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DESIGN OF A HOLLOW CATHODE THRUSTER – AN OVERVIEW OF ELECTRIC PROPULSION CONCEPTS BASED ON HOLLOW CATHODE TECHNOLOGY

Abstract

The presented study investigates three different concepts to use a low work function hollow cathode as a stand-alone millinewton electric propulsion systems. The first concept is an electrothermal thruster, in which the hollow cathode discharge is used to heat the propellant, which is then expanded and accelerated in a nozzle-shaped anode. This thruster concept was already investigated at University of Southampton using the space-qualified hollow cathodes of the T5 and T6 ion thrusters. However, design optimizations of the hollow cathode could enhance the efficiency of the thruster. Two design options have been realized using different electron emitter geometries. The second thruster concept represents a magnetoplasmadynamic (MPD) propulsion system using a hollow cathode. In a rectangular discharge channel, a current is drawn in the transverse direction of the thrust axis. Perpendicular to the current an external magnetic field is applied using permanent magnets. The resulting Lorentz force acts on the charged particles and accelerates them in the downstream direction. In contrast to conventional axisymmetric MPD thrusters, the magnetic field can be explicitly applied perpendicular to the current, resulting in the potential reduction of power and increase in efficiency. The third hollow cathode thruster concept is a miniaturized 30 mm diameter electrostatic gridded ion thruster. Here, a hollow cathode serves as both electron source and neutral gas inlet for the enclosed discharge volume. The ion accelerator grid uses holes of very small diameter in order to decrease the transparency for neutral gas atoms, and thus increasing the chamber pressure and ionization efficiency. A similar design approach was conducted by Patterson, but resulted in small efficiencies, mainly due to an inadequate grid system. The current research at Technische Universität Dresden aims at improving the efficiency of the concept by using small hole accelerator grids and a multi-orifice keeper electrode of the hollow cathode. In this paper, the operational principles, expected performances, and advantages of each concept are presented and discussed. A successful outcome of this study could expand the application envelope of hollow cathodes and present an alternative to conventional electrothermal, electromagnetic, and electrostatic propulsion systems for micro and small spacecraft.