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DEVELOPMENT STATUS OF 500 N - CLASS HTP/TMPDA BI-PROPELLANT ROCKET ENGINE

Abstract

The paper presents comprehensive experimental study on a Liquid Apogee Engine (LAE) - class thruster operating on green propellants: 98% hydrogen peroxide HTP-class and TMPDA (N,N,N,N-Tetramethyl-1,3-propanediamine). The engine has been designed for 500 N in vacuum. The prior catalytic decomposition of HTP and gas-liquid injection are applied. Hot mixture of gases, containing approximately 46% of oxygen, also serves as the source of ignition. TMPDA has been selected as the outcome of the trade-off analysis. The analysis included and was not limited to: performance, compatibility, physical properties, handling and environmental aspects.

The multi-phase development approach has been applied. Different materials for combustion chambers were used, depending on the development phase and hot firing duration in a single test. The investigation started from testing of the critical component: catalyst bed. Next, the experimental optimization aimed at the final selection of the injector and combustion chamber length. In these two cases performance, represented by C* (characteristic velocity) efficiency, was the determinant. Combustion chambers were made of AISI 316L stainless steel, since the combustion time was limited to 2.5 s. This phase, realized in 38 tests led to fix the engine geometry.

Based on previously determined geometrical parameters, with minimum required modifications, the second version of the engine has been designed for longer (10 - 60 s) firings. Authors considered refractory metals for combustion chamber. Limited budget influenced on the decision to select TZM (molybdenum alloy containing: titanium and zirconium) for the base structure. Due to unavailability of locally indentified technologies for anti-oxidation coatings, eventually the uncoated chamber was applied, with awareness of certain degradation while testing. Various inlet pressures of propellants for subsequent tests were applied in order to check the engine operation under wide range of chamber pressure and mixture ratio. It was realized in 22 firings, each lasting 10 s. Additional single 15 s and 20 s hot tests were run as the preface to the final 60 s firing.

Current research has proved that the concept is promising for further development. Based on requirements and results of the activity, the authors created the roadmap containing directions and aspects which still need improvement. It is expected that this engine may start in the open competition for the future GEO satellite propulsion subsystem.

The activity has been performed in the framework of GRACE project (Green Bi-propellant Apogee Engine for Future Spacecraft) realized for the European Space Agency.