Numerical Modeling of Powder Flow During Coaxial Laser Direct Metal Deposition - Comparison Between Ti-6Al-4V Alloy and Stainless Steel 316L

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Abstract

The quality and efficiency of laser direct metal deposition largely depend on the powder stream structure below the nozzle. The development of numerical models has proven useful in improving the process. In this paper, a 3D numerical model is presented to predict the whole process of coaxial powder flow, including the particle stream flow in and below the nozzle and the laser-particle interaction process. The Particle Tracing Module of Comsol Multiphysics® is used to solve the coupled momentum transfer equations between the particle and gas phase while incorporating particle temperature evolution. The gas phase is treated as continuum, while the particle flow is simulated as a discrete phase. A turbulence k-epsilon model is employed to describe the behavior of the gas flow. The trajectory of the discrete phase particle is calculated by integrating the force balance on each particle taking into account gravity and drag forces. Heating of powder particles is treated using a lumped capacitance approach. The energy balance accounts for laser intensity, convection and radiation losses. The heat convective coefficient is calculated from Nusselt number which depends on the gas velocity. The powder concentration and particle heating process are analyzed for two materials: Ti-6Al-4V alloy and stainless steel 316L. The influence of different operating parameters is studied, such as distribution and power of the laser, inlet gas velocities, substrate shapes. The numerical results are compared with experimental data.