Hollow-cone Spray of Viscous Liquid in High-pressure Gas Environment - Experimental Investigation for the Application of New Liquid Fuels to Gas-turbine -

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Abstract

Bio-liquid fuels and non-conventional fossil oils have attracted attentions recently as alternative energy resource for gas turbine power plant. It is convenient that the swirl atomizer can be used to spray these fuels, as was used in the current plants. To obtain fundamental knowledge which is indispensable to survey the applicability of these new liquid fuels for the plant, the experimental investigations were performed on the hollow-cone spray of viscous liquids in high-pressure gas environment. Test liquid employed were water, diesel fuel, palm methyl ester (PME) and silicone-oil #10. Ambient gas was nitrogen of room temperature. Test spray nozzle, Delavan oil burner nozzle 60°A-0.85, was installed in pressure vessel of about 14ℓ. Experimental investigations were performed within the range of liquid flow-rate from 50 to 140cc/min and the range of ambient-gas pressure from 0.1 to 1.0MPa. The behavior of injected liquid-sheet and ensuing spray-flow were observed in detail by flash photography. The apical-angle and the breakup-length of conical liquid-sheet and the cone-angle of spray were evaluated from the photographs. The Sauter mean diameter of spray was measured by the laser diffraction method, and the spray flow field was investigated by the PIV technique. The following conclusions were deduced: (1) The injected hollow-cone spray tended to contract at high ambient-gas pressures. The spray contraction could be observed in wider range of liquid flow-rate when liquid was viscous. (2) The breakup-length of liquid-sheet decreased with increase of the ambient-gas pressure and the liquid flow-rate. The higher viscosity the liquid had, the longer the breakup-length became. (3) The spray cone-angle decreased with increase of the ambient-gas pressure, although the apical-angle of liquid-sheet was almost constant. The spray cone-angle of non-viscous liquid became smaller with increase of the liquid flow-rate, but the spray cone-angle of viscous liquid did not depend so much upon the liquid flow-rate. (4) The Sauter mean diameter of spray decreased with increase of the liquid flow-rate. The mean diameter increased slightly with increase of the ambient-gas pressure. However, the mean diameter was not affected so much by the liquid-viscosity within this experimental range. (5) The surrounding gas should be drafted into the spray. The velocity of drafted-flow did not change so much with downstream-distance, did not change so much with the ambient-gas pressure, and increased linearly with increase of the liquid flow-rate. (6) When the viscosity of liquid was high, several peculiar atomization manners were also observed; roll-up of smooth liquid-sheet, perforation of liquid-sheet and spray pulsation. The experimental range for each manner was examined, and the mechanism of spray pulsation was discussed.

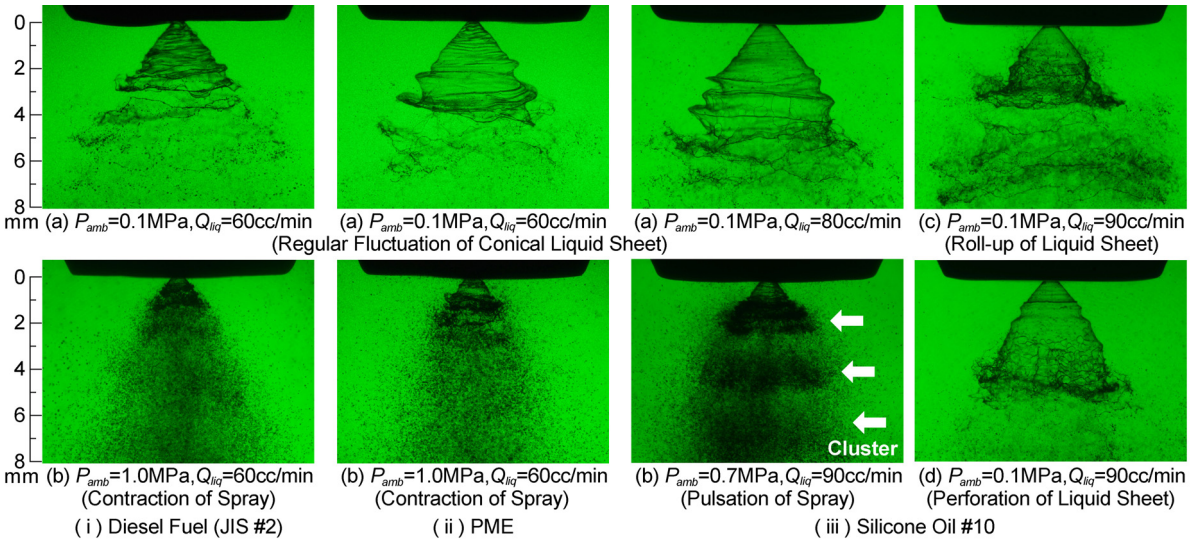

Figure 1 Flash photograph of hollow-cone liquid film.

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