Flow Field and Mass Flux Measurements Near the Exit Plane of Spray Jets

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Abstract

This paper provides velocity as well as mass flux measurements in a number of spray jets with varying droplet loading. A simple burner geometry consisting of a contraction and an annular pilot holder with an ultrasonic nebulizer mounted 215mm upstream of the jet exit plane was used. The spray particles are entrained in the carrier air at this upstream location with zero momentum such that the complexities of the atomization process are avoided and well defined boundary conditions can be obtained at the jet exit plane. A mineral turpentine spray jet was used as a base case to emulate non-evaporating conditions. Liquid mass flow rates of 0.0234, 0.045 and 0.075 kg/min were used as low, medium and high spray loading cases respectively. The carrier bulk velocity was fixed at 24 m/s. When conditioned with respect to droplet size, an anomaly was found in the measurements of turbulence at radial locations close to the jet wall: the rms fluctuations for larger droplets were higher than those for the smaller droplets. Probability density function plots of velocity near the wall reveal a bimodal distribution, which changes gradually to a mono-modal one as the jet centerline is approached. This bimodality is believed to be caused by droplets impacting the inner surface of the nozzle and slowed in the boundary layer. This effect is magnified with droplet size leading to the artificially higher rms at the exit plane. The bimodal pdf is then reconstructed where possible into two single-mode pdfs corresponding, respectively, to the droplets affected by the wall and those unaffected. The new rms fluctuations of the velocities obtained from the single-mode pdf of large droplets is no longer higher than the rms of small droplets and hence more akin to what is expected of turbulence fluctuations.

Key words: Probability density function (pdf), Bimodal pdf, Turbulence Fluctuations

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