SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations (IP)

Author: Mr. Jacob Verlander
University of Southampton, United Kingdom, jacob.verlander@outlook.com

Mr. Michael Pollard
University of Southampton, United Kingdom, mp10g14@soton.ac.uk
Mr. Edward Andrews
University of Southampton, United Kingdom, edandrews05@gmail.com
Dr. Angelo Grubisic
University of Southampton, United Kingdom, A.Grubisic@soton.ac.uk

DESIGN, MANUFACTURE AND TESTING OF A 20 CM ELECTRON CYCLOTRON RESONANCE GRIDDED ION THRUSTER AND NEUTRALISER USING ADDITIVE MANUFACTURING

Abstract

The process of Electron Cyclotron Resonance (ECR) is a tested plasma generation technique buts its applications to spacecraft propulsion are relatively new. The aim of this project was to design, build and test an ECR gridded ion thruster. As a feasibility study, the thruster is manufactured using selective laser melting additive manufacturing (AM) in 316L stainless steel.

The initial thruster design was created around maximising the thrust output for a grid size of 20 cm diameter, with a specific impulse of 3000 s using Nitrogen as propellant. The magnetic circuits of the discharge chamber and the neutraliser are created using permanent magnets; Samarium Cobalt for the main chamber and Neodymium for the neutraliser.

A single microwave supply was used powering the main chamber and neutraliser in parallel. Using a frequency of 2.45 GHz a resonant field of 0.0875 T is required inside the chambers for the ECR process. The chamber design was based upon the analysis of previous ECR ion thruster work and simulation testing with COMSOL Multiphysics platform. The magnet configuration is optimised for the generation of the resonant layer and to ensure good electron confinement and to increase the electron path length for more efficient plasma production. This resulted in two concentric rings of magnets on the back wall of the discharge chamber. In the neutraliser eight sets of magnets were used mounted around the outside of the chamber to generate the required field.

A two-grid system is used for ion acceleration. The additive manufacturing process allows for reduction of the thickness of the screen grid to increase effective grid transparency as well as allowing the apertures to be more precisely formed. AM allows for much greater complexity in the neutraliser design, reducing the overall size whilst keeping a high surface area to not reduce plasma density.

Post manufacturing verification and performance testing was carried out to measure the variation in manufacturing tolerances and validate operational performance to the theory around which the thruster was designed.