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MARS RETURN MISSION ENABLED BY SOLID METHANE HYBRID ROCKET TECHNOLOGY

Abstract

An important problem for a Mars exploration mission is represented by the propulsion unit, especially for the return leg of the mission. A return leg is important for more advanced robotic missions that would involve returning Mars soil probes to Earth as well as for human missions where the astronaut crew has to get back to Earth after completing the mission. The return leg imposes large demands on the launch vehicle due to at least fuel and oxidizer needed for the Mars ascent stage as well as from reliability point of view: the propulsion of the ascent stage has to work perfectly after periods of between 9 months and several years. A novel propulsion technology based on solid methane cryogenic hybrid rocket motors is being considered for such Mars missions together with the possibility to produce the fuel and the oxidizer in-situ without needing to carry the entire mass from Earth. It is further shown the potential that this fuel has for hybrid rocket motors from technical perspective with the inherent advantages of cryogenic fuels. An internal ballistic model is described together with a comparison table of performances for solid methane and various cryogenic and non-cryogenic oxidizers. The maximum specific impulse is obtained for the solid methane-LOX pair with a value of 315 seconds under specific conditions. A net advantage of solid methane- LOX pair is very high regression speed values, with values reaching 15-20 times the average regression speed for standard non-cryogenic hybrid fuels. Hybrid technology enhancement through oxidizer doping specifically designed for a typical Mars ascent stage is further presented and numerical results for a typical ascent trajectory are presented. A practical interdependence relation between structural optimization (dry mass) of the Mars ascent stage and the performance parameters of the motor is also determined through semi-analytical approach. As a practical application of the research, a typical Mars ascent stage for a probe return but scalable to human missions is presented together with typical restrictions imposed by the current technology.