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FEASIBILITY OF A SINGLE PORT HYBRID PROPULSION SYSTEM FOR A MARS ASCENT VEHICLE

Abstract

The Mars Sample Return (MSR) mission is one of the highest priority items planned for future Mars exploration. The Mars Ascent Vehicle (MAV), has been identified a critical area needing major technological development. The MAV propulsion system is required to remain on the surface of Mars for more than a year, during which time it will be subjected to more intense thermal cycling than has been encountered in previous systems. The diurnal surface temperature variations on Mars can be from -110 to +25C. In addition, stringent geometric constraints and a maximum total mass limit of 300 kg are imposed on the MAV. Previous designs required substantial thermal protection, which often rendered them infeasible.

A hybrid system design for the MAV has been developed using a paraffin-based fuel and nitrous oxide oxidizer. The regression rate of this fuel is three to four times higher than that of HTPB enabling a single port design for both stages of the MAV. Compared to a bi-propellant liquid system the hybrid can be more compact. Compared to a conventional solid the hybrid is less compact but can give better performance. In the context of the MAV, polymeric fuels such as HTPB have a relatively high glass transition temperature that can lead to grain fracture during launch in the low temperature Mars environment. Paraffin-based fuels are primarily crystalline with a much lower glass transition temperature (-108C) than typical solid propellants. Therefore, it is expected to survive the Martian environment including any temporary departures below the glass transition temperature because the transition is weak. Nitrous oxide has a freezing point of -90.8C and should require minimal or no thermal control during the thermal cycling on Mars.

In order to increase the technological readiness level of this non-legacy design, environmental testing of the fuel is being conducted at NASA Ames and compared with theoretical heat transfer data from a commercial code (COMSOL). Additionally, a system is being built to visualize the combustion mechanism responsible for the high mass flux of the paraffin-based fuel, one of its most crucial benefits. Through these tests and design studies, we hope to determine if a hybrid system can enable a MSR mission.