Low Temperature Hybrid Mars Ascent Vehicle Concept Development and Planning at MSFC

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Return of samples from Mars has been a goal of NASA’s for decades. The current Mars Sample Return mission concepts have a multiple launch rocket from the earth, where one mission delivers a caching rover to collect and package the Martian soil samples. Another rocket sends the Mars Ascent Vehicle that takes those samples to orbit. Another rocket sends an orbiter, that also meets up with the samples in orbit, and brings them back to earth. Our tasks have been focused on the Mars Ascent Vehicle. To leave the Martian surface, it requires a two burn trajectory, one to get off the planet and another to circularize the orbit. Recent studies have led to the investigation of a hybrid rocket solution. That technology has been under development for several years¹–⁷. This paper will discuss some of the work going on at MSFC to understand how to process the fuel, some test firings done to characterize some design features and some planning done to scope out what it would take to qualify a hybrid rocket motor for this application[Depending on length, etc, this may move to Ashley’s paper⁸].

I Fuel Processing

The baseline design for the Mars Ascent Vehicle, coming out of the Point of Departure review in December 2016⁹ was a Mixed oxides of Nitrogen oxidizer and SP7, a paraffin based fuel. SP7 was developed by Space Propulsion Group (SPG) (reference) to handle the temperature extremes seen on Mars¹⁰. The longer the rocket can handle the cold cycles without requiring heat, the more science that can be done since that energy won’t be required to keep the MAV warm. Thermal cycling testing has been done on representative samples and the fuel survived, however there was some debonding of the fuel to case¹¹. Flexible cold temperature insulation materials are needed and is an area of future work.

In the planning for the 2017 round of testing with vendors, it was decided to have MSFC update the SP7 processing and have MSFC provide the fuel for the tests of record to the vendors. The vendors were doing full scale testing of the MAV design. SPG and Whittinghill Aerospace have been doing testing in Butte, Montana and Mojave, California respectively⁸. This paper will discuss the process development in going

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from early development melting (Figure 1) to large mixers, from hockey pucks to monolithic grains (Figure 2).
II Solid fuel tests

After the thermal testing was complete\textsuperscript{12}, it was noted that the Coefficient of thermal expansion effects on the grain would be the worst in the longest dimensions. It was proposed that instead of stress relief flaps used in solid rocket motors, a segmented grain would be used. The grain interfaces might change how the grains reacted. A test program was developed based on the readily available solid fuel torch hardware (reference), using oxygen as the oxidizer instead of MON3.

III Qualification testing planning

A planning exercise was done to scope out what it would take to qualify a hybrid rocket motor for this application. This topic will be covered here or there\textsuperscript{8}.

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