EXPERIMENTAL METHODS OF THE STUDY OF VORTEX STRUCTURES EXCITED BY POINT INJECTION ON THE LEADING EDGE OF THE OBLIQUE WING

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The boundary layer of the oblique wing has a 3D structure and consists of a longitudinal and transverse components. The transverse velocity component profile (cross-flow) has an inflection point and is hence unstable. In the laminar-turbulent transition scenery, the governing factors are the stationary disturbances which modify the mean flow and create favorable conditions for secondary instability development [1].

The leading edge of any wing presents a curved surface, its shape depends on the chosen profile, which complicates significantly its study. This work presents the hot-wire measurements [2] on the leading edge near the spreading line; also the technique of liquid-crystal (LC) thermography was approved [3]. The disturbances were excited by the jet blown from a hole of 0.5 mm in diameter which was located on the leading edge near the spreading line.

The experiment was carried out in the low-turbulent wind tunnel T–324 in the Institute of Theoretical and Applied Mechanics SB RAS. The cross section of the working area is 1000×1000 mm, its length is 4000 mm. Flow turbulence degree was no more than 0.03%. Free stream velocity during the hot-wire measurements was U_∞ = 4.2 m/s, during the visualization by the LC method it varied within the range of a U_∞ = 3.4 – 9.4 m/s and was monitored with the Pitot-Prandtl tube.

The hot-wire measurements have shown the presence of two counter-rotating vortces, their behavior highly depended on the injection velocity. Stationary low-amplitude disturbance did not increase streamwise (Fig.1.a). In the high-amplitude injection regime, we observed increasing stationary disturbance streamwise (Fig.1.b.), secondary disturbances, and natural pulsations.

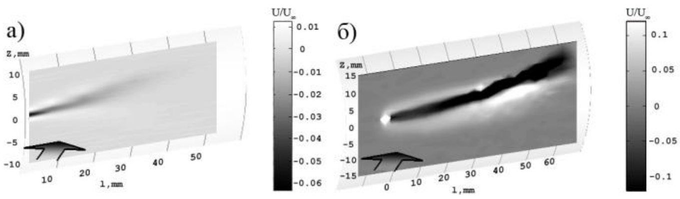

Fig.1. Velocity disturbance distribution.
a – low-amplitude regime; b – high-amplitude regime.

Visualization results obtained with the aid of thermal-sensitive liquid crystals are in agreement with the hot-wire anemometry results – the stationary point injection results in a couple of counter-rotating vortices in the boundary layer (Fig. 2), their amplitude and transverse size depend on the injection velocity.

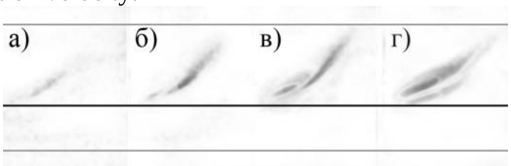

Fig.2. Patterns of stationary disturbance visualization obtained by subtraction technique. The disturbance was injected at the distance of 1.24 mm from the attachment line (black line). Exciting jet velocity is: 0.8 m/s (a), 1.1 m/s (b), 2.5 m/s (c), 13.8 m/s (d). Flow velocity is 3.4 m/s. Grey lines designate the top and bottom boundaries of the cylinder forming the wing leading edge.

The general result of the work is that the weak point injection can be used as a tool to study the boundary layer of the oblique wing leading edge. Strong injection results in the flow complication and heavy non-linear effects, thus it is an independent subject of research which results can be utilized for flow control and icing problems solution.

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