PDPA MEASUREMENTS IN A MACH 2 WIND TUNNEL

APPLICATION NOTE PDPA-004

Fuel is most often sprayed into a quiescent or nearly quiescent environment, such as inside an IC engine cylinder. In some cases, however, fuel is sprayed into a high-speed flow, as the case of a scramjet engine. A recent collaborative effort between the Wright-Patterson Air Force Base and TSI has investigated the application of Phase Doppler Particle Analyzer (PDPA) to scramjet engine flows. More information on the high-speed flow facility at Wright-Patterson can be found in the literature, such as AIAA 2004-0971.

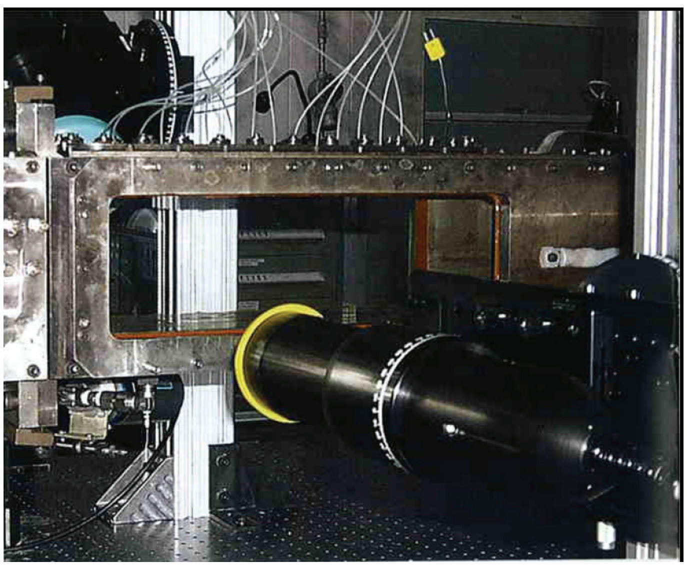

Figure 1: Supersonic test section, windows, and transmitter probe. The receiver is visible in the background.

Courtesy Dr. Kuo-Cheng Lin and AFRL/Propulsion Directorate at Wright-Patterson Air Force Base

A 2D PDPA was set up with a 5 W laser, FBL-2 fiberlight™ beam generator, and TM250 transmitter probe equipped with optional beam expander. Signals were captured by a RV2100 receiver and sent to a PDM1000-2P detector module. An FSA 4000-2P signal processor and FLOWSIZER™ software were used to analyze the data. Key processor features, such as dynamic sampling rate selection, burst centering, SNR-based burs detection, and intensity validation enabled the PDPA to make accurate and detailed measurements on this challenging flow. The supersonic wind tunnel was a steady flow design with a test section size of 150 mm x 120 mm. The injector was mounted on the bottom panel of the test section, injecting upwards into the ~650 m/s flow.

These and other results showed that aerated jets dispersed more rapidly than non-aerated jets. Atomization was complete by 100 orifice diameters downstream, after which the SMD shows much reduced variation. Moreover, it was found that normalized centerline droplet size and streamwise (x) velocity profiles collapse to universal “S” type curves. This result can be useful for modeling far-field distributions of liquid jets in supersonic cross flow environments. More results can be found in AIAA paper 2004-0971.

Certain unique issues arise with all supersonic flow measurements, and user experience is most valuable in dealing with these matters. Consultation with TSI and other expert users at conferences/trade shows is the best way to build your knowledge base. The above results illustrate some of the observations one can obtain with a TSI PDPA.

Sauter Mean Diameter (SMD), Streamwise Velocity (U), and Concentration (ND) for a Liquid Jet in Ma=2 Crossflow

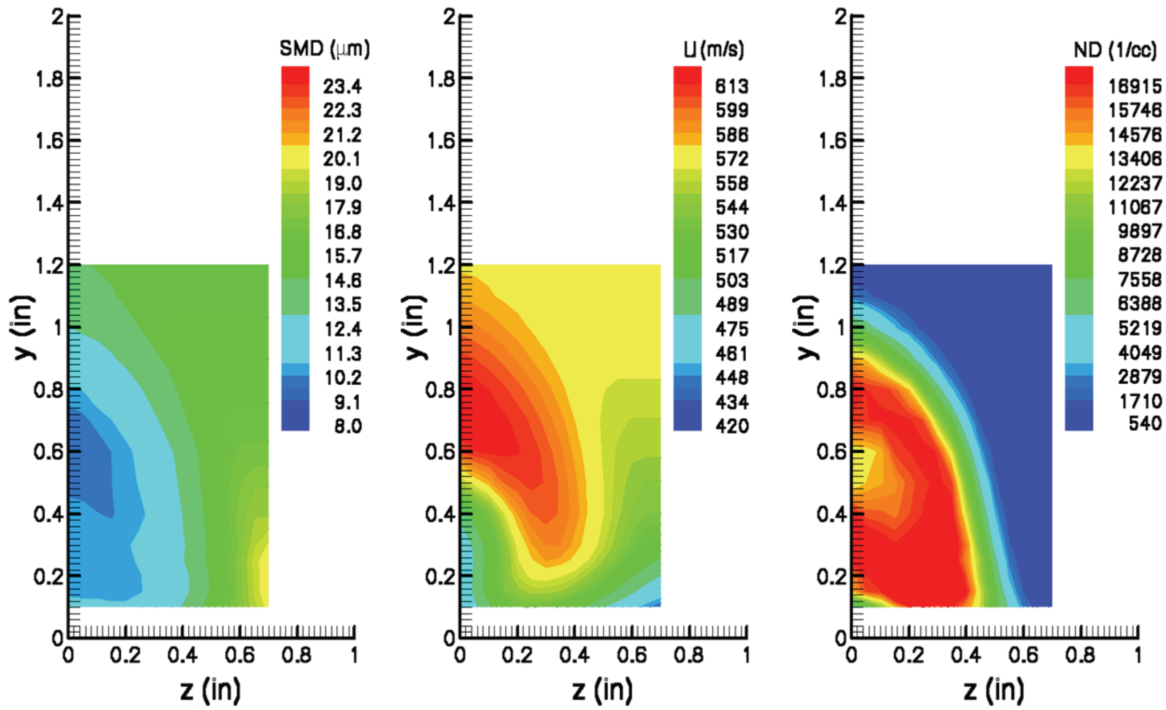

Figure 2: Measured Sauter Mean Diameter, velocity, and number density for an aerated liquid jet in the supersonic flow. The gas-to-liquid ratio was 5%. Measurements were made in a half-plane 100 mm downstream of the injector.

Courtesy Dr. Kuo-Cheng Lin. This work was sponsored by AFRL/Propulsion Directorate at Wright-Patterson Air Force Base.

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