

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

by

VIKRAM VENKATARAO DESHPANDE

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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.

*Sanjeev Sanghi, Ph. D.
Professor
Dept of Applied Mechanics,
Indian Institute of Technology Delhi
New Delhi-110016, India*

*Brijesh Eshpuniyani, Ph D,
Visiting Faculty
Dept of Mechanical Engineering
Indian Institute of Technology BHU
Varanasi-221005, India*

*S.N. Singh, Ph. D.
Professor
Dept of Applied Mechanics,
Indian Institute of Technology Delhi
New Delhi-110016, India*

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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.

Table of Contents

<i>Certificate</i>	iii
<i>Acknowledgement</i>	v
<i>Abstract</i>	ix
<i>Table of Contents</i>	- 1 -
<i>List of Figures</i>	- 5 -
<i>List of Tables</i>	- 11 -
Chapter 1. Genesis of the Problem	- 13 -
1.1 Introduction	- 13 -
1.2 Literature Review	- 13 -
1.2.1 High speed flow past fixed surface protuberances	- 14 -
1.2.2 Flow past moving surface protuberances	- 20 -
1.2.3 Flow control using fixed/moving surface protuberances	- 23 -
1.3 Conclusions from Literature Review	- 26 -
1.4 Objectives of the Study	- 27 -
1.5 Problem Investigated	- 28 -
1.5.1 Computations of Flow over a fixed Surface Protuberance	- 28 -
1.5.2 Effects of Moving Surface Protuberances	- 29 -
1.5.3 Flow control and maneuverability using fixed/moving surface protuberance	- 30 -
1.6 Organisation of Thesis	- 30 -
Chapter 2. Computational Methodology	- 33 -
2.1 Governing Equations	- 33 -
2.2 Transformation to Curvilinear Coordinates	- 37 -
2.3 Grid Generation and Grid Movement	- 40 -
2.3.1 Domain Illustration	- 40 -
2.3.2 Grid Generation and Smoothing	- 41 -
2.4 Spatial Discretization	- 47 -
2.5 Upwinding Scheme	- 49 -
2.5.1 First Order Scheme	- 50 -
2.5.2 Second Order Scheme	- 51 -
2.5.3 Selection Criteria of Schemes	- 53 -

2.6	Temporal Integration	- 54 -
2.7	Boundary conditions	- 55 -
2.8	Consistency and Stability	- 57 -
2.9	Code Validation, time step, grid and domain independence study	- 58 -
2.9.1	Code validation	- 58 -
2.9.2	Grid independence study	- 61 -
2.9.3	Domain independence Study	- 63 -
Chapter 3. Parametric Study of Flow past Static Protrusion		- 65 -
3.1	Introduction	- 65 -
3.2	Description of Problem	- 66 -
3.2.1	Computational Domain	- 66 -
3.2.2	Selection of Parameters for study	- 67 -
3.3	Results and Discussions	- 69 -
3.3.1	Spatial Patterns of the Flow Field without surface protuberance	- 69 -
3.3.2	Spatial Patterns of the Flow Field with surface protuberance	- 73 -
3.3.3	Effect of Protrusion Height	- 79 -
3.3.4	Effect of Free Stream Mach Number	- 86 -
3.3.5	Effect of Reynolds Number	- 91 -
3.3.6	Effect of Protrusion Shape	- 95 -
3.4	Summary	- 99 -
Chapter 4. Parametric Study of Flow past Moving Protuberances		- 101 -
4.1	Introduction	- 101 -
4.2	Description of Problem	- 102 -
4.2.1	Computational Domain-Ramp	- 102 -
4.2.2	Computational Domain-Protrusion	- 103 -
4.3	Results and Discussions	- 105 -
4.3.1	Part-I: Moving Ramp	- 105 -
4.3.1.1.	Upward moving ramp with impulsive stop at maximum angle	- 105 -
4.3.1.2.	Oscillating Ramp	- 111 -
4.3.2	Part-II: Moving Protrusion	- 115 -
4.3.2.1.	Upward moving protrusion with impulsive stop at maximum height	- 115 -
4.3.2.2.	Oscillating protrusion	- 119 -

4.4	Summary	- 122 -
Chapter 5. Aerodynamic Characteristics of Protuberance Mounted on a Projectile		- 125 -
5.1	Introduction	- 125 -
5.2	Description of Problem	- 126 -
5.2.1	Computational Domain	- 126 -
5.2.2	Boundary conditions	- 127 -
5.2.3	Equations for trajectory analysis	- 127 -
5.2.4	Selection of Parameters for study	- 134 -
5.3	Results and Discussions	- 135 -
5.3.1	Spatial Patterns of the Flow Field for Stationary Ramp/Protrusion	- 136 -
5.3.2	Effect of Angle of Attack	- 141 -
5.3.3	Effect of Pitch Rate	- 144 -
5.3.4	Effect of Moving Control on Force and Moment	- 146 -
5.3.5	Comparison of Effectiveness of Control Element	- 148 -
5.4	Summary	- 154 -
Chapter 6. Conclusions and Recommendations		- 157 -
6.1	Parametric Study of Flow past Stationary Protrusions	- 157 -
6.2	Parametric Study of Flow past Moving Protuberances (Ramp/Protrusion)	- 158 -
6.3	Aerodynamic Characteristics of Protuberance Mounted on a Projectile	- 160 -
6.4	Recommendations for Future Work	- 162 -
References		- 165 -
Brief Biodata of the Author		- 173 -