3D MODEL OF DROPLET IMPACT AND SOLIDIFICATION: IMPACT ON A SOLIDIFIED SPLAT

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Abstract

A 3D computational model of fluid flow and heat transfer including solidification was developed. The model is an extension of the Bussmann et al. model[1]. The model was used to simulate the impact of two droplets on a stainless steel substrate in conditions typical of thermal plasma spray processes. Two spraying conditions with two materials, alumina and nickel, were considered. After a completely solidified splat was made from the first droplet impact, the second droplet was introduced. Droplets had different center of impacts. Liquid breakup and splashing occurred with the impact of the second droplet. Void spaces were made between the splats and substrate at the location of the second droplet breakup. These spaces remained void until the end of the process. This may explain one cause of porosity formation in thermal spray coatings.

1. Introduction

Physical properties of thermal spray coatings, e.g. porosity, are sensitive to a large number of process parameters (such as droplet size distribution, velocity, temperature and degree of solidification; substrate material and temperature) which are optimized by trial and error[2]. Better control of the process requires a fundamental understanding of the fluid flow and heat transfer that occurs during the impact, spreading, and solidification of molten droplets.

In a previous study[3], we developed a 2D/axisymmetric model to simulate the impact of molten tin droplets on a steel plate; the predictions of the model were compared with photographs of impacting droplets. Modeling the impact of several droplets or the impact on a previously solidified splat, however, requires a 3D model.

The objectives of this study are: to develop a 3D numerical model of free-surface flows and heat transfer including phase change, and to demonstrate that the model can simulate a complex phenomenon of the impact of a droplet on a previously solidified splat.

2. Numerical Method

Fluid flow. Fluid flow in an impacting droplet was modeled using a finite difference solution of the Navier-Stokes equations in a 3D Cartesian coordinates assuming laminar.