Adaptive FEM for multiphase flows: towards physical couplings occurring in turbulent boiling

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ABSTRACT

In spite of the maturity of coupled numerical formulations for multiphase flows undergoing phase change, several involved mechanisms are still not well resolved. For complicated liquid-vapor dynamics: phase change, surface tension, interface mass transfer and discontinuous material properties have to be considered. We propose first a robust interface tracking method needed to follow efficiently and accurately the interfaces, but also to consider carefully high jump of different materials properties. It is based on the use of a modified conservative level set method that enables a direct localized level set reinitialization. An implicit implementation of the surface tension in the context of the Continuum Surface Force is proposed [1]. It enables to circumvent the capillary time step restriction and alleviate the computational cost. The obtained system is then solved using a unified compressible incompressible variational multiscale finite element method [2] designed to handle the abrupt changes at the interface and large density and viscosity ratio. Combined with an a posteriori error estimator [3], we show that anisotropic mesh adaptation yields an accurate 3D modeling framework for turbulent multiphase flows with phase change. We assess the behavior and the accuracy of the proposed formulation in the simulation of time dependent challenging numerical examples such as 3D bubble dynamics, turbulent boiling and solid quenching with experimental comparisons.

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