Секция: Технические науки

ГАЛАКТИОНОВ ДЕНИС ЕВГЕНЬЕВИЧ
студент кафедры летательных аппаратов
Институт космической техники
Сибирский государственный университет науки и технологий
имени академика М. Ф. Решетнева
г. Красноярск, Россия
ШЕВЧУГОВ ВАСИЛИЙ ОЛЕГОВИЧ
студент кафедры летательных аппаратов
Институт космической техники
Сибирский государственный университет науки и технологий
имени академика М. Ф. Решетнева
г. Красноярск, Россия
ЖДАНКИН АНДРЕЙ ВАСИЛЬЕВИЧ
студент кафедры летательных аппаратов
Институт космической техники
Сибирский государственный университет науки и технологий
имени академика М. Ф. Решетнева
г. Красноярск, Россия
КРАВЧУНОВСКИЙ АНТОН ПАВЛОВИЧ
студент кафедры летательных аппаратов
Институт космической техники
Сибирский государственный университет науки и технологий
имени академика М. Ф. Решетнева
г. Красноярск, Россия
ТИХОНЕНКО ЕКАТЕРИНА СЕРГЕЕВНА
студент кафедры летательных аппаратов
Институт космической техники
Сибирский государственный университет науки и технологий

имени академика М. Ф. Решетнева

г. Красноярск, Россия

ПРЯНИЧНИКОВ РОМАН АНДРЕЕВИЧ

студент кафедры летательных аппаратов

Институт космической техники

Сибирский государственный университет науки и технологий

имени академика М. Ф. Решетнева

г. Красноярск, Россия

КАРЧАВА ОЛЬГА ВИТАЛЬЕВНА

старший преподаватель иностранных языков

Сибирский государственный университет науки и технологий

имени академика М. Ф. Решетнева

г. Красноярск, Россия

CALCULATION OF CHARACTERISTICS AND DESIGN OF A MODEL ROCKET ENGINE

The article deals with an algorithm for calculating the characteristics of a solid-fuel model rocket engine. The results of the tests of several prototypes of engines on a load-measuring stand are presented and the results obtained were compared with theoretical results.

Key words: *model rocket engine, solid fuel, thrust, effective exhaust velocity.*

Nowadays rocket modeling has been a promising direction in cosmonautics since the first flight of a rocket model and the flight of real rockets. The model of the rocket engine (MRE) is an integral part of the rocket model, in fact it is a source of reactive force and it propels the rocket. Today about 20 MRE with thrust from 14 to 330 newton are being produced, but they have relatively large dimensions and high prices. As a result, the modelers are forced to manufacture the engine on their own.

The purpose of this work is to introduce the design, calculation and creation of a model of the rocket engine on solid fuel and its test at the stand.

In the process of the design of the model of the rocket engine, it is necessary to solve a number of problems. One of the most urgent problems is the calculation of thrust of the designed engine. At the moment, in most cases, the parameters of mrd are determined experimentally. To solve this problem, an algorithm and a program for calculating engine thrust with the given geometric parameters of the engine were developed. [2, p. 34-36]

The following assumptions are made in the calculation algorithm:

- fuel charge is uniform;
- effective exhaust velocity is constant during engine operation;
- the burning speed of the fuel is constant during the operation of the engine and is the same in all directions.

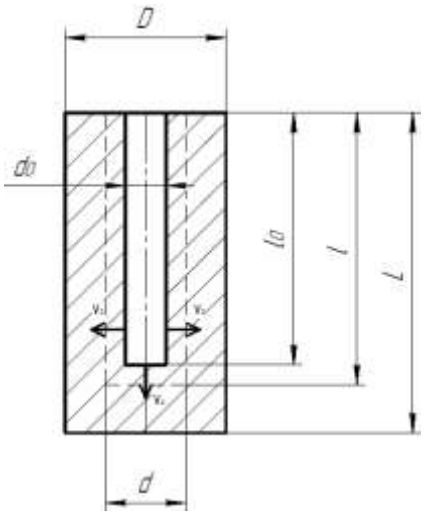

fig.1 Fuel charge: D-outer diameter of the charge; d0-starting diameter of channel; d-actual diameter of channel; L-length of the charge; l0-starting length of channel; l-actual length of channel; Vr-burning speed.

Taking into consideration these assumptions, the actual value of the mass of burned fuel can be described by the dependence (1.1) [1, p. 274]

$$m_{сгт} = \rho\left(\frac{\pi d^2}{4} l - \frac{\pi d_0^2}{4} l_0\right) \quad (1.1)$$

Where ρ – fuel density, g/mm^3. d, l – actual value of the diameter and the length of the channel. d_0 и l_0 – starting value of the diameter and the length of the channel.

The actual value of the diameter and length of the channel can be described by the dependences (1.2) and (1.3).

$$d = d_0 + 2V_r t \quad (1.2)$$

$$l = l_0 + V_r * t \quad (1.3)$$

Substituting (1.2) and (1.3) into (1.1) and differentiating the result, we obtain the value of the mass fuel consumption:

$$\frac{dm_{сгт}}{dt} = \rho(\pi d_0 V_r \left(\frac{d_0}{4} + l_0\right) + 2\pi V_r^2 t(d_0 + l_0) + 3\pi V_r^3 t^2) \quad (1.4)$$

Knowing the mass fuel consumption, and having set some effective exhaust velocity, we can determine the value of the vacuum thrust at any given time by the dependence (1.5).

$$P_п = \rho\left(\pi d_0 V_r \left(\frac{d_0}{4} + l_0\right) + 2\pi V_r^2 t(d_0 + l_0) + 3\pi V_r^3 t^2\right) * \omega_e \quad (1.5)$$

By the dependencies (1.1-1.5), the program calculates thrust at any given time and draws a graph of the theoretical dependence of thrust on time.

To compare the theoretical calculations with the practical values of the thrust of the engine, model of the rocket engine was designed. (fig 2.)

Today several prototypes of engines have been created which were tested on a load-measuring stand. The practical fuel combustion rate was determined, its value is 6,8 mm/s and practical exhaust velocity were found out. Its value is 640 m/s. [3, p. 18].

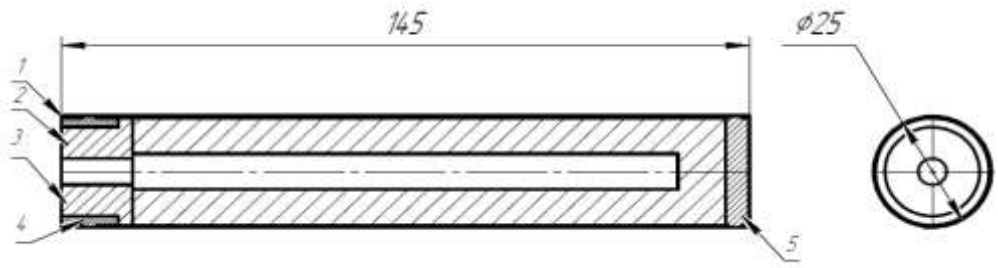

fig 2. Engine: 1-body; 2-nozzle block; 3-epoxy;
4-fuel charge;5 –back wall

The graph of theoretical and practical thrust is shown in Figure 3.

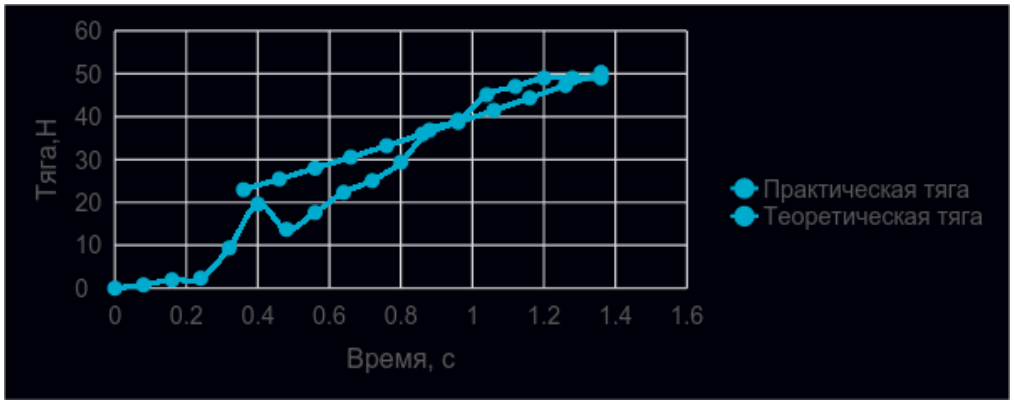

fig. 3. The graph of the dependence of theoretical and practical thrust on time

Thus, the algorithm for designing MRE and the program for its calculation were developed. It can be seen from the presented data. Theoretical calculations are close to practical data. The received program allows to design the engine with the specified characteristics for a short time, thereby saving the material resources is necessary for practical tests, and allows to use calculations in other programs to simulate the flight of a rocket.

References:

1. V.E. Alemasov, A.F. Dregalin, A.P. Tishin. *Ucheb. posobie. / Pod red. Glushko V.P.* - Moscow: Mashinostroenie, 1989. 464 p. (In Russ.).
2. Gorskiy V.A., Krotov I.V. *Raketnoe modelirovanie. Metodicheskoe rukovodstvo dlya vneshkolnoi i vneklassnoi raboti po raketno-kosmicheskomu modelirovaniyu* [Rocket modeling. Methodological guide for after-school and extracurricular work on rocket-space modelling]. - Moscow: Izd-vo DOSAAF, 1973, 193 p. (In Russ.).
3. N.A. Testoedov, V.V. Kolga, L.A. Semenova. *Proektirovanie i konstruirovanie ballisticheskih raket i raket nositelei*: *uchebnoe posobie* [Ballistic rockets and carrier rockets engineering and designing]. - Krasnoyarsk: SibSAU, 2014, 308 p. (In Russ.).