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Author: Dr. Victor Leonov
Bauman Moscow State Technical University, Russian Federation, lv-05@mail.ru

ANISOTROPIC COMPOSITE HEAT-SHIELDING MATERIALS BASED ON GLASSY CARBON AND PYROLYTIC GRAPHITE: ANALYZING EFFECTIVENESS IN CASE OF A RE-ENTRY MODULE OF A LUNAR PROBE

Abstract

When returning from the lunar orbit, a spacecraft approaches the Earth's atmosphere at a parabolic velocity. Its entry into the atmosphere at this velocity is accompanied by high-intensity thermal loads, which significantly exceed the ones occurring during the descent of an artificial Earth satellite from its orbit. This factor demands higher standards regarding the vehicle's heat shield coating.

This paper presents our analysis of the thermally stressed state of the multilayer anisotropic heat shield coating of a reentry module of a lunar probe. The outer heat shield coating is made of SU-2500 glassy carbon, which can withstand temperatures up to 2500 K. For the middle or basic layer, we have selected a composite material with a matrix of isotropic glassy carbon and inclusions of UPV-1T grade anisotropic pyrolytic graphite, which can withstand temperatures up to 2200 K. The inner heat shield layer is made of TZMK-10 isotropic fibrous heat-insulating material and is fastened to the titanium pressure shell of the sealed module. The outer heat shield is covered with a thin layer of anti-oxidation coating.

Our studies have shown that the use of a material with a high degree of anisotropy (defined as the ratio of thermal conductivity in the tangential direction to thermal conductivity in the normal direction) as part of a heat shield package allows to evenly redistribute the heat energy supplied through the outer coating surface over the entire volume of the anisotropic layer. This, in turn, allows to reduce the temperatures and stresses at the most stressed points and to avoid destruction of the heat shield coating material during the descent.