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TRACKING METHODS FOR FREE SURFACE AND SIMULATION OF A LIQUID DROPLET IMPACTING ON A SOLID SURFACE BASED ON SPH*

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Abstract: With some popular tracking methods for free surface, simulations of several typical examples are carried out under various flow field conditions. The results show that the Smoothed Particle Hydrodynamics (SPH) method is very suitable in simulating the flow problems with a free surface. A viscous liquid droplet with an initial velocity impacting on a solid surface is simulated based on the SPH method, and the surface tension is considered by searching the free surface particles, the initial impact effect is considered by using the artificial viscosity method, boundary virtual particles and image virtual particles are introduced to deal with the boundary problem, and the boundary defect can be identified quite well. The comparisons of simulated results and experimental photographs show that the SPH method can not only exactly simulate the spreading process and the rebound process of a liquid droplet impacting on a solid surface but also accurately track the free surface particles, simulate the free-surface flow and determine the shape of the free surface due to its particle nature.

Key words: Smoothed Particle Hydrodynamics (SPH) method, viscous liquid droplet, impacting on a solid surface, free surface

Introduction

The phenomenon of a liquid droplet impacting on a solid surface can be found extensively in nature, being studied in materials science, chemical engineering, metallurgy, aerospace, manufacturing sector, agriculture and other fields. It is an important issue in production and modern technology.

Wu^[1] predicted the size distribution of secondary ejected droplets by the crown splashing of droplets impinging on a solid wall based on experiments, Guo and Dai^[2] established a heat and mass transfer model for the thin liquid film on the hot solid surface cooled by the impinging small droplets, with consideration of the effect of the droplet impact, surface tension, thermocapillary, evaporation/condensation, and van der Waals attraction. Li et al.^[3] conducted a visual experimental study on droplets being impacted onto a hori-

zontal solid surface. Ma et al.^[4] carried out elastic / plastic impact simulations of water jet using the SPH and the finite element method. He et al.^[5] established a droplet-wall collision model based on Euler-Lagrange two-phase flow model; Zhang et al.^[6] simulated the breaking waves impacting on a building in a complex boundary with the Smoothed Particle Hydrodynamics (SPH) method. Various methods were used in studies of impacting problems related with free surface, and the key of a liquid droplet impacting on a solid surface is to track the free surface. Among many movement interface tracking methods, the most popular methods include the Volume Of Fluid (VOF)^[7] methods and the Level Set method^[8] based on grids, and the SPH method – a meshfree particle method.

The SPH is a new meshfree Lagrangian particle computational technique^[9], becoming popular in recent years. It was introduced by Lucy and Monaghan in 1977, was applied in astrophysics at first and then widely used in studying problems of hydrodynamics and other related fields. The SPH method uses a number of discrete particles to replace the whole continuous medium and uses the particle set and the interpolation function to estimate the space function and its derivatives, thus overcomes many

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Biography: LI Da-ming (1957-), Male, Ph. D., Professor