Paper ID: 44025
oral

IAF SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

Author: Dr. Ashley Karp
Jet Propulsion Laboratory - California Institute of Technology, United States, ashley.c.karp@jpl.nasa.gov

TECHNOLOGY DEVELOPMENT FOR A POTENTIAL HYBRID MARS ASCENT VEHICLE

Abstract

A hybrid propulsion system is currently being investigated for a potential Mars Ascent Vehicle (MAV) because of its predicted low temperature compatibility (>-70 C) and high performance (>310 s Isp). The Mars ambient conditions (low and variable temperatures) have brought focus to hybrid rockets as a potential solution because they are predicted to survive at lower temperatures than the current state of the art systems. Depending on the final allowable flight temperature for the MAV, the hybrid option could offer substantial system power and mass savings.

Several years of development have been completed with the goal of raising the Technology Readiness Level (TRL) of the hybrid MAV concept. A wax-based fuel called SP-7 was developed specifically for this application. Testing of the SP-7 with MON-3 has been completed at the small (7.5 cm) and around full (28 cm) scale at two subcontractors: Space Propulsion Group and Whittinghill Aerospace. The hybrid concept from the December 2016 Point of Departure Review (PoDR) has been used to represent full scale. Requirements for this potential mission have not yet been determined, so if it is continued to be pursued, the design will likely continue to evolve.

Liquid Injection Thrust Vector Control (LITVC) has been demonstrated by injecting MON-3 into the nozzle of the 28 cm motor. This was initially selected for its low temperature compatibility as well. More conventional thrust vector control systems require soft goods or lubricants (e.g. standard flex seal and trapped ball designs). Since the MON-3 is already carried onboard, only a small amount of additional plumbing is required. Valve operation at low temperature is fairly well understood since gas blowdown systems often reach the temperatures of interest.

Finally, hypergolic ignition of SP-7 mixed with Sodium Amide (NaNH2) has been demonstrated at Purdue. Multiple ignitions of a SP-7 grain with a relatively high loading of NaNH2 have been successful and have led to the desire to investigate more reactive additives in order to minimize the ignition delay and the additive loading.

The major concern with this new propellant combination is ensuring it works well after being thermal cycled on the journey to and in the Mars environment. This will require careful design, with the thermal expansion and contraction kept in mind. A preliminary investigation into this challenge will be presented.