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Numerical simulation of the ARTUR-2 arcjet

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ABSTRACT

With arcjet propulsion having entered the era of application [1, 2, 3], there is still the need for further optimization with respect to a higher specific impulse, higher thrust density, higher efficiency, and lower weight.

The arcjet research and development has reached a remarkable state at the Institut für Raumfahrtsysteme in the past decade [4]. A variety of thrusters have been built and tested, with power levels ranging from 0.7 to 100 kW using hydrogen, ammonia and hydrazine as propellants.

The ARTUR-2 is a 1 kW class arcjet with hydrogen as propellant. The goal of current investigations is to determine the operational characteristics like I_{sp} and efficiency when using helium as propellant.

In order to support the experiment and to understand the physical details of the plasma flow and its interaction with the electrodes, numerical simulation of the flow and the electrodes is required.

An advanced finite volume (FV) code has been developed in the IRS for the simulation of the argon plasma flow in high power magnetoplasmadynamic (MPD) thrusters on unstructured adaptive meshes [5]. The MPD code includes non–equilibrium of reactions and temperatures and solves a complex system of 13 hyperbolic–parabolic conservation equations. Weighted essentially non–oscillatory (WENO) reconstruction and adaptive mesh refinement enable very accurate second–order solutions.

For the simulation of the ARTUR-2 arcjet, the MPD code is currently being modified to include helium and hydrogen [6] chemistry and electrode effects [7, 8]. The implementation of the

new physical models is relatively straightforward because of the object–oriented C++ approach chosen.

With the variation of mass flow and current, the numerical results for voltage, thrust, I_{sp} and effiency of hydrogen and of helium flow will be compared with experimental data in order to check the validity of the physical models and to obtain a deeper understanding of the physical mechanisms involved. This will allow a further improvement of arcjet thrusters by "testing" geometrically modified arcjet thrusters numerically before actual hardware is being machined.

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