Conceptual Design and Analysis of Aerodynamic Vehicles at Mach speeds Re-entering Martian Atmosphere

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Abstract

Martian Atmosphere has an air density less than of Earth's but still produces tremendous heat and high Mach speeds during re-entry of aerodynamic vehicles such as Orion capsules etc. This paper investigates the possibility of using an aerodynamic design and therefore analyzing by numerical simulation such as CFD FLUENT at zero angle of attack with a constant Mach speed to find the efficient design to maneuver under those conditions. Aerodynamic design is primarily used to have a high lift to drag ratio which ensures smooth flow over the Martian atmosphere. The concept of using re-entry vehicles are studied to gain a better understanding of the planet's atmosphere when the fluid interacts with different aerodynamic shaped objects when sent from an orbit.

Keywords: Aerodynamic design vehicle, Mach speed, Re-entry, CFD.

Introduction

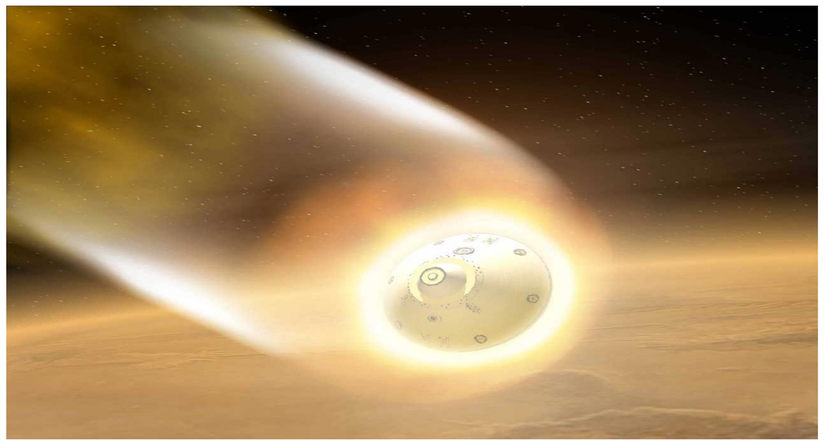


Fig.1 NASA Mars Exploration Rover during Mars re-entry

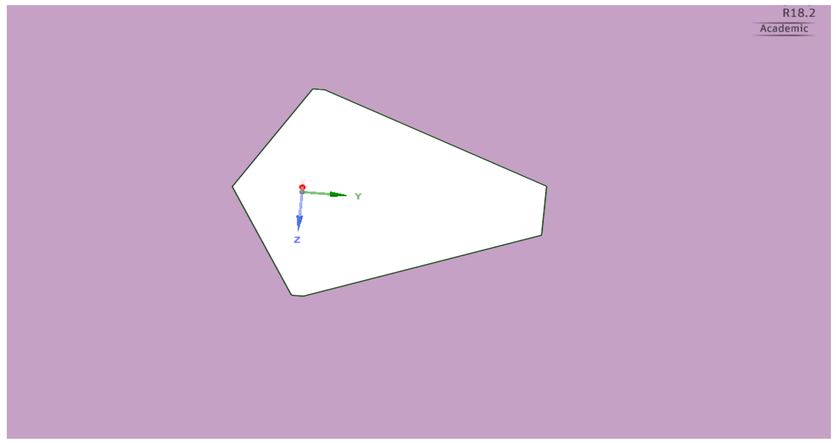
Atmospheric entry refers to the movement of human made or natural objects as they enter the atmospheric of a planet from outer space, in the case of Earth from an altitude above the "edge of space" [2]. The vehicle which enters into the atmospheric conditions from the outer space is known as **Entry Vehicle**. Entry vehicle design addresses the design of controlled entry vehicles which are intended to reach the planetary surface intact. Vehicles that typically undergo this process include ones returning from orbit and ones on exo-orbital trajectories.

In today's research world, engineers are trying to reduce the cost of spending million dollars for a spacecraft and which in one such method they try to improve the concept of reusability of the craft. So, the aerodynamic shape of the vehicle can effectively reduce the vibrations, shock and distortions to the crew. The use of **CFD methods** can valuable knowledge for future spacecrafts such as crew exploration vehicle, especially with the decision to move back to the old Apollo shaped entry vehicle capsule rather than the use of space shuttles. Hence, Entry capsules are a source of significant interest.

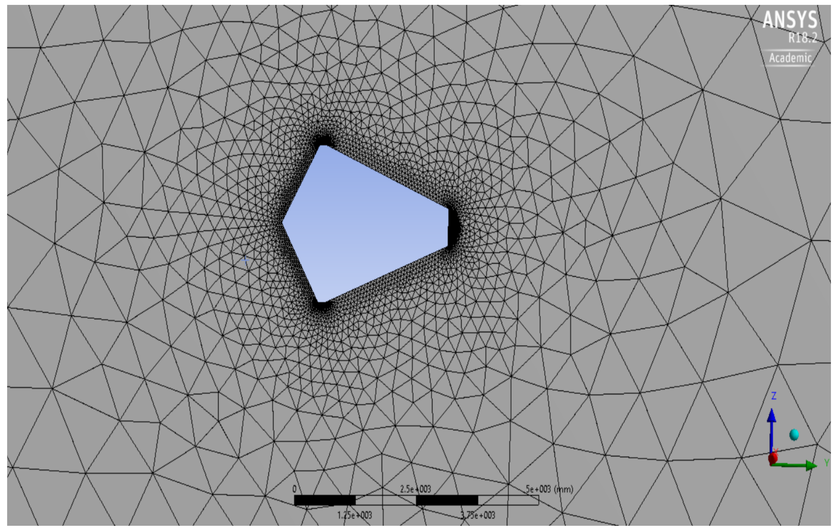
Methodology

The CFD commercial package **ANSYS- FLUENT** is used to do the 2-D design and analysis of the vehicle. The design parameters for consideration include:

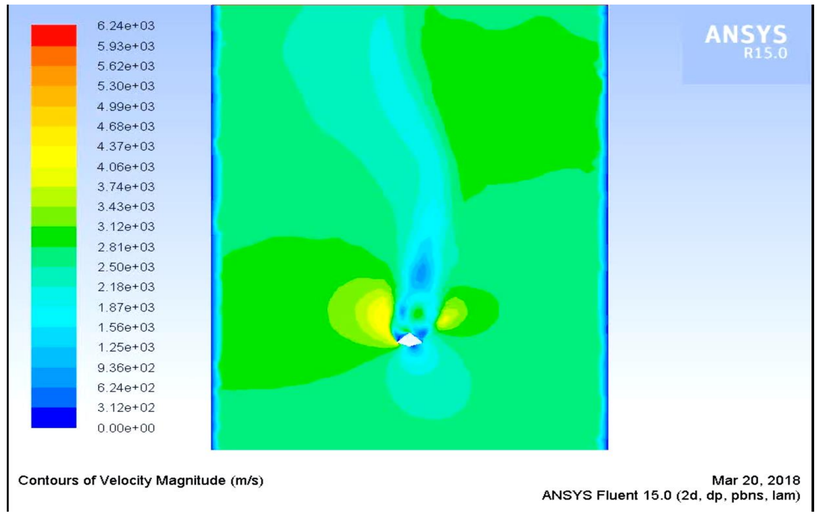
- **Surface gravity of Mars – 3.71 m/s^2**
- **Surface heat at constant pressure (Cp)**
- **Thermal conductivity (K)**
- **Viscosity of the fluid**
- **Material selection**
- **Zero Angle of Attack**
- **Two different Mach speeds**
- **Pressure contour and flow vector**
- **Temperature on the heat shield**



The mesh of the vehicle is done using triangular mesh grid with little amounts of confinement. This is done for the fluid to pass through a specific area around the body thus avoiding turbulent flow.



Results



Based on the simulation, the flow is efficient over the sharp edge tip body and done to ensure a constant flow over the surface leading to a smooth entry.

References

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Future Work

Future work will be based on:

- **3-D Analysis**
- **Re-entry trajectories**
- **Possibility of using other objects as heat shield**
- **Use of special suits for astronauts to enter the atmosphere.**

Acknowledgements

I would like to extend my gratitude to my advisor Dr. Pablo de leon and Dr. James Casler for supporting me to do this project. It would not have not been possible without my friend Sijo for taking his time to involve and doing the required research. Also, would like to thank NASA Space Grant Consortium for assisting during the project.