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Moon Exploration – Part 2 (2B)

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ANALYSIS OF APPROACHES TO ENSURE THE RETURN OF DESCENT VEHICLES OF VARIOUS TYPES FROM LUNAR ORBIT WITHOUT DESTRUCTION OF THEIR HEAT SHIELD COATING

Abstract

Unlike orbital vehicles, a vehicle returning from the Moon approaches the boundary of the Earth's atmosphere at a local parabolic velocity. As a result, along the atmospheric part of its trajectory, the descent vehicle is subject to highly intensive heat stresses.

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.

This paper presents a comparative analysis of the possibility and effectiveness of using the above-described approaches to return descent vehicles of various classes from the lunar orbit without destruction of their heat shield coating, which improves the reliability of the vehicles under consideration. We have considered spherical vehicles of the ballistic class, semi-ballistic (sliding descent) vehicles of a segmentally conical shape, which feature a hypersonic lift-to-drag ratio within a range of 0.15 to 0.5, and lifting body class vehicles, that is, vehicles with a hypersonic lift-to-drag ratio of 0.8 to 1.5.