FLOW MEASUREMENTS AROUND A FLEXIBLE SPHERE USING V3V-FLEX™ SYSTEM AND THE BUBBLE GENERATOR BG-1000

APPLICATION NOTE V3V-FLEX-009 (A4)

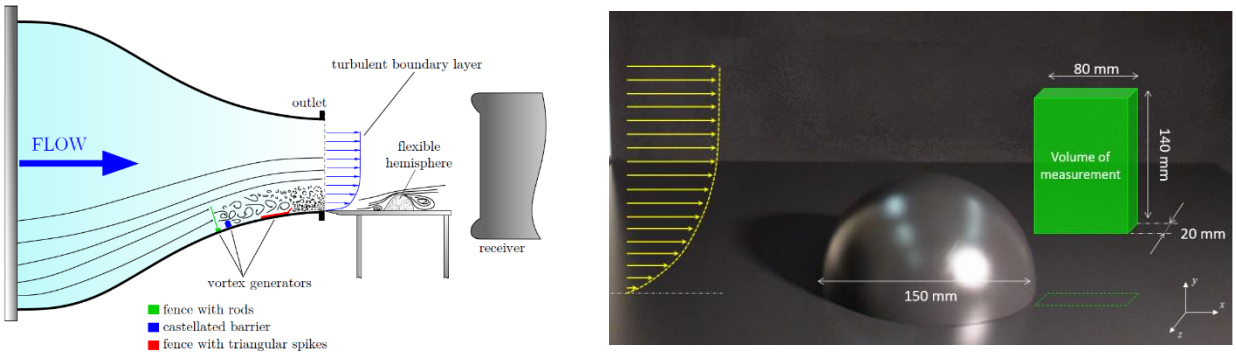
BUBBLES FOR VOLUMETRIC VELOCIMETRY

Flexible Hemisphere in Turbulent Boundary Layer

Flow fields around spherically shaped bluff bodies (such as domed structures) in turbulent boundary layers exhibit complex 3D flow pattern with an upstream horseshoe vortex system and a recirculation area with trailing vortices in the wake region. The present application note aims to show the capabilities of the soap bubbles used as a tracer for V3V-Flex™ 3D3C system to follow these structures.

Experimental Setup

The tests were conducted in the wind tunnel at the Department of Fluid Mechanics at HSU Hamburg in Germany. The velocity volume was measured behind a flexible hemisphere with a diameter of 150 mm. A V3V-Flex system composed of four CCD PowerView Cameras 8MP (P/N 630092) synchronized to a pulsed Nd-YAG laser delivering 200mJ/pulse was used to measure a volume of velocity vectors of 80 mm × 140 mm × 20 mm with a spatial resolution of 2 mm. The bubble generator (P/N BG-1000) was used for to generate soap bubbles to seed the air flow in the wind tunnel.



With courtesy of PfS (HSU Hamburg)

Figure 1. Experimental Setup

The calibration was performed by positioning manually a single plane calibration target at 21 different positions spaced of Δz=1 mm in the depth of the volume of measurement. A mean dewarping error of ~50 µm was calculated by Insight V3V™ 4G software for the four apertures as shown in the graph below:

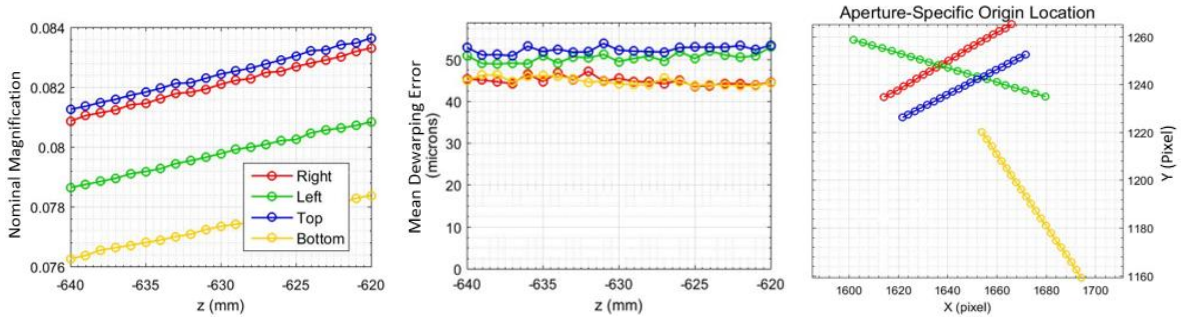
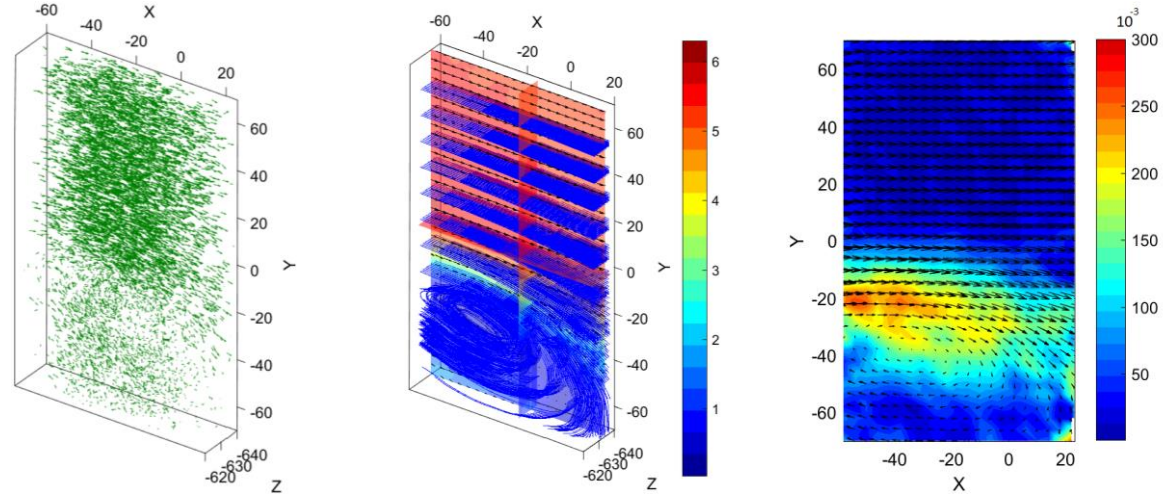


Figure 2. Calibration Results

Results

The 3D flow structure behind the sphere could be detected using V3V-Flex system as shown below.



Instantaneous velocity vector field

Streamlines superposed to Average velocity magnitude contours

Velocity vectors superposed to vorticity magnitude contours

Figure 3. Data Obtained from V3V System

The measurements obtained using V3V-Flex system were found consistent with high resolution 2D-PIV measurement (i.e. down to 0.15 mm and 1.5 mm resp. in *x* and *y*-direction) performed using a 29MP CCD camera (P/N 630094). The values for relaxation time and Stokes number for various particles are given in Table 1 below. The commonly used definitions for these quantities are listed according to those given in Melling (1997), Menon and Lai (1991), and Raffel et al. (2007).

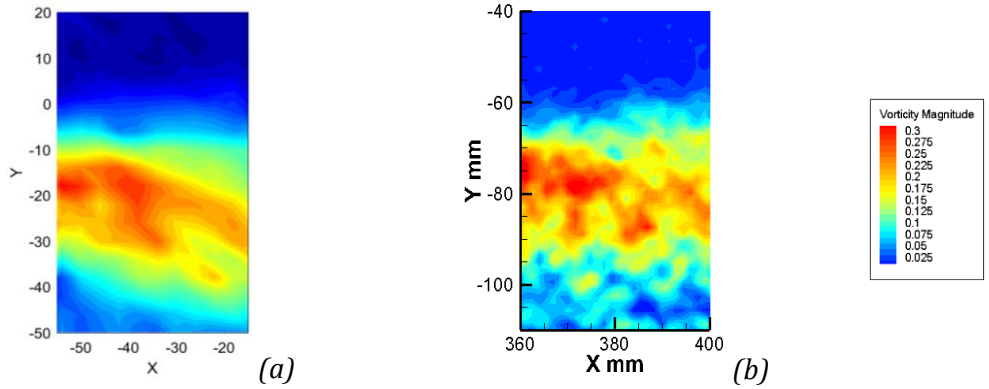


Figure 4. Vorticity Magnitude Fields Measured using V3V-Flex System *(a)* and High Resolution 2D-PIV *(b)*

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