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THE PROGRAM FOR CALCULATION OF THE MAXIMUM FLIGHT ALTITUDE OF THE ROCKET MODEL

The algorithm and the program for calculating the maximum flight altitude of the rocket model are presented in the article. The results of theoretical calculations with practical results are compared.

Keywords: *altitude of flight, model of rocket, calculation program.*

Nowadays there is an active development of rocket-model sport throughout the world. But there still exist the range of problems at design process, including selection of the optimum parameters for the most effective use of opportunities of the propulsion system, and achievements of the maximum flight altitude. And now they are being solved. However, this process is very labor-consuming. In the course of designing it is necessary to change repeatedly a design of the rocket and to anew the calculations made. It takes a lot of time.

The purpose of this work is the development of the program allowing calculating active and passive sites of the rocket's flight, to receive kinematic characteristics and to find the maximum flight altitude of the rocket.

When calculating, the following assumptions were accepted:

- the rocket flies vertically up;
- the weight force, force of front resistance and a vector of pull-rod of the engine are on one shaft;
- other forces are neglected;
- parameters of the atmosphere are accepted according to the values of the international standard atmosphere. [3, p. 76]

For the calculation, the program needs the following parameters to be introduced:

MT – the mass of the fuel, M0 is the dry mass of the rocket, tk – time of engine operation, Sa – the area of the nozzle, Sm – square middleware section.

After setting the initial parameters, the program starts the calculation according to the following algorithm:

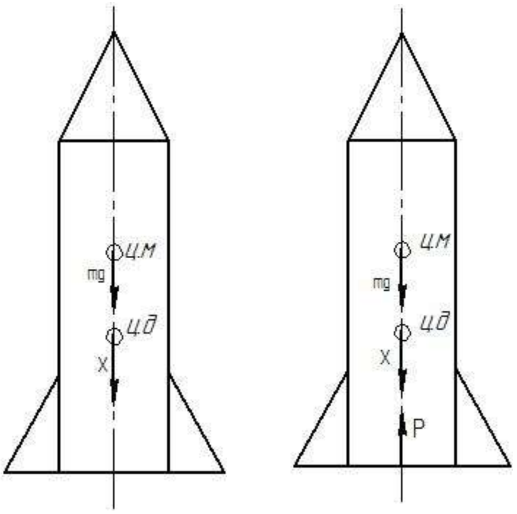

fig. 1. The scheme of forces operating on the rocket during the active and passive site of flight.

The equation of forces in a projection to a longitudinal shaft of the rocket:

$$m\frac{dv}{dt} = P - X - mg \qquad (1)$$

Here P – the current pull-rod of the engine. It is necessary to consider influence of barometric pressure upon a nozzle cut for obtaining of the current pull-rod .

Thus:

$$P = P_{п} - Sa * p_a \tag{2}$$

Here Sa is the area of the nozzle exit, pa is the pressure at the current altitude value is selected by program automatically depending on the height, in accordance with the values of the atmosphere international standard.

$$X = C_x * \frac{\rho V^2}{2} * S_m \tag{3}$$

X – force of drag.

Cx – the drag coefficient is chosen by the approximate dependencies, depending on the Mach number. ρ is the air density at the current altitude. V is the current speed. Sm – square middleware section.

To solve the equation analytically (1), in the view of the variable nature of action of all forces and also change of weight, it is impossible therefore to realize the iterative method of calculation in the program. For each time point it is possible to define:

$$dv = \frac{P - X - mg}{m} dt \tag{4}$$

$$V_i = V_{i-1} + dv \tag{5}$$

$$S_i = S_{i-1} + V_{i-1} * dt \tag{6}$$

Thus, the program starts the calculation with the moments of time t0=0 in which V0=0, S0=0, and generates data sets Vi and Si as in (4-6), up to some time tk, the time of operation of the engine. After that, the program calculates according to the following dependencies:

$$dv = \frac{-X - mg}{m} dt \tag{7}$$

$$V_i = V_{i-1} + dv \tag{8}$$

$$S_i = S_{i-1} + V_{i-1} * dt \tag{9}$$

The calculation is conducted until it is carried out the requirement: 0≤Vi. In the time point when this requirement ceases to be satisfied, the program finishes the calculation, and takes Si-1 for the maximum height. It builds schedules of height and speed depending on time. [1, p. 33]

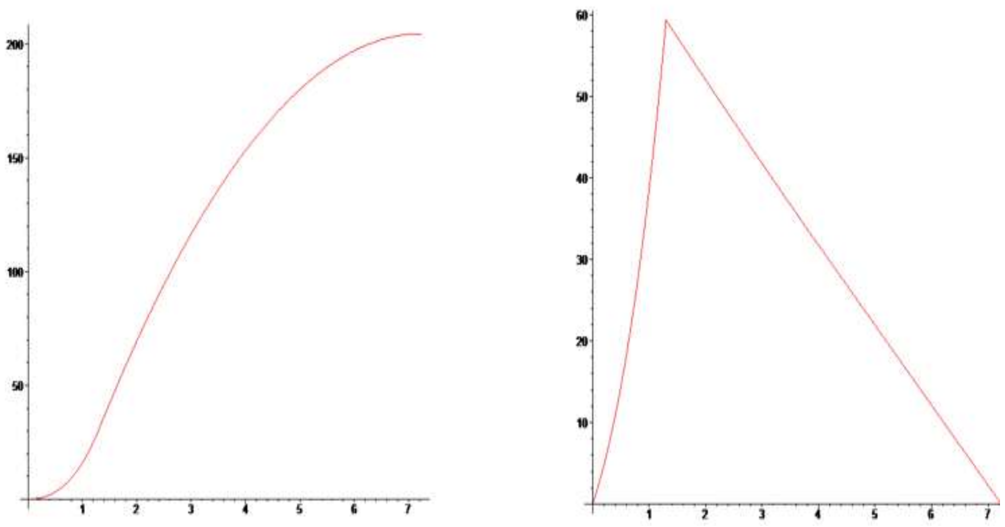

Fig. 2. Graphs of the estimated altitude and speed from time to time.

The result of this work, the software, was developed to be able to determine the maximum altitude, and the intermediate kinematic parameters on the active and passive parts of the rocket. The obtained results were compared with practical ones. [2, p. 56]

So, for a rocket with a dry mass 256г, and the outside diameter of the rocket body 26mm the theoretical value of the maximum altitude 204m was obtained. The practical result was obtained with the start model rockets, with specified characteristics, made 172м. Deviations of this value from theoretical can be connected with a row a factor, the most essential of which, is considerable losses of energy at the movement on guides of a launching table.

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