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Numerical and experimental modelling of back stream flow during close-coupled gas atomization

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Abstract

This paper reports the numerical and experimental investigation into the effects of different gas jet mis-match angles (for an external melt nozzle wall) on the back-stream flow in close coupled gas atomization. The Pulse Laser Imaging (PLI) technique was applied for visualising the back-stream melt flow phenomena with an analogue water atomizer and the associated PLI images compared with numerical results. In the investigation a Convergent–Divergent (C-D) discrete gas jet die at five different atomization gas pressures of 1 to 5 MPa, with different gas exit jet distances of 1.65, 1.6, 1.55, 1.5, 1.45 and 1.40 mm from the melt nozzle external wall, was combined with four melt nozzles of varying gas jet mis-match angles of 0, 3, 5, and 7 degrees relative to the melt nozzle external wall (referred to as nozzle types 1 to 4). The results show that nozzle type 1 with the smallest mis-match angle of zero degrees has highest back-stream flow at an atomization gas pressure of 1 MPa and a gas die exit jet located between 1.65 mm to 1.5 mm from the external melt nozzle wall. This phenomenon decreased with increasing mis-match angle and at higher atomization gas pressure. For nozzle type 2, with a mis-match angle of 3 degrees, a weak back-stream flow occurred with a gas exit jet distance of 1.65 mm from the melt nozzle external wall. For a gas pressure of 1 MPa with a decrease in the gas jet exit distance from the external wall of the melt nozzle this phenomenon was eliminated. This phenomenon was not seen for nozzle types 3 and 4 at any gas pressure and C-D gas exit jet distances.

Key words
Mis- match angle; Back–stream flow; Gas atomization; External wall; Melt nozzle

1. Introduction

Gas atomization is a technique for producing fine spherical powder metals and alloys. There are two general methods for the gas atomization; free fall and close-coupled gas atomization (CCGA). In free fall atomization, the molten metal falls a short distance from the melt delivery nozzle under gravity before being broken apart by an impinging gas jet. A positive aspect of the free fall design is that it is easier to control the gas and melt interaction when compared with a close-coupled design. However, in free fall designs the particle size distribution is difficult to control and the process efficiency is lower. As such, most commercial atomizer tends to be of the close-coupled design. In close coupled atomization, the molten metal stream pours from a tundish that acts as a reservoir controlling the flow rate