Getting Better ***Flow-Structure*** Information

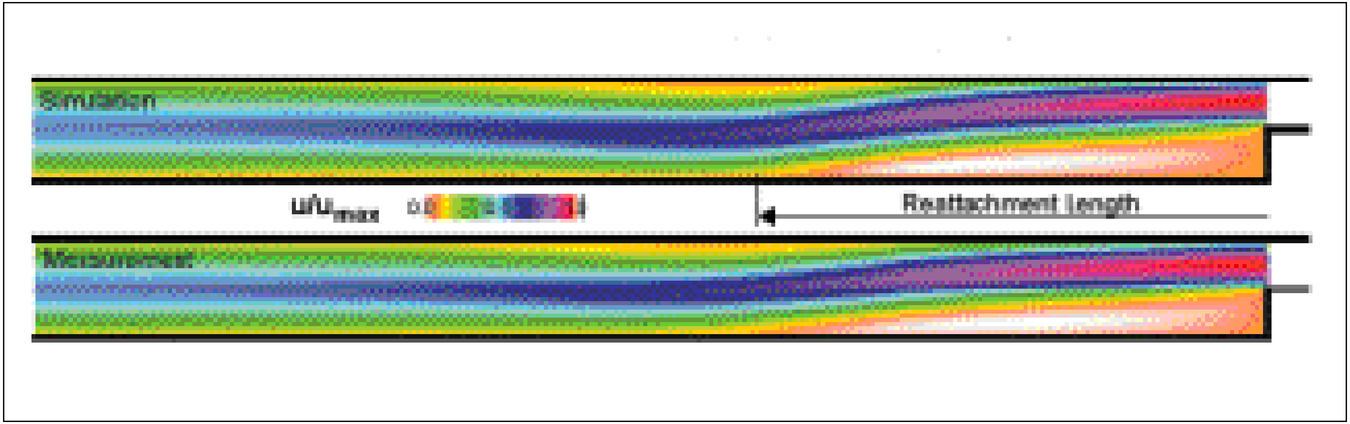
The Cooke Corporation's digital CCD camera increases the efficiency of an improved technique called digital particle image velocimetry (DPIV).

Experimental studies of flow-velocity fields have been greatly advanced by the development of optical techniques that do not interfere with or disturb the flow. One of these, the laser Doppler velocimetry (LDV) technique, has been widely used in velocity measurements. But since the technique provides time-resolved information about a single point of the flow domain, its capacity to provide spatial flow-structure information is limited. For investigation of flow fields with pronounced spatial structures and/or rapid spatial changes, new experimental techniques are necessary.

It is well known that multipoint measurements can be achieved by recording the motion of particles that have been added to the fluid as tracers. A broader group of whole-field velocimetry techniques, called pulsed light velocimetry (PLV), enables the capture of the quantitative flow velocity field instantaneously. The different PLV methods have been developed during the last decades based on various principles. In particular, the PLV method that uses a statistical analysis of the recordings defines the state of the art and can provide a high spatial resolution with reliable accuracy.

SensiCam system shown with lenses,trigger system,flash source, mounting hardware, computer and image processing/analysis software.

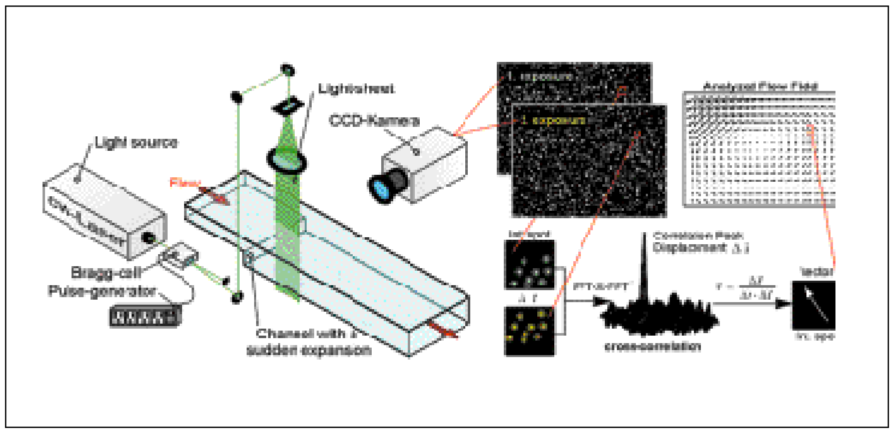
The targeted flow is seeded with small tracer particles with specific characteristics (spherical, identical density for water), which therefore follow the fluid. The investigated observation area can be illuminated with a thin light sheet designed by a lens system. During a measurement, two short laser pulses fired



Sample of the test device.

with a known time separation illuminate the flow. The images of the pulses represent the particle distribution respectively by their displacement in the observation area.

The displacement between the two scattered light images can be analyzed with correlation methods in small segments (interrogation spots) of the recorded image, where a uniform velocity is assumed. The analyzed image displacement, combined with the magnification factor of the optical setup, leads to the particle movement in the flow. This distance, divided by the given time interval, yields a velocity vector for each



Principle of particle image velocimetry.

interrogation spot. The analysis of all interrogation spots in the whole recorded image yields an instantaneous two-dimensional vector velocity field of the flow in the observation area.

Here a digital particle image velocimetry (DPIV) technique was implemented to study the so-called backward-facing step flow (BSF). As one of the fundamental problems in fluid mechanics, flow separation has received a lot of attention during the last few decades. The BSF flow (channel with a sudden expansion) has received most of the attention given to recent configurations. Despite the relatively simple geometrical configuration of the backward-facing step, the flow physics is quite complicated, and comprises the shear layer separating at the step corner, the separation region at the channel expansion, which is characterized by recirculating flow, and far downstream the fully developed channel flow. The availability of data of good quality combined with the feature that the primary reattachment length varies with Reynolds number makes the BSF flow an excellent test case for the accuracy of numerical and experimental methods.

The highly time-consuming image analysis of photographic recordings creates interest in an implementation of digital image processing. The Cooke Corporation's digital CCD camera system, the SensiCam, has been installed, with its ultrafast sequence capturing (200 ns) of two separate image for PIV, 12-bit digitization, and 1280 × 1024 pixels. The SensiCam offers the advantages of on-line observation, calibration of setup parameters, very fast image recording and processing, and accurate measurements. The advantage of digital PIV as compared to classical photographic PIV lies in fast and convenient interrogation of the images, as well as in the possibility of recording the scattered-light images of the two pulses in separated frames. This advantage creates the opportunity to obtain directionally resolved analysis by interrogating the images with cross-correlation techniques, which results in a precise determination of the flow direction and in a higher dynamic velocity range. Furthermore, series of double-pulsed image pairs are recordable, so that for low Reynolds numbers a certain time resolution can also be achieved.

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