SMALL SATELLITE MISSIONS SYMPOSIUM (B4)
Access to Space for Small Satellite Missions (5)

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FEASIBILITY STUDY OF A CUBESAT-SIZED SOLAR THERMAL PROPULSION TECHNOLOGY DEMONSTRATOR

Abstract

Solar thermal propulsion (STP) is an advanced means of space propulsion wherein solar power is used to heat the propellant. It offers achieving specific impulse levels beyond 900 seconds, which is about three times that of the best performing storable bipropellant systems. A major hurdle is to demonstrate that such a system is capable of operating in space. The goal of this research is to investigate the feasibility of a single unit Cubesat-sized STP space demonstrator module fit for integration in a 3-unit Cubesat. To this end a design model has been developed focusing on the use of Fresnel lenses to collect the solar light and optical fibers to transfer the energy to the thruster/heater chamber where it is used to heat up the propellant. In this paper we present the design method developed as well as the results obtained. A key element in our design is the analysis of boiling flow and the dimensioning of the heater chamber in relation with the resulting flow temperature and pressure drop. Another key element is to limit the impact of our design on the vehicle and the limitation of heat loss. Elements analyzed include for instance collecting area, need for pointing, disturbance torques and thermal loads. For our design, we opted for low cost and simple design solutions in contrast to optimizing the system for maximum specific impulse. The resulting design consists of a lens module, a propellant feed and storage module and a thruster module. The lens module consists of 2 lenses of 50 mm diameter collecting about 4.5 W of thermal power and the focusers that focus the sunlight into the optical fibers. The thruster module consists of a receiver/absorber body and nozzle. The module is capable of delivering a thrust up to 0.7 mN. This low thrust level is derived from limitations set by the satellite attitude control system. Specific impulse is about 160 s using water as propellant. Water is considered a safe propellant and offers high mass density. The thruster module can be positioned independent from the lens module due to the use of the optical fibers for transporting the thermal power. Total system mass including some 80 gram of water is within 350 gram and total volume is within 340 cm^3.