SOME RESULTS OF INVESTIGATION OF ANODE DESIGN INFLUENCE ON ANODE LAYER THRUSTER CHARACTERISTICS

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Abstract

Experiment for investigating the influence of the anode design on the integral characteristics of the thruster have been carried out. The main purpose of the work was attaining the prolongation of the service life without considerable deterioration of thrust power propulsion parameters.

Nomenclature

C - thrust cost
m - consumption
Un - conducting layer potential
Up - discharge voltage

Some results of investigation

Tendency to the prolongation of a space vehicle (SV) operation time up to 5-7 years and more requires creating a propulsion plant for the system of SV orbit correction with long service life. It is known that while using a plasma thruster with closed electron drift (TCD) as a propulsor, the erosion of exit edges of an anode block discharge chamber by accelerated ions is one of the main factors limiting the lifetime of the whole propulsion plant. The erosion results in irreversible changes of integral thruster parameters.

In the report some results of work on designing and investigating the characteristics of an anode block with prolonged service life carried out at Dniepropetrovsk State University in cooperation with the Central Research Institute for Machine-Building (TsNIIMash) are presented. The main purpose of the work was attaining the prolongation of the service life without considerable deterioration of thrust power propulsion parameters.

While designing the thruster, the standard model of a single stage anode layer thruster (ALT) was taken as a basis. The design scheme is shown in Fig. 1

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It includes a magnetic system and anode-gas distributor. The magnetic system consists of magnetoconductor 1, poles 2,3 and magnetization coil 4. Anode 5 has a number of orifices of small diameter providing the uniform propellant distribution over the channel cross-section. The propellant is delivered to the anode from a supply system through the gas bringing 8. The anode is fixed and electrically insulated from the body with insulators 6,7. Insulators 6,7 play a role of dielectric anode tips.

Using the hollow anode and improved magnetic system allows to remove the layer of ionization and acceleration to the thruster cut, thus eliminating the discharge chamber from the structure. So, accelerated ions erode the structure elements to the considerably lower extent, this bringing about the increase of service life.

Experiment for investigating the influence of the anode design on the integral characteristics of the thruster have been carried out.

In the first variant the anode design (Fig. 2) was a hollow anode without anode tips. Ceramic insertions were placed between the anode and magnetoconductor poles.
In the second variant (Fig. 3) anode tips made of steel 12X18H10T were installed on the anode.

In the third variant (Fig. 1) the ceramic insertions of a special form played the role of anode tips.

In the fourth variant a conducting copper layer insulated from the anode and magnetoconductor poles was deposited on the front butt-end of ceramic insertions. During the experiment the potential of the conducting layer in respect to the cathode depending on the voltage and xenon consumption was measured.

In all the cases the anode position in regard to the magnetoconductor poles remains invariable. The obtained experimental characteristics are presented in Fig. 4, 5. (1 - the first variant, 2 - the second variant, 3 - the third variant, 4 - the fourth variant)
The decrease of the thrust cost while using anode tips (especially at small consumptions) shows more effective propellant ionization in the anode cavity under the condition of pressure increase in it. Substitution ceramic tips for metal ones leads to performance improvement, this is probably connected with the reduction of electron current to anode in the zone of very curved field lines of the magnetic field near the front cut of anode tips.

The minimum thrust cost is obtained for the anode design with ceramic tips, in this case the conducting layer deposition on the front cut of the tips slightly tells on the thruster performance, thus making it insensitive to pollutions. This permits to be less exacting with regard to the presence of oil vapour in the vacuum chamber during tests and working out.

The experimental research carried out confirms the possibility of increasing the thruster service life with keeping rather high power and thrust characteristics.

The developed anode block with ceramic tips of special form has the nominal thrust of 4gf (with possibility of its increase to 6 gf) at specific impulse 19000 m/s, xenon consumption 2.1 mg/s and power consumption 670 W. Its predicted service life makes up 4000 hours.

One more thruster of analogous design has been elaborated on the basis of obtained results, its average anode diameter equals to 33 mm and nominal thrust equals to 2 gf.

The developed anode blocks can be used in the propulsion plants of SV orbit correction systems with the prolonged term of active service as well as for technological purposes.

Conclusions

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