V3V MEASUREMENTS ON VORTEX SHEDDING FROM A CIRCULAR CYLINDER IN A WINDTUNNEL

APPLICATION NOTE V3V-9000-TS-003 (US)

Introduction

One of the fundamental flows often explored in fluid mechanics is the wake structure and vortex shedding produced from a circular cylinder. Even at relatively low Reynolds numbers, the flow (which is often referred to as "two-dimensional") has significant three-dimensionality. Knowledge of the basic kinematics of this flow situation can extend to a broad range of applications and provide insights into flows that are more complex and more indicative of the flows encountered in a wide range of engineering disciplines. For this reason, the vortex shedding downstream of a circular cylinder was investigated using the TSI V3V-9000-TS volumetric velocity system.

The flow was generated by a calibration windtunnel with a cylinder placed horizontally across the cross-section just upstream of the measurement region. A photograph of the experimental setup can be seen in Fig. 1. The V3V camera mount is seen on the left side of the image, with the camera lenses focused on the measurement region inside the blue windtunnel.

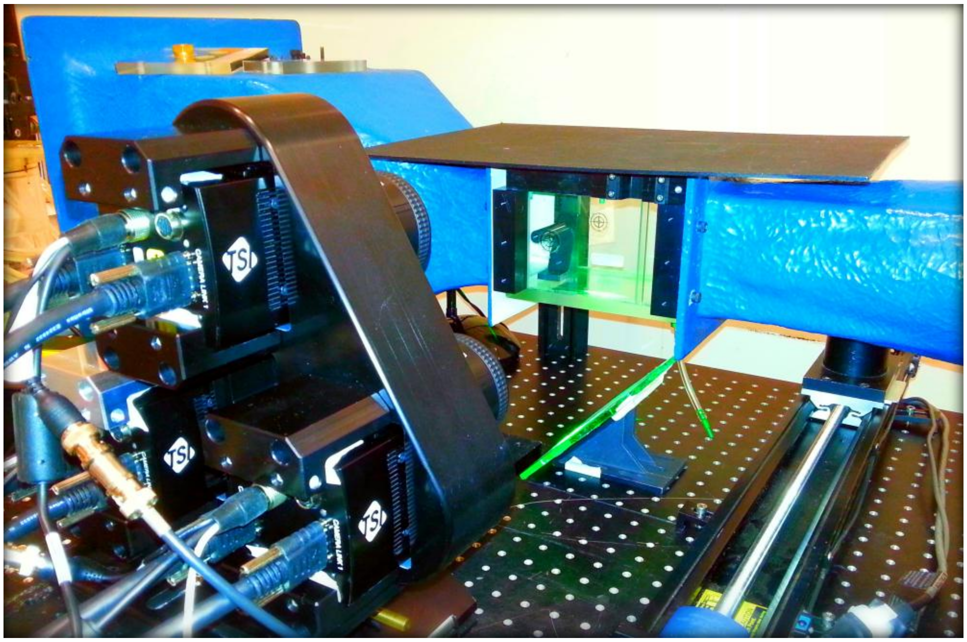

Fig. 1. Photograph of the experimental setup including the V3V-9000-TS camera probe and the cylinder in the windtunnel test section.

Experimental Setup

A circular cylinder of diameter 12 mm was placed in a calibration wind tunnel (TSI Model 8390) with a square cross section of 101.6 mm. The tunnel was operated at a freestream velocity of 1.27 m/s, with turbulence intensity of 0.36% without the cylinder in place. Tracer particles (mean diameter 1 micron) were generated using olive oil in a Laskin nozzle aerosol generator (TSI 9307) and introduced at the inlet of the wind tunnel. A dual-head Nd:YAG laser emitting 200 mJ/pulse was fitted with cylindrical lens optics such that the laser beam was formed into a volume, reflected off of a mirror at 45°, and transmitted upward through the test section, illuminating the measurement region of 40 × 50 × 12.5 mm. A second mirror was used at the top of the test section to reflect the illuminating light back down through the measurement region in order to increase the illumination intensity. The measurement region was centered on a located approximately 5 cylinder diameters downstream of the center of the cylinder.

The V3V-9000-TS camera system was used to capture pairs of images from three 4MP-HS cameras simultaneously, and transfer the data to the CPU. Images were captured at a rate of 30 Hz (15 velocity fields/second), and analyzed with Insight V3V 4G™ software

Results

The flow downstream of the cylinder exhibited two shedding modes, the von Karman shedding was the primary shedding mode and resulted in vortices initially parallel to the axis of the cylinder and traveling downstream, the secondary shedding mode resulted in streamwise oriented vortices, commonly referred to as lambda vortices. These vortices extend in a primarily streamwise direction and interact with adjacent Karman vortices. An instantaneous plot of the vortex shedding can be seen in Fig. 2. The planes are contoured by the streamwise velocity (m/s) with vectors, and the isosurface represents the Q-criterion (a vortex core identification quantity).

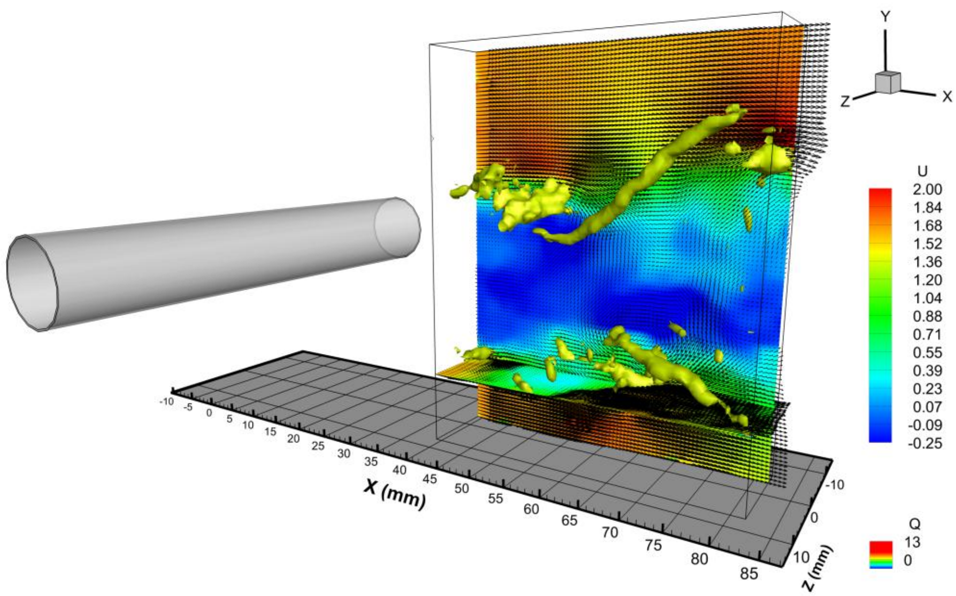

Fig. 2. Instantaneous plot of the airflow downstream of the cylinder. Isosurface represents the Q-criterion. The slice shows a contour of the streamwise velocity with vectors overlaid.

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