Numerical Simulation and Image Analysis of a Molten Metal Atomization focused on the Additive Manufacturing Route

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Abstract

Additive Manufacturing is an advanced process to tailor complex parts, offering new possibilities to the traditional manufacturing routes that uses metal powder as raw material. To ensure a good quality to the produced piece, flowability of the powder is essential, being dominated by the powder characteristics, such as diameter ranges and sphericity. The most common method to produce particles within these criteria is through the atomization of a molten metal assisted by a high velocity gas, which breaks apart the liquid surface and generates a collection of particles.

To better understand the phenomena during this manufacturing process, such as increased in mean particle size, lack of sphericity, interaction with the gas phase, and others, high-speed video of the atomization coupled with numerical simulation tools to describe the flow field can be beneficial for determining the ideal process conditions for this process.

In such manner, atomization experiments using different gas pressures and temperatures in a close-coupled atomizer were used to produce tool steel (AISI-H13) metal powder, with primary breakup images collected at high frequencies (20000 Hz). This allowed the identification of liquid ligaments being directed at the atomizer walls at lower Gas Melt Ratios (GMR), or in other words, due to a lack of the gas momentum to maintain the liquid centered during the atomization. At higher GMR's, short liquid burst from the nozzle were captured (superpulsating mode), which also directed part of the liquid to impinge with the walls, forming flakes (elongated particles).

Moreover, it was observed an increase in liquid mass flow rate as gas atomization pressure was increased, which can be explained by a decrease in the pressure below the pouring nozzle. Through numerical simulations using OpenFOAM, this behavior was later confirmed. In addition to that, the length of the primary breakup region obtained experimentally increased with the pressure, which was also observed within the simulations.

Keywords

Atomization, Numerical Simulation, High-speed Image Analysis, close-coupled atomizer

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