Paper ID: 56892
student

IAF SPACE PROPULSION SYMPOSIUM (C4)
Solid and Hybrid Propulsion (1) (3)

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INVESTIGATION OF A DUAL-FUEL HYBRID ROCKET ENGINE FOR MISSILE AND ROCKET APPLICATIONS

Abstract

A large number of modern rockets and missiles require a solid booster for rapid acceleration and a sustain stage for its continuous flight. Vehicles with two solid rocket motors operating in different flight regimes have additional design complexity and may reduce the reliability of a whole propulsion system. An alternative to this solution is a one-stage liquid propulsion system, where different throttling regimes can be realized. However, such a solution has various disadvantages, including cost, technological issues, and propellant storage complexity. A single-stage hybrid rocket motor that is using a liquefying high regression rate fuel for booster and low regression rate fuel for sustainer is investigated in this work as a part of the development activities at the Chemical Propulsion Laboratory of the University of Brasília. The relative simplicity of such a solution makes the hybrid system a competitive alternative to the liquid and solid propulsion systems. It is highly applicable for several types of missions, such as sounding rockets and cruise missiles, especially anti-ship. The designed engine allows thrust modulation during its flight. The thermochemical calculations and engine performance analysis on the ground and in-flight regimes have been performed. The rocket motor interface was designed taking into account the maximum static and dynamic loads. The propellant formulation model has been implemented in the design software, allowing to optimize the fuel grain geometry according to the flight program. A storable, low-cost propulsion system has been designed to utilize nitrous oxide as an oxidizer, and paraffin and HTPB as fuels for the boost and the sustain phases, respectively. Black carbon and other fuel additives like polyethylene and nanoparticles of aluminum have been included in the paraffin mixture in order to increase its performance, efficiency, and mechanical properties. An erodible nozzle insert has been used to guarantee the best performance on the sustain phase when the nozzle throat reaches its optimal diameter at the end of the booster phase. It was found that the dual-fuel hybrid motor has great potential, it may become a promising solution for a wide range of missions that require the two-phase operation of the propulsion system during its flight.