EAN '92
30th Conference of Experimental Stress Analysis
30. konference o experimentální analýze napětí
2. - 5. 6. 1992 ČVUT Praha Czechoslovakia

APPLICATION OF THE SPECKLE PHOTOGRAPHY METHOD FOR ANALIZING THE FLOW VELOCITY FIELD

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A paper contains a short description of a speckle photography possibility in flow velocity field measurement. Supporting on time intervals between following recordings and displacement of markers in the flow, the velocity components in the flow, the calculation of velocity vector components in every point of the tested area is possible.

Keydwords: speckle photography, measurement, velocity field.

The speckle photography method is used mainly for measuring displacements and deformations of the surface of solid bodies. It consists in utilizing the effects of the so-called speckling, i.e. forming at the front of the surface of an object illuminated by coherent light a granular structure being closely correlated with the state of this surface (Fig. 1). The families of the structures recorded on a light-sensitive material and corresponding to the successive loading states of the object being tested possess the properties of the diffraction grating (Fig. 2).

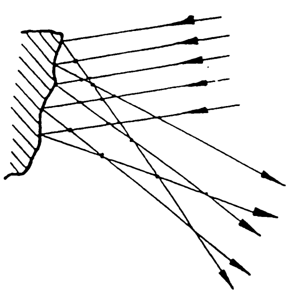


Fig. 1.

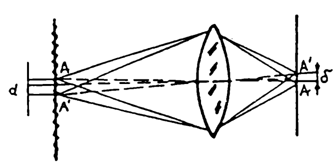


Fig. 2.

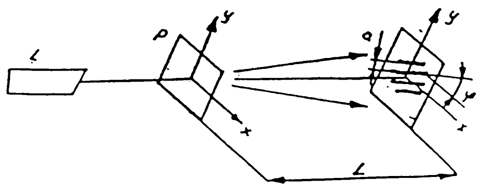


Fig. 3.

Information concerning the displacements of the surface being tested is obtained at the stage of the analysis carried out in the system presented in Fig. 3. A narrow beam of coherent light passes through the image being recorded. As a result of diffraction, interference patterns appear on the screen placed at a distance L from the specklegram.

By measuring the distance between the patterns and their inclination angle to the coordinate system assumed we determine the value of the displacement vector from the dependence (1), (2), (3) as well as the values of its components in the coordinate system:

$$|d| = \frac{\lambda \quad 4L^2 + a^2}{2pa} \tag{1}$$

$$u = |d| \sin \varphi \tag{2}$$

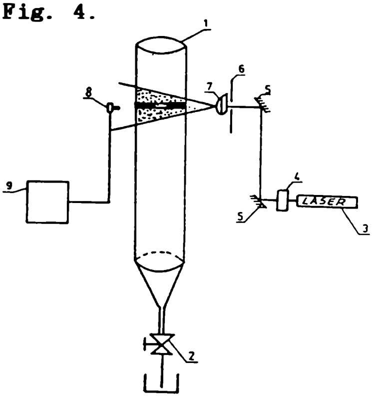
$$v = |d| \cos \varphi \tag{3}$$

where: d - displacement vector, L - distance of the specklegram from the screen, a - distance between the patterns, p - photographic magnification, φ - inclinantion angle of the patterns in relation to the coordinate system accepted.

The direction of the displacement vector is always perpendicular to that of the interference patterns. The condition for making the measurement is the occurrence of displacements being larger than the size of the speckles being observed.

The adaptation of the presented method for measuring the instantaneous velocity in to two-phase flow consists in replacing the recording of the speckle structure with that of the images of particles floated in the flow of liquid or gas. The attempt to apply the speckle photography method to test flow phenomena is connected with the fact that the velocity measurement techniques used so far are subject to numerous defects. For example, contact techniques such as velocity measurements by means of towering probes or turbines causes disturbances in the measurement area and fairly large averaging of results. Non-contact methods based usually on the combination of visual and photographic recording of the phenomena being tested make it possible to obtain qualitative information in the processes being investigated. As a rule the univocal deformation of the value of the velocity vector in an optionally chosen point is not possible on account of the difficulties in assigning the place of the initial information carrier about its movement in the course of recording.

The construction of the measurement stand is presented in Fig. 4.



1 - flow channel with a flange ϕ = 68 mm,
2 - release valve of 5 mm ϕ flange,
3 - source of coherent light,
4 - shutter (impulse divider),
5 - guiding mirror,
6 - diaphragm,
7 - cylindrical lens,
8 - optoelectronic probe,
9 - oscilloscope.

Fig. 4.

The parallel light beam emitted by a laser (3) is formed by cylindrical lens (7) into the so-called "light knife" which makes it possible to separate the optionally chosen measurement plane from the space of the flow channel. In the measurements double pulse ruby laser, operating in the Laboratory of Holography of the Central Laboratory of Optics Optics in Warsaw, was used.

The recording of two successive locations of particles and the allowance made for the time interval $\Delta\tau$ between the exposures make it possible to determine the direction and the value of the instantaneous velocity vector in each of the optionally chosen point of the cross-section recorded.

The results given in the present paper have been obtained by recording polyvinyl chloride particles floated in the water flow through the 18 mm ϕ channel with a 5 mm ϕ flange. The average flow velocity was 0,34 m/sec. Fig. 5 presents the diagrams of the instantaneous velocity distribution in the central cross-section of the flow channel.

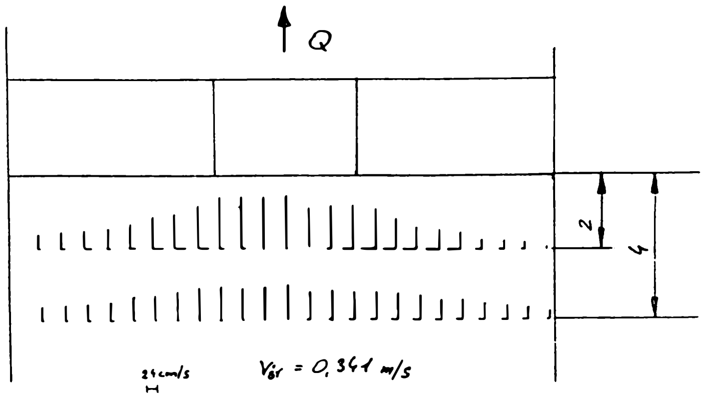


Fig. 5.

The analysis of the one recorded image, in the two section (2 and 4 mm in front of the flange), was carried out. The maximum velocities that have been measured were about 1,2 m/sec. The example presented confirms the vast possibilities of the speckle photography method in the range of the non-contact measurement and analysis of instantaneous velocity fields with diversified values.

References

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