PARTICLE VELOCITY MEASUREMENT BY HOLOGRAPHY

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Abstract

A double pulsed holography was used to measure the particle velocity and velocity distribution. Semiautomatic technique has been developed at the Department of Physics, Technical University Budapest and used to evaluate the hologram. The velocity of the particle at all points in the sample volume can be measured with high accuracy.

Introduction

Particle velocity and velocity distribution measurement finds application within a wide range of experimental situations, which include studies of spray characteristic distillation plates, flued flow, and sedimentation.

There are two different techniques by using coherent optical methods for measuring the particle velocity [1]. In the technique known as a laser doppler velocimetry, the flow is seeded with small particles that scatter incident laser light. By detecting the doppler shift of the scattered light with an optical heterodync receiver, the velocity of the particles passing through the focal region as a function of time can be determined.

In the other technique, referred to as holographic velocimetry, a double pulsed hologram is made of the particles in the flow. By observing the relative positions of a particular particle in the reconstructed images, the vector velocity of the particle can be determined. In both methods, the velocity of the flow is assumed to be that of the particle.

Laser doppler velocimetry and holographic velocimetry are complementary, since the first measures velocity at a point as a function of time and the other measures velocity at all points at a particular time. Holographic velocimetry potentially can provide very accurate three dimensional velocity data at specific points in the flow. Among the numerous holographic methods which have been proposed for particle velocity measurement, many may be considered to be particle counting methods in which a double exposure hologram is produced of a moving particle field, and in the subsequent reconstruction, particle displacements are measured in the set of focused image planes [2].

In many practical applications, for determination of the velocity distribution semiautomatic techniques are currently available [3]. In this experiment we used the particle counting method for recording and semiautomatic technique for evaluation.

Experiment

For the present particle measurement system, the experimental arrangement for recording is shown in Figure 1. The sample volume *S* was illuminated by a double-pulses ruby laser light through the beam expander *BE*. A diameter of the beam was 7 cm. The holographic plate *H* (Agfa Gevaert 8E75) was placed at distance 20 cm from the test volume.

The double pulsed Q-switched ruby laser *L* has been developed at the Department of Physics, Technical University of Budapest. Two pulses of the laser were monitored by an oscilloscope. This type of laser provides two pulses with time interval from 1 μs to 1000 μs. In this experiment the time interval between the two exposures was 25 μs. A He—Ne laser was used for the aligment. The pressure of the water studied in this work coming through a teejet 11 003 nozzle was 3 bar.

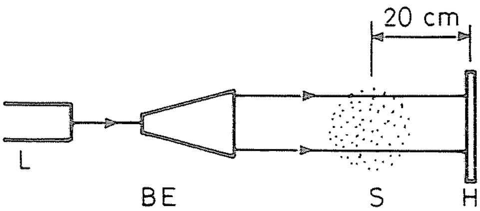

Fig. 1. Recording system: *L* is a ruby laser, *BE* beam expander, *H* is a hologram plate, and *S* is a water droplets

Reconstruction and evaluation

The reconstruction arrangement is shown in Figure 2. A He—Ne laser beam (2 mm diameter) with a power of 20 mW illuminated the development hologram plate. A twin real image of every particle was formed at a distance 20 cm behind the plate, as shown in Figure 3, and it was displayed on TV monitor. IBM compatible computer was connected with the TV monitor to measure the velocity distribution of the particle with the help of image processing system.

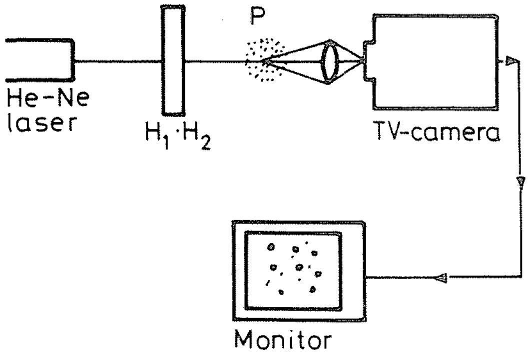

Fig. 2. Reconstructed system: *H* is a development hologram plate, *P* is a particle real image

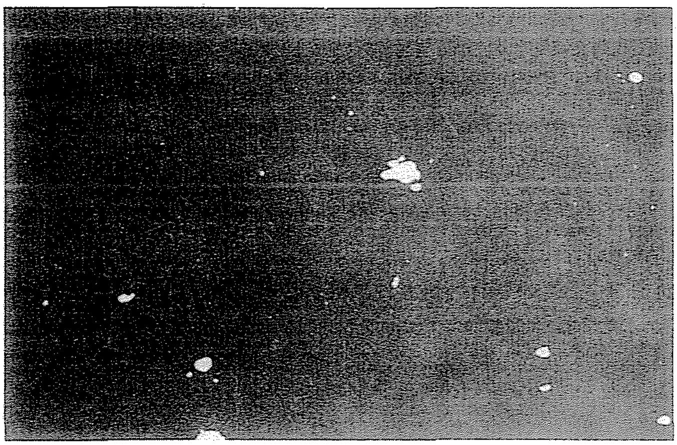

Fig. 3. Reconstructed real image

With this system we connected the Mouse device, which help us to measure the distance between the twin image quickly. The signal of the Mouse (square shape) can be moved by our hand, for this reason our system is a semiautomatic system. When the first real image is inside the signal of the Mouse, the program will calculate the $X_{\min}$, $X_{\max}$, $Y_{\min}$, $Y_{\max}$. From these measurement the center of the particle will be found. By moving the Mouse signal to the second image, the center of it will be found also, and the program will measure the vector distance (d) between the two images.

$$\text{the velocity} = d\,\Delta d/\Delta t$$

$$\text{where } \Delta d = 20\ \mu\text{m and } \Delta t = 25\ \mu\text{m}$$

By this way the velocity of all particles was measured in the sample volume, by divided it to small area 7 mm × 9 mm. The result is shown in Table 1. The average velocity under the pressure which was applied in this work is 25.1 m/s.

Table 1

Verticle distance	Area 7mm × 9mm particle velocity m/s									
9mm	1	2	3	4	5	6	7	8	9	10
1	18	22.5	33.6	21.6	30.5	—	—	—	—	—
2	17.8	15	36.2	22.2	21.8	—	—	—	—	—
3	23.2	28.6	17.8	36.2	19	28.6	21.9	—	—	—
4	22.2	24.1	25.3	26.9	28.9	22.7	18.6	27	21.6	—
5	22.5	22.7	24.4	22.6	31.9	25.5	23.5	25.2	24.2	—
6	23.6	22.2	23.8	23.4	20.6	28.8	24.5	26.5	25	34
7	26.4	33.2	25.5	23.3	20.7	23.3	27.9	35.8	—	—
8	24.4	40.6	28.2	17	32.2	22.6	—	—	—	—

The average velocity is 25.1 m/s

Conclusion

Holography is very useful technique for determining the particle velocity and velocity distribution. The particle counting is very simple method with high accuracy for measuring the particle velocity. By using a computer the hologram can be analysed in very short time with high accuracy, and the velocity of the particle at all points in the samples volume can be measured.

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