OPTIMIZING THE PARAMETERS OF AN EHD THRUSTER PLASMA MODEL

Eduardo M. Calvo[1,2], Mário J. Pinheiro[3], Paulo A. Sá[1]

[1]*Centro de Estudos de Fenómenos de Transporte e Departamento de Engenharia Física, Faculdade de Engenharia da Universidade do Porto*
[2]*Departamento de Física e Astronomia, Faculdade de Ciências da Universidade do Porto,*
[3]*Departamento de Física, Instituto Superior Técnico -IST, Universidade de Lisboa,*

In this study we module a corona discharge to describe the behavior of several key parameters in electrohydrodynamic (EHD) propellers for space applications in near space regions. In these environments, the altitudes can reach from 20 to 100km, pressure ranges from roughly 40Torr to 0.25Torr, and the ambient temperature from 190K to 270K. So, the design of the electric propulsion system must be able to operate within these variations. In this work, we used a needle-type anode and a hollow cylindrical cathode with an inner radius of 12mm and a height of 21mm and with 3 – 20kV of a potential difference between the anode and the cathode. The gas pressure and temperature used were 10Torr and 300K, respectively, as in the work developed by Granados [1]. To control the corona discharge, a ballast resistor with 500MΩ and a ballast capacitor of 1pF were implemented to control current peaks.

In a first approach, we investigated the influence of the intrinsic cathode geometry for two noble propellant gases, Argon (Ar) and Xenon (Xe). In terms of geometry, we began by changing the hollow radius of the cathode. Using Argon, we verified that the width was already optimized in 12mm, since any other variation, upper or lower, would decrease the output thrust and the thruster efficiency. On the opposite hand, when using Xenon, we concluded that the optimal hollow radius was 20mm since it was the one who resulted in a better output thrust and thruster efficiency. Still focusing on the geometry, we proceeded to verify the influence of the cylinder height. At 20kV, we discovered that for Ar, the cylinder height should be halved, to around 10.5mm, and that for the Xe, the cylinder height should be reduced by about 30%, i.e. to 14.7mm.

In the second part of our work, we studied the influence of secondary electron emission coefficient, γi, in the cathode. This coefficient depends on the bombardment of ions, neutrals or electrons from the gas in the cathode's surface and of the type of surface and if, as is well known, the surface electrons have an energy above the work function of the material they will be emitted out from the surface. In both propellants, we reported a decrease from the output thrust as γi increases as can be verified in literature [2]. Using the experimental coefficients measured for copper surfaces [3], we reach an output thrust, for single stage EHD thruster, of 2.75μN and efficiency of 259mN/kW for the case of Ar and an output thrust of 3.80μN and efficiency of 434mN/kW for the Xe as the working gas.

Acknowledgments: We would like to thank FuseNet for the financial support in travelling and staying in Kiten. We also thank the support of FEUP's *Centro de Estudos de Fenomenos de Transporte* and the *Department of Engineering Physics* for the computational facilities.

References:

[1] V. H. Granados, M. J. Pinheiro, and P. A. Sá, "Electrostatic propulsion device for aerodynamics applications," *Phys. Plasmas*, vol. 23, no. 7, p. 73514, 2016.
[2] V. H. Granados, M. J. Pinheiro, and P. A. Sá, "Study of the design and efficiency of single stage EHD thrusters at the sub-atmospheric pressure of 1.3 kPa," *Phys. Plasmas*, vol. 24, no. 12, p. 123513, 2017.
[3] G. Auday, P. Guillot, J. Galy, and H. Brunet, "Experimental study of the effective secondary emission coefficient for rare gases and copper electrodes," *J. Appl. Phys.*, vol. 83, no. 11, pp. 5917–5921, 1998.