University of Stuttgart
Institute of Space Systems

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Task Description Master's Thesis

Design of a low-power magnetoplasmadynamic thruster operating with ammonia as propellant for the EIC project BANTER

Motivation:

The EU EIC project „Bimodal Ammonia Nuclear Thermal and Electric Rocket“ (BANTER) aims at developing a bi-modal nuclear propulsion system, in which ammonia is used as single propellant for both the nuclear thermal and the nuclear electric propulsion system. Ammonia (NH_3) as propellant is of high interest in electric space propulsion systems, since it combines a large mass fraction of hydrogen with good storage capability. One goal of the project is to develop a propulsion system, in which NH_3 is used as propellant for an applied-field magnetoplasmadynamic (AF-MPD) thruster. For the experimental investigation phase, a small-scale prototype of this AF-MPD thruster will be designed, assembled and tested at IRS.

The AF-MPD thruster is an electromagnetic plasma thruster that generates thrust by means of applied electric and magnetic field. The small-scale prototype to be designed within BANTER is a 1 kW discharge power thruster, suitable to work with NH_3, and modulable to assess eventual different materials and components (e.g., anode and cathode).

One of the key challenges in the design of a low-power AF-MPD is the management of the heat load the plasma releases to the anode surface. In fact, such heat load can overheat not only the anode surface, but also the surroundings, especially the applied field module (AFM). It is therefore necessary to arrange a thermal management system (TMS) between the anode and the rest of the thruster to manage the heat load and avoid overheating. The TMS choice for a low power AF-MPD can be fully radiative, or partially water cooled from the chamber.

This work shall investigate the design approach for a low power AF-MPD thruster operating with ammonia. The work includes a preliminary literature research on AF-MPD thrusters in general, and in particular for thrusters that operated with NH_3. In addition, possible scaling approaches shall be assessed that can be adopted in order to design the thruster. The goal of the thesis shall be the design of a modulable 1 kW AF-MPD thruster and the optimization of the TMS by performing dedicated thermal simulations.

Task Description:

- Literature research on low power AF-MPD thrusters, especially working with ammonia, scaling laws, and thrust generation modelling.
- Identification of the requirements for the thruster resulting from the project requirements and the constraints given by the test facility.
- Design the low power AF-MPD thruster using proper CAD tools.
- Perform thermal simulations to optimize the thermal management system for the BANTER thruster.
- Documentation in English.

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Start date: as soon as possible