Atomization of metal droplets in production of powder for 3D printing application

Taher Abu-Lebdeh, Sameer Hamoush, and Genaro Pérez-de León

Department of Civil, Architectural, and Environmental Engineering

North Carolina A&T State University

This numerical analysis study entails utilizing computer software such as MATLAB™ to assess and create a model(s) that is capable of simulating molten metal droplets in production of powder for 3D printing applications. The model contains simple form of a user data input of the proper parameters and running the model that uses built methods such as an explicit Runge-Kutta formula and variable order solver based on the numerical differentiation formulas (NDFs). Further, the numerical modeling were based on Newtonian cooling and energy balance, and thus consisted of applying dynamics fluid mechanics and thermodynamics that dealt with the effects of the molten or liquid metal as well as gas entering a nozzle and exiting. The numerical formulation consisted of modeling gas dynamics, droplet dynamics, energy conservation or heat transfer between droplet and gas, and considered the properties of both the alloy and the atomization gas. The study produced data needed for the optimal processing parameters in producing molten metal alloy droplets as well as metal powder. The metal utilized within the model was an alloy mainly comprised of aluminum (Al90Gd7Ni2Fe1) that produced amorphous powders, through the gas atomization (GA) technique. Atomizations gases were Helium (He) and Argon (Ar), with each volume composition varying for different analysis. Assumptions for the modeling include: spherical droplets, Newtonian cooling with no nucleation, droplets travelled along chamber axis and were subject to same gas velocity profiles, and fluctuation in local gas velocities caused by turbulence were ignored. Results from previous sources concur with observations reached through the assembled model. Through the gas and droplet dynamics portion it is concluded that gas velocity reaches a maximum at the exit of the atomizer nozzle then decreases as an exponential decay as the flight distance increases and velocity of atomized droplets increases with increasing gas pressure. In regards to energy conservation and the cooling rate of the droplet, it is noted that gas composition is more effective than gas pressure on influencing cooling rate for a specific droplet size as well as droplet cooling rate increases with decreasing droplet size. Furthermore, increasing cooling rate by increasing He volume fraction or percentage is more effective than just by increasing gas pressure. He is superior to Ar or an Ar-He atomization gas mixture and produces greater values in regards to velocity and cooling rate (He density and viscosity is much less than that of Ar). Another factor that affects cooling rate is the melt superheat temperature, in which that as the melt superheat increases, the cooling rate does as well.