Proceedings of CHT-15
ICHMT International Symposium on Advances in Computational Heat Transfer

May 25-29, 2015, Rutgers University, Piscataway, USA

CHT-15-056

NUMERICAL ANALYSIS OF NON-ISOTHERMAL REMELTING AND SOLIDIFICATION DURING MOLTEN DROPLET IMPACT ON A SUBSTRATE

Vimal Ramanuj[§], Albert Y. Tong and Vignesh Dheenakumar
Dept. of Mechanical and Aerospace Engineering, University of Texas at Arlington, USA
[§]Correspondence author. Email: vimal.ramanuj@mavs.uta.edu

ABSTRACT

The fluid dynamics and thermal behavior of a molten droplet impacting on a substrate are studied using numerical techniques. A non-isothermal phase change behavior of the mushy region is analyzed. The estimation of remelting depth, solidification time and cooling rates is the main objective of this study. This information can be directly used to select the operating parameters in actual processes such as microcasting, shape deposition manufacturing and thermal spray deposition. A parametric study is done to examine the effects of certain parameters on the desired quantities.

A fixed non-uniform grid numerical model is used to analyze the flow field and the temperature distribution in the domain. The free surface is captured and constructed using the VOF method with a PLIC scheme. The governing equation for the flow field is solved using a two-step projection method. The surface tension is modeled using the Continuum Surface Force model. Enthalpy formulation of the heat equation is used and coupled with the flow field using a porosity model. An implicit source term added to the heat equation takes into account the latent heat addition during phase change. The latent heat is made a linear function of the liquid fraction or porosity and the mushy region is treated as a homogeneous phase in this model. The governing equation for the fluid flow is also modified to be consistent with the porosity model.

The results obtained are compared with experimental findings and are found to be in good agreement. The importance of convection terms in the numerical model is also emphasized. The effect of the flow field on the remelting and cooling rates is studied. A parametric study on the effect of substrate preheating and impact velocity has also been done. Results from the study establish that preheating of the substrate leads to deeper penetration of heat, more remelting and slower cooling rates. It is also observed that a droplet with a higher velocity spreads farther out on the surface of substrate rather than melting more of the solid material. The cooling rates are dependent on the convection effects and hence, slower droplets are found to have lower cooling rates as well as lesser remelting depth. These parameters can be used to control the amount of remelting and cooling rates and in turn the microstructure of the cooled part.

Key words: VOF, CSF, remelting, cooling rate, spreading, solidification, non-isothermal phase change.