A COMPUTATIONAL STUDY OF SUPERSONIC FLOWS OVER WALL MOUNTED STATIONARY AND MOVING PROTRUSIONS

by

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CERTIFICATE

*This is to certify that the thesis titled "**A Computational Study of Supersonic Flows over Wall Mounted Stationary and Moving Protrusions**" being submitted by Mr. Vikram Venkatarao Deshpande to the **Indian Institute of Technology Delhi**, for the award of the degree of **Doctor of Philosophy** in Department of Applied Mechanics is a bonafide research work carried out by him under our supervision and guidance. The research work presented in this thesis has not been submitted in parts or in full to any other University or Institute for the award of any degree or diploma.*

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ABSTRACT

The present work is motivated by the long term perspective of using locally generated shockwaves near micro-actuated surface protrusions (that can emerge into the flow field when needed and withdraw at other times to avoid unnecessary drag expenditures) to assist or replace conventional control surfaces in maneuvering supersonic missiles. The overall problem of designing suitable control laws based on the fully three dimensional, turbulent dynamics of supersonic flow past moving surface protuberances is an extremely challenging proposition that will possibly need to be addressed through a series of studies of increasing complexity. This thesis considers a two dimensional laminar supersonic flow and presents a systematic computational study in three steps using the finite difference method with the particle velocity upwinding scheme to discretize the convective term in the Navier-Stokes equations: (i) flow past fixed surface protrusions of different shapes on a flat plate for a range of free stream Mach and Reynolds numbers and protrusion heights, (ii) flow past a moving ramp as well as protrusion for a range of ramp/protrusion velocities and (iii) application of understanding obtained to a simple model problem in which ramp and protrusion type control elements are mounted as tail controls on a conical nosed 2-D projectile. The protrusion type control element is seen to be more effective and it is felt that the values of pitch acceleration achieved are significant enough to maneuver supersonic projectiles. A more detailed study under realistic conditions (3D, turbulent, etc.) is however required before the viability of the proposed approach can be confirmed.

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