Pressure Correction Method for Fluid-Particle Interaction and Two-Phase Flow

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A pressure correction method coupled with a direct-forcing immersed boundary (IB) method and the volume of fluid (VOF) method is developed to simulate fluid-particle interaction and two-phase flows. This method uses a pressure correction method to solve incompressible flow fields, an IB method to handle fluid-particle interactions, and the VOF method to solve the two-phase flow. A direct forcing method is introduced in the IB method to capture particle motions. A volume fraction function is introduced in the VOF method and is governed by an advection equation. A third-order modified monotone upwind scheme for conservation law (modified MUSCL) is used to solve the solutions of the advection equation. Moreover, by applying the Gauss theorem, the formulas for computing the hydrodynamic force and torque acting on the particle from flows are derived from the volume integral of the particle instead of the particle surface. For demonstrating the efficiency and capability of the present method, sedimentations of many spherical particles in an enclosure, three-dimensional broken dam problem, three-dimensional rising bubble, and three-dimensional wave impact on a tall structure are performed. Finally, the numerical method is applied to investigate the granular flow impact on a tall structure.

Keywords: Pressure correction method, Volume of fluid, Immersed boundary method, Fluid-particle interaction, Two-phase flow.