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A LOW COST PARTICLE IMAGE VELOCIMETRY

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Abstract: A low cost PIV was developed for Fluid-flow measurement and studies of flow around structural models or industrial facilities in wind tunnels. The analysis were conducted in a 100 mm x 150 mm optical window. The results show that the PIV prototype is working even though further development is necessary.

Keywords: Particle image velocimetry, fluid-flow measurement, field flow velocities

1. INTRODUCTION

To characterize flow fields is a problem that has no simple solution. Depending on the type of flow, it is very difficult to develop appropriate mathematical models and even if such models are available and used with powerful numerical methods (CFD) it is still important to compare numerical and experimental results.

In Brazil, laboratories interested in fluid flows use intrusive techniques that can measure the flow field in a single point. The most common instruments are Pitot tubes and thermo-anemometers. These instruments are introduced in the flow and several points in space are used to determine the flow field. This method is common and presents good results but has a few disadvantages, for instance: usually these instruments measure a single component of velocity. Thus it is necessary to measure each component (with multi-tube Pitot tubes or multi-wire anemometers). If the flow field is to be determined, several measurements are necessary. Even if enough probes are available, they can not be used simultaneously if too much interference is to be avoided. In the mean time the flow may change. Therefore mapping the flow may takes a long time and flow changes may affect the experimental results.

To overcome these difficulties, sophisticated techniques are appearing. These techniques are a natural development of visualization methods very common in fluid dynamics research which allowed a qualitative analysis of the flow from, for example, the observation of streamlines in the flow [1-3]. The development of computer vision allowed the automatic identification of these streamlines and a mathematical description of the flow field was possible and visualization methods developed into tools that can identify and map fluid flows.

This project proposes the implementation of a visualization and characterization technique based on the seeding of the flow with micro-particles, known in the literature by the initials PIV, *Particle Image Velocimetry*. This technology is used in universities and research centers usually related to automobilistic, chemical, mechanical, aeronautical, naval and civil industries.

This research developed a low cost PIV using a near infrared laser-diode with a rated maximum power of 100 W. The basic principle of the PIV, the instrumentation and software developed for this device are described in what follows.

2. METHODS

The implementation of the PIV required the parallel development of several devices and softwares. The optical setup used is shown in Fig. 1 and the basic tools developed are described below.

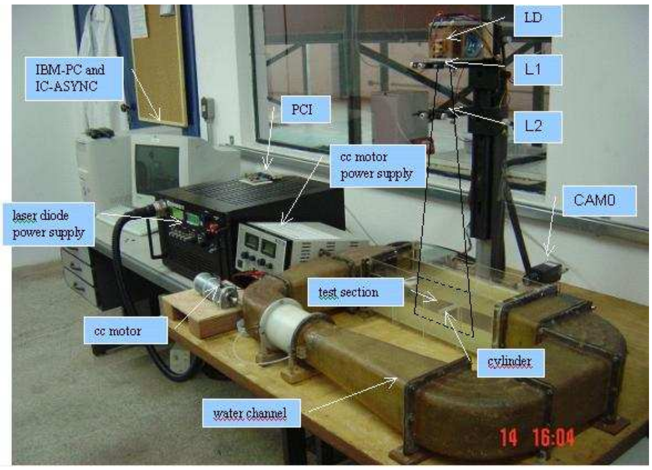

Fig. 1. PIV – Optical Setup.

The acquisition software developed is called SCIVA (Sistema Computational de Inspeção Visual Automatica). In this software, the images generated by the camera are presented live on a visualization screen where they are available for storage or processing. The PIV software is a set of Matlab scripts that simplify the velocity calculation and flow field visualization of two images acquired in successive instants of time. This software is based on scripts MATPIV and URAPIV, available in the internet and developed in matlab. The basic principle of the image processing is as follows:

Two images of the flow in different time intervals should be acquired. Each image is a matrix with the intensities of each pixel that vary from 0 (clear) to 255 (dark). The images are divided in small rectangles (interrogation cells) with sides that have powers of two pixels. The first interrogation cell is compared to the interrogation cell of the second image resulting in a cross-correlation of every pixel of the image. The interrogation cells are displaced, resulting in a new cross-correlation. This process is repeated until a maximum correlation for each correlation cell is achieved. Then a probable displacement was found. The velocity in this interrogation cell is simply the displacement divided by the time interval elapsed between between the two images. Noise in the data may result in wrong evaluation of velocity. To avoid this problem, the data obtained by the cross-correlation is filtered. There are several possible filters but the ratio signal/noise filter should be pointed out. It eliminates data above a certain critical value defined by the operator; this value is the ratio of the cross-correlation in the observed position and the mean values near this point.

3. RESULTS

Analysis were conducted to verify the PIV system. using one or two cylinders positioned across the flow were used to disturb the mean flow. All analysis were conducted in a test section of 150 mm x 100 mm, width and height, respectively, and the mean velocity was 0.2 m/s.

3.1. Single cylinder *wake*

In this analysis a cylinder was positioned before the test section. This cylinder has a 10 mm diameter and was positioned upstream from the test section. Results are shown in Fig. 2. In this figure, the velocity field subtracetd by the mean velocity is plotted (arrows) over the vorticity of the flow. Even though the results are noisy, it is clear on this figure a presence of vortices. On the upper side of the figure, the vortices turn anticlockwise and on the bottom of te figure the vortices turn clockwise, as is expected on the wake of a circular cylinder flowing from right to left (the von Karman vortex street).

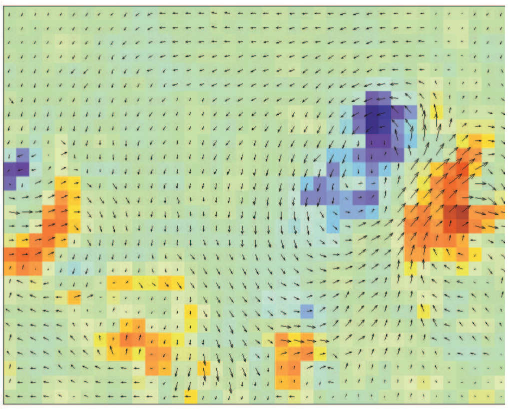

Fig. 2. Vorticity field result for the flow on the wake of a single circular cylinder.

3.2. Wake of two cylinders placed side-by-side

This analysis was conducted with two cylinders side-by-side. The cylinders had a gap of 2 diameters. The gap is defined as the center to center distance.

The results obtained with a gap of two diameter are shown in Fig. 3. These results are, again, very noisy, and the mean velocity was subtracted from the velocity field so that vortices could be more easily distinguished.

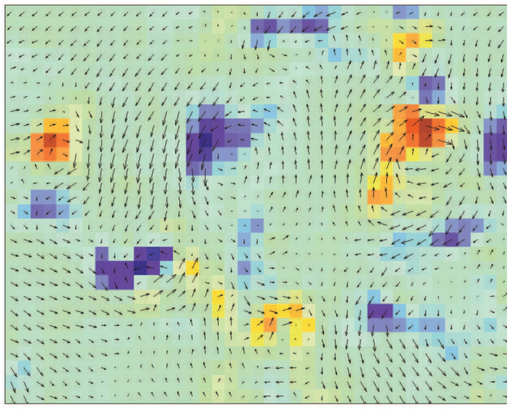

Fig. 3. Vorticity field result for the flow behind two circular cylinder.

3. CONCLUSION

This paper showed the possibility of a low cost PIV using a laser-diode with 800 nm wave length and 100 W rated power as a light source. The results obtained with this PIV shows the advantages of the use this optical technique to measure fluid flow.

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