# A FLOW VISUALIZATION STUDY OF THE GAS DYNAMICS OF LIQUID METAL ATOMIZATION NOZZLES

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## ABSTRACT

An assessment of how well close-coupled liquid metal atomization nozzles expand high-pressure gas to high velocities, and of how effectively they bring the high-velocity gas to bear on the liquid metal, may point the way towards enhancing powder production capability through improved nozzle design. The first step towards this is to study the gas-only flowfields produced by these nozzles. The gas dynamic behavior of three different nozzles is examined through flow visualization. Two of these nozzles are representative of the current state of technology: a converging (HPGA) and a converging-diverging (Ünal) design. A truncated plug nozzle from the propulsion literature is included for comparison. All nozzles are examined using flow visualization over a range of operating pressures between 2 and 5.5 MPa. Base (aspiration) pressures are measured, and pitot surveys of the flowfields are taken to complement the visualizations. The HPGA nozzle produces a highly underexpanded flowfield which undergoes an abrupt change, called wake closure, at a high pressure ratio. Shock waves resulting from underexpansion cause high kinetic energy losses in the flow, especially at wake closure, which may inhibit atomization downstream. The Ünal nozzle produces a large wake at all pressure ratios, keeping high-velocity gas away from centerline, while its converging-diverging design limits underexpansion losses. The truncated plug nozzle flowfield combines some features of the other nozzles, and suggests design alternatives.

## INTRODUCTION

Gas atomization of liquid metal via close-coupled nozzle technology is used to produce metal powders with characteristics that cannot be achieved with other methods. It is often used to fabricate fine, spherical powders typically used in applications requiring dense packing and good flow characteristics. Alloy powders that cannot be made with chemical techniques are readily made using gas atomization. In addition, the rapid cooling rates inherent in the process show the potential to produce