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SPACE PROPULSION SYMPOSIUM (C4)
New Missions Enabled by New Propulsion Technology and Systems (6)

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DESIGN AND DEVELOPMENT OF A SUBLIMATING SOLID PROPELLANT TANK FOR CUBESAT AND POCKETQUBE APPLICATIONS

Abstract

One of the micro-propulsion research activities currently conducted at Delft University of Technology is concerned with the development of a low-pressure micro-resistojet based on a sublimating solid propellant. Specifically the heater chip and expansion slots for this thruster have already undergone extensive research and testing and are at a very good level of maturity. In contrast, the propellant tank still requires some numerical and experimental analysis and is currently considered the main obstacle towards full implementation of this system in a spacecraft. The tank shall be designed to work with sublimating water ice, at temperature and pressure not exceeding 273 K and 611 Pa respectively, which are the triple-point conditions of water. A sublimation stationary model has been developed using the software COMSOL Multiphysics, showing the feasibility of the basic concept. However, this model operates under a number of assumptions and simplifications which need to be removed in more accurate future models, in order to achieve a better understanding of the thermodynamics inside the tank. To this end, some basic sublimation experiments have been carried out in a low-pressure environment, in order to physically evaluate the effects of pressure, temperature and surface area of the exposed sublimating fluid on the overall mass flow rate of produced vapour. The tests are performed on both an open and closed system. In the open system, different exposed surface areas are evaluated in terms of sublimation rate and, consequently, achievable mass flow rate in the thruster. In the closed system, the temperature and pressure are controlled in such a way to always keep them below their maximum acceptable values. In this case a proportional valve is used to regulate the mass flow rate of vapour reaching the thruster and, consequently, the thrust generated. The final goal is to develop a viable and optimized control system for the propellant tank, to be integrated in the complete miniaturized propulsion system as a last step towards the design of an integrated system for small satellite applications such as CubeSats or PocketQubes. This would enable nano-satellites to be precisely orientated and navigated with very small thrust forces which would adhere to the size, mass and power limitations associated with this type of satellites. Such a system would greatly benefit CubeSat and PocketQube missions such as; formation-flying of distributed systems of spacecraft, characterization of the lower thermosphere (90-350km) with in-situ measurements as well as Earth observation, sensing and mapping.