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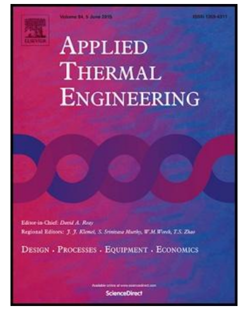

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Author: D. de Faoite, D.J. Browne, J.I. Del Valle Gamboa, K.T. Stanton

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Thermo-Structural Modelling of a Plasma Discharge Tube for Electric Propulsion

D. de Faoite[a], D. J. Browne[a], J. I. Del Valle Gamboa[b], K. T. Stanton[a,*]
[a]*UCD School of Mechanical and Materials Engineering, University College Dublin, Ireland*
[b]*Ad Astra Rocket Company, Liberia, Costa Rica*

Highlights

- Thermo-structural analyses were performed for an electric propulsion space thruster
- Thermal stresses arise primarily from mismatches in thermal expansion coeffients
- Aluminium nitride is a suitable material for a plasma containment tube
- A design is presented allowing a thruster to operate at a power of at least 250 kW

Abstract

Potential thermal management strategies for the plasma generation section of a VASIMR® high-power electric propulsion space thruster are assessed. The plasma is generated in a discharge tube using helicon waves. The plasma generation process causes a significant thermal load on the plasma discharge tube and on neighbouring components, caused by cross-field particle diffusion and UV radiation. Four potential cooling system design strategies are assessed to deal with this thermal load. Four polycrystalline ceramics are evaluated for use as the plasma discharge tube material: alumina, aluminium nitride, beryllia, and silicon nitride. A finite element analysis (FEA) method was used to model the steady-state temperature and stress fields resulting from the plasma heat flux. Of the four materials assessed aluminium nitride would result in the lowest plasma discharge tube temperatures and stresses. It was found that a design consisting of a monolithic ceramic plasma containment tube fabricated from aluminium nitride would be capable of operating up to a power level of at least 250 kW.

Keywords: thermo-structural modelling, plasma, discharge tube, electric propulsion

1. Introduction

The Variable Specific-Impulse Magnetoplasma Rocket [1, 2, 3, 4] (VASIMR®) is an electric propulsion space thruster being developed by the Ad Astra Rocket Company (Houston,

*Corresponding author
Email address: kenneth.stanton@ucd.ie (K. T. Stanton)