RESEARCH OF FORMATION AND DEVELOPMENT OF STATIONARY VORTICES AND ITS SECONDARY INSTABILITY AFTER THE ROUGHNESS ELEMENT ON THE LEADING EDGE OF THE OBLIQUE WING

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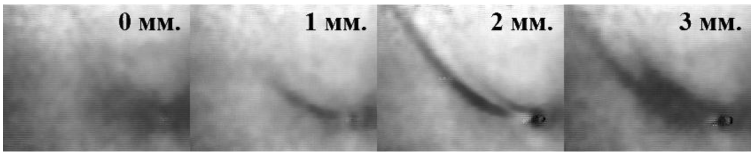
The problem of air drag reduction in aircrafts actualizes the task of near-wall flow laminarization on lifting planes. The process of laminar-turbulent transition on the oblique wing is of our main interest, because today this wing is in most common use.

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. The scenery of the transition on the oblique wing looks as follows: under the conditions of the favorable pressure gradient, near the wing leading edge, the cross-flow instability occurs in the boundary layer [1, 2]; this instability reveals in the form of longitudinal vortices which modify the mean flow [3, 4]. Extra inflection points occur on the velocity profile, and secondary high-frequency disturbances appear on them [5]; they increase streamwise and finally result in the laminar-turbulent transition. In this scenery, the main role belongs to stationary disturbances which apparently occur on the leading edge irregularities. It is interesting to consider the case when non-stationary disturbances develop along the leading edge and excite the flow above the whole wing surface.

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 varied within the range of a U_∞ = 2.8 – 24 m/s and was monitored with the Pitot-Prandtl tube connected to a hydrostatic manometer.

The study of the oblique wing leading edge is difficult because of its complex shape. In this case, the methods of data generation from the model surface can help. In the experiment, we used the liquid-crystal thermography technique [6] which enables to visualize the heat flux from the surface which is proportional to dU/dy, where U is the local velocity, and y is the distance from the wall. In this way it is possible to visualize the stationary disturbances and laminar-turbulent transition areas.



Stationary mode size and intensity vs irregularity dimension at the free stream velocity of 7.6 m/s.

As was shown by the research within the velocity range from 2.8 m/s to 24 m/s, the turbulence does not develop along the leading edge. At the same time, stationary disturbances occur and rise behind the irregularities; they contain extra inflection points which promote the development of the secondary instability and may later result in the laminar-turbulent transition.

Moreover, the turbulizer can operate as Gaster bump and be utilized to suppress the strike structures which can come off the fuselage on wings.

It should also be noted that the increasing velocity results in higher sensitivity of the boundary layer to the irregularity dimension from which the stationary disturbance mode occurs and rises.

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