Centrifugal instability development near critical line of cylinder placed in supersonic flow

Igor I. Lipatov

Central Aerohydrodynamic Institute (TsAGI)
140160, Zhukovsky-3, Moscow region, Russia
e-mail: lipatow@postman.ru

ABSTRACT

The mathematical model is derived describing centrifugal instability in compressible flows with the natural streamlines curvature. Usually streamlines curvature is supposed to be known beforehand and determined by the surface curvature. But there are many flows where streamlines curvature is caused for example by positive pressure gradient. Analysis done by Goertler and Hammerlin [1] for centrifugal instability in Hiemenz flow near the critical point revealed growing modes.

This paper is devoted to the compressible flow analysis. The flow near critical line of infinite cylinder is analysed. It is supposed that Mach number of external flow tends to infinity and that the specific heat ratio tends to unity. It was shown by Neyland [2] that the flow between the bow shock and the cylinder surface contains in general three distinct regions. The flow in the first region located near the shock is inviscid. Due to large density ratio pressure gradient doesn't influence the flow in the first region. At the same time there is the second region characterized by small longitudinal velocities where pressure gradient influences the inviscid flow. The third region is characterized by viscosity influence and is located near the surface of the body.

Such flow structure exists if Reynolds number is large. As a result of analysis solution may be found for all three regions. Obtained velocity and density profiles are used in subsequent stability analysis. System of linear equations is derived describing centrifugal instability development in compressible flow near the critical line of infinite cylinder. Presented are results of numerical analysis of the linear equations for different similarity parameters values.. The non-linear problem formulation is also discussed.

REFERENCES

[1] H. Goertler *On the three-dimensional instability of laminar boundary layers on concave walls*, NACA Rept. 1375, 1954.

[2] V.Ya. Neyland *Asymptotical problems describing viscous supersonic flows,* Trudy TsAGI, 1529, 1974 (in Russian).