In our days the interest of using the Electric Propulsion on board of space crafts of different types is greatly raised. Doubtless the stationary plasma thruster (SPT) is one of the most perspective because of their satisfactory levels of thrust and working performances.

Now the works for designing the SPT thrusters with power range 1-20 kW is widening. So it is necessary to create the new effective methods of calculating their performances on the stage of advance projecting.

The first engineering method of the SPT integral parameters calculating basing on the great experimental material was proposed by Dr. V.Kim [1]. It permits to calculate the SPT integral parameters as a dependence of accelerating channel geometry sizes, value of working medium flow rate and its kind, the discharge voltage for the optimal working regime. But this method is empirical and it has many correction coefficients which may be chosen arbitrarily (5-15% from its maximum value). Because of it we may reliably calculate parameters only of that SPT which structural scheme was used as a base for this procedure.

This method unfortunately does not take into account the influence of the magnetic field distribution and plasma electron interactions with the accelerating channel walls to the discharge parameters. But now many scientists point out that these factors must be taken into account.

Our engineering method permits to calculate the SPT current-voltage and thrust characteristics taking into account the magnetic field configuration and emission properties of the accelerating channel walls substance. We are not use the empirical coefficients for the particular thruster regime, which

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wides its properties of calculating and optimizing the SPT of different structure schemes.

Our method based on the balance physic-mathematical model which dealing with the stationary flow of three components kvasyneutral plasma in the cross electric and magnetic fields. The atoms moving are free molecular with Maxwell distribution function at the anode temperature. The electrons are magnetized; their moving are supposed to be isodrift (drift velocity is constant). The heat velocity obeys to the Maxwell distribution. The ions and atoms heating, the discharge particles recombination, ions pressure gradient, viscosity, heat conductivity and influence of induce magnetic field are not considered. The charge passing by electrons due to their scattering on the plasma potential oscillations and ions – atoms interactions also are not considered. The electrons interaction with the channel walls (secondary electron emission and electrons reflection from the channel walls) are taken into account.

Considering these simplifications the mathematical model contains the equations of mass flow invariability, the impulse equations of electron and ion components, the ion and electron energy and also the Maxwell equations. The assumed equations system transformed into the algebraic equations system, which may be solved by the asymptotic methods. Analyze of the obtaining equations permits to discover the full number of SPT similarity factors, which greatly simplified the thruster designing when its power is changing.

Comparison of the calculated results with experimental one shows that the obtaining calculation dependence satisfactory, on the quantitative level, permits to define the SPT performances or the preoptimal and optimal working regimes, making the discovery of the optimal configuration and value of the magnetic field (optimal regime). In this case the thruster will have the maximum thrust efficiency. In our methodic the the discharge current tolerance level is not more, then 10%; the error of the obtaining optimal magnetic field value is not more, than 30%.

Creating numerical method based on the closed equations
system, which permits to optimize SPT by any parameters. For example, it is possible to define the geometrical sizes of the accelerating channel and the SPT magnetic field distribution by calculating way. This thruster for the prescribe thrust efficiency, will have the maximum service life, defining by the minimum value of the ions energy flow density in the channel exit edge zone.

REFERENCES

Fig. 1. SPT physical model.
NOMENCLATURE

- magnetic field induction.
- current.
- geometric "Area" of ion.
- middle diameter of SPT channel.
- electric field strength.
- charge.
- width channel.
- current.
- current density.
- length of channel.
- semidiameter of magnetic lens.
- length of accelerating area.
- mass flow-rate.
- ion mass.
- concentration of particles.
- pressure.
- temperature.
- voltage.
- kinetic energy.
- potential.
- ionisation and excitation potentials.
- collisions frequency.
- efficiency.

INDEXES

- middle line of channel.
- channel cut.
- channel wall.
- atom.
- electron.
- ion.

MATHEMATICAL MODEL OF SPT WORKING PROCESS

\[ n = kx \phi(n_0 \cdot v), \]  
(1)

\[ \text{div} j = \epsilon n \cdot \varepsilon \alpha, \]  
(2)

\[ \text{div}(jE) = \text{div}(j, \varepsilon), \]  
(3)

\[ \varepsilon = E \cdot \frac{dp}{dr} + \varepsilon v \cdot \varepsilon v, \]  
(4)

\[ j = j_0 (54 \cdot 2 \pi v), \]  
(5)

\[ \text{div} B = 0. \]  
(6)

\[ \text{rot} \varepsilon = 0. \]  
(7)

\[ \text{div} B = 0. \]  
(8)

\[ \text{rot} E = 0. \]  
(9)

Fig. 2. Voltage-current characteristics of SPT:
- Mass=1.5 \times 10^{-5} \text{ kg/s}, \quad B_0 = 1.3 \times 10^{-2} \text{T}

Fig. 3. Discharge characteristics of SPT:
- Mass=4 \times 10^{-6} \text{ kg/s (Xe)}, \quad U=200 \text{ V}