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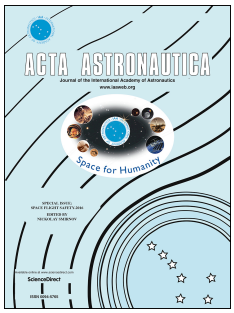

Aerodynamics and Aerothermodynamics of undulated re-entry vehicles

K. Kaushikh, S. Arunvinthan, S. Nadaraja Pillai

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Aerodynamics and Aerothermodynamics of Undulated Re Entry Vehicles

K. Kaushikh[1], S. Arunvinthan[2], S. Nadaraja Pillai[3]

[1, 2, 3]School of Mechanical Engineering, SASTRA University, Tamilnadu, India

Abstract:

Aerodynamic and aerothermodynamic analysis is a fundamental basis for the design of a hypersonic vehicle. In this work, aerodynamic and aerothermodynamic analyses of a blunt body vehicle with undulations on its after-body are studied with the help of numerical simulations. A crew exploration vehicle (CEV) is taken for initial analysis and undulations with varying amplitude and wavelength are introduced on CEV's after-body. Numerical simulations were carried out for CEV and for CEV with undulations at Mach 3.0 and 7.0 for angles of attack ranging from -20^0 to $+20^0$ with increments of $+5^o$. The results show that introduction of undulations did not have a significant impact on mono stability and lift-drag characteristics of the vehicle. It was also observed that introduction of undulations improved the aerothermodynamic characteristics of CEV. A reduction of about 36% in maximum heat flux at Mach 3.0 and about 21% at Mach 7.0 compared to the maximum heat flux for CEV was observed.

Keywords:

CEV, CFD, Undulations, Hypersonic, Aerodynamics, Aerothermodynamics,

1. Introduction:

Of all the challenges faced by researchers of aerodynamics, the problem of understanding nature and behavior of vehicles operating at hypersonic speeds are dominant. There are multitudinous reasons why the design of hypersonic vehicles is challenging. Prominent of these are inability to accurately recreate hypersonic conditions in an experimental setting, very high velocities associated with the flow, a chemically reacting environment, variation of aerodynamic properties, boundary layer transition, viscous and boundary layer interaction, etc. [1, 2]. Despite facing many hurdles, there have been many projects that overcame these challenges. NASA Projects Mercury, Gemini and Apollo were the initial successful manned missions. Project Mercury's objective was to successfully complete a manned mission to Earth's low orbit and return to Earth safely. Project Gemini's primary objective was to support Project Apollo by developing safe and viable travel techniques like conducting missions for durations of the flight time to moon, perfecting working outside the space craft using Extra Vehicular Activity (EVA) suits, and performing orbital maneuvers to perfect docking and space rendezvous. These observations formed the basis for Project Apollo whose primary objective was a manned mission to the moon and back. This goal was achieved in 1969 with Apollo 11. Project Apollo was succeeded by the Space Shuttle Program. The unique feature of this program was that the Space Shuttle was winged, unlike other programs which were blunt bodies. Project Orion is NASA's next manned mission whose goal is to provide a means to reach the International Space Station, Moon and Mars [3]. NASA believes that CEV like Orion shown in Fig. 1(a) may enable a successful human space exploration programs like Lunar and Mars mission [4].