«Thermoemission» Experiment

THERMAL EMISSION ELEMENTS OF CATHODE — NEUTRALIZER FOR PLASMA THRUSTER OF SPACE VEHICLES

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The application of electro-jet propulsion systems (EJPS) in space vehicles (SV) allows an essential increase in the life of the propulsion system (PS) simultaneously with its weight reduction compared to the chemical PS, that is especially important for long-term space flights and commercialization of space.

At present, one of the most effective and used EJPS is the stationary plasma thruster (SPT).

The SPT has a comparatively simple design of an accelerator and power supply system, as well as a wide range of thrust. It can be easy controlled by the rate of flow of a propulsive mass and accelerator voltage. The SPT has a possibility of precisely maintaining the trust at the required level, as well as a long service life (up to 10^4 hours and more), a great number of potential switching cycles (10^5).

One of the SPT blocks is the cathode-neutralizer, which has the greatest influence both on the service life and start-up rate, and possible number of switching cycles. The cathode-neutralizer should provide not only the initialization of plasma discharge in a thruster, but also the neutralization of volume charge at the PS outlet.

Since 1963 the development and manufacture of thermal emission elements from lanthanum hexaboride has been one of the areas of activity of the I. N. Frantsevich Institute for Materials Science Problems (IMSP). Starting from 1968 these thermal emission elements have been used in cathodes-neutralizers for development of SV thrusters. The customer for these thermal emission elements was the Special Design Bureau «Fakel» (Kaliningrad region, Russia). Thermal emission elements designed and manufactured in IMSP laboratory have been successfully used in the space programs of the Former Soviet Union. From 1982 the manufacture and supply of thermal emission elements for the regular thrusters of SV has been performed in keeping with the appropriate Specifications.

During this time the technology of both material production and thermoemitters treatment were optimised to improve the stability of their operating characteristics and service life. Extensive experience on modification of the structure of material and the configuration of the working channel of thermoemitters after SPT trials in the test installations has also been accumulated. However, there is a lack of results on comparison of the data obtained on Earth with the data obtained under the actual space conditions. It is known that the conditions of ground-based tests do not coincide completely those of space, especially in the SV vicinity. In particular, it concerns the composition of environmental gases, which is the determining factor both for the erosion rate of the thermal emission material and for its serviceability as a whole.

During 25 years (1972 — 1997) of EJPS service, more than 220 cathodes were operated in space, of which 104 cathodes are still operating. The total duration of their operation was 8950 hours until February 14, 1997, with the maximal duration of 976 hours for one cathode. At the same time, the service life of one cathode in the test installation reached 7500 hours (it is still in service now, and can be used for further experiments).

It is highly necessary to provide direct experimental confirmation of the fact that extension of the experience accumulated on Earth to the process of actual operation under the space conditions is well-grounded, in particular, taking into account most of the recent developments of PS for the orbital tow vehicles and manned flight to Mars. From this point of view, it is useful to conduct the investigation of structure and properties of materials (first of all, material for the thermoemitters) after SPT operation under the ISS Program. In addition, this experiment could provide also the lowering or practically complete compensation of the braking of the Earth's atmosphere due to the use of the SPT impulse.

At present, the modules having the thrust force from 3 grams up to 60 grams are designed and manufactured at the SDB «Fakel». It allows selection of the type of SPT, the schematic of their layout and modes of their operation so as to stabilise the orbit and orientation of the ISS and, therefore, to mini-

mise the gravitational perturbations during performance of other scientific experiments. Considering that the energy of solar batteries is used for this type of PS, and only the propulsive mass (xenon) is consumed, this method of ISS orbit stabilisation is rather cost-effective one.

Within the framework of co-operation between the SDB «Fakel» (SPT manufacturer), the Rosaviacosmos and the IMSP, this experiment is accepted for feasibility study. It is intended to use the standard PS, namely the batch SPT-70 with the power of 700 W (1.5 kg mass) and SPT-100 with the power of 1350 W (3.5 kg mass). The consumption of the working gas (xenon) in the design mode is up to 2.8 mg/s for SPT-70 and up to 5.5 mg/s for SPT-100. It is also possible to use various tanks for the working gas depending on the purpose of the work (test of the cathode-neutraliser and/or compensation of the braking moment) and on the ability to replace them (for example: a) V = 1 l, M = 1 kg, M_{Xe} = 1.78 kg; b) V = 15 l, M = 6 kg, M_{Xe} = 1 kg; c) V = 50 l, M = 15 kg, M_{Xe} = 78 kg).

When SPT of other types are used, the power rang can be increased up to 1500 W (for each thruster).

For carrying out this study under the conditions of the ISS, it is possible to define the following two technical problems:

1) Study of the behaviour of the thermal emission elements made from lanthanum hexaboride. The initiation moment is the most critical for the serviceability and operating life of the cathode-neutraliser. From this point of view, it is desirable to provide the multiple switching on/off of the SPT with various modes of heating, operation and cooling. This will provide a substantiation for extension of the experience of ground-based tests to SPT operation under the space conditions.

2) Use of the EJPS for stabilisation of the orbit and/or control of the position of the ISS with the operation time of not less than 8000 hours.

«Optocoupling» Experiment

FIBER OPTIC ROTARY JOINTS FOR NON-CONTACT TRANSMISSION OF INFORMATION TO AND FROM ROTATING EQUIPMENT

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The purpose of the experiment is to develop, study, and manufacture high-quality pilot models of the multipass fiber optic rotary joints (FORJs). The FORJs are designed for optoelectronic transmission of different digital and analog data from the rotating objects installed onboard the ISS to the stationary objects.

To date, the contact, capacitance, and inductance slip rings have been used for data transmission from rotating to stationary equipment. Contact slip rings have been mostly used as the simplest and cheapest ones. The advancement of information technologies has been accompanied by the impetuous increase of transmitted information scope and by introduction of fiber optic sensors and communication lines on rotating equipment. Due to this factor, the traditional application of electrical slip rings in modern facilities has become more and more problematic and in some cases impossible because of their principal disadvantages. For example, the number of physical channels in electrical slip rings for transmission of large volumes of information amounts to as much as several hundreds of channels because of lack of sufficient bandwidth. Thus, the weight of these devices can be up to several hundred kilograms. A high level of noise, as a result of friction and sparking of contacts, and a high sensitivity of contact slip rings to the electromagnetic barrier, cause serious problems in their use in equipment where strong electromagnetic fields are present. Besides, both sparking and the possibility of self-ignition of contacts create unsafe conditions for slip rings use in facilities where explosion hazard exists.

Development and introduction of fiber optic rotary joints instead of the traditional slip rings as their functional analog is the alternative solution of the problem of information transmission from rotating equipment.

The creation of FORJs is of great importance in such developed countries as the USA, Canada,