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EXPERIMENTAL AND NUMERICAL INVESTIGATION OF A PARAFFIN-BASED HYBRID ROCKET ENGINE TO BRAKE A 24U MICROSATELLITE IN A MARS ORBIT

Abstract

Hybrid rocket propulsion is an option for small spacecrafts propulsion system, mainly if high thrusts are required, as in missions to Mars. Paraffin/N2o have been chosen as propellant as they combine safety, availability and multitasking: In fact, nitrous oxide can be used for the ignition procedure and makes unnecessary the use of pressurization system. 4 small engines are designed to produce energy enough to brake and insert a 24U microsatellite, weighting 20 kg each, in a capture orbit around Mars, respecting the restrictions of the CubeSat Standart. Performance have been verified in the propulsion laboratory at the School of Aerospace Engineering.

The test bench consists of a hybrid rocket which has 266 mm of length and 60 mm of external diameter. The injection system is composed by four injectors that introduce N2O into the combustion chamber with a O/F mixture fraction of 5. The injectors diameter is 1.3 mm each. The grain has been realized by melting the pure paraffin at a constant temperature by means of an electrical heater, and pouring it into a PVC mold. Different tests have been conducted in order to verify the best conditions for the ignition and flame anchoring. Tests with the pilot flame showed unstable combustion and detonation behavior when the pilot flame is used to ignite the combustion. Pyrotechnic ignition has shown a stable flame for 15 seconds. 3d Numerical simulations have also been done to analyze the hybrid rocket performance at different operative conditions. The regression of the grain has been estimated by simulating different grain diameter. Numerical simulations results are in a good agreement with experimental tests.