EXPERIMENTAL AND NUMERICAL COMPARISON OF HIGH POWER STEADY STATE MPD-THRUSTERS WITH RADIATION- AND WATER-COOLED ANODES

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Abstract

For several years, extensive investigations have been carried out at the **I**nstitut für **R**aumfahrt**s**ysteme (IRS) of the University of Stuttgart on self-field **m**agneto**p**lasma**d**ynamic (MPD) thrusters in the high power range from 100 kW up to 1 MW. A broad spectrum of plasma accelerators have been examined, all operated in steady state mode [1]. The experimental work has been accompanied by the development of numerical codes, allowing for a theoretical calculation of the MPD thrusters and a comparison with experimental data [2-6]. To investigate the effect of a glowing anode on thrust efficiency, thruster characteristics and especially on onset phenomena observed in nozzle type MPD-thrusters, an MPD-thruster with a radiation cooled anode (**h**ot **a**node **t**hruster - HAT) has been developed which is a hybrid between thermal thrusters and pure MPDs. Since the nozzle geometry is slightly different from the formerly investigated water-cooled thrusters, a water-cooled version (CAT – **c**old **a**node **t**hruster) has been designed for comparison with numerical investigation.

Several attempts have been made to obtain thrust measurements. Recently, the thrust stand has been modified and thrust values for different mass flow rates of argon have been measured. Unfortunately, a strong thermal drift of the thrust balance caused by the high anode temperatures could be seen. Additionally, the high weight of the thruster complicated the thrust measurements. Within this paper, measurements with a redesigned thrust balance are presented. Although the tests are not performed as of yet, it is expected that both thermal drift and effects of the high weight are compensated by the new design. The thrust measured with the thrust balance will be compared to thrust values determined from stagnation pressure profiles in the free stream.

The experimental data will be completed by data gained by numerical simulation which contains information about integral data like thrust, local data like pressure and species temperatures, as well as reveal the reason for the beginning of plasma oscillations. The newly designed solver for the calculation of the self-magnetic flow in chemical and thermal non-equilibrium incorporates a new Riemann solver for proper upwinding, randomized time stepping for convergence acceleration and a mathematically founded adaptation criterion for refinement of unstructured meshes. The system of partial differential conservation equations includes 13 hyperbolic-parabolic conservation equations for the species densities, momentum, energies, turbulence and the magnetic field. More specific details of the finite volume code and the numerical methods will be presented in the paper entitled "Numerical Simulation of High Power Steady State MPD thrusters".

References

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