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POWDERED METAL AND LIQUID OXYGEN COMBINATION AS A HYBRID PROPULSION SYSTEM FOR FUTURE SPACE MISSIONS

Abstract

Over the previous decade, there was a growth in the commercial use of space; for the next decade, the major technical challenge in space will be the human exploration of the Moon and Mars, including key questions about the potential for life on Mars and the possibility of making our solar system habitable in the future. Once this has been achieved, the space age can truly be said to have arrived. The efficiency of a rocket in terms of spacecraft propulsion depends on the achievable exhaust velocity and mass ratio; thrust is mostly important for the first stage of a launcher. All these parameters are defined by the rocket design and propellants combination. Hybrid systems are known for their simplicity, safety and environmental advantages over conventional ones. However, such systems have not been commercially viable, because they usually use Polymeric fuels with low evaporation rate, and thus low thrust, which limits their use for large launchers. The requirement is to increase the rate at which the fuel evaporates. One approach is to reduce the viscosity in the layer of the melted fuel, by adding a certain amount of Paraffin-wax to the fuel to lower its viscosity. Other approaches attempt to increase the heat supply by adding powdered metals to the fuel, or even solid oxidants in a reduced amount in a way to enable the grain sustain combustion by itself. Further studies focused on propellant systems consisting of N2O/HTPB, N2O/HDPE and H2O2/HDPE, bringing also satisfying results. However, many advantages arise from combining powdered metal with liquid oxygen, since the monopropellant could be treated like a liquid. Other advantages of this concept include the ability to control thrust by controlling the oxygen flow, thus to throttle, stop, and restart the engine. Also, exploiting metals produced in situ from extra-terrestrial resources, i.e. Lunar crust, as propellants is an approach which may lower the cost of future space missions by reducing the mass of propellant launched from Earth. The objective of this work is to study, theoretically and thermodynamically, the main parameters controlling the rocket design (combustion chamber and nozzle) and propellants combination performances of various hybrid system concepts, including powdered metal and liquid oxygen combination. At the same time, providing an overview on the current and future challenges that can encounter the future space exploration and transportation missions using hybrid systems.