2008 Award Winner

Airfoil Wake

Application Note V3V-003

Airfoil wakes find themselves under constant scrutiny due to their importance in the fields of aerodynamics and fluid mechanics.

In this study, the flow around a NACA 0009 airfoil was measured in a water channel with cross-sectional dimensions of 180 mm × 180 mm in order to examine the nature of the stalled recirculation zone. The airfoil was set at an angle of attack of 20°. The freestream velocity was 0.15 m/s, and the Reynolds number based on chord length was 21,000.

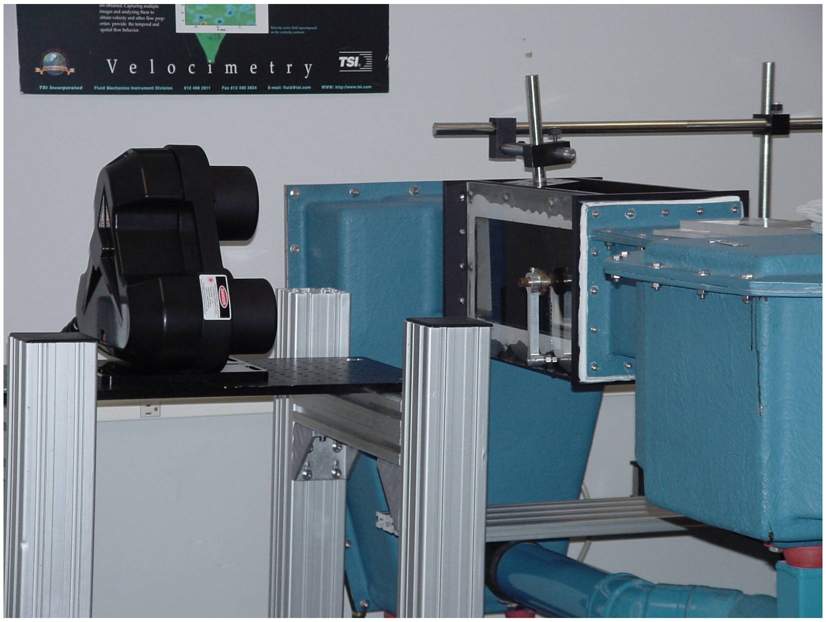

Figure 1: V3V camera probe mounted to take data on the water channel.

The TSI V3V™ (Volumetric 3-Component Velocimetry) system was used to analyze the resulting flow structure (Fig. 1). The flow was illuminated by a model YAG120-NWL 120 mJ dual-head pulsed Nd:YAG laser operating at 7.25 Hz and 532 nm wavelength. Light cone optics were used at the exit of the laser to shape the beam into an illuminating cone. The laser cone was formed with two -50 mm cylindrical lenses mounted at 90° to each other. These cylindrical lenses diverged the beam in the horizontal and vertical directions to illuminate a volume approximately 120 mm × 120 mm × 120 mm at the measurement location. The model V3V-8000 3D camera probe consists of three apertures and a total of 12 million pixels. The camera was aligned and calibrated with the CCD a distance of approximately 700 mm from the back plane of the measurement volume. The data capture was synchronized with the model 610035 synchronizer. The images were streamed to the model HYPER2 *HyperStreaming*™ computer, and subsequently analyzed.

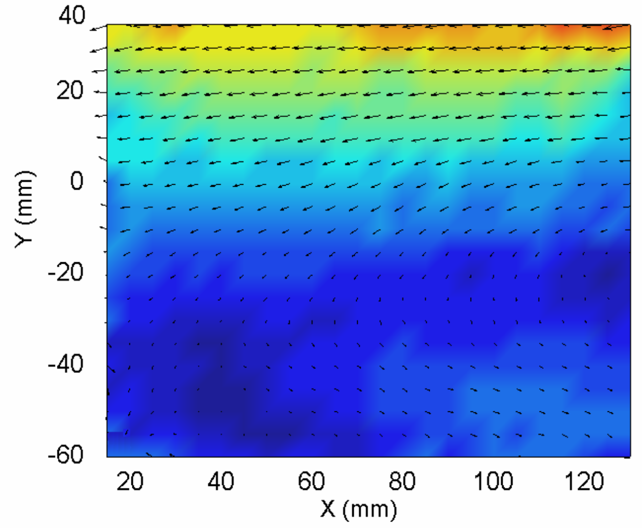

Figure 2: Standard 2D PIV velocity magnitude field downstream of the airfoil. The flow is from right to left.

The flow was seeded with polycrystalline tracer particles. Two image captures were taken with a Δt of 10 ms, and volumetric velocity fields were obtained through unique particle identification, triplet matching, and particle tracking algorithms in TSI's *INSIGHT* V3V™ software.

Figure 2 shows a standard 2D PIV velocity magnitude field downstream of the airfoil. The color represents velocity magnitude, and the vectors represent the flow direction.

Figure 3 shows the volumetric 3-component velocity field obtained by time-averaging 100 captures. Vectors represent velocity magnitude and direction, while the stream ribbons represent the velocity magnitude and flow path. Notice the highly 3-dimensional nature of the recirculation zone. Instantaneous plots revealed great fluctuations in the z-component of velocity.

This study utilized TSI's unique V3V™ technique in order to examine the time-averaged flow structure downstream of a NACA 0009 airfoil in a stalled condition. The average volumetric velocity field was obtained from 100 captures (time to capture 100 datasets ~ 14 sec), and processed (time to process 100 datasets ~ 10 minutes), without the need for traversing or repositioning any component of the system.

The resulting data gives an accurate representation of the 3D flowfield.

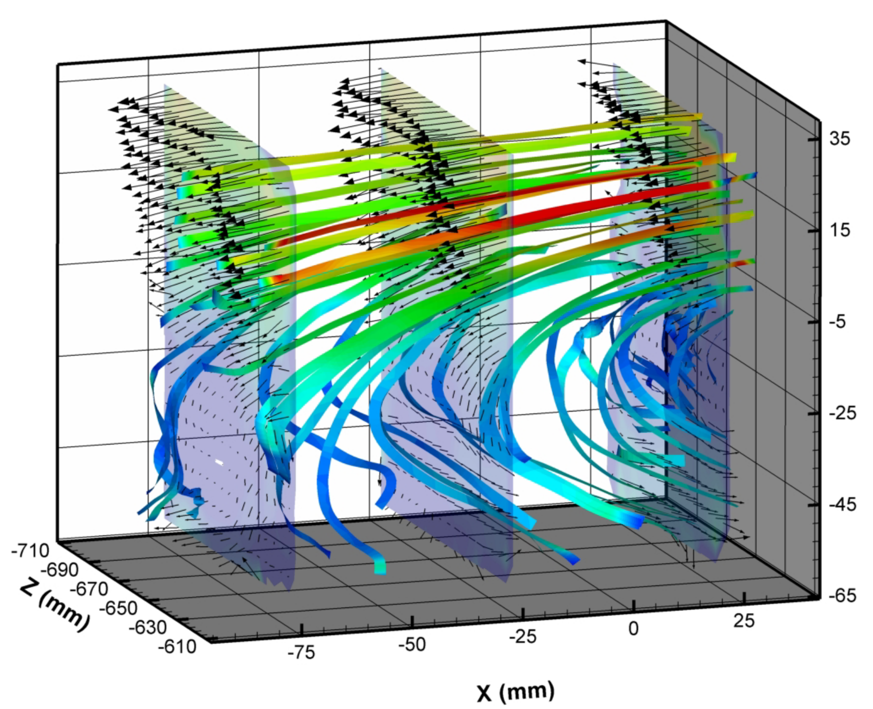

Figure 3: Volumetric 3-component velocity field downstream of an airfoil at α = 20°.

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