COMPUTATIONAL STUDY OF SUPERSONIC FLOW OVER A FLAT PLATE WITH PROTRUSION

Vikram Deshpande
Research Scholar
Department of Applied Mechanics
Indian Institute of Technology Delhi
Hauz Khas, New Delhi – 110 016, India

Sanjeev Sanghi
Professor
Department of Applied Mechanics
Indian Institute of Technology Delhi
Hauz Khas, New Delhi – 110 016, India
Email: sangi@am.iitd.ac.in

Brijesh Eshpuniyani
Assistant Professor
Department of Aerospace Engineering
Indian Institute of Technology Kanpur
Kanpur – 208 016, India

Abstract

Motivated by a development approach of using micro-actuated surface protrusions to control/maneuver slender bodies in supersonic flight, this paper presents a detailed study of a two dimensional laminar supersonic flow over a flat plate with a surface protrusion. The flow field is computed by solving the Navier-Stokes equations using the finite difference method with the particle velocity upwinding scheme (PVUS) for spatial discretization, and the explicit Mac Cormack scheme for temporal integration. A range of free stream Mach numbers (2.0-4.5), Reynolds numbers (1000 - 100000) and protrusion heights (0.866% to 8.66% of the characteristic length) has been considered for a thorough parametric study. The parametric study indicates that the oblique shock structure and strength are influenced by all the variables height, Reynolds number, and protrusion shape, while the influence of Mach number is only marginal. An increase in the protrusion height results in an increased wall pressure as well as increased separation lengths on both sides of the protrusion. In contrast, an increase in Mach number increases the wall pressure, but moves the separation point marginally towards the protrusion. Increase in Reynolds number and protrusion bluffness (triangular → trapezoidal→ rectangular) increases separation lengths on both sides of the protrusion. In addition to taking a close look at the flow physics, particularly in the protrusion vicinity, considerable attention has also been devoted to important design parameters such as wall pressure, skin friction and the overall normal and tangential force coefficients.

Paper Code: V63 N4/748-2011.