IAF SPACE PROPULSION SYMPOSIUM (C4)
Electric Propulsion (4)

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EXPERIMENTAL DEVELOPMENT OF RADIO-FREQUENCY POWER BASED PLASMA ENGINE FOR DEEP SPACE MISSIONS

Abstract

ISRO has taken up the development of a 10 kW plasma engine that explores the radio-frequency (RF) plasmas for deep space propulsion. With the advent of high power sources available in space, a need arises to have a propulsive device for handling high power densities without any adverse impact on thruster lifetime. The system to be developed will enable constant power throttling by adjusting the RF power distribution. It can be used with virtually any fuel with minor modifications in the hardware and has a major advantage of being erosion-less due to absence of interaction of plasma with the materials. The engine is configured with a helicon plasma source and a system for ion-cyclotron resonance heating for plasma heating. Theoretical simulations have been carried out for the helicon discharge section and the design of the Helicon wave launcher has been completed. An experimental system consisting of RF power amplifiers, superconducting magnet system, engine interfaces, mechanical structures, radio-frequency feed system and gas feed system has been designed. The configuring of the water cooling through the antenna without any impact on the EM wave structure was intricate and a coaxial feed-system has been implemented for the same. The RF amplifiers are two-stage amplifiers with solid-state amplifier as first and a vacuum tube as the second. Operating frequency of the amplifiers is 2-50 MHz. This was decided based on experimental findings in helicon discharge and ICRH section with a consideration of lower-hybrid frequency and ion cyclotron frequency for first and second stage respectively. The RF feed system for helicon stage starts with a Matching network which connects to the inside vacuum single half-turn antenna through a high-power RF feed through and a rigid coaxial cable. Similar configuration is constructed for handling power input to the double half turn ICRH antenna. The helicon antenna will

be used to excite right-hand circularly polarized waves and the ICRH antenna will excite the left-hand circularly polarized waves. The superconducting magnet system was chosen for having a compact system where axial position of magnets can be changed conveniently and for enabling long-duration testing. The system development is under progress and major sub-systems have been finalized. This work describes the overall system configuration in detail along with theoretical aspects that are used as the basis of the design.