SPHERE WAKE

APPLICATION NOTE V3V-006

The vortex shedding downstream of a sphere has been studied extensively in the field of fluid dynamics due to its fundamental nature and application to a wide variety of flows such as biological locomotion, hydrodynamics, and propulsion.

Fig. 1: Experimental setup showing the 3D camera in relation to the sphere in cross flow.

In this experiment, the flow downstream of a sphere was studied in an enclosed water tunnel (Fig. 1). The Reynolds number was 2200. Studies have shown that hairpin-like structures are shed from a sphere at this Reynolds number. Figure 2 shows a schematic of the typical resulting flow structure at this Reynolds number. The flow is moving from left to right past the sphere. The light blue structures represent regions of vorticity. The boundary layer on the sphere has the effect of slowing down the fluid, which then curls backward into the wake. A distinctive hairpin structure is formed and shed into the downstream wake. A preferential axis of symmetric vortex shedding is established typically due to some asymetry in the flow environment. Hairpin-type structures are alternately shed off of one hemisphere, then the opposite.

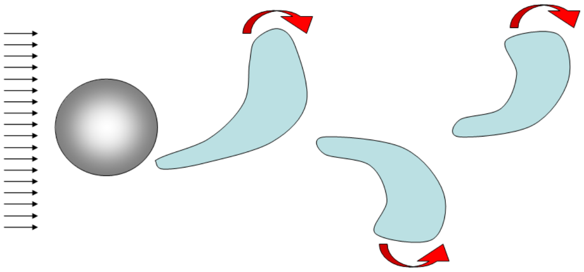

Fig. 2: Schematic diagram showing typical vortex structures downstream of a sphere in cross flow at Re = 2200. Light-blue represents vorticity magnitude with arrows to represent direction of rotation.

The TSI V3V (Volumetric 3-Component Velocimetry) system was used to analyze the flow structure. The flow was illuminated by a model YAG200-NWL 200 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 -25mm 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 140 mm × 100 mm × 100 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 750 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.

The freestream velocity was 0.1 m/s and was seeded with 12 μm silver-coated hollow glass spheres. Two image captures were taken with a Δt of 3500 μs, and volumetric velocity fields were obtained through unique particle identification, triplet matching, and particle tracking algorithms in TSI's *INSIGHT* V3V™ software.

In Fig. 3, an instantaneous (single capture) plot of the vorticity magnitude (shown in green) and the velocity magnitude (shown in red) can be seen in the wake downstream of the sphere. Note the distinctive vortical structures alternately shedding from one side of the sphere and then the other.

In this study, the flow structure downstream of a smooth sphere was examined with the TSI V3V system. Instantaneous volumetric velocity fields were obtained, which showed good agreement with the literature.

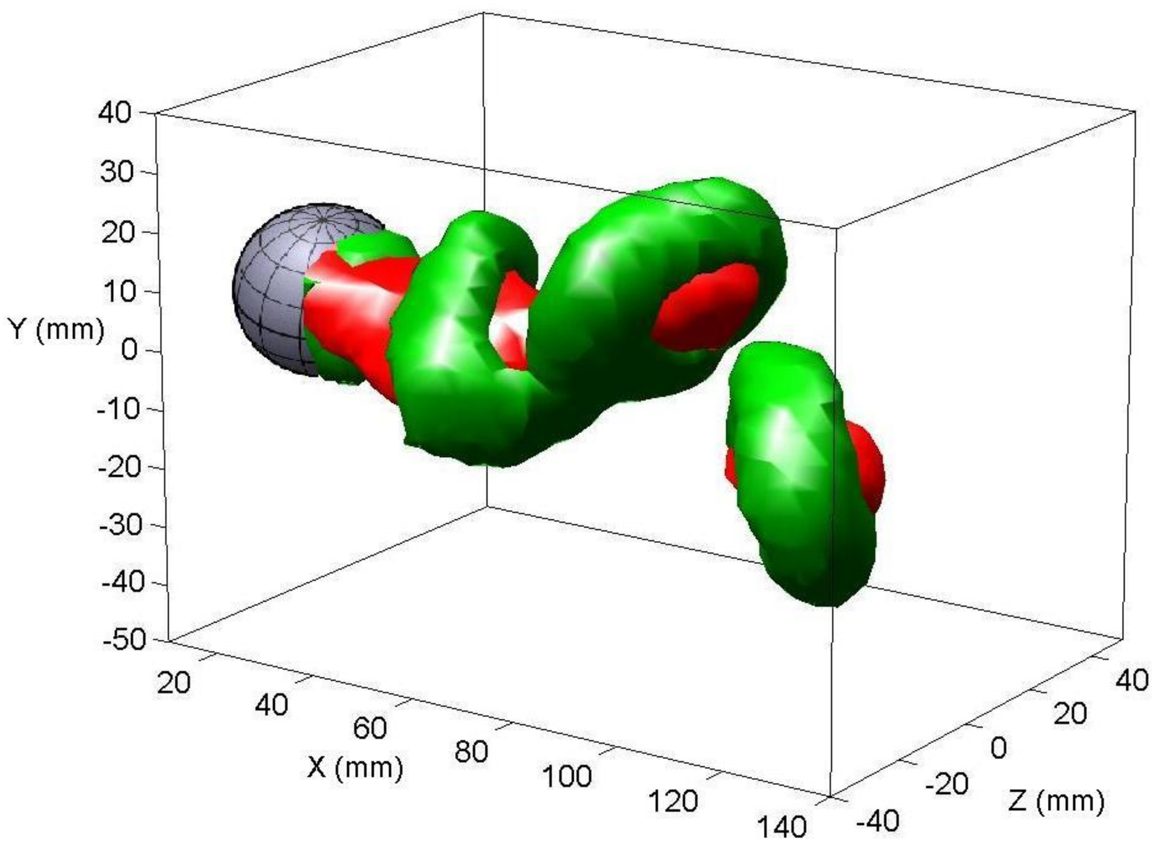

Fig. 3: Volumetric 3-component velocity field of the flow downstream of a smooth sphere in cross flow. Green isosurfaces represent vorticity magnitude. The red isosurface represents velocity magnitude. Flow is from left to right out of the page.

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