Numerical and experimental investigation of the optical connectivity technique in cross flow atomization

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Abstract

The optical connectivity technique has been proposed for the characterization of the morphology of continuous liquid jets before breakup. The technique is based on internal illumination of a liquid jet by a laser beam through the spray nozzle. The liquid jet acts as a light guide and the laser beam propagates along the length of the jet in the same way that light travels along the length of an optical fibre. The laser beam excites a fluorescent dye that is dissolved in the liquid jet, making the volume of the liquid jet luminous. However, unlike an optical fibre, there are laser beam intensity losses along the length of the liquid stream due to refraction at the liquid/gas interface and due to absorption by the fluorescence dye. While the technique has been shown to work well in 'straight' jets, for liquid jets exposed to a cross stream of air, where the liquid jet becomes gradually inclined relative to the axis of the jet exit, laser light losses due to refraction through the liquid interface may increase and lead to limitations of the technique. A numerical and experimental investigation of the performance of the optical connectivity technique is conducted for liquid jets exposed to a cross stream of air. The numerical investigation revealed that the fluorescent intensity profiles along the liquid column length are highly sensitive to the divergence of the illuminating laser beam. In addition, the wavelength and deflection of the jet had a significant effect on the fluorescent intensity profiles only for a collimated illuminating laser beam. The experimental investigation showed that the fluorescent intensity is not uniformly distributed throughout the volume of the jet but a fluorescent intensity maximum exists at the point of maximum jet inflection. The rate of decay of the fluorescent intensity along the length of the jet is similar among the jets regardless of the length of the jet, which suggests that after the jet maximum inflection, there are considerable losses of the illuminating laser beam intensity due to refraction.

Key words: Optical Connectivity, Diagnostics, Laser-induced Fluorescence, Geometrical optics

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