High fidelity anisotropic adaptive FEM towards physical couplings in turbulent boiling

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ABSTRACT

We propose in this work an adaptive variational multiscale FEM framework for multiphase flows undergoing phase change. In spite of the maturity and the popularity of numerical formulations, 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 re-initialization. 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 stabilized 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.

To assess the behavior and the accuracy of the proposed formulation, we perform simulation of time-dependent challenging benchmarks and compare the results with the literature. We also perform 3D quenching simulations and compare the results with experimental data.

REFERENCES

[1] M. Khalloufi, Y. Mesri, R. Valette, E. Massoni, E. Hachem, High fidelity anisotropic adaptive variational multiscale method for multiphase flows with surface tension, *Computer Methods in Applied Mechanics and Engineering*, Volume **307**, 1 August 2016, Pages 44-67

[2] E. Hachem, M. Khalloufi, J. Bruchon, R. Valette, Y. Mesri, Unified adaptive Variational MultiScale method for two phase compressible-incompressible flows, *Computer Methods in Applied Mechanics and Engineering*, Volume **308**, 15 August 2016, Pages 238-255

[3] T. Coupez and E. Hachem, Solution of high-Reynolds incompressible flow with stabilized finite element and adaptive anisotropic meshing, *Computer Methods in Applied Mechanics and Engineering*, Volume **267**, 2013, Pages 65-85,