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SELF-PRESSURIZED SMALL-SATELLITE PROPULSION SYSTEM USING SUPERCRITICAL PHASE TRANSITION

Abstract

The use of small satellites for increasingly demanding missions is steadily increasing. With missions that range from dense constellations around Earth all the way to interplanetary exploration, one common requirement is the availability of a propulsion systems that is capable of delivering continuous thrust for formation flight and orbital maneuvers. To enable and support such missions, propulsion systems with the capability to reliably perform larger delta-v maneuvers and provide continuous thrusting capabilities are a key element. At the same time, low cost and easy/safe handling are critical; even more so when it comes to small satellite systems.

The High Density Cold Gas Jet (HDCGJ), presented in this paper is a liquid stored, self-pressurized propulsion system that is capable of delivering continuous thrusting capabilities for small satellites, through its use of supercritical phase transition from its liquid to gas state. This concept ensures that no liquid propellant is present in the gas-side of the system, including the thrusters. The system hereby uses a fraction of the generated gas to maintain supercritical pressure.

The paper analyzes the capabilities of the HDCGJ system in regard to its application in small satellites, and a trade-study of promising propellant candidates is presented. Results show a trade-off between propellant mass, volume, and heating power requirements. Additional aspects such as safety, easy handling, propellant availability, and the use of green propellants are also taken into account.

As a result, a HDCGJ system for a 50 kg, $(500 \times 500 \times 500\,\mathrm{mm}^3)$ small satellite with thrust and delta-v requirements of 120 mN and 5 m/s has been selected for development and flight demonstration. The system uses 1 kg of the refrigerant R-116 (Hexafluoroethane) as propellant, which has a specific impulse of 40 s.

Results of previous Breadboard Model (BBM) experiments, presented during last year's International Astronautical Congress, have confirmed the concept and stable operation of the HDCGJ during continuous thrusting. As a continuation of the system development and testing, the current status of the Engineering Model (EM) will be presented, which represents the hardware to be used for the flight demonstration in size, mass, and component selection. The results of the EM test campaigns using EM hardware are shown, providing data on the system's expected flight performance and and its capabilities for application in future small satellite missions.