ABSTRACT

Computational algorithms have been developed to simulate multiphase flow of different types. Attention has been focused particularly to two categories of flow phenomena namely well dispersed (bubbly) flow and flow with complex interfaces.

Population balance equation coupled with two fluid model is used for the prediction of well dispersed bubble evolution of gas liquid two phase flow through vertical conduits. Coalescence of two similar or different sized bubbles and homogeneous and non homogeneous binary break up of a bubble has been tracked using the methodology. Present model is capable of tracking various distributions of void fraction profiles (wall peak, core peak, two peak etc.) efficiently. Using the model an effort has been made to propose unique criteria for transitions from bubbly flow to slug flow and dispersed bubbly flow by tracking the coalescence frequency and breakup frequency along the conduit axis. The developed transition criteria exhibit excellent match with the available literature. The present model has also been applied successfully for simulating bubbly flow through an annular passage.

Lagrangian Smoothed Particle Hydrodynamics (SPH) model is described to tackle the complex interfaces in typical multiphase flow situations. Surface tension force is added in the present numerical technique to avail the exact shape of the interface. The developed algorithm has been used to simulate the process of bubbling through submerged orifices. Effect of different properties of the surrounding liquid, like density, viscosity and surface tension, on bubble formation has been investigated in detail.

The concept of diffused interface is incorporated in the present numerical technique to improve the prediction of the interfaces. Liquid drop over an inclined plane is modeled successfully using the described methodology. Motion of the contact line and the overall dynamics of the drop are predicted analyzing the fluid flow inside the drop. Efforts have also been made to simulate unique phenomena like drop translation, uphill movement, splitting and merging of drops due to wettability gradient. Diffused interface based SPH can efficiently track the complex, dynamic interfaces in the scale of the droplet. New methodology for drop surgery is proposed using the developed numerical tool.

Finally a model has been proposed based on SPH to describe gas liquid phase change. Pseudo particles of zero mass are initially placed to locate the interface. Mass generated due to phase change is assigned to the pseudo particles and their positions are updated at intervals to track the mobility of the interface. The developed algorithm has been used to simulate vapor formation around solid spheres both in the absence of gravity and in the normal gravitational field. Finally, bubble growth over a hot horizontal surface due to boiling has been simulated. Simulated results showed good matching with the reported literature.

Keywords: Two fluid model, Population balance equation, Smoothed particle hydrodynamics, Diffused interface, Gas-liquid phase change, Bubbly flow, Wettability gradient.