EFFECT OF PROTRUSIONS ON THE SURFACE FLOW AND PRESSURE FLUCTUATIONS IN THE INTER-STAGE REGION OF A LAUNCH VEHICLE MODEL

G.K Suryanarayana
Professor
Department of Aerospace Engineering
Dayananda Sagar University
Bangalore-560 068, India
Email : surya-ae@dsu.edu.in

A.E. Sivaramakrishnan
Former Scientist/Engineer
Vikram Sarabhai Space Centre (VSSC)
Department of Space, ISRO Post
Thiruvananthapuram-695 022, India

Abstract

Experiments were carried out to assess the effects of geometrically scaled and viscous scaled protrusions on the surface flow and unsteady pressures in the inter-stage region of a typical launch vehicle model in the Mach number range 0.8 to 1.6. Formation of bow-waves due tothe protrusions, and three-dimensional boundary layer separations and reattachments of the shear layer were seen from flow visualizations. Measurements of unsteady pressures show that protrusions cause substantial increases in fluctuation levels on the core vehicle. The highest levels on fluctuations were found to be at a location behind the viscous scaled protrusion, close to the shear layer reattachment. The spectra of pressure signals suggest that the reattachment may be periodic in the range $0.90 \leq M \leq 1.60$; the associated frequency was found to vary in the range 1 kHz to 3.2 kHz (corresponding to Strouhal number in the range 0.034 to 0.051) depending on M. Streamlining the viscous-scaled protrusion was found to replace bow-waves with multiple oblique shocks, resulting in reduced levels of pressure fluctuations, comparable to the basic levels.