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

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FEASIBILITY OF AN INTEGRATED SOLAR THERMAL POWER AND PROPULSION SYSTEM FOR SMALL SATELLITES

Abstract

There is an increasing demand on small satellites to provide greater mission flexibility and capability while reducing their associated launch costs. Solar thermal propulsion (STP) has been identified as a candidate to meet this requirement. STP provides specific impulses between 200 and 1000 s and thrust-to-weight ratios of 10^{-4} to 10^{-3} which fall in-between that of conventional chemical and electric propulsion systems.

The novel coupling of a STP system with a solar power dynamic energy conversion system to further enhance the capability of small satellites by co-generating on-board electrical power and propulsion is investigated. The feasibility of using a micro-Organic Rankine Cycle (ORC) to generate the low on-board power level required by a small satellite and its associative design challenges are also discussed. The expected benefits of including a micro-ORC system are to increase the electric conversion efficiency, life expectancy, and cost-saving compared to traditional photovoltaic (PV) systems.

The design of critical ORC components, such as the micro-turbine and heat exchangers, are also detailed. These components limit the order of magnitude of power generation to a minimum of 100 W_e. The micro-ORC system was designed as a trade-off between improving the thermodynamic cycle and reducing the size of the heat exchangers. The heat exchangers were analyzed based on single node lump modelling method. Preliminary results on the design and performance of the integrated solar thermal system are discussed focusing on the system configuration and fluid selection. This includes investigating the effects of the working fluid's molecular complexity and incorporation of regeneration on the system performance while adhering to the strict design constraints of a satellite with a mass of 100 kg. The integrated system is constrained to between 30 and 40% of the dry mass of the satellite. The system shall be compact to ensure adequate volume is available for the payload and other sub-systems. Thermal energy storage options, comparing direct and indirect heating techniques on sensible and latent heat materials, are also analyzed to ensure continuous power generation is provided to the satellite.