ELECTRIC PROPULSION SYSTEMS WITH FAST NON-INCANDESCENT START

Mykola V.Bilan, Volodymyr I.Bilokon, Mykola M.Koshelev, Andriy V.Loyan, Sergiy Yu.Nesterenko, Anatoliy I.Oranskiy, Mykola P.Stepanushkin

Scientific & Technological Center of Space Power & Engines at
National Aerospace University “Kharkov Aviation Institute"
Address: 17, Chkalov St. Kharkov, 61070, Ukraine.

The basic achievements of Scientific & Technological Center of Space Power & Engines at National Aerospace University “Kharkov Aviation Institute" (STC SPE KhAI) in the domain of creation and use of systems fast non-incandescent start (SFNS) of electric propulsion systems (EPS) are shown in the report.

SFNS are created on the base of non-incandescent cathodes (NIC) of own elaboration and producing, which provide the EPS functional start (thrust and electric descriptions going out on nominal values) during the time order of 1 – 100 milliseconds. It is necessary to mark, that traditional EPS with incandescent cathodes have a time of functional start not less then 100 s.

Other positive properties of EPS SFNS are:

- higher start reliability and produce ability because of the absence of heater in NIC – one of the less reliable and complicated in producing elements of thruster;
- considerably lesser power supply in start period.

This considerably broadens the domains of EPS effective use in systems of orientation and stabilization of geo-stationary space vehicles, in motion control systems of small low orbit satellites, in space vehicles static charge neutralization systems and oth.

The SFNS worked up are used for creation of EPS laboratory models based on SPT M70, SPT M30 and PIT-200 on xenon.

LM EPS-SFNS-1 on the basis of thruster unit (TU) 182E (SPTM70) and NIC БК-4 jointly with Design Office “Fakel” was worked up in 1990-1992 yy., which had the following basic parameters:

- Discharge voltage in TU 270 – 280 V;
- Discharge current 2,0 – 2,3 A;
- Summary xenon expense 2,0 – 3,5 mg/s;
- Xenon expense through the cathode 0,2 – 0,6 mg/s;
- Going out time on stationary routine ~3 ms.

For confirmation of capacity more over 1000 statrts of this installation were seen out.

Laboratory model EPS-SFNS-2 on the basis of modified SPT-70 model and NIC of type was worked out in 1994-1996 yy. jointly with State Design Office “Yuzhnoye” [1, 2]. The basic parameters of this system are shown in Table 1. The changes of electric parameters of this EPS during start time are represented on Fig. 1.

Table 1. EPS laboratory model with fast non-incandescent start (SFNS-2)

Thruster type	SPT M70
Propellant	Xenon
Thruster power	700 W
Thrust	40 mN
Specific impulse	1500 s
Life-time in steady-state routine	$(7\text{-}10)\cdot 10^3$ hrs
Summary impulse	$0.7\cdot 10^6$ Ns
Function life-time	3 ms
Starts number	10^4

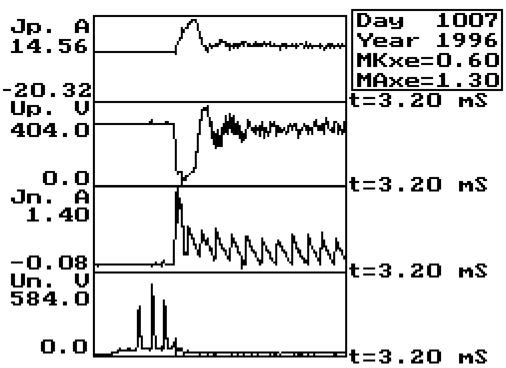

Fig. 1. EPS LM SFNS-2 start oscyllogram

The works started in 2002 y. jointly with DO “Fakel" on base SPT-70 to creation EPS-SFNS-3 of new generation, which will be manned by last modifications of NIC and ignition unit of KhAI elaboration. It is supposed, that this system will have lesser voltages and time and more high reliability of start.

The works began from 2000 y. in KHAI on creation LM EPS-SFNS-4 of small power (to 100 W) on base SPT M30 and low current NIC of M1.03 type (discharge current about 1 A) of own elaboration [3, 4].

Now KHAI jointly with SDO “Yuzhnoye” and with LIP (PRC) creates working on xenon laboratory model of EPS XIPS-200 on the basis of plasma-ion thruster with radial magnetic field PIT-200 RMF. As ionization chamber cathode and neutralizer-cathode here also NIC are used, that allows to carry away XIPS-200 to class EPS-SFNS.

Basic descriptions XIPS-200 represented in Table 2.

Table 2. EPS LM XIPS-200

Thruster type	PIT-200 RMF
Propellant	Xenon
Thruster power	950 W
Thrust	40±4 mN
Specific impulse	3000-3500 s
Life-time	$\geq 8 \cdot 10^3$ hrs
Start time	$\leq$ 2 s
Starts number	$\geq$ 5000

The arcjet thrusters with power 100-500 W and start time of 2-3 ms based on NIC are worked up in STC SPE KhAI.

The experimental models AJT Д500.01 and Д550.02 based on NIC are worked up in KHAI, destined for work in power range 100 – 1000 W [5, 6]. The Д500.01 and Д550.02 thrusters tests on row of propellants (argon, hydrogen, nitrogen, nitrogen mixture with hydrogen, ammonia, N_2H_4) bore out stability of their work in stated power range with specific impulse from 200 to 800 s and with efficiency of 20-40%. AJT of new generation going on ammonia and N_2H_4 on the basis of got results is in the design in KHAI at present. The expected parameters of these thrusters are shown in Table. These AJT can occupy “an intermediate position” between liquid propellant engines and EPT. They can begin advantageous replacement to gas-reactive thrusters. AJT has a row of advantages on comparison with EPT, including a small elaboration risk and application possibility of systems, created previously to, that will allow to decrease considerably a project cost.

An experimental sample of low temperature plasma with power of 75 W using SFNS is created for neutralization of electrostatic charge, which appears on space vehicles surface. This neutralizer by his main functional parameters excels analogous devices, working in routine of smouldering discharge.

The source of low temperature plasma based on Hall plasma source with NIC is created and experimentally checked out in STC SPE KhAI for neutralization of electrostatic charge on space vehicle surface. This neutralizer on basic parameters excels analogous devices, going in routine of smouldering discharge. So, an expected potentials difference level on space vehicle surface lowers in 10-20 once (to 30 V) in range of device working parameters. It is established, that consumed power of this device, going in routine of arc discharge, bears extreme nature and in minimum is 75 W [7].

The continuous works on perfection of SFNS take place in STC SPE KhAI:

The works are continued now in STC SPE KhAI on creation of new modifications, perfection and inculcation of worked up NIC and non-incandescent start systems. This is such a research works, as:

- mathematical modeling and computations;
- search and approbation of new effective thermal emitters;
- studying of all of discharge development stages and improvement of electrodynamics and optimizing of clamp intervals;
- study and improvement of gas dynamics;
- studying of thermal processes and perfection of thermal scheme.

Experience-design works:

- design, elaboration and creation of new modifications and type-size of NIC;
- perfection of worked up constructions and their experience-design working off;
- creation and modernization of production base and making technologies;
- modernization of stands, methods and measuring means.

Marketing:

- expansion of NIC use domain;
- search of new enterprises and organizations – the customers and consumers of cathodes.

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