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Algebraic Coupled Level Set-Volume of Fluid Method with Capillary Pressure Treatment for Surface Tension Dominant Two-Phase Flows

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Abstract : In this study, an Algebraic Coupled Level Set-Volume of Fluid (A-CLSVOF) method with capillary pressure treatment is proposed for the modeling of two-phase capillary flows. The Volume of Fluid (VOF) method is utilized to incorporate one-way coupling with the Level Set (LS) function in order to further improve the accuracy of the interface curvature calculation and resulting surface tension force. The capillary pressure is determined and treated independently of the hydrodynamic pressure in the momentum balance in order to maintain consistency between cell centered and interpolated values, resulting in a reduction in parasitic currents. In this method, both VOF and LS functions are transported where the new volume fraction determines the interface seed position used to reinitialize the LS field. The Hamilton-Godunov function is used with a second order (in space and time) discretization scheme to produce a signed distance function. The performance of the current methodology has been tested against some common test cases in order to assess the reduction in non-physical velocities and improvements in the interfacial pressure jump. The cases of a static drop, non-linear Rayleigh-Taylor instability and finally a droplets impact on a liquid pool were simulated to compare the performance of the present method to other well-known methods in the area of parasitic current reduction, interface location evolution and overall agreement with experimental results.

Keywords : two-phase flow, capillary flow, surface tension force, coupled LS with VOF
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