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

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APPLICATION OF MICRO ELECTRIC PROPULSION SYSTEM BASED ON ADDITIVE MANUFACTURING TECHNOLOGY ON MICRO SATELLITES

Abstract

Small satellites have experienced rapid development in recent years, with evolving mission requirements that pose new technological challenges to propulsion systems, thereby driving technological innovations in this field. The tasks of propulsion systems often include orbit raising, phase distribution, orbit maintenance, and deorbiting. Due to the low operating orbits, and available electrical power is usually limited, the total impulse required for orbit raising is not typically high. Due to the fast-paced nature of technological iterations, the mission cycles are usually around 3-5 years. However, factors such as weight, volume, and cost are particularly critical for small satellites. Considering the characteristics of small satellite mission mentioned above, the requirements for propulsion systems are summarized as follows: (1) maximum thrust, complete orbit elevation and phase distribution as soon as possible, and generate revenue as soon as possible; (2) The total impulse does not need to be very high, often hundreds or thousands of Ns can meet the task requirements; (3) aiming to accomplish the mission within tight constraints of weight, volume, and cost. Under the aforementioned constraints, electric thermal propulsion technology is an optimized choice within a wide range due to its non-toxicity and high thrust to power ratio, despite its relatively low specific impulse. This paper introduces a solution for an electric thermal propulsion system utilizing ammonia as propellant with additive manufacturing technology, incorporating both arcjet and resistance heating techniques. The resistance thermal thruster, through optimized heat transfer design and catalytic decomposition of ammonia at lower temperature regimes, achieves a specific impulse of over 200 seconds and provides over 10 mN thrust at 20W, adapting to the needs of rapid orbit lifting and phase distribution of small satellites. The arcjet thruster, operating stably at around 300W, achieves a specific impulse of approximately 550s and a thrust of around 35mN, offering an economical and efficient solution for orbit raising of small satellites. Meanwhile, as both types of thrusters use ammonia as propellant, they can also be combined to form a more complete propulsion system solution using arcjet thrusters for orbital control and resistance thrusters for attitude control. The above solution provides an optimized solution

for tasks with a total demand of several hundred to 20000 Ns. This solution has been applied on more than 30 satellites since 2023, and successfully complete tasks such as orbit raising, phase distribution, orbit maintenance, and satellite formation, demonstrating excellent performance and stability.