V3V-9000-TS VOLUMETRIC 3-COMPONENT VELOCIMETRY ON A FAN BLADE IN AIR

APPLICATION NOTE V3V-9000-TS-001

Data was taken downstream of a model propeller blade using the TSI V3V-9000-TS volumetric velocity system. The propeller blade and V3V-9000-TS camera body can be seen in Fig. 1.

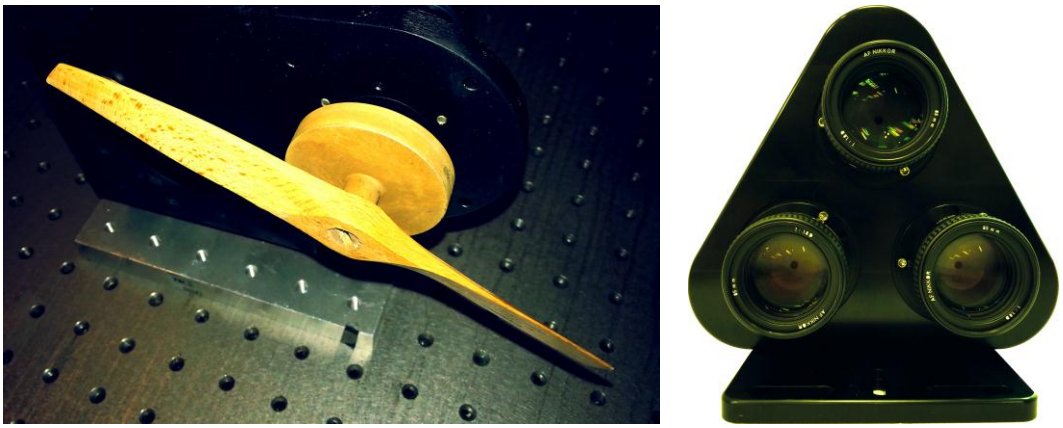

Fig. 1. Image showing the propeller blade used in the Test (left), V3V-9000-TS Camera Body (right).

The propeller had a diameter of 7 inches (177.8 mm) and was powered by a motor operating at approximately 180 rpm. The measurement volume (50 × 50 × 20 mm) was positioned approximately 5 mm downstream of the blade tip when the propeller was in a horizontal position. A schematic representation of the measurement volume location in relation to the propeller position can be seen in Fig. 2.

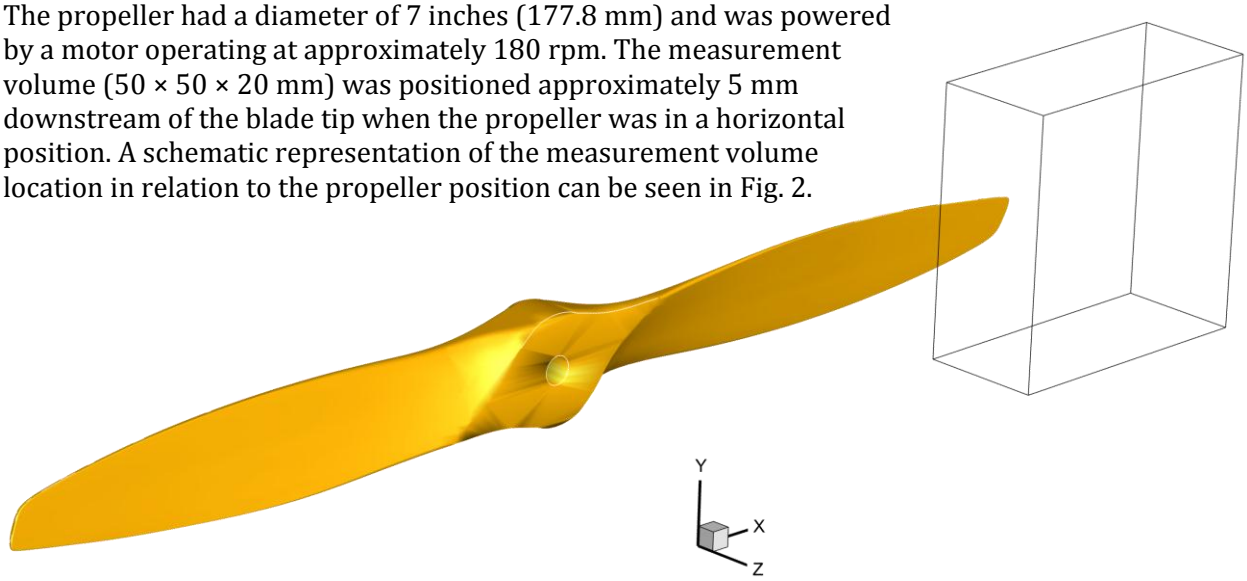

Fig. 2. Schematic representation of the measurement volume in relation to the position of the propeller blade. The propeller rotation was clockwise.

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The V3V-9000-TS system was used for the measurements. The V3V system utilized three 4MP cameras with 85 mm lenses positioned in a fixed triangular frame located at a distance of 450 mm from the measurement volume. The illumination source was a 200 mJ dual-head pulsed Nd:YAG laser operating at 7.25 Hz and illuminating 1 μm olive oil droplets as tracer particles, positioned at 90° to the central camera viewing angle. Two cylindrical lenses were used in combination to produce an ellipsoidal cone of laser light, illuminating the measurement volume. For each capture, a total of six images were captured, three images at one instant, and three images at the second instant, δT = 100 μs later. The images were then analyzed using INSIGHT 4G™ V3V Global Image Acquisition, Analysis and Display Software from TSI to produce volumetric vector fields.

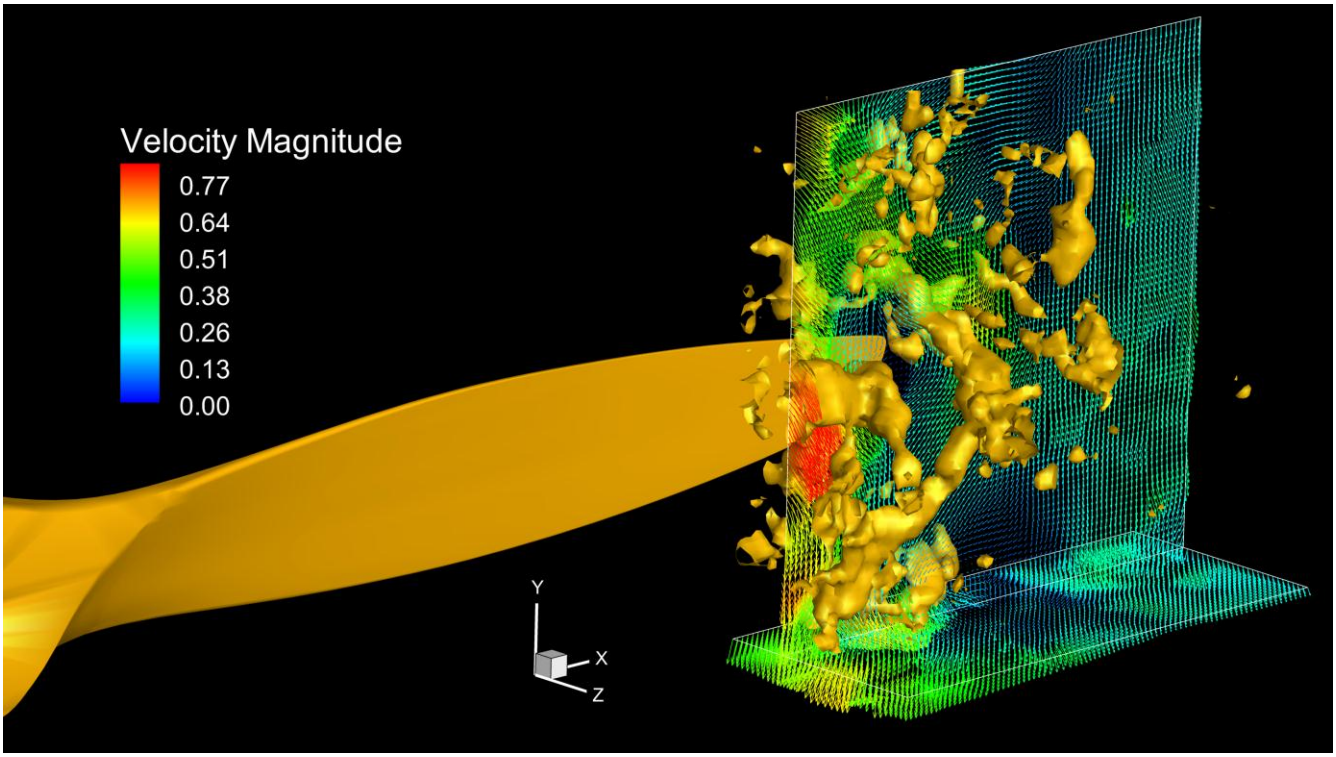

Fig. 3. A single, instantaneous volumetric velocity field showing the near wake region of the propeller tip. Gold-colored isosurfaces represent Q-criterion and the two orthogonal planes of vectors are colored by velocity magnitude.

An instantaneous volumetric velocity field can be seen in Fig. 3. The isosurfaces are Q-criterion, a vortex core identification parameter, and two orthogonal planes of vectors are shown, with the coloring of the vectors representing the velocity magnitude. This volume is at the very near wake region of the tip vortex formation, so that portions of the tip vortex can clearly be seen as the isosurface extending up and to the right of the foreground of the volume and then extending back toward the back of the volume. Other vortex cores in the volume represent vortices from previous tip blade passages, as well as remnants of the vortex sheet generated at the trailing edge of the blade as a result of the circulation generated around the blade. These vortices twist, mingle and merge with the primary tip vortex to create the larger vortex structure typically associated with tip vortices.

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