MACH NUMBER INFLUENCE ON WAVE-TRAIN GENERATION AND DEVELOPMENT IN SUPERSONIC BOUNDARY LAYER

A.V. Panina, A.D. Kosinov, N.V. Semionov, Yu.G. Yermolaev

Khristianovich Institute of Theoretical and Applied Mechanics SB RAS
630090, Novosibirsk, Russia

This paper presents investigations of the Mach number influence on generation and development of disturbances in supersonic boundary layer. A comparative experimental study of the evolution of controlled fluctuations in the boundary layer on a smooth flat plate at a fixed electrical power of source disturbances and the same unit Reynolds number were performed. The experiments were conducted in T-325 supersonic wind tunnel of ITAM SB RAS at Mach 2 and 2.5 and unit Reynolds number $Re_1 = 5\times10^6$ m^{-1}. Constant temperature hot-wire anemometer was used for mean and pulsating flow characteristic measurements. The model of a flat steel plate with a sharp leading edge was used. Controlled pulsations penetrated into boundary layer through an aperture of 0.4 mm in diameter and they were excited by high frequency glow discharge in chamber. The spanwise measurements were made at the fixed normal distance from the model surface and at $y/\delta \approx$ const for each position at the maximum perturbation across of the boundary layer. It was found that at Mach 2.0 source of disturbance primarily excites pulsations of fundamental frequency (for the chosen power of glow discharge). It was determined that oblique breakdown mechanism is started at about x = 90 mm from the leading edge. The subharmonic perturbations development at the conditions of the experiment took place in the stable region, and a slight linear increase in the subharmonic perturbation was found only for x > 100 mm. Thus for x = 120 mm in β-wave spectra strong inclined waves is appeared. They are excited due to subharmonic resonance. It was found that growth of subharmonic disturbances is more intensively than growth pulsation in the oblique breakdown. At Mach 2.5 is found out that the disturbance source mainly excites subharmonic disturbance in supersonic boundary layer. The amplitude of the fluctuations of the fundamental frequency is less in 1.5 – 2 times than the subharmonic disturbances. The mechanism of oblique transition is appeared at x = 100 mm.

Keywords: supersonic boundary layer, laminar-turbulent transition, aerodynamic experiment, nonlinear stability.