Modeling of transport phenomena in metal fusion cutting using high power laser

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Abstract

In the present study, a three-dimensional transient numerical model was developed to study the temperature field and cutting kerf shape during laser fusion cutting. The finite volume model has been constructed, based on the Navier–Stokes equations and energy conservation equation for the description of momentum and heat transport phenomena, and the Volume of Fluid (VOF) method for free surface tracking. The Fresnel absorption model is used to handle the absorption of the incident wave by the surface of the liquid metal and the enthalpy-porosity technique is employed to account for the latent heat during melting and solidification of the material. To model the Physical phenomena occurring at the liquid film/gas interface, including momentum/heat transfer, a new approach is proposed which consists of treating friction force, pressure force applied by the gas jet and the heat absorbed by the cutting front surface as source terms incorporated into the governing equations. All these physics are coupled and solved simultaneously in Fluent CFD®. The main objective of using a transient phase change model in the current case is to simulate the dynamics and geometry of a growing laser-cutting generated kerf until it becomes fully developed. The model is used to investigate the effect of some process parameters on temperature fields and the formed kerf geometry.