Mathematical Model of Acceleration Stage of Magnetic Inductive Pulsed Plasma Thruster for Quasi-Stationary Mode of Operation

IEPC-2013-xxx

Presented at the 33rd International Electric Propulsion Conference,
The George Washington University • Washington, D.C. • USA
October 6 – 10, 2013

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Abstract: Mathematical model of acceleration mechanism in magnetic inductive pulsed plasma thruster and possible modes of operation are presented. The mathematical model based on quasi-one dimensional model. Plasma is considered as a plasma sheet with own boundary conditions. One-component magneto hydrodynamic model and two-component plasma dynamic model are used as basic equations in Mathematical model.

Nomenclature

$\vec{A}$ = *electromagnetic field vector potential*

$\vec{B}$ = *magnetic induction*

C = *capacity*

$\vec{E}$ = *electric field tension*

$\vec{j}$ = *current density*

J = *kinetic tensor charge analogue*

L = *inductivity, mutual inductivity*

m_e = *electron mass*

m_i = *ion mass*

n_e = *plasma components densities*

p = *plasma bulk motion*

R = *resistance*

t = *time*

T = *summary temperature*

T_e = *electron temperature*

T_i = *ion temperature*

v_e = *mean electrons velocity module*

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$\vec{V}$ = *plasma mass flow velocity*

$\vec{V}_e$ = electrons mass flow velocity

$\vec{q}$ = *plasma energy flow density, W/m*^{2}

δ = *unitary (trivial) tensor*

Π = *plasma kinetic tensor*

I. Introduction

Pulse plasma thrusters is the sort of more common class of magnetic plasma dynamics accelerators where axial force, which accelerates plasma and generates the thrust, appears because of interaction of plasma current and magnetic field with separate particles movement similar to Hall's drift.

In axial symmetric geometry axial plasma acceleration can take place in two cases:

- azimuth magnetic field B_φ with radial electric field E_r;

- azimuth electric field E_φ with radial magnetic field B_r.

The first combination is possible when electrodes are made as rotation figures – cones, cylinders. Azimuth magnetic field here is generated by axial current inside the central electrode (usually – cathode). Accelerators with this geometry can operate both in stationary and in pulse modes. The second combination is possible with solenoids system use. Magnetic field here must necessary be variable in time because of the fact that azimuth (closed) electric field can be generated by only non-stationary magnetic field.

This paper is purposed to description of processes inside magnetic inductive pulse plasma thruster, which relates to the last acceleration mode represented above.

References

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