Development of Permanent Magnet Hall Thrusters for Applications on Future Brazillian Space Missions

Jose Leonardo Ferreira[1], Lui T.C.Habl [1,2] , Lais Souza[1,] Arthur C.B. Serra[1], Paolo Gessini [1,2], Rodrigo Miranda [1,2] and Adriane Schellin
[1]*Plasma Physics Laboratory of University of Brasilia,70910-900 Brasilia-DF, Brazil.*
[2]*Aerospace Department , Faculty of Technology of UnB at Gama-DF, Brazil.*

The Plasma Physics Laboratory of UnB has been developing a Permanent Magnet Hall Thruster (PHALL) for the Brazillian Space Program since 2004. The project consists on plasma source design, construction and characterization of plasma propulsion engines based on Hall current generated inside a cylindrical channel with an axial electric field produced by a ring anode and a radial magnetic field produced by permanent magnets. Electric propulsion is now a very successful method for primary and secondary propulsion systems. It is essencial for deep space long duration solar system missions and for station keeping of geosyncronous satellites, where the thrusting system can be designed to be used on orbit maneuvering or on satellite attitude control in long term space missions. One of the main advantages of PHALL thruster is the production of a steady state magnetic field by permanent magnets providing electron trapping and Hall current generation within a significant decrease on the electric energy supply. This advantage turns PHALL thruster into a specially good option when it comes to space usage for longer and deep space missions, where solar panels and electric energy storage on batteries is a limiting factor. Two prototype models, PHALL I and II, were already developed and tested with different types of permanent magnets. This work describes the Hall plasma source construction and characteristics and the plasma diagnostics system used on BID, an Integrated Plasma Diagnostic System. This system contains Langmuir probes that are used for plasma density and temperature measurements. Faraday Cup, Ion probes and Spectrograph (Andor SR-750-B2, within 435nm to 700nm) line broadening measurements are used to measured ion temperature and transport from Hall current channel to the ejected plasma plume. In order to control argon fuel purity a mass spectrometer is also planned to be used. Thrust and Specific Impulse measurements will also be shown. Important to notice relevant plasma physics phenomena investigation that may significantly interfere on PHALL performance. It is the occurrence of instabilities that can occur inside and outside of the Hall current channel. In order to better understand the turbulence and plasma oscillations that occur during the thruster operation, we propose and test a wide frequency range instability detection system based on a RF detection probe connected to a Spectrum Analyser (Agilent CSA 100 khz-6 Ghz). Instabilities on PHALL discharge current is monitoring using a real time data acquisition system, based on a PCI-DAS 1602/12 board containing 16 analogic inputs, 24 digital channels operating within a 330 khz sampling rate. Near future developments will include PHALL lifetime test system assembly in a vacuum system with bigger volume and pumping speed capability. A direct thrust and specific impulse measurement instrumentation it is also been considered.

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[2]Ferreira J.L.Ferreira I.S., Moraes B.S., Santos J.C., Miranda R. , Gessini P. , Possa G. and Habl L.T.C. Proc. of The 33nd International Electric Propulsion Conference IEPC 2013, pg.418, 2013. Washington D.C. USA.