation are part of the interface-resolved moving meshes. The numerical scheme is validated for problems with known analytical solutions. Several computations to study the surfactants' influence on the flow dynamics of the 3D-axisymmetric rising bubbles and impinging droplets have been performed. The proposed scheme shows excellent conservation of fluid mass and the total mass of the surfactant.

REFERENCES

- [1] S. Ganesan, “Simulations of impinging droplets with surfactant-dependent dynamic contact angle”, *J. Comput. Phys.*, 301, 178 - 200, 2015.
- [2] S. Ganesan and L. Tobiska, “Arbitrary Lagrangian-Eulerian finite-element method for computation of two-phase flows with soluble surfactants”, *J. Comput. Phys.*, 231(9), 3685–3702, 2012.
- [3] J. Venkatesan, S. Ganesan: Finite element computations of viscoelastic two-phase flows using Local Projection Stabilization. *Int. J. Numer. Meth. Fluids*, (2020) 92(8), 825-854