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Computational Fluid Dynamics (CFD) Simulation of Transient Flow in a Rectangular Bubble Column Using a Coupled Discrete Phase Model (DPM) and Volume of Fluid (VOF) Model

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Abstract : In this work, we present a computational study for the characterization of the flow in a rectangular bubble column. To simulate the dynamic characteristics of the flow, a three-dimensional transient numerical simulations based on a coupled discrete phase model (DPM) and Volume of Fluid (VOF) model are performed. Modeling of bubble column reactor is often carried out under the assumption of a flat liquid surface with a degassing boundary condition. However, the dynamic behavior of the top surface surmounting the liquid phase will to some extent influence the meandering oscillations of the bubble plume. Therefore it is important to capture the surface behavior, and the assumption of a flat surface may not be applicable. So, the modeling approach needs to account for a dynamic liquid surface induced by the rising bubble plume. The volume of fluid (VOF) model was applied for the liquid and top gas which both interacts with bubbles implemented with a discrete phase model. This model treats the bubbles as Lagrangian particles and the liquid and the top gas as Eulerian phases with a sharp interface. Two-way coupling between Eulerian phases and Lagrangian bubbles are accounted for in a single set continuous phase momentum equation for the mixture of the two Eulerian phases. The effect of gas flow rate on the dynamic and time-averaged flow properties was studied. The time averaged liquid velocity field predicted from simulations and from our previous PIV measurements shows that the liquid is entrained up flow in the wake of the bubbles and down flow near the walls. The simulated and measured vertical velocity profiles exhibit a reasonable agreement looking at the minimum velocity values near the walls and the maximum values at the column center.

Keywords : bubble column, computational fluid dynamics (CFD), coupled DPM and VOF model, hydrodynamics
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