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LATTICE BOLTZMANN SIMULATION OF A KEROSENE DROPLET IMPACT ON WALL OF COMBUSTION CHAMBER IN RBCC

Abstract

In recent years, RBCC has emerged as a promising reusable vehicle, which can reach orbit with low cost, increased reliability and little or no maintenance while operating hundreds of hours. In RBCC, the impact of a kerosene droplet impact on wall of combustion chamber is a commonly encountered phenomenon and has a great influence on the combustion efficiency. In this paper, a color-gradient lattice Boltzmann model (LBM) is developed to simulate the dynamical behavior of droplet on solid surface. In the last two decades, LBM has shown great potential for modeling interfacial interactions. It is a pseudo-molecular method tracking evolution of the distribution function of an assembly of molecules and built upon microscopic models and mesoscopic kinetic equations. Its mesoscopic nature can provide many advantages of molecular dynamics, making the LBM particularly useful for simulation of multiphase flows. In the present work, a perturbation operator based on the continuum surface force concept is introduced to model the interfacial tension, and the recoloring step is used to produce phase segregation. In addition, a wetting boundary condition is proposed to model fluid-surface interactions, which can improve the accuracy of the simulation and suppress spurious velocities in the contact line regions.

Numerical simulations are first conducted to verify the developed model, including the static and dynamic simulations of droplet partial wetting. Then, the model is applied to investigate the influences of the typical parameters such as Reynolds number, Weber number and contact angle on outcomes of droplet impact on the surface. The present study can not only provide useful data in predicting the dynamical behaviors of a kerosene droplet impact on wall of combustion chamber, but also help understand the mechanism of droplet impact process.