Numerical Simulation of Bubble Rising by IMPS-based Multiphase Method

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Abstract

The numerical simulation of bubble rising is challenging since the tracing of deformed multiphase interface. In this paper, a new mesh-less multiphase method is developed based on the IMPS (Improved Moving Particle Semi-implicit) method and applied to simulate the phenomena of bubble rising.

In this method, the multiphase system is treated as the multi-density and multi-viscosity fluid. To consider the interaction between particles belonging to different phases, inter-particle viscosity defined by the harmonic mean viscosity is firstly adopted. Then the density smoothing technique is employed to reduce pressure discontinuity crossing the interface to obtain the continuous acceleration and velocity fields. Since the shape of bubble is dominated by the tension on the interface, a contoured continuum surface force (CCSF) model is utilized in the present method.

The new multiphase MPS method is validated through comparisons with published numerical data. In particular, the multiphase MPS method is verified against Hysing et al.'s (2009) quantitative benchmark computations of two-dimensional bubble dynamics. Two benchmark cases have been studied by the present method and the evolution of a single bubble rising in a liquid column is concerned. In the first case which corresponds to a low Eötvös number, the present numerical result indicates that the bubble withstands a moderate deformation and ends up in the ellipsoidal regime, while in the second case with a high Eötvös number, the bubble undergoes significant topology change and breaks up eventually. For both cases, good agreements achieved for the benchmark quantities, including circularity, center of mass, and mean rise velocity, which demonstrate the accuracy and stability of the present multiphase MPS method.

Keywords: Multiphase flow; IMPS; Bubble rising; Numerical simulation; Surface tension