IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IP)

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NUMERICAL ESTIMATION OF HEAT LOSS AND THRUST PERFORMANCE CHARACTERISTICS IN MICRO PROPULSION

Abstract

This paper reports the effect of heat loss on thrust generation performance of a micro propulsion system. Miniature satellites such as CanSat and PocketQube have been tested with increasing numbers in recent days, which are systematically convenient to design, manufacture, and launch for practical operation in space due to their reduced size and weight, and compatibility for constellation operation, a group flying of several satellites simultaneously. Satellites in such scale for missions of that kind, attitude control and orbit manoeuvring capability is prerequisite, which makes it essential for propulsion systems to be downsized. There are various types of space propulsion, which are normally classified as chemical propulsion and electric propulsion. While electric propulsion entirely relies on an electric energy source to accelerate a propellant using electrostatic field, or electromagnetic field, or thermal energy converted from the electric energy, chemical propulsion uses chemical energy stored in propellant and a limited amount of additional energy in an electric form is required. Thus, in a miniature satellite system condition without sufficient electric energy sources to be utilised, chemical propulsion can be a good option. For chemical propulsion, energy conversion to thermal energy before to kinetic energy for thrust generation is commonly involved, which is affected by heat loss. In microscale, there is excessive heat loss that stems from the large surface to volume ratio in such scale, and it has been the main concern that has caused performance degradation of propulsion systems in micro scale. Particularly for monopropellant thrusters which have a catalyst for propellant decomposition in the main chamber, it has been a long lasting issue due to the catalyst reactivity affected by surrounding temperature. In this work, heat loss aspects of thrusters in micro scale have been investigated, considering different MEMS(Micro-electro-mechanical Systems) fabrication processes and substrates that are compatible for micro thruster fabrication. A numerical heat transfer estimation has been conducted considering different materials for MEMS thrusters and corresponding propulsion performance characteristics have been analysed and evaluated.