ABSTRACT

Modeling of heat transfer and fluid flow during the impingement and solidification of metal droplets on a substrate is a helpful tool for the better understanding and control of related spray casting and thermal spray coating processes. In the present work a comprehensive model for heat transfer and solidification during impingement of a falling liquid Al-33wt%Cu droplet on a 304 stainless steel substrate has been developed on FLUENT 6.3.16 platform. Al-33wt%Cu was selected so that Jackson – Hunt theory can be utilized for the validation of the impingement model.

The model simultaneously takes into account the fluid flow and heat transfer in the liquid droplet and surrounding gas, and heat transfer in the substrate. Liquid – gas interface was tracked using volume of fluid method and the contact resistance between Al-33wt%Cu and the substrate was taken into account. Surface tension was modeled as a body force acting on a fluid near the free surface. The energy equation in the droplet region was solved using enthalpy method and that within the substrate by solving the heat conduction equation. The thermal contact resistance between substrate and impinging droplet was included in the model by incorporating a special solid material between the substrate and droplet. The conductivity of the additional layer of special material was determined experimentally.

The comprehensive model correctly predicted the total spread in the droplet. As per the predicted transient thermal field, the solidification front speed oscillated as one moves radially outward from the center of the spread droplet. Based on the estimated front speeds at these locations and Jackson – Hunt plot for Al-33wt%Cu the variation of interlamellar spacing along the radial direction was found out. It matched well with the variation of the experimentally measured interlamellar spacing at different locations along the radius.

Work was further extended to study the interaction phenomenon of impingement of two droplets. The second droplet was having the same conditions as the first one. Simulation of sequential droplet impingement is not easy as the surface structure of the previously formed splat is complex. The time lag between two droplets was measured using a high speed camera and it was taken as an input in the model. This model was also validated using Jackson – Hunt theory.

Keywords: Droplet impingement, Modeling, Eutectic, Alloy droplet; Substrate, Solidification.