Experimental Study of the Spray Characteristics of Liquid Jets in Supersonic Crossflow

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Abstract

The spray characteristics of a water jet in Mach 2.85 air crossflow were investigated experimentally using a Phase Doppler Anemometry (PDA) system. The droplet diameter and velocity of liquid jets with various nozzle diameters were measured and analyzed. Experiments with liquid jets positioned ahead of a cavity were performed to investigate the effects of the cavity on the spray characteristics. For the liquid jet distributed from a nozzle positioned from the plane wall, the SMD distribution presented a C shape, and the u presented a mirrored C shape. The maximum u did not appear at the maximum height of the spray, due to the interaction between the air crossflow and the spray boundary. An inverse tendency was observed, in that the SMD became larger downstream at $y/h > 0.5$. A reasonable explanation was proposed based on the motion of the droplets. Large droplets were more prone than small droplets to move from the lower layer to the upper layer of the liquid jet, which resulted in an increase in the SMD downstream. For the liquid jet distributed from a smaller nozzle positioned from the plane wall, the secondary atomization was accomplished earlier, and the final SMD had a lower value. The SMD distribution was related to the x-component velocity, because the small nozzle resulted in a shorter acceleration process with the same condition of the airflow. Consequently, the leeward region of the liquid column injected from the nozzle receded somewhat. That led to a difference in the u of the liquid jets injected from the three nozzle diameters tested. The v of the droplets mainly depended on the injection velocity. The nozzle diameter had little effects on the average y-component velocity of the droplets. The existence of the cavity resulted in an increase in the SMD and a decrease in the u. In the central symmetry plane of the liquid jets positioned ahead of the cavity, most droplets near the cavity tended to spread to the outside of the cavity. The shear layer collides on the oblique outlet of the cavity and mixed with the airflow. This mixing process caused an oblique airflow at the outlet of the cavity and changed the distribution of droplets. Droplets were lifted to a certain height, resulting in a flow gap at y/h <0.35.

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