MEASUREMENTS OF A NEAR-WALL PLANE JET CHARACTERISTICS BY PARTICLE IMAGE VELOCIMETRY

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Introduction

Near-wall plane jets call much interest from the engineering point of view as they can be used, for example, for cooling of turbine blades and different electronic devices, as well as for control of a wing boundary layer.

During the present experiment, qualitative behaviors of the jet development with help of smoke visualization of the jet flow and shooting by the video camera of cross-sections and longitudinal-sections of the jet with application of stroboscopic flow illumination by laser "knife" have been studied. Examinations were conducted with help of particle image velocimetry (PIV) method.

That fact is well-known, that in the jets, shear layers and mixing layers at high enough Reynolds number upstream the linear instability amplifies before saturation and is folded in primary axisymmetric rings. Are observed as other organized vortices developing as longitudinal counter-rotating vortices which for the first time are shaped in an interval between two primary Kelvin – Helmholtz rings following one after another and then will penetrate into their cores. The purpose of this study was examination of origination process of the longitudinal structures, their streamwise development and interaction with Kelvin – Helmholtz rings, and as their role during laminar-turbulent transition.

Experimental set-up

The studies were carried out on the experimental set-up is shown in Fig. 1. Near-wall plane jet was shaped on an exit of the plane nozzle and developed along a horizontal flat plate in length is 2.1m and width is 3.2 m. The nozzle width is 11 mm and its length is 500 mm. The used coordinate system is presented in Fig. 1 where the axis x is streamwise direction, the axis y

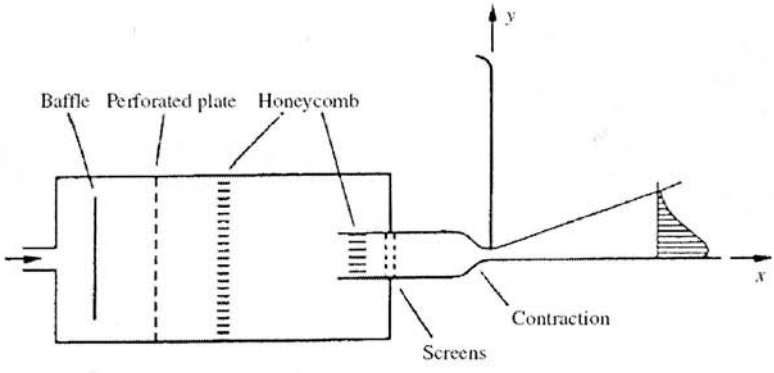

Fig. 1. Experimental set-up for study of the near-wall plane jet.

is a wall-normal direction and the axis z is transverse direction. Air was pumped by a ventilator in the stabilization chamber in which have been installed: a punched plate, two honeycomb and grids. Then the stream went out the plane nozzle with coefficient of contraction is 36:1, see Fig. 1. The level of turbulence, measured on an exit from the nozzle in frequency band from 10 Hz up to 10 kHz, was less than 0.05 %, a Reynolds number is $0.5 \cdot 10^4$. During measurings, velocity U_0 was inspected by a Pitot – Prandtl tube, arranged in the jet core.

Results of experiment

Visualization of the stream has shown the longitudinal structures position and their reference sizes (see Fig. 2). Instantaneous smoke visualization pictures (1–2 μs) of flow in plane xz at $\mathrm{Re} = 0.5 \cdot 10^4$ are shown in Fig. 2,*a,b*. The light knife is arranged in parallel a wall, and longitudinal streaky structures are well distinct in a xz-plane. First instability of the Kelvin – Helmholtz which lead to sequential turning of shear layer into the vortex structures. Similar observations have been made in the round jet where it has been shown, that longitudinal structures exist be-

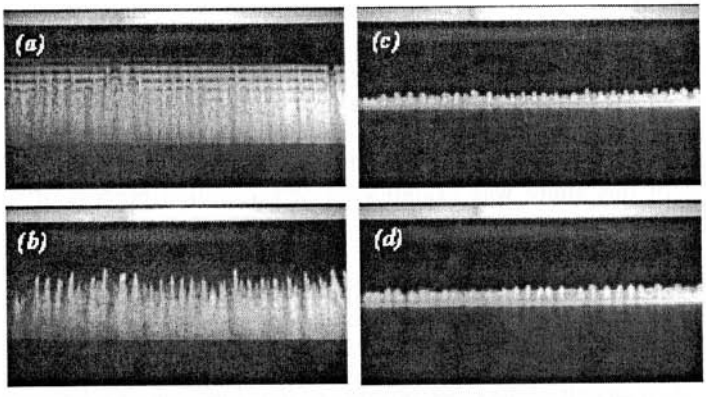

Fig. 2. Visualization of nonlinear structures in near-wall plane jet. The laser knife is arranged in parallel a wall (*a, b*) and perpendicularly to the stream (*c, d*) [1].

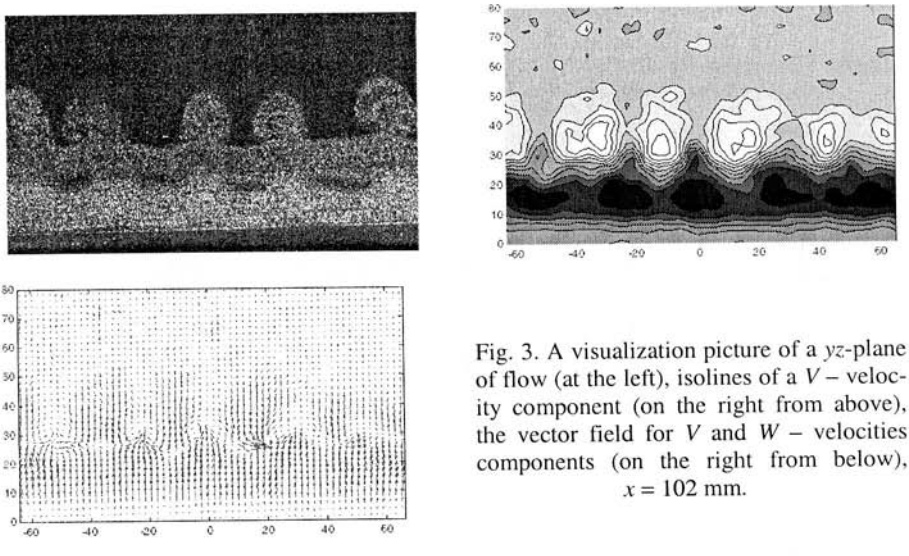

Fig. 3. A visualization picture of a yz-plane of flow (at the left), isolines of a V – velocity component (on the right from above), the vector field for V and W – velocities components (on the right from below), $x = 102$ mm.

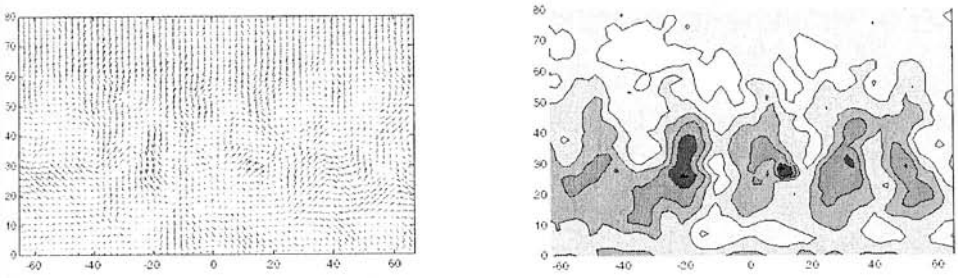

Fig. 4. The vector field of velocities for V and W- velocity components (at the left), and isolines of V- velocity component (on the right), $x = 154$ mm.

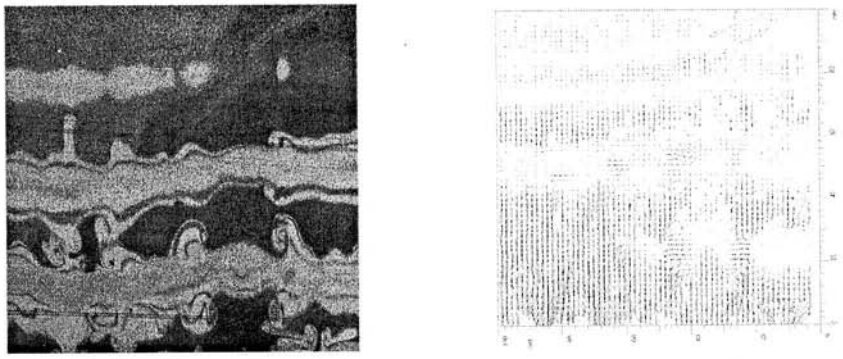

Fig. 5. A visualization picture of a xz-plane of flow (at the left), and vector field of velocities for V and W-velocity components, $y = 19$ mm.

tween primary vortex structures, so called Kelvin – Helmholtz rings. As longitudinal structures are well visible and at the normal to the wall position of the light knife (see Fig. 2,*c,d*) where the yz-plane of a jet is shown.

Results of the near-wall plane jet examination with help of PIV-method are shown in Figs. 3–5. The example of the longitudinal structures with obviously expressed mushroom-like structures measured perpendicularly to the stream is shown in Fig. 3.

The results of near-wall plane jet studies with help of hot-wire measuring are shown in paper [2].

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