IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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AEROTHERMODYNAMICS OF A SPHERE-CONE WITH A FORWARD FACING CAVITY IN MARTIAN ATMOSPHERE

Abstract

Human civilization is moving fast towards becoming an interplanetary species, exploring the universe in search of resources to develop sustainable civilizations on various planets and their moons. With various successful missions to the Martian surface and plenty more in the near future, spacecraft need to have a successful and effective Entry Descent and Landing (EDL). Despite a thin atmosphere, a descent through the Martian atmosphere induces substantial aerodynamic heating energy possessing thermal damages to the critical payloads and crew. These thermal loads must be minimized for the safety of the crew and payloads. Thermal Protection Systems (TPS) along with the blunt bodies would reduce the heat loads significantly, the body however must be equipped with systems that would submissively reduce the heating loads in case of TPS failure. A passive heat reduction device, extensively studied for stagnation point heat reduction in Earth's atmosphere, is being investigated for its effectiveness in the Martian atmosphere.

The paper aims at investigating the aerothermal environment during an entry mission to Mars for a 70° axisymmetric sphere-cone with a nose radius of 19 cm and a base radius of 38 cm. Circular cavities of varying radii and elliptic cavities of varying eccentricities are placed at the stagnation point of the blunt-body and their effectiveness in reducing the total heat transfer rates, and peak reattachment heat flux is investigated. A 2D axisymmetric, coupled finite volume solver has been used to simulate the chemically reacting flow field around the blunt-body with and without a cavity, in a uniform freestream of 4.86 km/s at an altitude of 28.5 km from the Martian surface with a pressure and temperature of $27.4N/m^2$ and 173 K respectively. The atmosphere is assumed to be a chemically reacting mixture of 5 species gases C, CO, O, O_2, CO_2 in thermal equilibrium, with 6 elementary reactions. The preliminary results suggest significant reductions in total heat transfer rates, peak surface heat fluxes, and overall drag of the blunt-body with a cavity is reduced, as compared to the clean configuration. The analysis will help in better design and selection of TPS for vehicles manned entry and descent into Martian atmosphere.