Three-Dimensional Shock-Wave/Boundary-Layer Interaction on Sharp and Blunted Flat Plate

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A great number of works (for-example [1-2]) are dedicated to the investigation of interaction of the oblique shock waves, generated by a single fin or a fin pair, with boundary layer of the plate on which they are installed. Almost in all the papers, the interference flow on the sharp plate is studied. At the same time, the investigations of two-dimensional interference between an oblique shock wave and boundary layer of the plate [3] show that even a small bluntness of the plate leading edge significantly decreases heat transfer in the shock incidence region. It also turns out that there is a threshold value of the plate blunting radius [4]: the maximum heat transfer coefficient significantly decreases as the radius increases only up to a certain threshold value; the further blunting slightly influences on the maximum value of the heat-transfer coefficient. These peculiarities are related to the influence of the high-entropy layer, generated by the blunted leading edge, on the flow in the separation zone, caused by the incident shock wave.

In the present work, interaction of shock waves with turbulent boundary layer boundary layer is investigated. Numerical and experimental investigation of gas flow on a flat plate near a single fin and a fin pair, generating crossings shocks, is performed. The study is focused upon the plate bluntness influence on the flow field and heat transfer in the interaction region. The numerical calculations and experiments were carried out at Mach numbers M=5 and Reynolds numbers $Re_{\infty L}=27\times10^6$. For numerical flow simulation, the three-dimensional Reynolds-averaged Navier-Stokes equations are solved, using the q-ω turbulence model.

In Fig. 1 results of Stanton number calculation are compared with results of measurements, fulfilled using luminescent coating and thermocouples. At turbulence parameters and value of inflow turbulence chosen numerical results satisfactory agree with experimental data, computational data closer to readings of thermocouple sensors, which are slightly more accurate, than optical measurements.

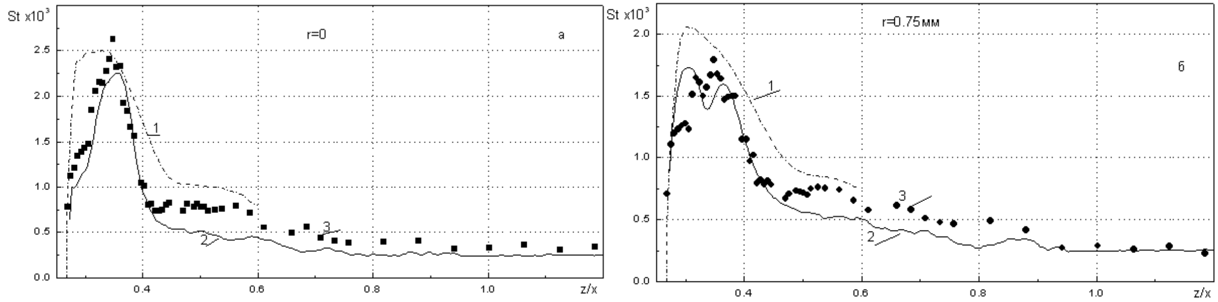

Fig. 1. Comparison of computational results with results of heat transfer coefficient measurements in section I ($X = 211$ mm, $x/X_0 = 0.64$) at $M = 5$, $Re_{\infty L} = 27 \times 10^6$ and $\theta = 15^o$: a – r = 0, b – r = 0.75 mm, 1 – calculations, 2 – luminescent coating, 3 – thermocouples.

It is established that even small plate blunting significantly influences on heat transfer and pressure distributions. Moreover in some cases, it can cause global transformation of the flow structure in the area of interference between the shock waves and boundary layer.

References

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