IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advanced Materials and Structures for High Temperature Applications (4)

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ANISOTROPIC HEAT-SHIELDING MATERIALS: EVALUATION OF EFFECTIVENESS IN CASE OF A RE-ENTRY MODULE

Abstract

The materials traditionally used in the creation of heat-shielding coatings for re-entry module are characterized by low thermal conductivity. This circumstance, due to the uneven high-temperature heating of the heat-shielding coating surface, leads to the occurrence of areas with an increased temperature. When the temperature exceeds the permissible values for the material used, the heat-shielding coating begins to deteriorate. One of the ways to mitigate the negative effect of intense local heating on the heat-shielding coating performance is to use a material with a high degree of thermal conductivity anisotropy or anisotropic heat-shielding materials.

Studies have shown that the manufacture of a heat-shield from an anisotropic heat-shielding material only, for example, from pyrolytic graphite, is ineffective for large-sized vehicles. For such vehicles, it is more efficient to use multilayer heat shield. In such embodiment, the isotropic inner layers with a low thermal conductivity serve as a barrier on the path of the heat flow to the load-bearing part of the structure. At the same time, the anisotropic outer layer with an extremely high thermal conductivity ensures the redistribution in the tangential direction of the thermal energy supplied through the outer surface of the coating.

The paper analyzes several options for anisotropic multilayer heat-shielding coatings with different structures and layer thicknesses, evaluating their efficiency in comparison with traditional heat-shielding coatings. Various types of vehicles and options for their reentry without destruction of the anisotropic heat-shielding coating are considered.