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Multi-Physics CFD Simulation of Three-Phase Flow with MPS Method

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In the present study, we develop a new numerical procedure to simulate a three-phase (i.e. solid-gas-liquid) flow with a free surface. One of the typical three-phase flows can be seen at the impact phenomenon of a solid particle to a free liquid surface. In the case, the particle rapidly decelerate at the impact position, and then sink into the liquid. In addition, at the impact, air bubbles are generated behind the solid particle. This phenomenon is very difficult to be simulated with a grid-base method because of the large deformation of the liquid surface and the air bubble engulfment. Therefore, a MPS method is employed to model the motions of liquid and gas by using those of virtual particles. However, since the density ration of liquid to gas is roughly one thousand, the computation always becomes unstable and sometimes divergence of the computation occurs. To overcome this numerical problem, we propose a tentative one-way coupling method. That is, when gas motions are solved, we assume that liquid does not affect the gas motions, and vice versa. This numerical procedure is verified to the three-phase flow described above. Investigating the numerical results, it is confirmed that our proposed method can satisfactorily reproduce the phenomenon without any numerical instability.

Keywords: Multi-Physics CFD, Three-Phase Flow, Incompressible Flow, MPS Method