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# DEVELOPMENT OF A HIGH DENSITY LIQUID PROPULSION SYSTEM FOR APPLICATION TO SMALL SATELLITES

**Abstract**

The utilization of small satellites for sophisticated missions, such as interplanetary exploration has accepted increasingly high demand. To enable their use in such scenarios, a new type of propulsion system was devised and is being developed at the Japan Aerospace Exploration Agency (JAXA), designated High Density Cold Gas Jet (HDCGJ). It was submitted as a PCT application in 2014. The HDCGJ system is capable of providing an increased amount of delta-V, enabling even small spacecraft to perform extended continuous thrust maneuvers, beyond attitude control. This enables both formation keeping and trajectory correction maneuvers by small satellites. The HDCGJ system stores its propellant in liquid state, above critical pressure. The propellant is heated up to supercritical state using an electrical heat-exchanger, and then expanded to its gas state using an evaporator valve. This avoids boiling during the heat exchange process, also at the same time avoids inefficient heating, which restricts the system to perform only small impulsive thrusting. Overcoming this difficulty inevitably requests the propellant to be heated up through super criticality and to be evaporated. To maintain the stored propellant in liquid state, a newly developed Charger device is introduced. It makes the HDCGJ operable and workable via self-pressurization mechanism that utilizes gas pressure obtained by itself. The Charger device, in the simplest configuration, consists of two cylinders with different diameters, connected by a single piston. The liquid propellant is stored in one side of the cylinders. A portion of the generated gas is re-directed to the other side of the cylinders, keeping the liquid propellant pressurized. This does not require any external power at all. As a part of the HDCGJ system development, a BBM test was carried out. For this BBM experiment, hexa-fluoro-ethan (C2F6) is used as propellant, in view of its non-flammable properties and vapor-pressure suitable for constructing the light weight components. This experiment was intended to verify the operability and performance of the HDCGJ system, especially about the main components; the electrical heat-exchanger and the Charger device. Both nominal and off-nominal operation tests were attempted and the results are presented. This includes impulsive and continuous thrusting modes, as well as recovery behavior in the end-of-life operations that should face the loss of super criticality. This shows the feasibility and practicality of the HDCGJ system for a variety of applications.