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Numerical Solver for Multiphase Flows

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ABSTRACT

The technological development of micro-scale electronic devices is bounded by the challenge of dissipating their heat output. Latent heat absorbed by a fluid during phase transition offers exceptional cooling capabilities while allowing for the design of compact heat exchangers. The understanding of heat transport dynamics in the context of multiphase flow physics is hampered by the limited access to detailed flow features offered by experimental measurements. Computational Fluid Dynamics (CFD) can overcome such difficulties by providing a complete description of the three-dimensional instantaneous flow field. Unfortunately, the majority of the numerical investigations in this field at Purdue are carried out with closed-source commercial CFD software which is computationally inefficient, (financially) expensive, and allows for extremely limited algorithmic development. The goal of this project is to initiate the development of an in-house code at Purdue that can simulate multiphase-flow physics that can exploit state-of-the-art supercomputing architectures, performing very large-size computations in a cost-efficient way. A first step has been the development of a simple 2D Python toy code relying on the volume of fluid (VOF) method coupled with a continuum surface force model (CSF), which treats surface tension effects as a localized body force. Results are compared with companion simulations carried out with the commercial software Fluent, revealing a noticeable improvement in the quality of the solution and a reduced computational cost. Future works involves the implementation of interface tracking methods and the extension of an existing highly-parallelized 3D incompressible Navier-Stokes code to include multi-phase problem capabilities.

KEYWORDS

CFD, Volume of fluid (VOF), Continuum surface force (CSF), Multiphase flows, Interface tracking.