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The use of pyrotechnic composition for dispersing fairings during atmospheric re-entry

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Abstract

Considered alternative technical solutions for solving the allocation of the impact area for the leaf of the payload fairing of launch vehicles, including technology-based aerodynamic manoeuvres (different types of parachute systems) and the burning of the segment of the payload fairing with the use of pyrotechnic composition (PC). Conducted formulation studies of the thermal stress and strength in the process of its motion during the atmospheric phase of the trajectory of the descent in summing up additional heat from the initiation of PC. Adduced the mathematical methods and models for solving the formulated problem. Proposals for experimental facilities based on University research and education laboratory.

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Keywords: payload fairing; pyrotechnic compositions; aerodynamics; thermostability.

1. Introduction

Dropping the leaf of the payload fairing (LPLF) in selected areas of the surface of the Earth is a source of economic, environmental and social problems. After separation from the launch vehicles (LV) of the LPLF not burning up in the atmosphere, due to the stochastic nature of the motion and requiring the allocation of significant areas of the impact areas, which are 3-5 times higher than the impact areas of the exhaust stages LV.

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Calculating the control program insertion LV to ensure the fall of the LPLF in the highlighted areas leads to a substantial reduction of the payload mass (up to 10%). The cost of post-commissioning activities associated with the withdrawal from the economic turnover of these territories, searching, cutting, export, LPLF disposal, reaches 5% and more of the cost of the launch, and the problem is exacerbated by the location of these areas in different administrative-territorial regions.

Currently the known technical solution which provides almost a complete lack of the impact areas of the used stages of LV, for example, the flight development tests conducted for a soft landing first used in the launch vehicle USA "Falcon-9" [1], spacecraft “Sheppard” [2] and the project called "the Russian" [3]. In the development stage of the "Baikal" project [4], which considered the provision of a controlled aerodynamic descent of the used stage of the "Angara" in a given area relative to the launch site.

However, the use of technology to reduce the acreage of impact areas caused by spent stages LV [1-4] does not solve the problem of the impact areas of LPLF.

Fig. 1 shows a standard design fairings LV, the dimensions of which can exceed the diameter of the stages LV (e.g., for LV of family "Souz"), and the height to 10 m and more.

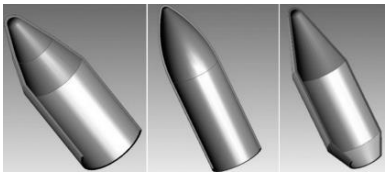

Fig. 1 Typical leaves of the payload fairing

For making modern payload fairings LV composite polymer materials are used, forming a three-layered structure consisting of aluminium honeycomb covered on both sides by carbon fiber (Fig. 2).

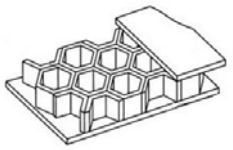

Fig. 2 Three-layered panel with cellular filler

Conducted search for patent information, which revealed several lines of research, aimed at reducing the areas of impact areas of the LPLF for the modern LV. They can be divided into 2 main groups:

- Aerodynamic braking using a variety of systems reducing dispersion;
- The burning of the LPLF during its movement on the trajectory of the descent through the dense atmospheric layers.

The first method includes:

- The application of an aerospace parachute system which provides a focused entrance LPLF in dense layers of the atmosphere with simultaneous damping of hypersonic speed. Reduce the aerodynamic and thermal loading on the design of the LPLF to prevent the destruction starting from the moment of separation from LV and until the landing and subsequent evacuation, as a whole from the landing site [5].
- Application of the supporting planes (wings) during the descent in the dense layers of the atmosphere; [6]