Imaging the Interaction of Multiple Water Sprays to Demystify the Atomization Zone During Ferrous Metal Atomization

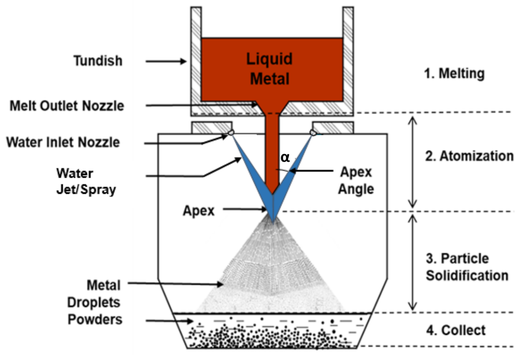
Ali Asgarian[1], Cheng-Tse Wu[1], Ziqi Tang[1], Markus Bussmann[1], and Kinnor Chattopadhyay[1]
Sylvain Lemieux[2], Bruno Girard[2], and Francois Lavallee[2]

[1] University of Toronto
[2] Rio Tinto Metal Powders

Introduction

Water atomization of ferrous metals is the most economical route for production of iron and steel powders, and offers the highest throughput of all techniques. Despite these advantages, water atomized powders suffer from some drawbacks including irregularity of particle shape and a wide particle size distribution. To find a remedy to the latter and narrow the spread of the PSD, the process of water atomization must be better understood. There is a substantial gap in the literature on the intermediate processes involved in producing water atomized powder using multiple high-pressure water sprays. Therefore, the aim of this study is to shed light on one of the important aspects of the water atomization process, i.e. the interaction of multiple water sprays.

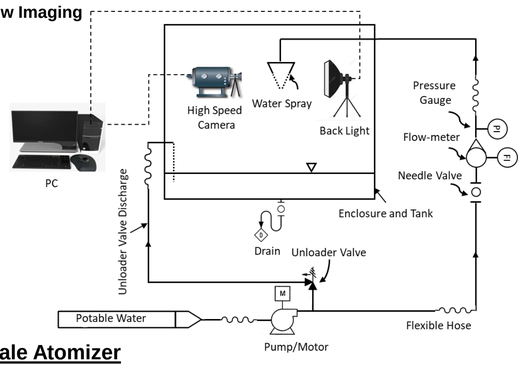
Water Atomization Process



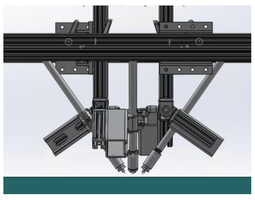
Materials and Methods

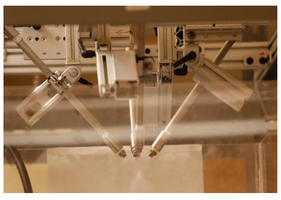
Process Flow Diagram

1) Lab-scale Atomizer
2) Shadow Imaging



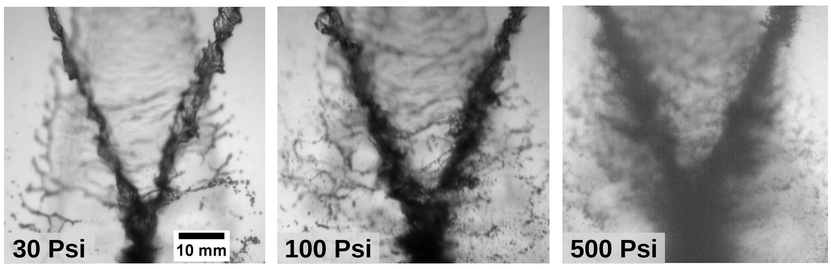
Lab-Scale Atomizer





Results and Discussion

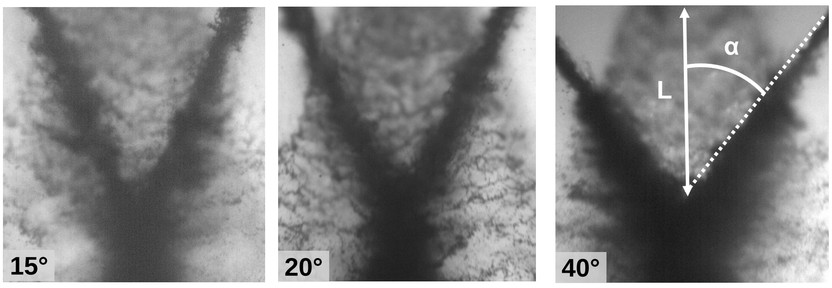
Effect of Pressure: 30, 100, 500 Psi



At higher pressure,

- ❑ water jets break up at a shorter distance from the water nozzles. Ligaments and droplets form prior to the impingement.
- ❑ water travels at a higher velocity (proportional to $\sqrt{P}$), so the momentum transfer at the atomization zone is stronger which is expected to reduce the median powder size.
- ❑ surrounding gas is dragged at a higher velocity, so intense gas circulation and turbulence are observed inside the atomization zone resulting in mist formation and upward flow of water droplets, thus higher risk of nozzle freeze-up.

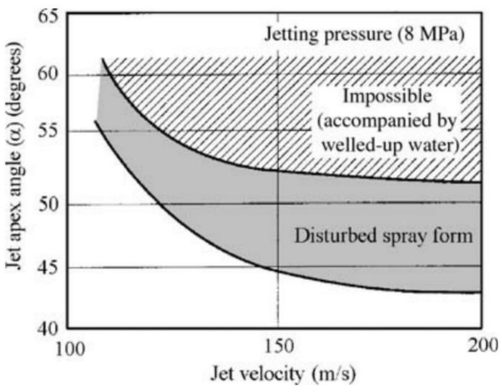
Effect of Apex Angle: 15°, 20°, 40°



At higher apex angle,

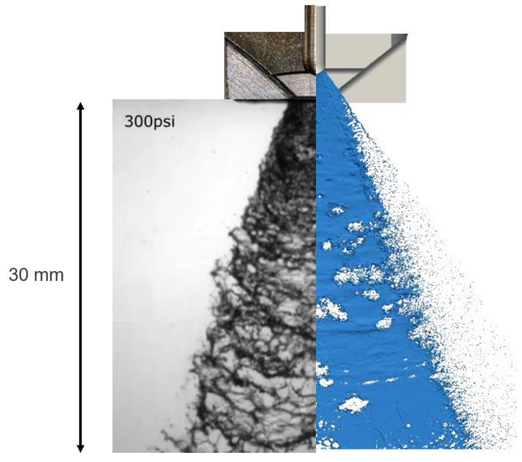
- ❑ the momentum transfer and the travel distance of water increase (when L is fixed), the former is expected to reduce the powder size while the latter results in a lower water speed at the impingement zone and so a less efficient atomization. The combined effect is being studied.
- ❑ mist formation and upward water flow are more intense, thus a higher risk of nozzle freeze-up.

Comparison with Previous Studies



Effect of jet apex angle on stability of water atomization at various water velocities.

Dunkley , J.J. , *Atomization of Metal Powders in Powder Metallurgy* . Institute of Metals Publishers ,1991.



Experimental and numerical modelling of a flat-fan sheet break-up

Asgarian, A. et al., *Experiments and Modeling of the Breakup Mechanisms of an Attenuating Liquid Sheet, submitted for publication in 2019* .

Summary and Future Work

- ❑ High-speed optical shadowgraph imaging has been employed to visualize the impingement of four water sprays at different apex angles and water pressures; the results provide a wealth of information about the atomization zone.
- ❑ Future work will add a molten metal stream to the experimental setup.

Acknowledgements

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