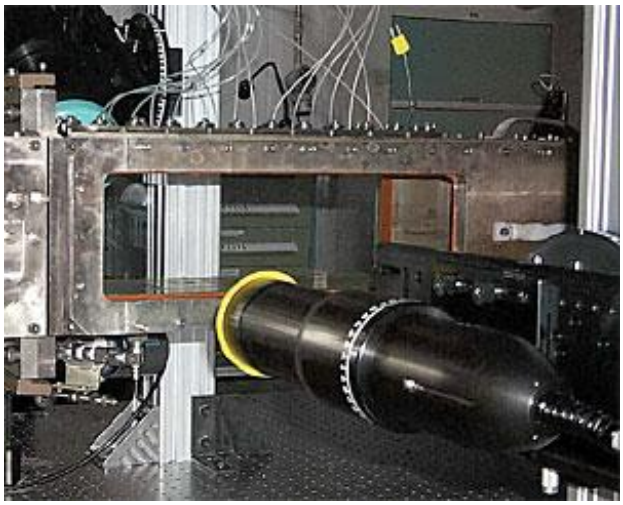
LDV MEASUREMENTS IN A BOUNDARY LAYER

APPLICATION NOTE LDV-002

Detailed velocity measurements in a boundary layer are of interest in the study of momentum and energy transport associated with many of the problems in fluid mechanics. Getting an accurate velocity map in this thin layer close to a surface demands the use of a non-invasive measurement technique such as LDV.

The noninvasive nature combined with the small measuring volume of an LDV system makes the technique ideally suited to measure velocity in the boundary layer. Reflections of laser light from the wall surface and presence of fewer scattering particles in the boundary layer cause the photodetector output signal to have poor SNR. This makes the measurements near the wall more demanding from the standpoint of signal processing.



TSI PDPA/LDV system making measurements in a supersonic wind tunnel (Courtesy: WPAFB)

The purpose of this experiment was to make velocity measurements as close to the wall as possible using an LDV system. This was done by traversing the measuring volume from the free stream region in the flow to the wall of the boundary.

Experimental set up

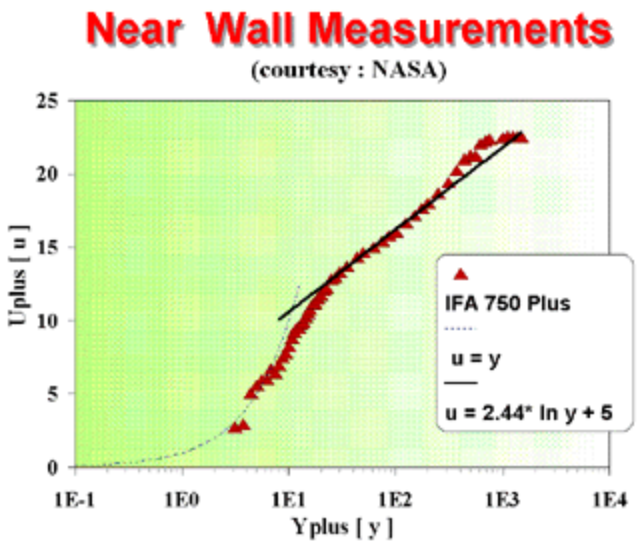
A single channel LDV system operating in backscatter mode was used for making the velocity measurements. The entire LDV system was mounted on a traverse so that the measuring volume could be traversed in steps. The signal processor used for the measurements was an IFA 750 Plus Digital Burst Correlator. Measurements were made in a flat plate boundary layer. The air flow was seeded and the free stream velocity was about 10 m/sec.

Results

Velocity measurements are shown in wall coordinates. The non-dimensional values of the mean velocity U and the distance Y from the wall are given by

$$u = Uplus = U/Ut \text{ and } y = Yplus = YUt/v$$

where v is the kinematic viscosity and Ut is the friction velocity. Comparisons with the well established Law of the Wall and the Logarithmic law are also shown. The ability of the signal processor to extract accurate velocity information in the boundary layer region is clearly exhibited.



Law of the wall
In the sublayer, u and y are related by the following expression, u = y.
Outside the sublayer, the velocity distribution follows a Logarithmic law.

Comments

It should be noted that the diameter of the measuring volume was about 250 microns. This means that the velocity measurements at the five measurement locations close to the wall were made with the measuring volume buried in the wall!

According to the researchers, these measurements using the IFA 750 Plus gave the most detailed and accurate measurements in the boundary layer. In addition to the mean velocity, other statistical properties of the flow were also obtained from these measurements.

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