PROPELLER WAKE

2008 Award Winner

APPLICATION NOTE V3V-004

The application studied here is the downstream wake generated by a propeller in water.

Propeller wakes are important in the field of fluid mechanics for the design and optimization of water vehicle propeller blade and hull design.

The propeller used here was three-bladed with a diameter of 50 mm (Fig. 1).

Figure 1: The wake from this propeller was analyzed.

The TSI V3V™ (Volumetric 3-Component Velocimetry) system was used to analyze the resulting flow structure (Fig. 2). 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. 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.

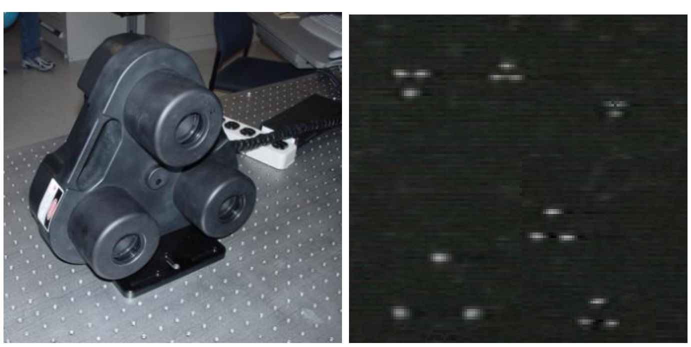

Figure 2: V3V-8000 camera probe (left), portion of an image of the three combined apertures (right).

The data capture was synchronized with the model 610035 synchronizer. The images were streamed to the model HYPER2 *HyperStreaming*™ computer, and subsequently analyzed.

Volumetric velocity fields were obtained through unique particle identification, triplet matching, and particle tracking algorithms in TSI's INSIGHT V3V™ software.

The propeller was in water seeded with polycrystalline tracer particles. Two image captures were taken with a Δt of 500 μs, and volumetric velocity fields were obtained through triplet matching and particle tracking in INSIGHT V3V™ software.

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An instantaneous velocity field can be seen in Fig. 3. In this figure, the propeller was at the top of the plot propelling fluid downward. The blue dots represent the locations of the tracked particles, and the green arrows represent the velocity magnitude and direction. Over 17,000 vectors were obtained from one instantaneous V3V™ capture.

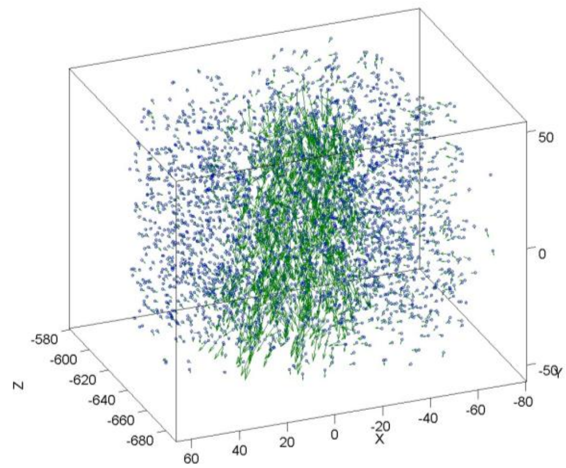

Figure 3: Instantaneous particle tracking velocity field of the propeller wake.

Figure 4 shows an instantaneous volumetric vector field. The propeller is located just above the plot, with the fluid moving downward. Randomly spaced vectors obtained from the particle tracking algorithm have been interpolated onto a rectangular grid. The slices represent velocity magnitude, the isosurface represents vorticity magnitude, and streamlines are also shown. Notice in particular the well-defined location of the hub vortex, as well as the blade tip vortex spiraling down through the flow.

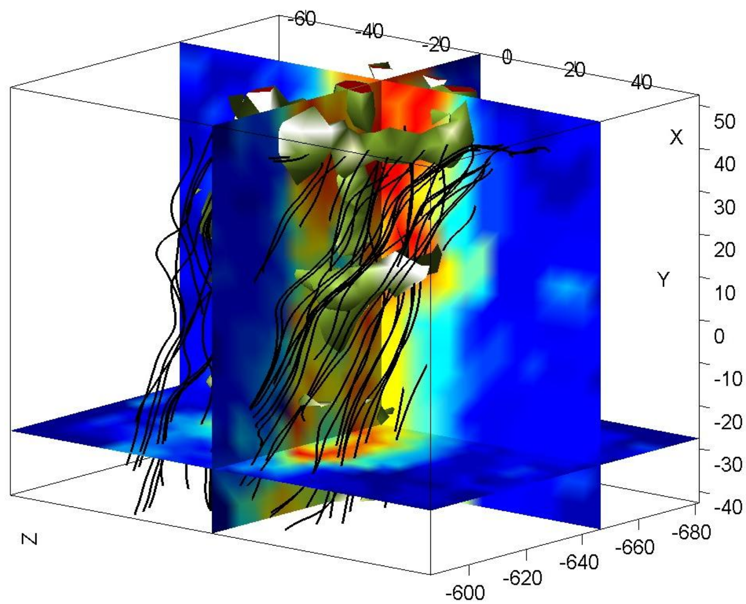

Figure 4: Instantaneous volumetric 3-component velocity field of the propeller wake. The isosurface represents vorticity magnitude and the slices represent velocity magnitude. Streamlines are also shown.

In this study, the structure of a propeller wake was examined with the TSI V3V™ system. Instantaneous volumetric velocity fields were obtained. The time to capture and process one instantaneous realization, such as that seen in Fig. 4, was less than 1 minute. The TSI V3V™ system is well-suited for this type of measurement.

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