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DESIGN AND OPTIMIZATION OF INTAKE DEVICE FOR ATMOSPHERE-BREATHING ELECTRIC PROPULSION SYSTEM

Abstract

Atmosphere-breathing electric propulsion (ABEP) system is a promising concept for very low orbit space missions, which can capture the rarefied atmospheric particles as the propellant of electric thruster to compensate the aerodynamic drag. In the best case, it can allow spacecraft (S/C) complete a long-time mission without carrying any propellant at any planet orbit with atmosphere (such as Earth and Mars). As the key component of ABEP system, the intake device can collect the atmosphere particles and drive the propellant to the electric thruster. Considering the requirement of electric thruster for propellant mass and ionization efficiency, the performance of intake must be improved including particles capture efficiency and compression ratio. However, the intake designed in the respective publications do not seem to meet the propellant requirement of electric thruster. Therefore, the intake device needs to be designed and optimized furtherly.

In this paper, intake designs in previous studies are researched firstly, and the general structure of intake can be summarized. Based on the literature review, a new intake device is proposed with different sizes and configurations of inlet grid-ducts (honeycomb type, split-ring type), different sizes and configurations of tapered chamber (parabolic type, conical type, trumpet type and brachistochrone type) and different sizes of long-straight tube. The atmosphere models of Earth/Mars are also be analyzed to obtain the inlet boundary condition of intake device. Due to the characteristic of rarefied atmosphere, the DSMC method is used for numerical investigation. Then, different combinations of configurations and sizes are analyzed under different gas-surface reflection models, including the fully diffuse reflection, the specular reflection model and the Maxwell reflection model. According to the analysis of parameters sensitivities, an optimal intake device can be optimized to improve both particles capture efficiency and compression ratio.

Results show that the combination of honeycomb inlet ducts, the parabolic type chamber and a short tube has a better performance for intake device, which is under the combination of specular and Maxwell

reflection model. As future development we are aiming at the material processing of intake surface to adjust the reflection of particles, such as the MgF/MgO coating material.