LASER DIAGNOSTICS OF SHOCK WAVES IN EXPERIMENTAL GAS DYNAMICS

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Application of optics–laser diagnostics in experimental gas–dynamics is discussed. Specifically, investigations on the dynamic structure of a shock wave and disturbances in air induced by the shock wave are considered.

In modern experimental gas dynamics an importance of optical measurements of kinematic and structuring characteristics is beyond question. Primarilly it refers to measurement of such kinematic parameters as velocity and turbulent pulsations of streams in supersonic wind tunnels, shock tubes and also at research of explosive processes. From the requirement of not disturbing character of measurements the necessity of application for these purposes of laser technologies is evident. One such method is Laser Doppler Anemometry based on filtration of the space and time structure of the light scattered in fluid under study and on measuring the Doppler frequency shift which is the well–defined linear function of velocity of the scatterers in the assigned coordinated basis [1]. Qualitatively new diagnostic possibilities in experimental gas dynamics are provided by Laser Doppler visualization and measurement of dynamic fields of the velocities. This method is based on the optical discrimination of the Doppler shift of the frequency in the scattered light. At the first time the velocity of the dynamic structures at the shock wave front was measured by the modified Laser Doppler Anemometry techniques (Fig. 1).

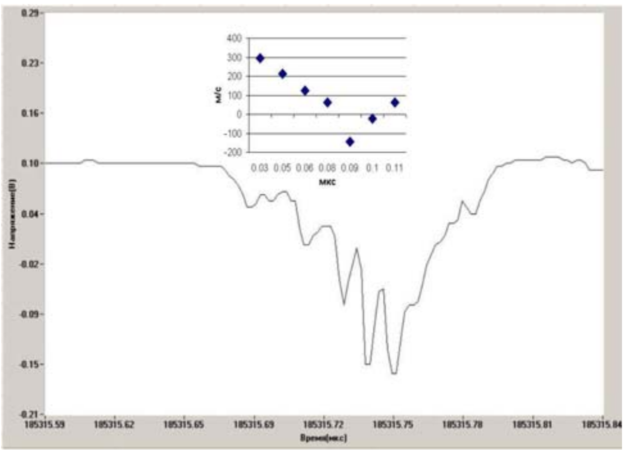


Fig. 1.

The space patterns of the optical density at the front of the nonstationary shock wave were revealed. These patterns take the form of oscillatory mode structures.

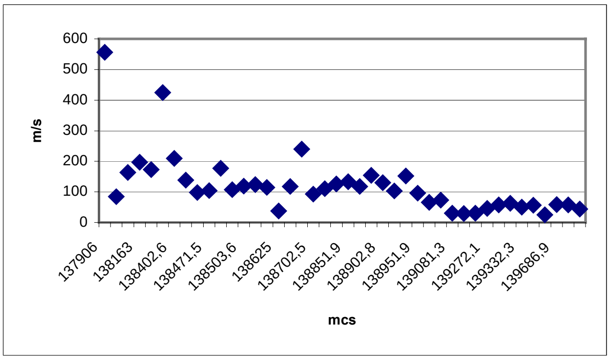


Fig. 2

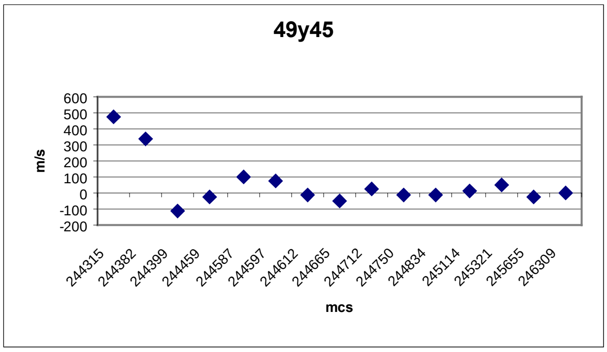
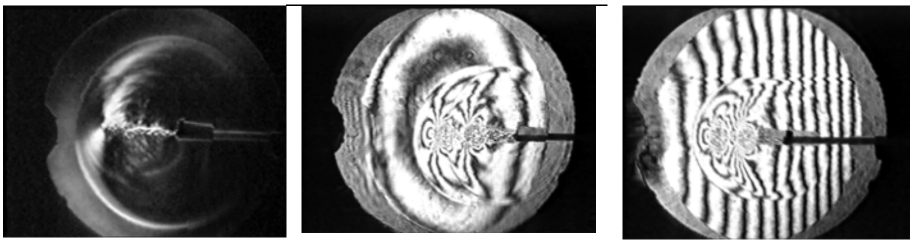


Fig. 3

As an example, the results of measurement of the dynamic velocity of dusturbances in the air fluid, induced by a shock wave in the direction orthogonal to the front of a shock wave (fig. 2) and parallel to the wave front (fig. 3) are given. Measurements were carried out on an output of the portable shock pipe created on the basis of a pneumatic gun. The shock wave was formed at break of diaphragm from an aluminium foil. Calibre of the gun of 4.5 mm. Local velocity was measured on the distance of 10 calibres from a cut of the trunk.
Fig. 4 shows a schlieren pattern reflecting the process of distribution of a shock wave (a) and a shift interference pattern (b and c) obtained with the application of a modified shadow device IAB 463 with the 400 mm diameter of observing field. In figures the front shock wave, dynamic dusturbances and helicoid vortical structure in the direction of the axis of the channel are well seen.



a b c

Fig. 4

Development of schlieren methods for experimental gas dynamics is connected with the increase of the sensitivity of the sacrifice of the Hilbert–filtration of an optical signal. The possibilities of laser Doppler visualizations and measurements of the dynamics fields of velocities for experimental gas dynamics are discussed. The necessity of nonconventional approaches for optical diagnostics arises in problems on non-stationary gas dynamics, connected with the research of the structure of shock waves, dynamic disturbances induced by shock waves, with studying the zones of turbulent mixing and explosive processes. A qualitatively new level of diagnostic methods is determined by development of multidimensional measuring technologies. Qualitatively new opportunities in laser diagnostics give 2D and 3D measuring technologies.

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References

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