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ANALYSIS OF APPROACHES TO ENSURING THE RETURN OF A SEGMENTAL-CONICAL SHAPE RE-ENTRY VEHICLE FROM A LUNAR ORBIT WITHOUT DESTRUCTION OF THE THERMAL PROTECTION COATING

Abstract

A spacecraft returning from the lunar orbit approaches the Earth atmosphere at a near-parabolic velocity. Entry into the atmosphere at that speed is accompanied by high-intensity thermal loads, much higher than the thermal loads encountered during the descent from the orbit of an artificial Earth satellite.

Thermal impact on the descent vehicle's surface can be reduced by reducing the speed at which it enters dense atmosphere. If not using descent engines, the same effect may be achieved by charting trajectories with multiple atmosphere entries. In that case, after the vehicle first passes the Earth atmosphere, its orbit would look like an ellipsis with the apogee getting progressively lower on repeat reentries. Short duration and low depth of the device's immersion in the upper atmosphere serve to incrementally reduce its speed.

Although multiple entry trajectories reduce thermal flow intensity, the relatively low heat transfer properties of the traditional heat shield materials and uneven thermal load distribution around the descent vehicle's outer surface, occurrence of local spots of extremely high temperature is possible. If those temperatures exceed the material's heat threshold, the material fails.

High tangential heat transfer properties of the heat shield help distribute heat more evenly over the vehicle's surface. At the same time, the material should have relatively low lateral heat transfer properties in order to avoid overheating the vehicle's internal compartments. Those are properties of heat shield materials with high heat transfer anisotropy.

In this paper, the options for combined use of anisotropic heat shield materials and multiple entry trajectories to ensure return of segmental-conical spacecraft (Soyuz, Apollo, etc.) from lunar orbit without destroying their heat shield coatings, thus improving reliability of the spacecraft in question was analyzed.