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DESIGN AND DEVELOPMENT OF AN ENGINEERING-MODEL LOW-POWER LIQUIFIED-GAS RESISTOJET

Abstract

Resistojet thrusters are one of electrothermal propulsion systems which are capable to operate both at high-power modes and low-power modes utilizing various propellants. High power resistojets operate at a power level of 0.5 - 1.5 kW and a specific impulse of 300 – 350 s using Hydrazine or Ammonia as propellant. They have been in operation for some decades. However, with respect to the growing interest for the smaller satellites, low power systems are currently of more interest as they can operate at a power level of below 100 W producing thrust up to 100 mN with a specific impulse of more than 100 s based on the choice of propellant. The propellant can be almost any compressed- or liquefied-gas as long as it is compatible with the high-temperature operating condition. Resistojets operating at low power and using liquid propellants have become attractive propulsion options for small satellites. Therefore, following the design and development of a laboratory-model resistojet in 2011, an engineering-model low-power liquified-gas resistojet has been designed and developed to operate at low power levels of 15 – 50 W using normal Butane as propellant. The paper describes the design and development of a butane resistojet of nominal power level of 15 – 50 W, producing near 50 mN of thrust at a specific impulse slightly below 70 seconds. The butane is stored in liquid form in the tank and converts to gas as it emerges. Then, it is heated to a maximum temperature of 350C while flowing through heaters inside the thruster. It is finally accelerated inside a micro-machined steel convergent-divergent nozzle with a 0.4 mm throat and approximately 250:1 area ratio. The thrust measurement tests were carried out on a cantilever beam test stand measuring the thrust using a high-precision load-cell inside a 1 2.5 m vacuum chamber at a pressure of near 3 Pascal.