Effect of Geometric Parameters in Close-coupled Gas Atomization: Numerical Study

Franz Hernandez, Jordan Tiarks, Emma White, Trevor Riedemann, David Byrd, Bo Kong and Iver E. Anderson
Ames Laboratory of US DOE
Ames, IA 50011-3020, USA

Thomas Ward
Department of Aerospace Engineering, Iowa State University
Ames, IA 50011, USA

Jonathan D. Regele
Los Alamos National Laboratory
Los Alamos, NM 87545, USA

ABSTRACT

The performance of close-coupled gas atomization of liquid metals depends on flow conditions, geometry, and fluid properties. Two important parameters influencing particle size distribution are the gas-to-liquid mass and momentum flux ratios. The gas-to-liquid coupling is inherently linked to the atomization gas die design (with discrete jets) and melt pour-tube tip geometry. Therefore, a better understanding of coupled flow and geometric effects can impact the criteria employed in die and pour-tube tip design. We have explored numerically the effect of parameters, e.g., gas die dimensions and apex angle, on the gas flow and particle size distributions for fixed molten aluminum and nitrogen gas flow conditions. These parameters affect the efficiency of close-coupled gas atomization. Conditions of high coupling tend to reduce particle sizes. This study employs a multiphase compressible 5-equation model in two dimensions (Cartesian).

INTRODUCTION

Close-coupled gas atomization of liquid metals is employed to produce powders for the additive manufacturing industry. The size, sphericity, mechanical properties and chemical composition of the particles, among other characteristics, determine the distinctive process and applicability of the powder. Some of these properties are associated with the flow mechanisms and the gas-melt coupling. In terms of size control, the particle size distribution of the powder is typically dependent on the gas die, pour tube and atomization chamber geometry, as well as on the flow conditions, melt superheat and material properties. A complete knowledge of the close-coupled gas atomization process is still missing due to flow complexity and the spectrum of nozzle shapes and configurations. Two important parameters that require control are the standard deviation and the median particle size of the distribution, especially when the distribution behaves as log-normal. The yields and the quality of the powder for a given particle size range can be improved by controlling such parameters.

Several types of close-coupled flows have been described in the literature. Two common flows are pre-filming, or melt-sheet flow, which is characterized by the formation of a sheet of liquid that flows radially