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Numerical Simulation of Two-Phase Flows Using a Pressure-Based Solver

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Abstract : This work focuses on numerical simulation of two-phase flows based on the bi-fluid six-equation model widely used in many industrial areas, such as nuclear power plant safety analysis. A pressure-based numerical method is adopted in our studies due to the fact that in two-phase flows, it is common to have a large range of Mach numbers because of the mixture of liquid and gas, and density-based solvers experience stiffness problems as well as a loss of accuracy when approaching the low Mach number limit. This work extends the semi-implicit pressure solver in the nuclear component CUPID code, where the governing equations are solved on unstructured grids with co-located variables to accommodate complicated geometries. A conservative version of the solver is developed in order to capture exactly the shock in one-phase flows, and is extended to two-phase situations. An inter-facial pressure term is added to the bi-fluid model to make the system hyperbolic and to establish a well-posed mathematical problem that will allow us to obtain convergent solutions with refined meshes. The ability of the numerical method to treat phase appearance and disappearance as well as the behavior of the scheme at low Mach numbers will be demonstrated through several numerical results. Finally, inter-facial mass and heat transfer models are included to deal with situations when mass and energy transfer between phases is important, and associated industrial numerical benchmarks with tabulated EOS (equations of state) for fluids are performed.

Keywords : two-phase flows, numerical simulation, bi-fluid model, unstructured grids, phase appearance and disappearance
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