Trajectory of Liquid Jets in High Pressure and High Temperature Crossflows

A. Amighi, M. Eslamian and N. Ashgriz*
Department of Mechanical and Industrial Engineering
University of Toronto
Toronto, ON, M5S 3G8 CANADA

Abstract
Atomization of a liquid jet by impaction of a crossflow air stream is a robust and versatile spray generation technique with applications in gas turbines and aerospace industry. Parameters such as jet penetration, trajectory and deflection are required prior to the design of the combustion chamber in these types of engines. In this paper, the breakup and atomization characteristics of a liquid (water) jet under atmospheric and elevated pressures and temperatures are studied at steady state conditions. This has been achieved by using a compressor capable of providing 750 scfm at 100 psig. The high pressure air produced by the compressor enters a circulation heater operating at 150 kW and 600 V. The test section has a 25 mm × 35 mm rectangular cross section equipped with glass windows at the bottom and two sides for the optical measurements. The nozzle is mounted flush with the upper side of the test section. Over 250 test conditions were considered with liquid to air momentum ratios varying from 10 to 80, air temperatures of 25, 200, and 300°C, cross flow pressures of 30, 55, and 75 psi, air velocities ranging from 32 to 170 m/s and liquid jet velocities from 6.8 to 54 m/s. For each test condition 400 images were obtained, using pulsed laser sheet illumination technique. The obtained images were averaged and filtered and then the spray center, windward and leeward trajectories were calculated using an automated method. Using a regression analysis, two correlations were obtained for the trajectories of spray windward and center as a function of liquid to crossflow air momentum ratio, the aerodynamic Weber number, and variations of the air viscosity at various conditions. These correlations are reliable tools for design of atomization chambers. In addition, comparison of the spray center and windward trajectories provides a means to study spray dispersion at various conditions.

Key words: Jet in crossflow, spray trajectory, spray dispersion

*Corresponding author, Email address of author: Ashgriz@mie.toronto.edu (N. Ashgriz)