Experiments on Secondary Instability of Supersonic Boundary Layer on Swept Wing

- BIFD 2011 -

N.V. Semionov*, A.D. Kosinov*, Yu.G. Yermolaev* and R.I. Kazantsev*

* Khristianovich Institute of Theoretical and Applied Mechanics (ITAM SB RAS)
Institutskaya 4/1, 630090 Novosibirsk, Russia
e-mail: congreso@cimne.upc.edu, web page: http://www.cimne.com

ABSTRACT

The problem of turbulence beginning in 3-D boundary layers is very interesting for the practical applications (similar boundary layers are observed in the flow around a swept wing of an airplane), and, on the other hand is very complicated. It is well-known [1] that high-amplitude crossflow waves are subject to a high-frequency secondary instability preceding breakdown to turbulence in swept wing boundary layers. Currently, the secondary instability is investigated experimentally (only for subsonic flows) and theoretically (and for the compressible too) in different countries. But up to now, no experimental studies of this problem in a supersonic boundary layer on a swept wing. Compare results of supersonic stability experiments on swept wing [2] with subsonic case, note, that so excitation and fast growth of high-frequency disturbances with a frequency one order higher than the fundamental disturbance in our supersonic experiments was not observed.

The experiments are made in a supersonic wind tunnel T-325 of the ITAM with test section dimension 200×200×600 mm at Mach numbers M=2 ÷ 4 at low unit Reynolds numbers. Model was a symmetrical wing with a 45° sweep angle, a 3-percent-thick circular-arc airfoil. The disturbances are measured by constant temperature hot-wire anemometer. The frequency spectra of disturbances are determined by the discrete Fourier transformation.

Evolution of natural disturbances in supersonic boundary layer of swept wing is investigated in detail. The characteristic zones of disturbances development are defined. It is found that for M= 2 and 2.5 measurements can be performed in the region of linear stage of disturbances evolution. At M= 3, 3.5 and 4 non-linear processes are observed from the beginning of region of measurements. With the help of statistical analysis and analysis of amplitude-frequency spectra confirmed the existence of the mechanism of secondary instability and its features are revealed in supersonic flow of swept wing. Fluctuations grow at the frequency range from 8 to 35 kHz in the linear region. Nonlinear processes lead to increasing of high-frequency disturbances. Assume that at M = 2 the growth of high-frequency part of the spectrum (f ≥ 35 kHz) is caused by secondary instability. Similar results are obtained for other Mach numbers.

This work has been supported by the RFBR grants 09-01-00767, 11-01-00195.

REFERENCES

[1] Y. Kohama, W.S. Saric, J.A. Hoos, "A high-frequency, secondary instability of crossflow vortices that leads to transition," *Proceedings RAS Conf. Boundary-Layer Transition and Control*, pp. 4.1–4.13, (1991).

[2] N.V. Semionov, A.D. Kosinov, Yu.G. Yermolaev, "Experimental study of stability of supersonic boundary layer on a swept wing at M=2", *TsAGI Science Journal*. 2011. In press.