STATIONARY PLASMA THRUSTER FOR SMALL SPACE SATELLITES

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Abstract

SPT α-37 operation in a power range of 140-200 W for space application was studied. Integral characteristics were investigated during the operation of the thruster working on Xe, with a predicted lifetime of 2500 hours.

The directions of development of SPT, naturally, are connected with development of space equipment. So, in recent years [1] actual task is creation of the reliable and effective plasma thrusters consuming low power, about 160 W. Such thrusters can be used for maneuvering and correction of orbits of small spacecrafts weighing no more than 200 kg.

Development of such SPT goes in many countries and the organizations [2-6]. It is known [7] that with reduction of overall dimensions decreases consumed SPT power, but efficiency also decreases. The main difficulty in developing low power SPT is creation of an optimum magnetic field in accelerating channel.

This work is devoted to development of low power SPT and experimental study of its integrated parameters. The main objective, creation of the compact thruster with the maximum stability and reliability was, at high integrated parameters. The special attention was paid for the long-term operation of the thruster determined by a lifetime not less than 2500 hours.

Estimated calculations showed that at the power consumed by SPT, equal 160 W the consumption of xenon via the anode is approximately 0.8 $\frac{mg}{s}$, discharge voltage is approximately 170 V – 210 V. Determination of the radial sizes of model is based on Melikov- Morozov criterion , in detail described in [8].

As a result the optimum design of a magnetic conductor of the thruster was chosen, it is presented on fig. 1a. Distribution of a magnetic induction (Br a component) on the channel center is presented on fig. 1b.

a. b.

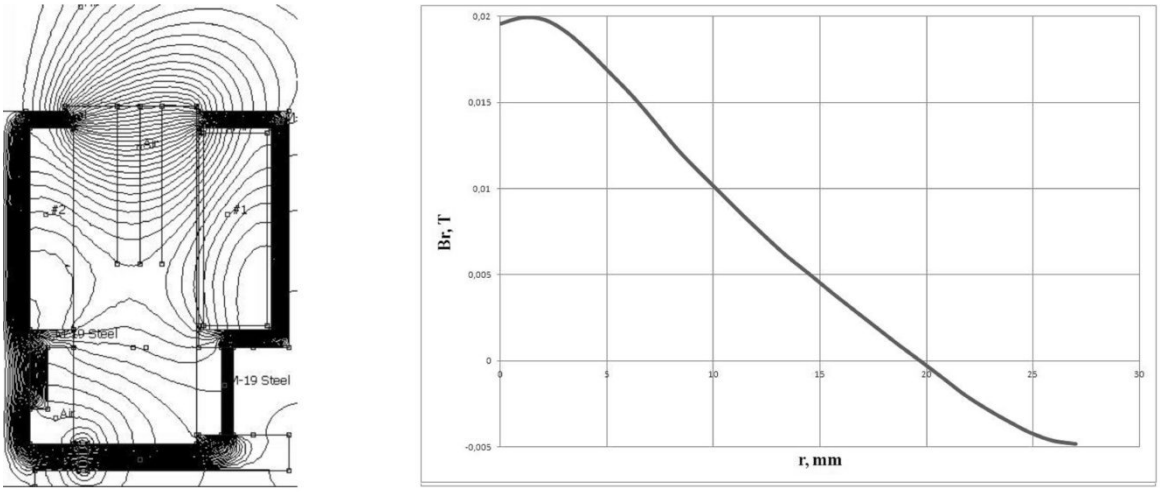


Fig. 1 Optimum configuration of magnetic power lines (a) and Br component of a magnetic induction(b) on the channel center (r =0 – a channel edge)

To achieve the goal, on the basis of the calculations and modeling the thruster SPT α – 37, relating to new generation - a class α [9], for average power

about 160 W, with possibility of use of the forced mode, with a power of 200 W was designed. Its overall dimensions of D = 66 mm, L = 76 mm.

Experiments on measurement of integral parameters were carried out on the vacuum stand with a chamber volume 2000 l, equipped with diffusion pumps with a total productivity of 28000 l/s. Static pressure was 10^{-6} Torr and the dynamic pressure was $1 * 10^{-4}$ Torr.

For the developed model integral parameters for three values of an anode gas flow rate(0,8, 0,9 and 1,0 $\frac{mg}{s}$)were measured in the range of discharge voltages 140 – 210 V.

Previously the optimum channel gap was selected experimentally. So, for the internal diameter of the external channel 37мм, and gap size, in a final version, was 8mm. Dependence of efficiency on gap size b one can see on fig.2.

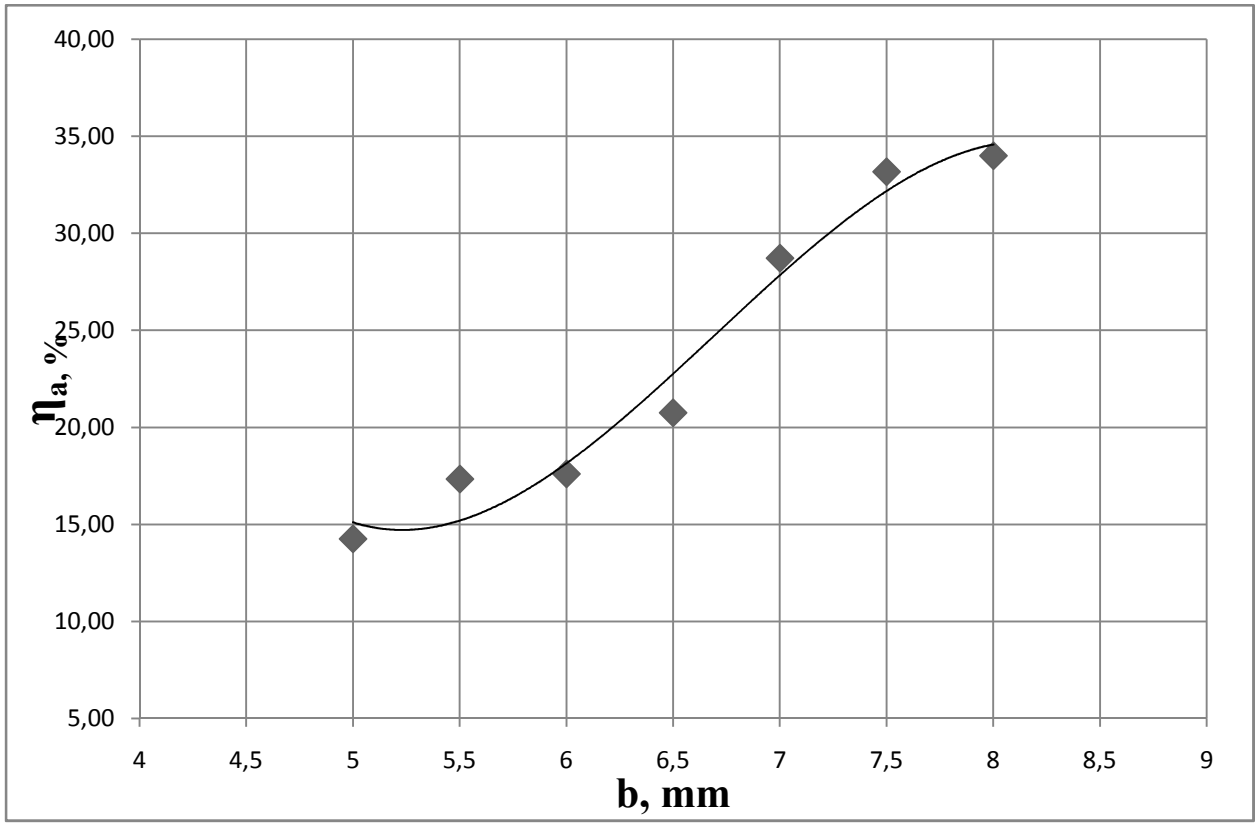
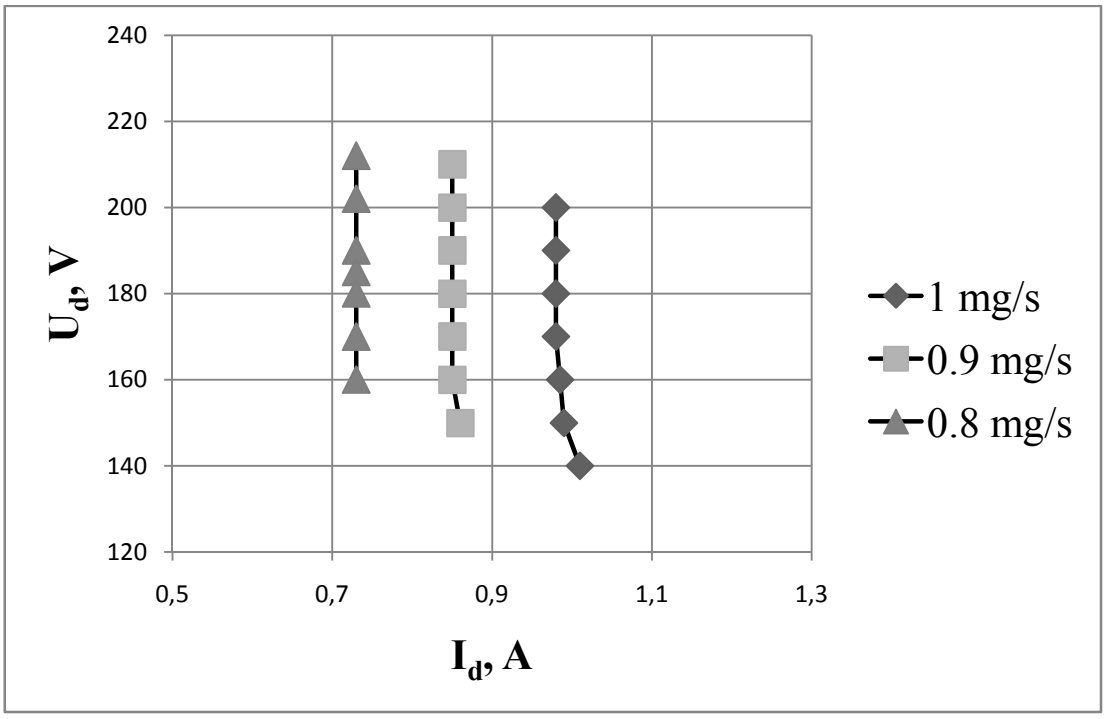


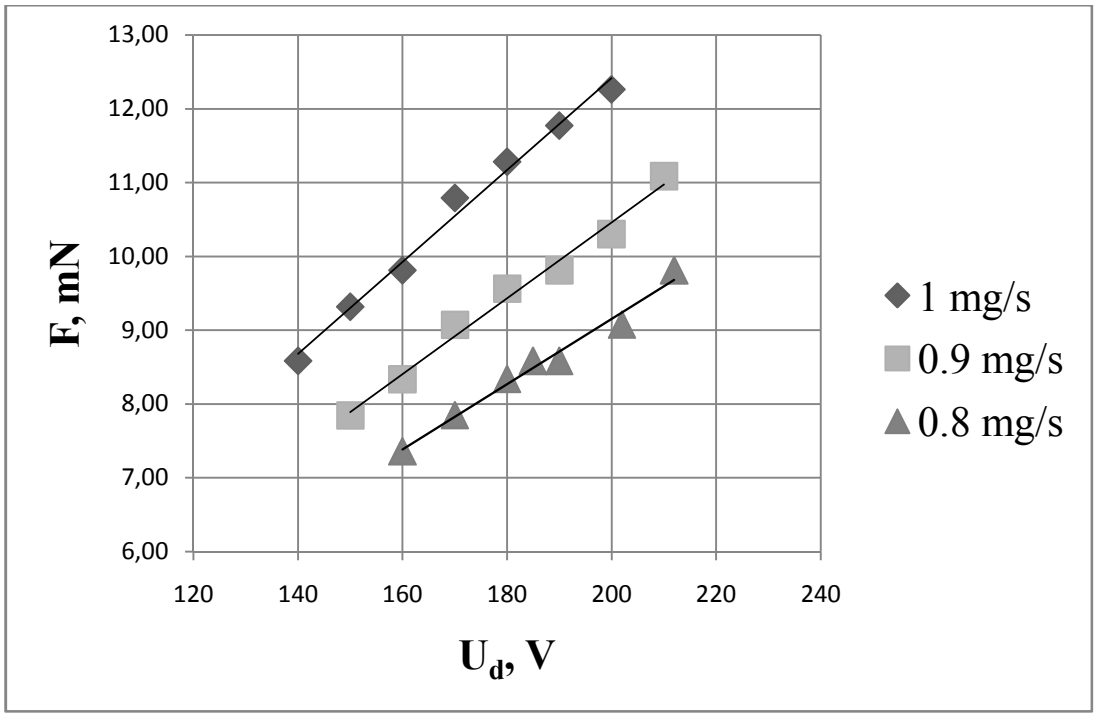
Fig. 2 Dependence of Anode efficiency on the Gap Size of the Discharge Chamber.

Values of the received thrust lie in the range of 7 – 12 mN, and a specific impulse 850 – 1250 s. Anode efficiency of the SPT α – 37 model reached values 35 – 39 %. The integral parameters of the thruster received at the stand of MSTU MIREA are given in fig. 3.

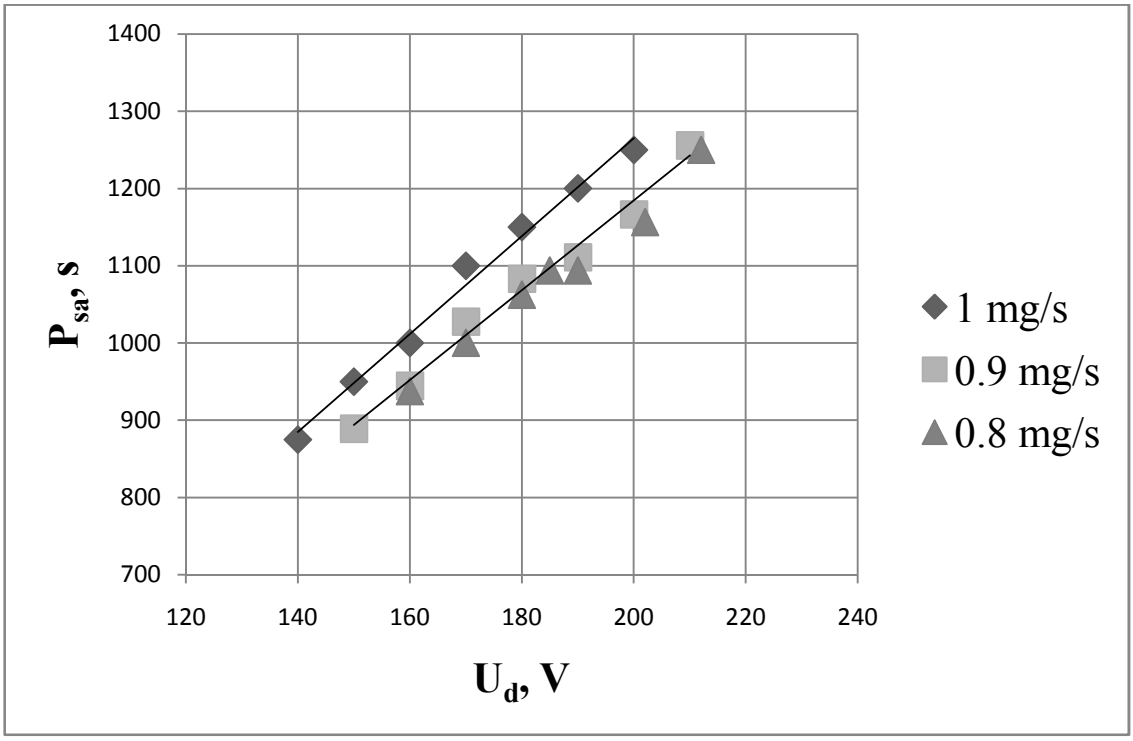
a.



b.



c.



d.

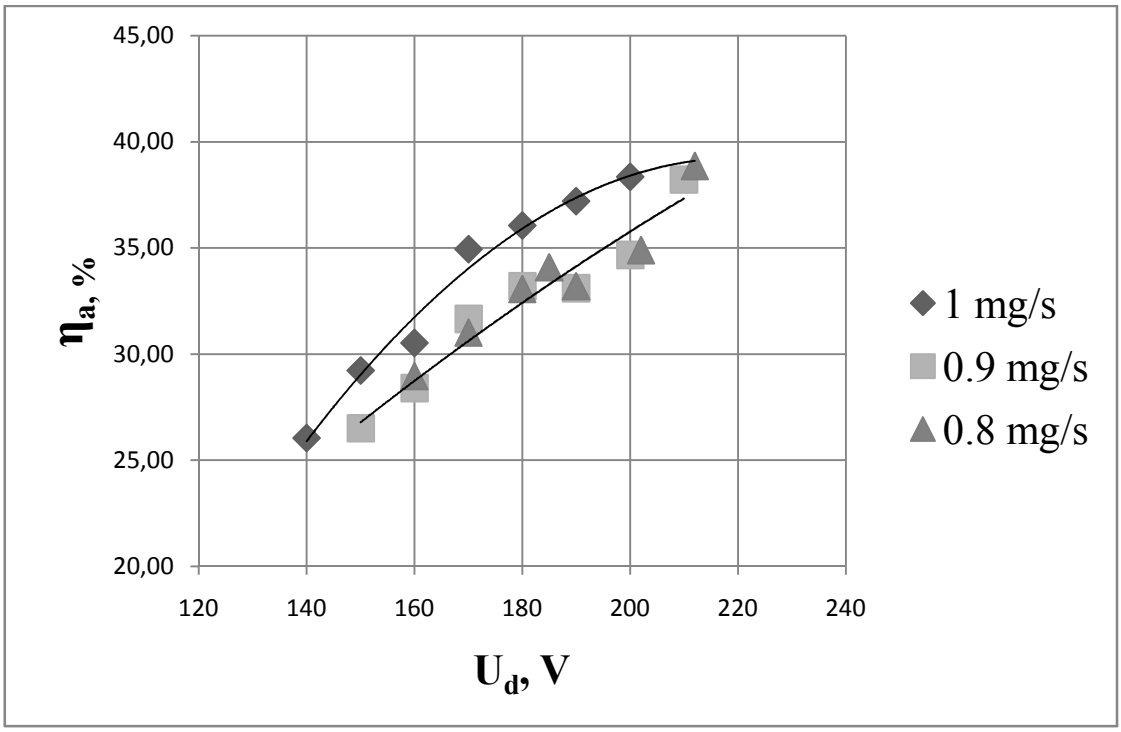
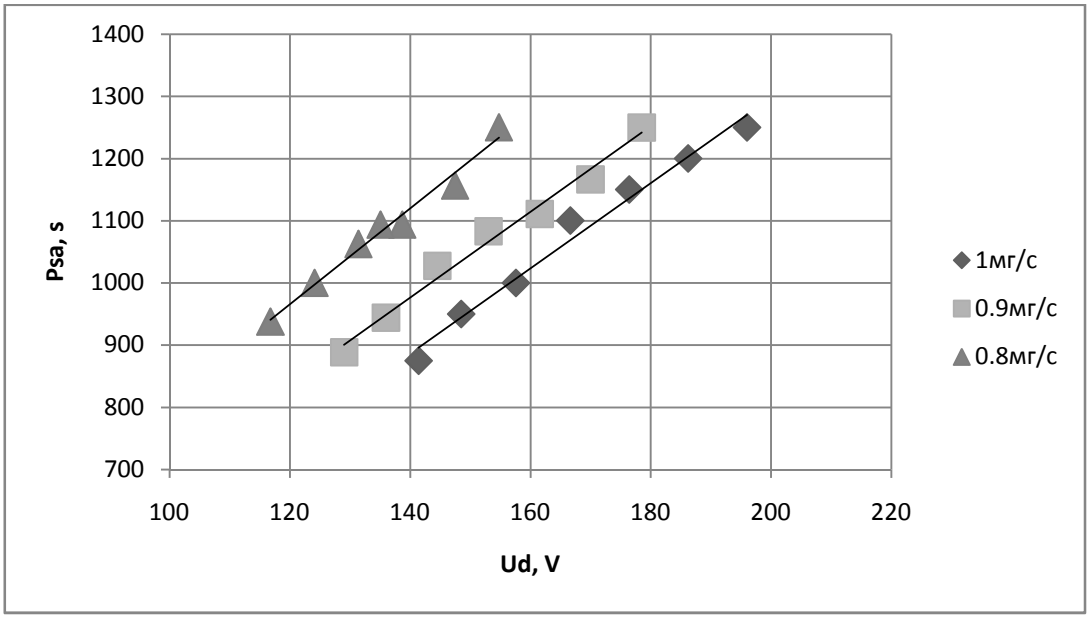


Fig. 3 Integral parameters of the thruster α-37. VAC (a), dependences of thrust (b), specific impulse (c) and anode efficiency (d) on discharge voltage Ud

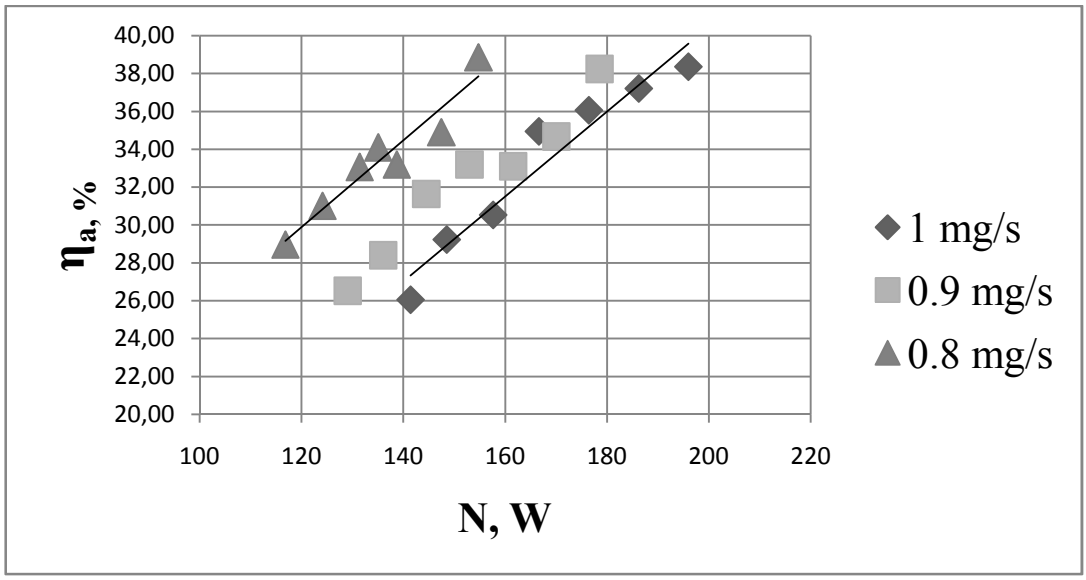
The analysis of the received results shows that an operating mode with the best efficiency is: Up=210V, = 0,8$\frac{mg}{s}$. For these values thrust is 11 mN, the specific impulse is 1250 s.

Dependence of efficiency and specific impulse are given on fig. 4.

a.



b.



The fig. 4 Dependence of a Specific Impulse (a) and Anode efficiency (B) on the input power

The lifetime was estimated on the basis of ~ 50 hours tests results. The radial erosion of an insulator of the channel in its output area is mostly important. Speed of thinning internal and external channels was measured. From received results of the accelerated tests, taking into account empirical dependences(10), calculation of necessary thickness of walls of ceramic insulators, for providing a lifetime of 2500 hours was carried out.

Average speed of an erosion on channel edge in the radial direction was: internal wall - $3\frac{mkm}{h}$, and external wall – $2{,}25\frac{mkm}{h}$.Width of erosion coil on an internal wall of the discharge chamber is equal - 6 mm, external – 3 mm. According to these data it is possible to calculate thickness of walls of an insulator of model for a lifetime of 2500 hours. For external ceramics thickness is $h_н = 2{,}2mm$, for the internal one - $h_{вн} = 2{,}9mm$. Based on these data calculations show that the α – 37 SPT lifetime is not less than 2500 hours.

Thus developed in MSTU MIREA SPT of the small power has demonstrated the stable integral parameters under the operation on the selected modes.

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