INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Supersonic/hypersonic flights often encounter issues like a high drag, shock and its interactions, and high-temperature effects. Thus, to design a high-speed aircraft, efficient prediction of these flow complexities is extremely important. Therefore, numerical investigations are carried out for various flow phenomena associated with high-speed flow by employing an in-house developed CFD reacting gas flow solver which accounts for reaction kinetics of Earth and Mars atmosphere. In the case of Energy deposition based drag reduction studies, the golden section search optimization algorithm is effectively integrated with the solver to evaluate the optimum energy deposition required to obtain the maximum power effectiveness. The study reveals the need for a comparatively more amount of energy deposition in the case of the Mars gas model to attain maximum power effectiveness. Further, the investigation related to the Mach reflection studies in Earth and Mars atmosphere reveals that, for either flow medium, the increase in freestream enthalpy initially decreases the Mach stem height and as the enthalpy crosses a threshold value, the transition to the regular reflection occurs. Further, the perfect and reacting gas simulations are performed to investigate various shock/shock interaction patterns induced by double wedge geometries. Significant differences in the flow structures are noticed between the perfect and reacting gas outcomes for both atmospheric conditions. The reasons for these discrepancies are identified and discussed. Further, it is noted that for the same geometry, the interaction type changes with the variation in enthalpies for both flow mediums. In continuation, the real gas effects on shock/expansion wave interactions are also investigated. It is noted that an increase in the enthalpy has a decreasing effect on the post-shock Mach number and an increasing effect on the post-expansion wave Mach number. Further, the peak pressure ratio is noted to be on the lower side for higher enthalpy cases. Later, shock wave boundary layer interaction (SWBLI) study in Earth and Mars atmosphere has been carried out with the real gas flow solver. For both flow mediums, the separation size is found to be directly proportional to the wall temperature and inversely proportional to the Mach number and enthalpy. Here, the percentage change in the separation size is always found to be more for the Mars gas model. The present investigation confirms that, for both planetary conditions, sufficiently large leading-edge bluntness can be a useful tool to mitigate the boundary layer separation.

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