Paper ID: 85411
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IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IP)

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GEOMETRIC CHARACTERISTICS OPTIMIZATION AND INTEGRATED DESIGN ANALYSIS OF AIR-BREATHING ELECTRIC PROPULSION INLET

Abstract

Spacecraft operating in Very Low Earth Orbit (VLEO) enjoy performance advantages, but the operational lifespan is severely limited by the additional propellant requirements due to the rarefied atmospheric drag. The Air-Breathing Electric Propulsion (ABEP) system collects sparse atmospheric particles within the orbit to provide propellant for the thruster. Therefore be able to compensate for air resistance for satellites, and can fundamentally solve the problem of propellant demand. A high-performance intake is crucial for providing a stable working condition for the thruster and is vital for the entire Air-Breathing Electric Propulsion system. This paper aims to explore the characteristics of particle flow in high-speed rarefied flow using the Direct Simulation Monte Carlo (DSMC) method and to investigate optimization designs for the intake system. Based on the open-source solver dsmcFOAM, which is for rarefied gas dynamics implemented within the OpenFOAM software framework, simulations were conducted on two-dimensional axisymmetric intakes with different geometric features and orbital altitude conditions. Multi-objective optimization was performed on parameters such as aspect ratio, contraction angle, and the number of ducts, achieving an intake efficiency of 43