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NUMERICAL SIMULATION OF DROPLETS CAPILLARY UNDER MICROGRAVITY WITH SMOOTHED PARTICLE HYDRODYNAMICS

Abstract

The capillary phenomenon plays an important role in multiphase, combustion and complex fluid dynamics under microgravity. It has theoretical significance to study on this problem, and it will greatly promote the progress of the new fluid mechanics system, interface processes, phase transformation, heat transfer and mass transfer, colloidal science, and soft matter science etc. The grid methods are usually used in the traditional simulation of capillary phenomena, such as finite element method, finite volume method, finite difference method, and so on. These methods has many disadvantages in dealing with such complex problems as gas, liquid and solid multiphase flow, as well as interface tracking, heat conduction, evaporation and combustion. Smoothed particle hydrodynamics (SPH), as a Lagrange meshless method, can easily deal with the physical and chemical effects and irregular, moving, even deformed interface because the numerical diffusion does not exist in the transmission fluid interface. These advantages of SPH can be extended to three dimensions. A new SPH method for solving the problem of droplet deformation, motion, polymerization and collision in microchannel under microgravity is presented in this paper. The multi-phase SPH method was used to solve the gas-liquid-solid three-phase and multi-medium coupling problems. The continuous surface force (CSF) model was used to calculate the surface tension, and the correction technique for the normal of surface was used to cope with the surface tension between the gas-liquid-solid three phases. A numerical test that the deformation of the liquid surface in a water tank under microgravity is used to simulate. The results are compared with the experiments and other numerical methods. The wetting process of microgravity droplet on the solid surface in the microchannel was then simulated combined with the heat transfer model and viscous force model and the action of surface tension between three interfaces were captured. The polymerization of liquid droplets with different wetting angles was calculated, and the mechanism of polymerization deformation of droplets under microgravity was analyzed. Finally, the thermal capillary of droplets caused by the droplet temperature gradient is studied. A thermal capillary model of droplets is constructed and a group of SPH discrete equations including thermal capillary model is derived. Then the two droplets polymerization in microchannel under thermal capillary is calculated. The result is in accordance with the physical reality. This study provides an effective method for numerical simulation of space microgravity fluid physics.