Tomographic and Time-Resolved PIV measurement of an Impinging Jet on a Slotted Plate

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Abstract. In order to reveal the complete topology of unsteady coherent flow structures the instantaneous measurement of the 3D velocity field is being of the great interest in fluid mechanic. Several different methods were proposed to achieve a 3D version of the technique (scanning light sheet, holography, 3D PTV). We aimed in our study to develop a 3D technique than enables to obtain the 3D kinematic field of an impinging jet by using 2D measurements. In this study and in order to validate the proposed technique [1], the tomographic particle image velocimetry technique has been applied to time resolved PIV recordings. The first step before the validation was to study the vortex shedding phenomena between the jet exit and the slotted plate. The experiments were performed at a Re=4458 with an initial velocity U_0=7m/s using three cameras Phantom V711 and a Nd: YLF LDY 300 Litron laser. In the present study, we analyzed the coherent structures organization by a 3D-velocity visualization. Both mean and fluctuating part of velocity were analyzed for several positions in z. The results has shown that a couple of vortex rolls are created downstream the flow at y/H=2.

1 Introduction

The complete analysis of unstable coherent flow structures in the plans is essential to understand the flow and its dynamic evolution over time. The experimental study of turbulent flows techniques allowing three-dimensional measurements with high spatial and temporal resolutions in the field of fluid mechanics is now accessible through the application of PIV. On the other hand, the three-dimensional velocity field measurements are primary because some information flows over the entire volume due to unsymmetrical spatial evolution and transverse structure.

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Several measurement techniques have been used in recent decades. Some are planar such as SPIV [2], scanning PIV [3] and multi-plane PIV [4] and [5]. Others are volumetric such as holographic PIV [6] and tomographic PIV [7]. In previous works [1], we proposed a volume reconstruction method based on a combination between SPIV measurements of parallel planes and both POD and Phase Average methods. The results gave very good 3D results. In order to validate the developed technique of volume reconstruction of the impinging jet by using 2D measurements a Tomographic PIV campaign was applied. The investigation of the structures occurring on the slotted plate were discussed by the study of the transversal profiles of the mean and fluctuating components. The tomographic PIV technique was applied to determine the global flow topology.

2 Experimental Setup

An impinging jet on a slotted plate was generated at our laboratory at a free stream velocity of U_0 = 7 m/s and for a confinement of 4. An aluminum plate of thickness 4 mm equipped with a slot of 10 mm height was implemented in order to develop the configuration of an impinging jet on a slotted plate. Measurement of low speed airflows are operated by the time resolved PIV. Generally, available pulsed laser impose a compromise between its energy and the repetition rate required. For this campaign, a 527 nm Nd: YLF LDY 300 Litron laser was used with an energy of 30 mJ per pulse extended with a laser arm of 1800 mm length. Three cameras of type Phantom V711 with 1280 x 800 pixels and a maximum speed of 7530 fps at a full resolution were used.

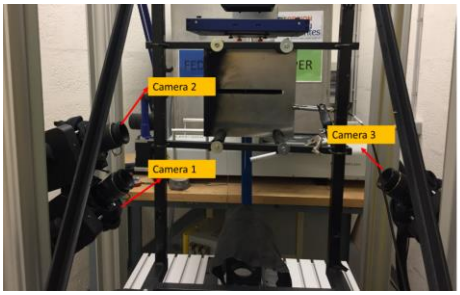

Fig. 1. Experimental Setup

3 Results

In the present study, the velocity components are named along the axes respectively V_x, V_y and V_z. The position z=0 mm corresponds to the median plane i.e. the middle transversal plane perpendicular to the plate. The volume treated in this measurement campaign is of 18 mm width with z extending from -10 mm to 8 mm. Note that V_x denotes the vertical transverse velocity, V_y is the longitudinal velocity and V_z is the horizontal transverse velocity.

We began by visualizing the volumetric results obtained by the tomographic measurements. Fig. 2 shows the vector and intensity fields of the three velocity components for the volume of flow measured by Tomo-PIV at an arbitrary instant. For the studied configuration, corresponding to a confinement of L/H = 4 and a Reynolds number equal to 4458, we can observe that the transversal component shows a couple of vortices which are situated from both sides of the jet axis. This couple of vortices extends along the z from P_{-18} until P_8. As for the longitudinal component, we deduce that this component is responsible of the

training that takes place from the jet exit to the slotted plate. A maximum of amplitude is detected simultaneously with the appearance of the couple of vortices in the transversal velocity component.

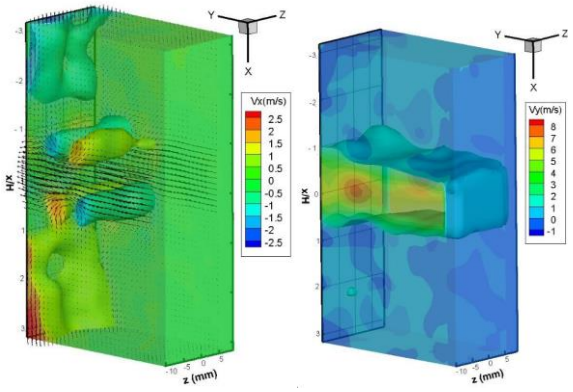

Fig. 2. 3D Kinematic fields measured by Tomo-PIV

4 Conclusions

A PIV 3D-3C or Tomo-PIV volume measurement campaign was carried out for a confinement L/H equal to 4 and a Re=4458. The 3D-3C kinematic fields measured by Tomo-PIV were then visualized. The results has shown, that for a configuration of an impinging jet for L/H=4 and Re=4458 a couple of vortex rolls are created constantly (i.e. periodically) for y/H=2 from both sides of the jet axis.

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