Development of point Doppler velocimetry for flow field investigations

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Keywords: pDv, DGV, Iodine Vapor, Flow Spectra, flow field

T A one-component Point Doppler Velocimeter (pDv) was developed in a methodical, evolutionary manner to evaluate the capabilities of the instrument and address problems encountered in earlier pDv research through controlled laboratory experiments. As with Doppler Global Velocimetry (DGV), pDv employs a vapor-limited iodine vapor cell (IVC) as a light frequency discriminator to make velocity measurements through the detection of Doppler shifts in light scattered by collections of submicron particles. By replacing the cameras used in DGV with photomultipliers, pDv has the potential for making continuous velocity measurements at a point in the flow. This offers the possibility to uniformly sample the velocity measurements in time that could lead to the measure of the flow turbulence power spectra without the variability errors caused by Poisson sampling in fringe-type laser velocimetry.

The pDv system was constructed as shown in the schematic in Fig. 1 to include the Laser Frequency Monitor (LFM) along with a single measurement component. The system was first tested by measuring the velocity of a rotating wheel. These results compared to the calculated velocities to within ±1 m/s throughout a traverse along the diameter of the wheel. The system was then installed about a jet exiting a 50.8-mm pipe flow and configured to measure the streamwise

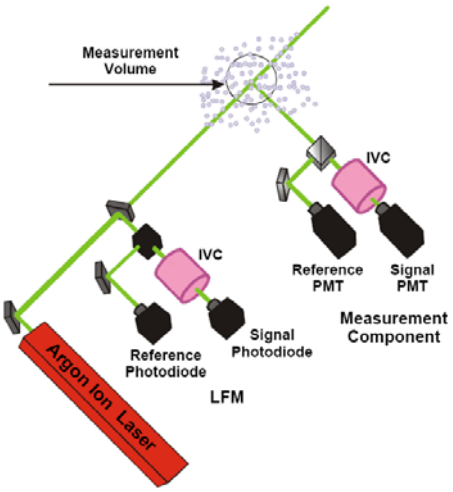

Fig. 1 Schematic of the Point Doppler Velocimeter.

velocity component. The spherical 2-mm diameter measurement volume was scanned radially at several downstream locations. These results were compared to simultaneously acquired pitot probe measurements, Fig. 2, yielding a difference standard deviation of 0.32-percent of the freestream velocity.

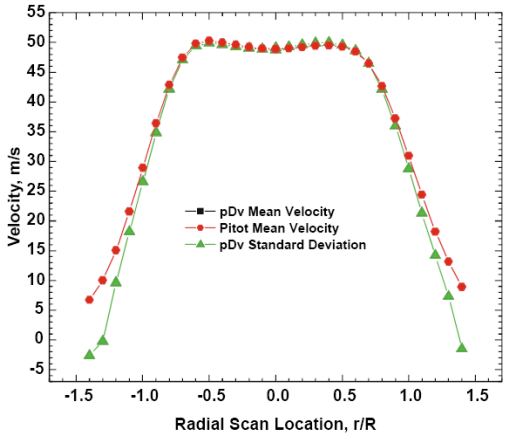

Fig. 2 pDv and pitot probe velocity profiles obtained at the x/D = 2 location of the 50.8-mm jet flow.

The pDv system was then evaluated for its ability to measure the flow turbulence power spectra. The photomultipliers were sampled uniformly at 50 kHz and the velocity spectra computed. These results were compared to hot wire measurements (obtained without flow seeding) to yield the spectra shown in Fig. 3. The primary blower fan frequency is clearly found with both techniques along with the second harmonic at the x/D=4 location. While these results indicate that pDv can measure flow turbulence power spectra, the noise floor was found to be higher than the hot wire. Work continues to develop methods to reduce this noise.

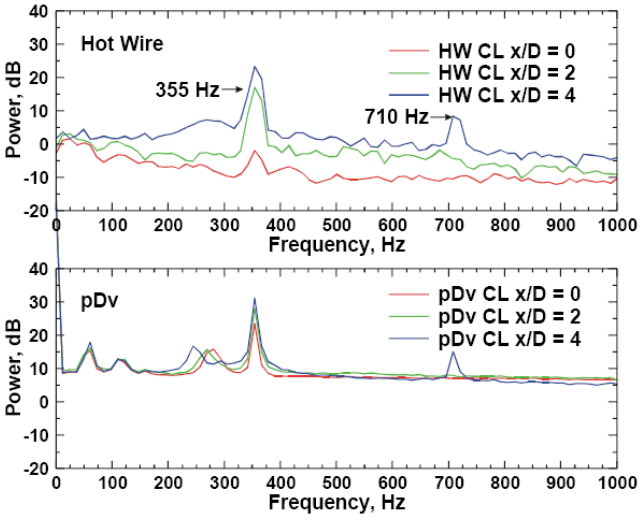

Fig. 3 Spectral content of the flow exiting a two-inch pipe.