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Letters to the Editorial Board

On the Possibility of Obtaining an Orbital Rocket of the Ultra-Light Class by Installing an Upper Stage

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Abstract

The paper analyzes the possibility of replacing the payload of a geophysical rocket with a second stage to obtain an ultra-light orbital rocket. The single-stage rocket MN-300 was chosen as a basis, for determining the necessary parameters of which a general design of a similar rocket was carried out. The result was a single-stage geophysical rocket with a payload mass of 200 kg and a lift altitude of 300 km. After detailed development, it was possible to obtain a rocket with a launch mass of 995.6 kg and a lift altitude of 353.8 km, which is slightly better than the analogue. But even in such a rocket, the installation of the second stage instead of the payload did not provide the ability to launch a micro-satellite into orbit.

Keywords: micro-satellite, geophysical rocket, analogue, launch into orbit.

1. Introduction

Geophysical rockets are unmanned systems flying along a ballistic trajectory in the upper atmosphere for research purposes. They are used to measure parameters that are inaccessible to ground stations, balloons or satellites. They can take measurements at high altitudes, such as temperature, gas concentration, wind speed and direction, etc. Geophysical rockets are currently one of the most reliable methods for direct (contact) research of the atmosphere, studying climate and geophysical processes. They also contribute to the development of new technologies and methods for monitoring climate change. These data are necessary for accurate weather forecasts, warnings about natural disasters, as well as for scientific research in the field of climate and ecology. A geophysical rocket with a payload mass of 200 kg and a lift altitude of 300 km (analogous to the MN-300 rocket) was chosen as the object of study. Particular attention was paid to the possibility of using the payload as an additional stage for launching a microsatellite into orbit.

2. Materials and methods

Based on the methods of general design of geophysical rockets, the appearance of the rocket was determined in accordance with the technical specifications. As materials for the study, typical

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elements and materials were selected, the use of which is recommended for the design of rockets of this class.

3. Discussion

A large number of works that have appeared in recent years are devoted to the problems of designing an ultra-light geophysical rocket. These are mainly small notes that give only the most general idea of the rocket (Saltykov et al., 2024), (Khaltaeva, 2023). But there are also more detailed descriptions (Komissarenko et al., 2017). Sometimes the description of the rocket itself is given in the context of the geophysical problems it solves (Kuminov et al., 2021; Song et al., 2024). In general, the works discuss both single-stage and multi-stage (usually two-stage) rockets, usually with a vertical launch.

Geophysical rockets were considered as the closest analogues, the characteristics of which are summarized in Table 1. As can be seen, the proposed rocket is an analogue of the MN-300, in which the payload mass is increased by 50 kg, so that it can accommodate a heavier orbital stage.

Table 1. Analogues of the proposed rocket

Rocket	Launch weight, kg	Payload, kg	Lifting altitude, km
MR-12	1600	250	180
MR-20	1620	100	230
MN-300	1560	150	300

4. Results

Among the analogs there are both single- and two-stage rockets. After preliminary calculations it was established that the required parameters can be achieved in a single-stage version. The selected design and layout scheme of the designed rocket is shown in Figure 1.

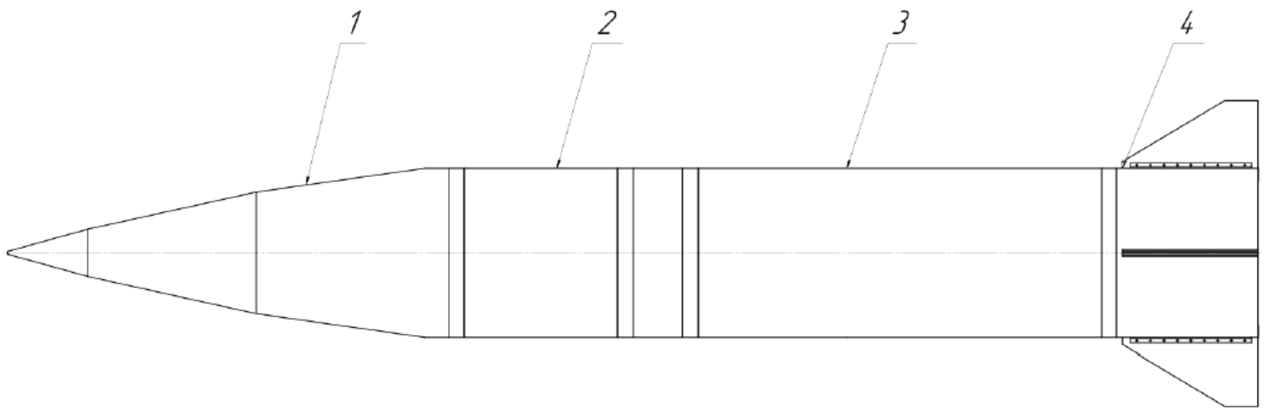

Fig. 1. Structural layout diagram of the designed missile:
1 – head-part; 2 – parachute compartment; 3 – propulsion system;
4 – tail compartment with empennage

To facilitate the design, all the main calculations were output to the Mathcad package. After that, the midsection diameter was concluded to be from 0.45 to 0.50 m with a step of 0.01 m. The starting mass varied within the range from 1000 to 1500 kg with a step of 100 kg. The pressure in the combustion chamber was calculated from 7 to 10 MPa with a step of 1 MPa. For selected type of fuel with a single pulse of 210 s. and the parameters of the channel-slot charge are obtained as follows: the midsection diameter is 0.5 m, the starting mass is 1000 kg., the pressure in the combustion chamber is 8 MPa. They are the ones that provide support the maximum for the lift height. For the Standard atmosphere (GOST 4401-81), it was 353.8 km, which is 53.8 km more than preassigned the technical specifications.

More careful design made it possible to adjust the value of the launch mass, which was equal to 995.6 kg, the fuel mass was 668 kg, the engine operating time was 23 s, and the total length of the rocket was 4.85 m.

However, various versions of the second stage within the allotted 200 kg launch mass did not give satisfactory results in terms of the possibility of launching a micro-class satellite into orbit. In all the considered versions, the first cosmic velocity was unattainable.

5. Conclusion

Since all the necessary parameters for assessing the possibility of replacing the payload of the MN-300 rocket with the second stage for launching a micro-satellite into orbit are not known, a similar rocket was designed. As a result, it turned out to have a launch mass of 995.6 kg and a lift altitude of 353.8 km, which is slightly better than the analogue. But even such a rocket, installing the second stage instead of the payload does not provide the possibility of launching a micro-satellite into orbit.

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