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THE NUMERICAL ANALYSIS OF THE THRUST CHARACTERISTIC OF THE MAGNETO PLASMA SAIL IN THE NON-UNIFORM MAGNETIC REYNOLDS NUMBER CONDITION

Abstract

Magnetic Sail and Magneto-Plasma Sail(=MPS) are new generation space propulsion systems that produce the thrust utilizing the interaction between magnetic field formed by an on-board superconducting coil and the solar wind. These systems are expected to realize a long-time space transfer with extremely smaller quantity of propellant than other plasma propulsion systems, because these systems convert the momentum of solar wind into thrust. Magnetic Sail uses only the magnetic field which is generated by the on-board superconducting coil as "Sail". On the other hand, MPS is a system that generates larger thrust than Magnetic Sail by magnetic field inflated by plasma injection from the spacecraft. Magnetic field is inflated by the ring current which is formed by the interaction of the injected plasma and the magnetic field, and the thrust increases due to the inflation of the magnetic field. The conditions of injected plasma has a large impact on the thrust. In addition, the velocity of plasma around the spacecraft is low inside of magnetosphere and so the effect of diffusion of the magnetic field is large. Therefore, we cannot exclude the influence of the diffusion effect of the magnetic field on injected plasma. In previous study, the influence of the magnetic Reynolds number(=Rm), which represents the strength of the diffusion effect of the magnetic field on the thrust characteristic of MPS was investigated. It was investigated by using three-dimensional resistive magnetohydrodynamics(MHD) simulation for the flow-field of MPS. Then, it showed that the thrust of MPS in resistive condition is smaller than ideal condition by the effect of magnetic field diffusion and this diminution of thrust is not negligible in low Rm condition. However, in previous study, Rm is uniformly set in the whole simulation space. This assumption is not valid, because Rm changes depending on the condition of plasma, and the flow field around MPS consists of two regions with totally different characteristics. In this study, we developed two-dimensional axis-symmetric resistive MHD analysis model considering local change in Rm for high precision evaluation of the thrust characteristics. We have conducted the validation of the numerical model, and confirmed that the trend of numerical results of this 2D model is the same as that of previous study in the uniform Rm condition. This paper provides the details of the numerical result and influence of Rm on thrust characteristic of MPS, which calculate Rm at each cell.