Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Smoothed Particle Hydrodynamics in Materials Processing: Code Development and Applications

By

Mingyu Zhang

Thermal spray is a continuous, direct melt-spray process in which particles of virtually any materials are melted and accelerated to high velocities. The molten or semi-molten droplets impinge on a substrate and rapidly solidify to form thin “splats”. The deposit is built up by successive impingement and interbonding among the splats to form a well-bonded deposit. Due to the complex of the interaction between momentum and heat transfer and crystal growth kinetics, it is difficult to handle spreading and solidification of molten droplets on impact theoretically. Meshless method, Smoothed particle hydrodynamics (SPH), is developed to investigate the problem in this work.

SPH is a meshless Lagrangian method for modeling fluid dynamics. As a particle method, SPH uses a set of particles to represent fluid flow. Each SPH particle has its own physical properties such as viscosity, density, velocity, pressure or internal energy and mathematical properties like position, related gradients.

First, the vdW model is applied to simulate surface tension. However, there is tensile instability in the simulation. Then XSPH is included into the vdW model to remove tensile instability. Also, the SPH model is applied to a droplet impacting on substrate with different roughness. Spreading, solidification, oxide redistribution, and droplet pinch-off are presented in two and three dimensional geometry configurations. This work demonstrates the SPH model as a powerful tool to study transport phenomena in the problems with free surface deformation and solidification.

Then, SPH is applied to simulate inclined impact of ZrO_2 droplet on the cold substrate. Heat transfer during droplet impact is considered by using an improved artificial heat model. The temperature distribution of the droplet during impact is given. A simple solidification model is proposed to simulate the movement of the solidification interface. The effects of the impact angle on the splat formation have been studied.

Finally, the droplet impact into porous media is investigated by using SPH method. The cases for the porous media with different shapes, stick or sphere, different sizes, and different distributions, orderly or random, are simulated. The SPH method can predict the droplet impact into porous media very well.

Date: April 10, 2007
Time: 10 AM
Place: Light 250

Program: MEC
Dissertation Advisor: Professor Hui Zhang