UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING, SCIENCE & MATHEMATICS

SCHOOL OF ENGINEERING SCIENCES

Doctor of Philosophy

LAMINAR/TRANSITIONAL SHOCK-WAVE/BOUNDARY-LAYER INTERACTIONS (SWBLIs) IN HYPERSONIC FLOWS

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Numerical investigations of laminar shock-wave/boundary-layer interactions (SWBLIs) in hypersonic flow have been carried out at $M_\infty = 6.85$ and $M_\infty \approx 8$, with unit Reynolds numbers ranging from $2.0 \times 10^6\ m^{-1}$ to $7.60 \times 10^6\ m^{-1}$. This thesis deals with a simplified 2-D geometric configuration to simulate SWBLIs on vehicle surfaces or engine intakes, i.e. the interaction of an oblique shock (produced by a wedge) impinging on an incoming laminar boundary-layer on an isothermal flat plate. The numerical simulations were performed with weak/moderate to strong shock. The results were compared with available theoretical and experimental results.

Limited experimental work at $M_\infty = 6.85$ for obtaining qualitative data were performed to provide the location of separation and re-attachment points using surface oil flow. Schlieren photographs were taken to provide the general flow features.

A comprehensive analysis was performed on the 2-D numerical results with various Mach numbers, Reynolds numbers and shock strengths, to verify whether numerical solutions were able to confirm the established trends for the laminar *free-interaction* concept. An analysis was also performed using a well-established power-law relationship of pressure and heat flux in the region of interactions.

An unstable first oblique mode disturbance was imposed with the strongest wedge angle, 9°, at $M_\infty = 6.85$ and unit Reynolds number $2.45 \times 10^6\ m^{-1}$ to determine the boundary-layer stability and its propensity to undergo transition in the linear regime. Several unsteady 3-D simulations were performed with varied parameters. Streamwise vortices were generated in all cases especially downstream of maximum separation bubble height. However, as the amplifications of the disturbance were quite small, transition was found to be unlikely at these conditions.