RESEARCH OF THE DYNAMIC PRESSURE DISTRIBUTION IN THE PLUME OF THE SPT

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ABSTRACT

The given work contains results of researches of measurement of dynamic pressure in jet of the stationary plasma thruster (SPT). Possibility of a method was demonstrated on an example of performance of measurements in jet of experimental model of a type SPT70. The method can be used for diagnostics of a jet of various types of electrojet thrusters (ERT). The results of measurement of dynamic pressure allow to calculate the revolting moments for a surface (for example, panel of the solar battery), placed in a jet of ERT.

INTRODUCTION

With use of electrojet thrusters on space vehicles (SPACECRAFT) there is a line of interactions between the working thruster and SPACECRAFT:

- Electromagnetic interaction of the thruster with systems of SPACECRAFT at the expense of electromagnetic thruster electromagnetic and light radiation;
- Erosion of elements of SPACECRAFT under influence of a jet of plasma;
- Power of influence of a jet on elements of a design of SPACECRAFT.

The power of influence of a ERT jet is usually defined by indirect methods on the basis of results of measurements of distributions of density of a ion current and ions energy of a jet of plasma. However, these methods do not take into account presence neutral accelerated components arising owing to processes of recharging of ion beam[1]. As show direct measurements, of a neutral component in jet ERT makes an essential share of total share. Therefore definition of total power influence all the component of a jet (ions and neutral components), expiring from ERT, represents difficult account-experimental task.

THE MEASURING DEVICE AND TECHNIQUE OF PERFORMANCE MEASUREMENTS

The method of measurement of dynamic pressure is based on measurement of forces working on a body, placed in a ERT jet. The circuit of the measuring device is shown in a fig. 1.

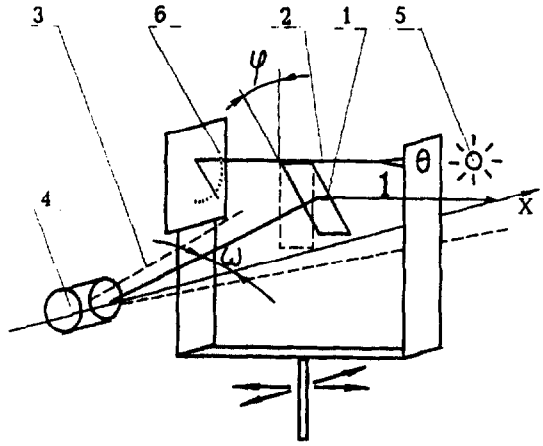

Fig. 1. The circuit of the measuring device

As the sensor of power influence the plate (1), freely suspended on an axis (2) was used. The device has a measuring scale (6) and illuminator (5). With a displacement of a plate in a jet (3) of the working thruster (4) it deviates an initial vertical rule on some corner.

The corner of a deviation of a plate in any of points of a jet depends on balance of the moments of forces of dynamic pressure a component of a jet in the chosen point of measurement and weight of the plate. The size of a corner of a deviation was defined on a shadow from a plate on a measuring scale.

The distribution of dynamic pressure in the chosen section of a jet was defined at the expense of movement of the measuring device in a plane, perpendicular axis "X".

With use as the sensor of a thin plate of the any form and with uniform density the size of dynamic pressure (Psum) can be found under the formula:

$$Psum = \frac{k \ \rho \ tg(\varphi)}{b \cos(\varphi) \cos(\omega)} \cdot \quad [1],$$

Where ρ- density of a material of a plate (kg/m^3);

φ- corner of a deviation of a plate from an initial rule;

ω- corner between an axis of the thruster and line connecting the sensor of pressure (a plate) and the thruster;

b - thickness of a plate (m);

k - accommodation factor .

The sensitivity of the device depends on thickness of a plate and sort of a material, of which it is made. For example, with use as sensors of plates from aluminium and molybdenum foil by thickness 0.02 mm with action on them of dynamic pressure by size 3.5 Pa the deviation from an initial rule of an aluminium plate makes 5 degrees, and molybdenum plate - 1 degree. The received sizes of corners of a deviation can be measured by tool methods.

RESULTS OF MEASUREMENTS DISTRIBUTION DYNAMIC PRESSURE IN SPT70 JET

The measurements of distribution of dynamic pressure in jet of experimental model SPT70 were carried out in a plane, perpendicular axis of the thruster, on distance of 500 mm from cut of the discharge chamber. The range of moving of the sensor was chosen so that it could pass through an axis of a jet of the thruster. As the sensor the plate from molybdenum foil by thickness of 0.02 mm with the sizes 25x40 mm was used. The thrust of the thruster made 42 mN with work in a mode: a current of discharge Id = 2.2 A, pressure of discharge Ud = 300 V.

The results of measurements of corners of a plate deviation (φ) on various (l) of an axis of a jet and results of account of size of dynamic pressure (Psum) (k = 1) are shown in a fig. 2.

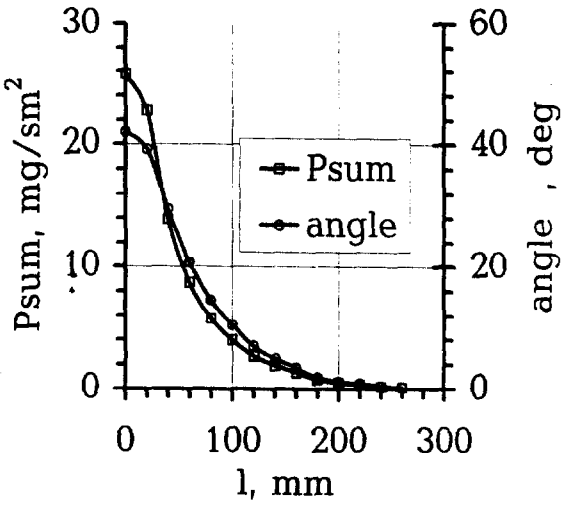

Fig. 2. Results of measurements of corners of a deviation of a plate on various (l) of an axis of a jet and results of account of size of dynamic pressure (Psum).

The change of size of dynamic pressure with change of distance from an axis of a jet is shown in a fig. 3.

The distribution is good approximated by exponential function of a type:

$$Psum = A \ e^{(-B \ l)} \quad [2],$$

Where **A** and **B** - factors;

l - distance from an axis of a jet.

The results of measurements of dynamic pressure and results of account Psum (calc) on approximation dependence also are shown in a fig. 3.

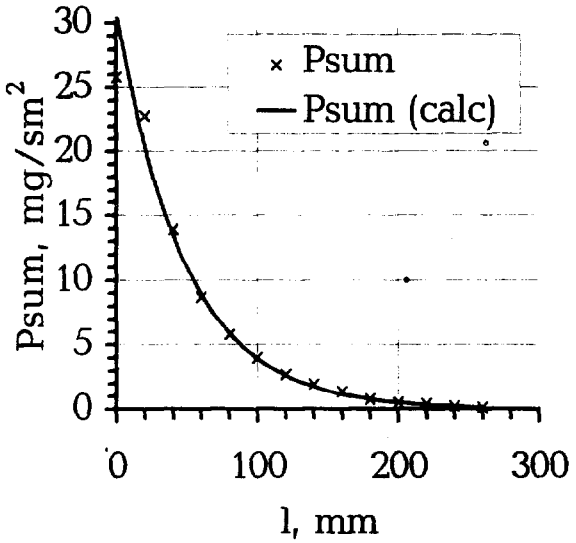

Fig. 3. Sizes of dynamic pressure with change of distance from an axis of a jet (measured and settlement).

With use approximation function the size of thrust (Fsum) was designed with integration of distribution of dynamic pressure (Psum) for a plane located on distance 500 mm from cut of the discharge chamber of the thruster. The calculating meaning of thrust has made 44.15 mN. The received calculating size of thrust within the limits of 7 % coincides with thrust measured on thrust- measuring device.

The results of account of total effort of braking of the thruster SPT70 for various meanings of a corporal corner are shown in a fig. 4. 90 % of total effort of braking of a jet of the thruster SPT70 is in a corporal corner with a half-corner in top equal to 20 degrees.

The method of direct measurement of distribution of dynamic pressure can be used for diagnostics of a jet of various types of ERT. On the basis of results of direct measurement of dynamic pressure in jet the efforts of braking of a jet and revolting moments for any surface (for example, panel of the solar battery), placed in a ERT jet can be designed.

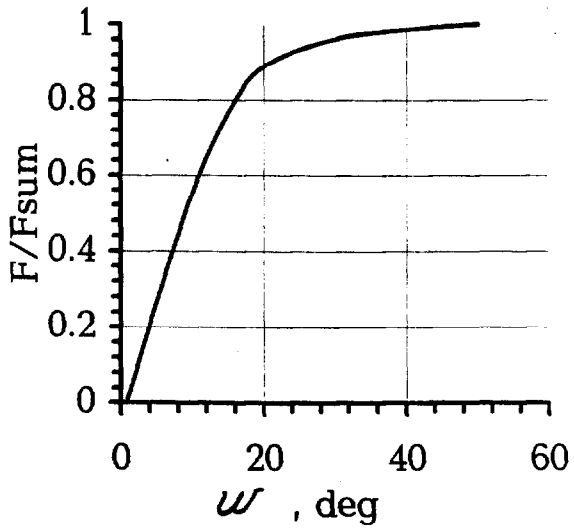

Fig. 4. Results of account of total effort of braking of the thruster SPT70 for various meanings of a corporal corner

THE CONCLUSION

The direct measurement of size of dynamic pressure in jet ERT is carried out. The possibility of measurement of distribution of a pulse of braking in jet of plasma is shown. The method can be used for diagnostics of a jet of various types ERT. By results of direct measurement of distribution of dynamic pressure in jet the sizes of efforts working on a surface, taking place in jet ERT (for example, revolting moments for the panel of the solar battery) can be designed.

THE LITERATURE

King, L.B., and Gallimore, A.D., " Ionic and Neutral Particle Transport Property Measurements in the Plume of an SPT-100 " AIAA-96-2712, Joint Propulsion Conference, July 1-3, 1996, Lake Buena Vista, FL.