A TALBOT INTERFEROMETRY FOR MEASUREMENTS OF TURBULENT JET FLOWS

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Currently, the self-imaging effect associated with intensity distributions of a coherent monochromatic radiation field with a periodically modulated front finds wide use for diagnostics of inhomogeneity and quality of optical media. This is commonly referred to as the Talbot effect in the literature [1]. In [2–4] this technique is adopted to study the optical homogeneity and the quality of laser-active media, including gas flow lasers. Since possible amplitude and scale spectra for flow inhomogeneities are sufficiently broad, the measuring technique must possess the corresponding accuracy, measurement dynamic range and resolution. The Talbot interferometry obeys these requirements because of the sensitivity of this technique to varying local light refraction angles. In this case, two components of the deflection angle can be simultaneously measured at many points of a phase object with a high concentration in space. This concentration, much like the measurement range, is determined by the period of the Talbot structure. Moreover, registering an ordered interference pattern in the self-imaging plane yields some of the advantages, as compared to the methods based on the random interference effects [5,6], because of much higher sensitivity, spatial resolution and contrast of a resultant image. This enables one to essentially simplify a procedure of processing a Talbot image and to enhance the measurement accuracy.

The applied potentialities of the above technique are illustrated by the examples of its use for measuring the averaged parameters of turbulent axis-symmetrical and two-dimensional helium-air jets (fig.1). Two-dimensional sets of light refraction angles are determined from the time-averaged Talbot images with a step of 0.7mm in space (fig.2). Distributions of averaged values of the spatial gradient of the refractive index of the medium as well as the helium concentration in the flow are calculated in both cases (fig.3). From an analysis of the intensity distribution shape and the location of the maximums of the Talbot image it follows that the turbulence of given jets is locally inhomogeneous and non-isotropic.

These studies enable one to conclude that the Talbot effect-based technique is a powerful tool for

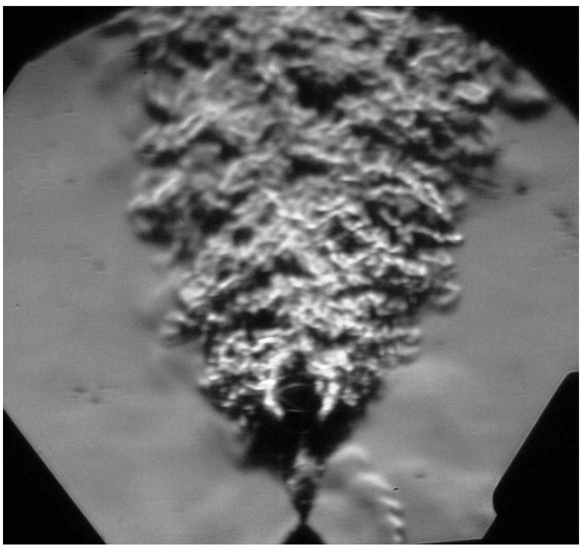

Fig. 1. The schlieren flow pattern of a two-dimensional vertical helium-air flow past a horizontal cylinder

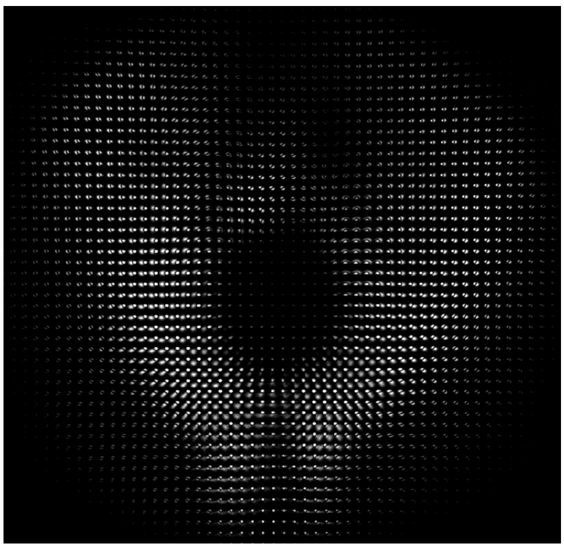

Fig. 2. The difference flow pattern between the intensity distributions in the Talbot images of the two-dimensional jet and the undisturbed flow

diagnostics of liquid or gas flows, including turbulent ones. This technique allows for the measurement of a two-dimensional set of local angles of light refraction with a high spatial resolution (step up to 200 μм) throughout the flow and with the sensitivity up to 10^{-5} rad that is compared with that of high-quality schlieren devices. The optical schematic of the Talbot interferometer is not difficult to construct, does not require expensive optical elements, is illustrative and, easy to use. Owing to a small number of optical elements, including a periodically transparent Talbot grating and a collimator, the adopted technique is insensitive to environmental actions and can be used under production conditions. The possibility of measuring the distribution of averaged admixture concentrations in space makes this technique very promising for turbulent mixing studies.

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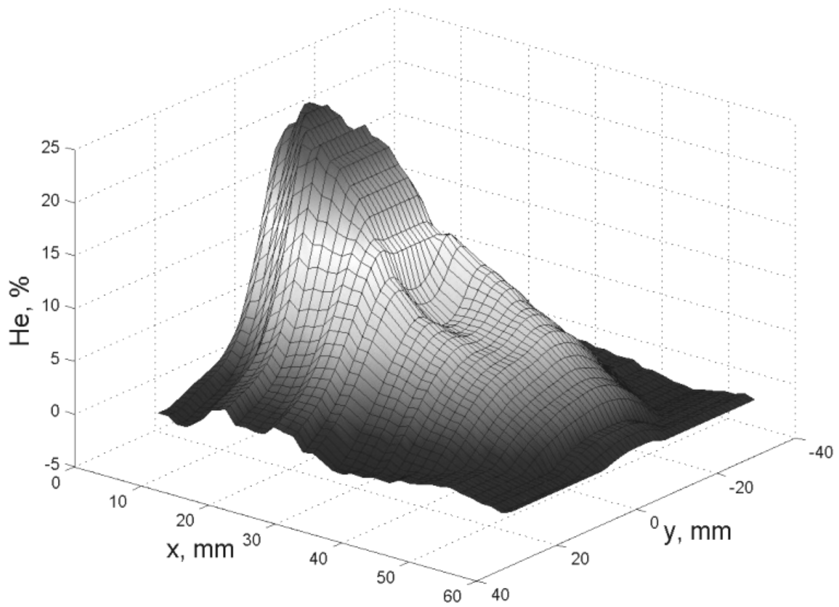

Fig. 3. The average distribution of a helium concentration at the jet-cylinder interaction.

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