University of Stuttgart
Institute of Space Systems

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Task Description Master's Thesis

Development of a permanent magnet applied field module for a low-power magnetoplasmadynamic thruster

Motivation:

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. A new development in this field is the exploitation of NH_3 as a multi-purpose working fluid in a so-called bimodal propulsion system. Currently, this is under investigation at IRS in the scope of the EU EIC project „Bimodal Ammonia Nuclear Thermal and Electric Rocket“ (BANTER). 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.

An integral component of AF-MPD thrusters is the applied field module (AFM) which is needed to externally apply a magnetic field to the discharge space. Conventionally, solenoids made out of copper wire are used for this purpose, which can generate comparably high field strengths in the range of 50–400 mT. The drawback of such solenoids are high power consumption and large heat losses, resulting in high requirements for the power supply and cooling capabilities of the test setup. Therefore, permanent magnets are investigated as an alternative to solenoids, as their use eliminates the power consumption of the AFM and potentially reduces cooling needs. Especially for small dimensions and at lower field strength levels, as needed for the BANTER prototype, this can be beneficial.

This work shall investigate, how the AFM of the thruster developed for BANTER can be realized, especially within the constraints of the test facility. The work starts with a literature research on permanent magnets and plasma interaction. Then, the objective is to design the field topology based on simulations (e.g. FEMM), supported by preliminary work at IRS on the modelling of permanent magnets. In conclusion, the AFM shall be assembled and tested in order to validate the field topology.

Task Description:

- Literature research on AF-MPD thrusters magnetic field generation, permanents magnet properties and plasma interaction.
- Identification of the requirements for the thruster magnetic field and the constraints given by the test facility for the AFM.
- Design the field topology with exclusively permanents magnets or with a combination of permanent magnets/solenoid, based on simulations performed in proper software like FEMM.
- Manufacture and assemble the AFM, and final testing to validate the field topology with appropriate measurements (Hall sensors).
- Documentation in English

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Start date: as soon as possible