EXPERIMENTAL INVESTIGATION OF SHOCK WAVE–BOUNDARY LAYER INTERACTION INSTABILITY

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As instability caused by Shock Wave–Boundary layer interaction can lead to serious control issues [1], it is a subject of investigation. It was discovered that unsteady behavior of separation bubble contains the low frequencies fluctuations [2]. Current work is devoted to the investigation of the instabilities caused by interaction of shock wave with turbulent boundary layer on the heated ramp surface.

By means of PIV detailed flow structure of separation and reattachment regions for the case of 30° ramp angle were measured. For the evaluation of the surface heating influence the ratio of wall temperature towards outer flow temperature $T_w/T_\infty$ in the experiments was varied in the range from 1.8 (adiabatic conditions) to ~3. Average velocity fields for temperature ratios of 2.77 and 3.11 have shown regions of reverse flow (separation bubble), and velocity in this region reaches ~0.1$U_\infty$. The averaged velocity profiles of the reattached boundary layer shows that rising of temperature ratio leads to the increase of boundary layer recovery length from 4.6 mm for adiabatic case to 11 mm for $T_w/T_\infty = 3.11$. In order to study fluctuations of separation bubble statistical analysis was applied. According to the POD analysis about 60% of whole energy is stored in the first 5 spatial modes. The first 2 modes represent pulsation of separation region. In case of ramp with temperature ratio of $T_w/T_\infty = 2.77$ and 3.11 first spatial mode contains almost 40% of energy meanwhile in case of adiabatic surface the amount of the energy stored in the first mode is 15%. It is obvious that elevation of surface temperature leads to redistribution of energy stored in spatial modes represented separation region motion. RMS velocity fields also have shown amplification of separation bubble fluctuations with surface heating. Velocity fluctuation near separation and reattachment points reaches 0.38$U_\infty$.

It was shown that increase of temperature ratio affects both incoming and reattached boundary layer and amplifies separation bubble motion.