CFD Modelling of Interfacial/Multiphase Flows using Front Tracking Method

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The multiphase or interfacial flows exist widely when there are two or more immiscible fluids or fluid/solid systems. These flows play very important roles in many industrial processes and engineering design of many systems. Some examples are cell circulation flow, inkjet flow, boiling flow, bubbly flow, solidification, particle suspension, free surface flow and fluid-structure interaction. Due to difficulties in both experiments and numerical modelling, the characteristics of multiphase/interfacial flows are not well understood. Hence, a lot of effort has been beckoned towards this field on both fundamental and applied researches.

A numerical model known as front tracking method has been developed to simulate the complex multiphase / interfacial flows. In this method, the different phases are treated as a single fluid with different material properties, and a single set of governing equations is solved for the whole computational domain. The interface is tracked explicitly by an unstructured adaptive front mesh. The interface properties, such as surface tension, are computed on the front and interpolated to the background mesh for the flow solver using sharp interface approximation function. Advection of fluid properties, such as density and viscosity, is achieved by following the motion of the front. The conventional algorithms of this method are limited to flows with small Reynolds numbers, Bond numbers, and low density ratios between the fluids.

In this workshop, a solving algorithm for CFD modelling of multiphase / interfacial flow using front tracking method will be introduced. Here, implicit approach for fluid flow, AMR feature and parallel computing technique has been developed. The new algorithm is applied to 2D/3D simulations of rising and deformation of single bubble and multi-bubbles in a viscous liquid due to buoyancy. The simulation results show that the new algorithm could extend the capability of the front tracking for modelling the multi-fluid systems to much wider flow regimes. In addition, application examples of this method to modelling droplet formation, bubble interaction, elastic membrane will also be illustrated. These simulation examples demonstrate the strong capabilities of this method in simulating the deformation and movement of multiple fluid systems with complex interface.