SPT-ATON TESTS AT KURCHATOV INSTITUTE STANDS.

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Abstract

Experiments have shown,that the decrease of thruster integral parameters is caused mainly by three processes, which are differed in duration.The first process is the covering of insulators with dust and its covering with thin films.This process is practically instant, efficiency decreases at about 10%.The second process is the heat-up of the model.This process lasts 10-15 min., and the efficiency decreases additionally at 3-5%. The third process is the covering of the anode with nonconducting film.It lasts during several hours,for "classic" anode, the efficiency drops at 10%. There are offered various methods of fight with films on insulators. Because each stand has its own specificity, it is too hard to work out the universal method (except vacuum cleanness) of fight with flying of particles into the channel of the thruster.

1.Results of thruster A-4 tests on the stand T-1.

The vacuum chamber of the stand T-1 is pumped down with diffusive pumps with vacuum oil BM-5. The static pressure was p = 6E-5 mmHg. When the mass flow rate $\dot{m}_A$=3mg/s, the dynamic pressure (respectively to the air) was 2.2E-4 mmHg. The thruster was mounted on the torsion balance. The thrust measurement was performed by collaborators of Kurchatov Institute. The efficiency, when $\dot{m}_A$ was 2.84mg/s, was always higher, than 70%; when $\dot{m}_A$ was 2.34mg/s, it was slightly lower,but sufficiently high. When thrust F was 8.3g, the efficiency was 70%. Slight decrease of efficiency, when the discharge voltage increased, may be explained by appearance of nonconducting film on the "classic" anode.It must be noted, that the values of currents in all coils were in accordance to those for thruster tests in MIREA.

2. Test results for thruster A-4 (stand E-1).

The silicon oil was used for pumping down.The dynamic pressure, when $\dot{m}_A$ = 3mg/s, was from 8E-5 Torr to 1E-4 Torr, depending on the start conditions.

The thruster A-4 was tested in MIREA (work point $\dot{m}_A$ = 3 mg/s, U_d =350V, η =72%) and was mounted on the balance apparatus of the stand E-1.The thruster efficiency after, 20 min after its start was 60% and after 1.5 hours - 48%. At the end of thruster operation,the current in the second coil became less, than in the first coil.The "spoke" appeared.There was no separation of plasma flow from the walls of the channel. Thus, the simple transport of the thruster from MIREA stand to Kurchatov Institute stand led to the 10% drop of efficiency.

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In order to clarify the reasons of the initial decrease of the efficiency to 60%,we started the thruster with cleaned anode next day. Insulators were not cleaned, and were covered with slight yellow deposit. Measurements revealed , that, when only the anode was cleaned,the efficiency did not change and was 50%.
Basing on performed experiments,we made two conclusions.At first, since the decrease of thruster parameters takes place at once (at the first start of the thruster), hence, the film on insulator surfaces appears during the pumping down. At second, if the thruster parameters became worse temporary, the film on insulators increases during the thruster operation. Therefore, in all next experiments,the anode mass flow rate was applied into the channel before the opening of the shutters, and,after opening,the chamber was filled with Xe up to the pressure 3E-4 mmHg. After approximately 15 min after thruster start of operation,the Xe feeding into the chamber was switched off, and the pressure decreased. The results of measurements with cleaned insulators, when we used the new method of start, have shown , that the
cleaning of insulators gave the positive effect, and efficiency remained at 60%-65% during two hours. We carried out the experiment, which confirmed, that the film on the insulators was precipitated in vacuum. The thruster, after 2 hours of operating at characteristic point $\dot{m}_A$=3.1mg/s,U_d =350V, I_d =2.96A, η =63.3%,was remained in the chamber for night. In the next morning, after slight pumping down, its efficiency became equal 58%.

The integral parameters were investigated during 1 hour operation. Fig.1a represents temporary dependence of efficiency, 1b - of thrust,1c - of discharge current. One may see, that the efficiency drops during 10-15 min. from 63% to 61.5%,and then decreases monotonously to the "shelf" 60%. The decrease of efficiency is due to the thrust decrease (fig.1b,c).The decrease of efficiency during 10-15 min. may be explained by the heat-up of the thruster, and this heat-up occurs from initially low efficiency.

New method of thruster start allowed us to note, that, when the pressure decreased from 3E-4 Torr to 7.5E-5 Torr,there was no deterioration of thruster parameters, but, on the contrary, the discharge current decreases, when the pressure decreases, and efficiency increases slightly. Thus, the pressure in the chamber, is not the main factor of thruster operation.

3. Methods of fight with films on dielectric surfaces.

The initial instant decrease of thruster efficiency from 70% to 60% may be explained by the presence of negative ions. The negative ions fly along the flow into the thruster and cover the insulator surfaces with film. The thrust decreases.

Three methods were proposed to avoid this effect. Each of them was tested in MIREA. One of them is the use of the tangential plate with positive potential.

The second method of fight with negative ions is the use of positive column of glow discharge. This additional discharge creates the hole of potential around itself, in which the negative ions are captured.

The third method of fight is use the target, made with material, which does not produce negative ions during sputtering. We use the sheet of iron, plated with zinc, as the target.

Using these methods we could rise the efficiency up to 70%.

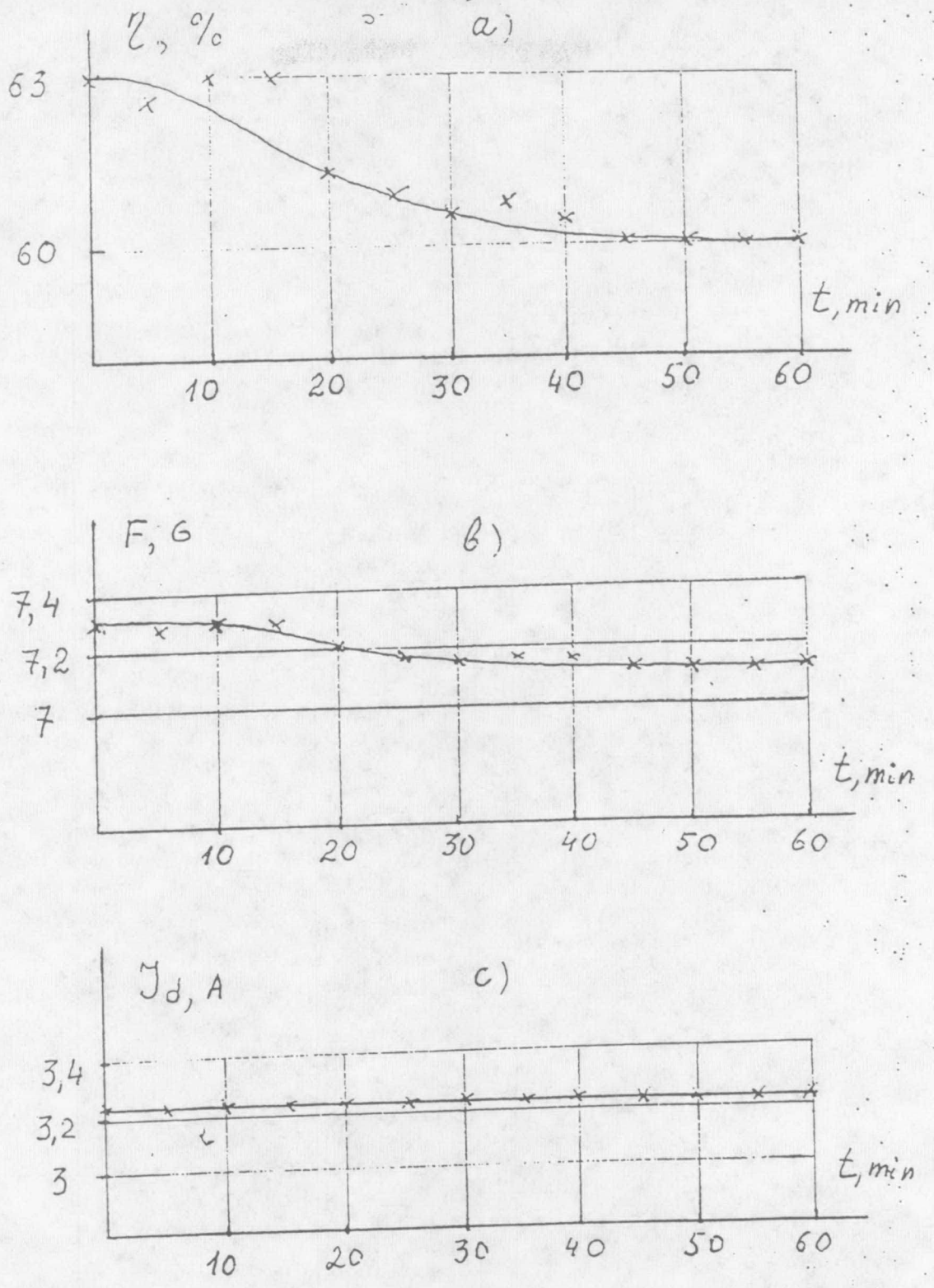

Fig.1. Efficiency, thrust and discharge current time dependencies. Anode is modificated.

$\dot{m}_A$ = 3.13 mg/s, U_d = 400 V, p = $8 \cdot 10^{-5}$ Torr.