Studies of Pure- and Aerated-Liquid Jets Using the X-Ray Phase Contrast Imaging

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Abstract

For the successful design of a liquid-fueled, air-breathing propulsion system, liquid jets atomization play an important role in establishing stable and efficient combustion within an extremely limited distance and time scale inside a combustor. The aerated-liquid jets have been explored extensively to illustrate its favorable characteristics for air-breathing propulsion applications. While the general features of the aerated-liquid jets are very promising, detailed near-field spray structures cannot be easily attained, due to instrumentation limitations. The objective of this study is to experimentally investigate the near-field structures of pure- and aerated-liquid jets injected into a quiescent environment, using the phase contrast imaging technique combined with the x-ray light source at the 32-ID Beamline of the Argonne National Laboratory. Water and nitrogen were used as the injectant and aerating gas, respectively. Two aerated-liquid injectors with orifice diameters of 0.5 and 1.0 mm were utilized for liquid injection. Pure-liquid jets were generated by turning off the aerating gas supply. It was found that the present diagnostic technique provides the unique capability in depicting line-of-sight interfacial features on the entire periphery of the liquid column, ligament, and droplet. Highly-convoluted wrinkle structures on the column surface of a turbulent pure-liquid jet were observed. The length scale of the wrinkle structures decreases as the liquid flow rate, liquid Weber number, or Reynolds number increases. The near-field structures of aerated-liquid jets, which are optically dense, can be clearly depicted by the present diagnostic technique. With a modest level of liquid aeration, the liquid column can be dispersed into fine droplets and ligaments. Increase in aeration level enhances liquid atomization. The entrained gas inside the droplets and ligaments of aerated-liquid jets expands into bubbles, which can be clearly observed in the x-ray images. These bubbles eventually burst to generate fine droplets at downstream locations.

Key words:
Aerated-Liquid Jet, Pure-Liquid Jet, Droplet, Aeration, Air-Breathing Propulsion System, X-Ray, Phase Contrast Imaging

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