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New Missions Enabled by New Propulsion Technology and Systems (6)

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CONTROLLED SUBLIMATING SOLID PROPELLANT-TANK FOR NANO-AND PICO-SATELLITE APPLICATIONS

Abstract

The increased usage of nano-and pico-satellites is largely accredited to their affordability, while their utility has been steadily increasing due to the development of new technologies. One major obstacle is the lack of dedicated propulsion systems, which needs to be compact and powerful enough in order to perform formation flight, station keeping or orbit change manoeuvres for PocketQubes and CubeSats.

To this end, TU Delft has been developing two types of MEMS micro thrusters, the Vaporising Liquid Microthruster (VLM] and the Low Pressure Microthruster (LPM]. The LPM focusses on lower operating pressures w.r.t. the VLM in order to mitigate the negative effects of thick boundary layers. The operating range of the LPM is in between 50 Pa and 300 Pa, which offers a unique opportunity in terms of propellant storage and mass flow generation.

Water in the solid state will be stored in a controlled propellant tank, where the pressure and temperature will be kept below the triple point values of water i.e. 611.66 Pa and 273.16 K. This causes the ice to sublimate directly to water vapour at a certain mass flow rate depending on pressure and temperature in the tank.

The research has been primarily experimental, consisting of two series of experiments. The first series was aimed at testing basic concepts of sublimation and identifying the practical challenges of the setup, improving it with each iteration. All of these iterative changes eventually led to the design of the second experimental setup, which offered a higher degree of control over the relevant parameters influencing the sublimation rate. The most significant change was a heater on top of the ice surface, in order to directly control the temperature at the sublimating interface. The latent heat of sublimation for water is 2.838 kJ/kg, hence the sublimation process should be most efficient when the heater supplies 2.838W of power to the ice-interface. Any additional power will still increase the mass flowrate, though to which extent will be determined by the end of the second series.

The setup makes it possible to directly control the mass flow rate of the sublimated water vapour in the tank. This in turn facilitates the composition of a complete propulsion system utilizing the LPM, where the tank will provide the mass flow rate necessary for the LPM to produce thrust.