MEASUREMENTS IN A SHOCK TUBE FLOW

APPLICATION NOTE LDV-003

In flow situations associated with aerodynamics, rotating machinery, engines and other propulsion systems flow diagnostics involve accurate measurement of high speed flows. Very often, these types of flows involve high velocities combined with high dynamic range. Since these types of flows often exhibit temperature, pressure and other property variations, a non-invasive measurement technique that does not depend on the properties of the flow medium is desired.

LDV systems are frequently used to explore and map these types of flows. In order to make accurate flow measurements, the aerodynamic size of the scatterers needs to be small so that they faithfully follow the flow. Further details are provided in the TSI Seed Particles for LDV and PIV brochure. The signals generated by these particles are often small in amplitude and may be low in signal quality (SNR). The ability of the signal processor to extract accurate velocity information from these types of signals is crucial to getting the needed information about the flow.

Experimental set up

The flow in a shock tube was measured using a TSI LDV system. The flow was created by bursting the diaphragm separating high pressure and low pressure regions in the shock tube. This caused the passing of a shock into the quiet medium. This resulted in the velocity going from a very small value to sonic speeds within a few milliseconds.

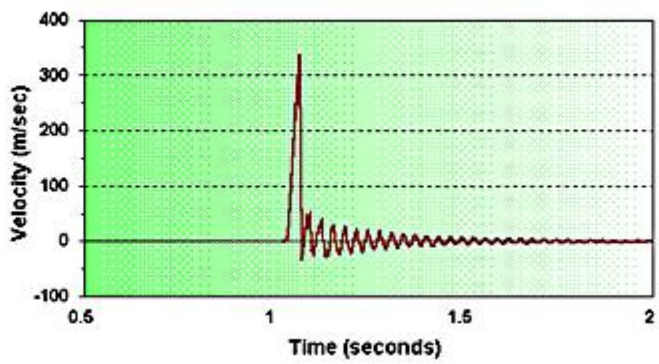

Figure 1. Velocity time history showing the effect of shock reflections

COLORBURST and COLORLINK are trademarks of TSI Incorporated.

To characterize the flow, the aim was to get as high a data rate as possible. In addition, the LDV system should be able to measure the flow velocities changing from sonic values to zero and negative values in a very short time.

The measurements were carried out with a water-cooled argon-ion laser-based system using TSI's 83 mm fiberoptic transceiver probe and signal processor. The measuring volume was located in the center of the shock tube in the low pressure region downstream of the diaphragm. The measurements were carried out in forward scatter mode using an optional off-axis LDV receiver probe.

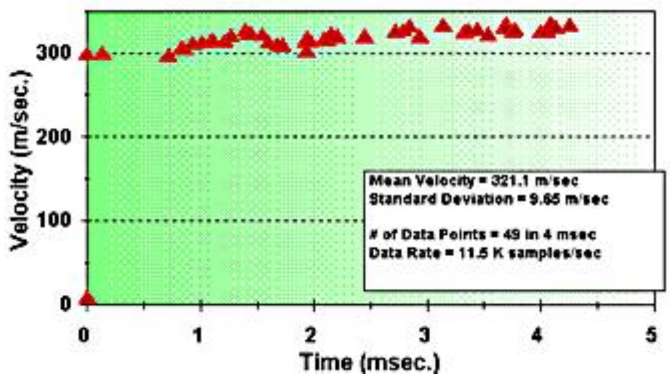

Figure 2. Velocity time history--expanded view of the effect of the shock passage

Results

The system not only measured the sudden increase in velocity but also the effect of the reflection of the shock from the ends of the tube, exhibited by the oscillatory nature of the velocity variation. The velocity is shown to vary from sonic speeds (approximately 330 m/sec) to negative (-34 m/sec) values (Figure 1). This as particularly where TSI’s automatic sampling rate selection can provide the maximum resolution by matching the sampling rate to the particle velocity, while never using a sampling rate that is too high. This would cause poor resolution in all but the highest velocity measurements.

The ability of the signal processor to cover the large dynamic range and to obtain a high data rate is clearly exhibited. Because of the high data rate obtained with the TSI system, velocity variations that took place during the shock passage time (approximately 2 to 3 millisecs) were clearly identified (Figure 2).