University of Stuttgart
Institute of Space Systems

Pfaffenwaldring 29 · 70569 Stuttgart · www.irs.uni-stuttgart.de

Task Description Master's Thesis

Für First and Last Name

Simulation and Design of an improved Magnet Configuration for an RF Helicon-based Plasma Thruster

Simulation und Entwurf einer verbesserten Magnetkonfiguration für ein RF-Helikon-basiertes Plasmaantriebwerk

Motivation:

Very low Earth orbits (VLEO) ranging of 150-400 km can provide significant advantages for satellite missions. Optical instruments or communication devices would greatly benefit to gain better resolution or to reduce cost. However, due to residual atmosphere, a satellite orbit would decay in short order. An atmosphere-breathing electric propulsion (ABEP) utilizing the atmospheric particles as propellant could be an alternative, where continuous thrust compensates the drag, allowing feasible mission lifetimes.

Within the EU DISCOVERER project, an RF Helicon-based plasma thruster (IPT) lab-prototype was developed at IRS and successfully operated with Ar, N_2 and O_2. Its electrodeless design mitigates erosion of its components caused by atomic oxygen, while it delivers a quasi-neutral plasma plume, avoiding the need for a neutralizer. The thruster concept consists of an advanced antenna design, called birdcage antenna, coupled with a solenoid to provide the ionization and acceleration mechanisms. During the ESA ram-CLEP project, a vacuum-capable IPT designed and built, replacing the solenoid with a set of permanent magnets, reducing the mass, power and the thermal management requirements. While a major challenge is the design of a configuration which gives magnetic field topology similar to a solenoid, a mass-efficient configuration is also required towards to a flight-capable thruster. Therefore, a configuration study shall be conducted via simulations and an optimal design shall be implemented, in terms of mass and field topology.

The student shall conduct a literature study of the thruster's working principle and the concept of magnetic nozzle. Then, suitable mass-efficient permanent magnet configurations shall be identified and simulations shall be conducted. A design process and a procedure shall be implemented based on the findings. Potential design limits shall be identified. Documentation of the methodology and the results shall conclude the thesis.

Task Description:

- Literature study on RF helicon plasma thrusters and relevant magnetic nozzle theory,
- Optimization of permanent magnet geometries and configurations via simulation software,
- Autonomously conduct and debug simulations with ad-hoc numerical codes in C++ and Matlab,
- Development of a design process and procedure for the optimal magnet configuration,
- Sensitivity analyses of different magnet configurations and exploitation of different related parameters over performance of produced magnetic field,
- Documentation in English.

Research is performed at IRS, University of Stuttgart.

Internal Advisor:	apl. Prof. G. Herdrich, K. Papavramidis
External Advisor:	Prof. N. Souhair
Start Date:	Choose Date
Submission Deadline:	Choose Date

Acknowledgement of Receipt:

I hereby confirm that I read and understood the task of the thesis, the legal framework as well as the study and exam regulations.

apl. Prof. Dr.-Ing. Georg Herdrich	External advisor	Student
(Verantwortlicher Hochschullehrer)		

Declaration

I, First and Last Name hereby certify that I have written this **Master's Thesis** independently with the support of the supervisor, and I did not use any resources apart from those specified. The thesis, or substantial components of it, has not been submitted as part of graded course work at this or any other educational institution.

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