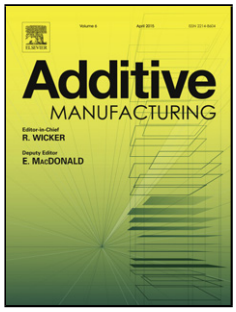

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Author: John Romano Leila Ladani Jafar Razmi Magda Sadowski

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Temperature Distribution and Melt Geometry in Laser and Electron-Beam Melting Processes – A Comparison among Common Materials

John Romano[1*], Leila Ladani[1], Jafar Razmi[1] and Magda Sadowski[1]
[1]*University of Connecticut, Storrs, CT, U.S.*
john.romano@uconn.edu, lladani@engr.uconn.edu, razmi@engr.uconn.edu, magda.sadowski@uconn.edu

Abstract

Due to the relative youth of metallic powder bed additive manufacturing technologies and difficulties with monitoring the process *in situ*, there is little consensus in the user community on how to optimize user variable parameters to ensure the highest quality and most cost effective build. Temperature distribution is the critical factor that dictates melting, microstructure and eventually the final part quality. Monitoring or measuring the temperature during the process is extremely difficult due to the ultra-high speeds and microscale size of the laser or electron beam. Therefore, other tools such as finite element modeling can be utilized to optimize these processes and predict the behavior of the system for different materials. This research presents transient, dynamic finite element model of the build process for both laser and electron beam melting techniques. The model includes melting and solidification of the powder as well as different thermal aspects such as conduction and radiation. Diffusivity of the powder is modeled and phase change is modeled such that latent heat of fusion is considered. Melt pool geometry and temperature distribution was obtained for different heat sources and different materials such as Ti6Al4V, Stainless Steel 316, and 7075 Aluminum powders. It was determined that heat accumulation is most consolidated within titanium powder beds, with steel being the second most consolidated, and aluminum powder beds having the most heat dissipation. As a result, titanium was seen to exhibit the highest local temperatures and largest melt pools, followed by steel and aluminum in decreasing order. Naturally, laser models showed smaller melt pool sizes and depths due to lower power. The beam speed and power used for Ti were found inadequate for creating a sustained and continuous melting of Al and Steel. Therefore, adjustments were made to these parameters and presented in this research.

Keywords: Powder Bed, Laser Melting, Electron Beam Melting, Finite Element

[*] Corresponding author