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THERMALLY AND DIMENSIONALLY STABLE STRUCTURES OF CARBON-CARBON LAMINATED COMPOSITES FOR SPACE APPLICATIONS

Abstract

It is well known that panel and shell sandwich structures made of polymeric composite materials based on carbon fibers are widely used for the items meant for long-term operation in the near-earth orbits, that is, items for telecommunication, remote sensing systems and for use as dimensionally stable supports of highly-sensitive transceivers.

Structural designs including carbon honeycomb plastic (CHP) are finding ever-widening applications. CHP when compared to other types of honeycombs features the highest specific indices of strength and stiffness, in combination with minimal linear thermal expansion coefficients (LTEC) which provide for high level of dimensional stability at cyclic effects of temperature within the limits of 70 .

However, polymeric binder in the structures of that class not always satisfies ever-increasing requirements to the range of their operating temperatures. Therefore, analysis of opportunities of using carbon-carbon composite materials in such structures is of great practical interest.

The paper reveals the preconditions of using carbon-carbon composite materials of laminated structure which are obtained by processing of finished products of carbon fiber reinforced plastic by carbonization in the furnace with non-oxidizing medium at high temperatures. It is shown that obtained items get a possibility of operation in the temperature range corresponding to and considerably exceeding the conditions of operation of objects in near-earth orbits with the allowable level of change in their shape and pre-stress providing for specified service life.

We synthesized approximate dependencies of physical-mechanical and strength characteristics of obtained carbon-carbon composite material on the basis of the theory of reinforcement of polymeric composites' mechanics, with the use of which finite-element analysis of the degree and the nature of change of thermal and dimensional stability of polymeric composite structure after its carbonization and turning into carbon-carbon composite material has been carried out.

With the use of approximate criteria of optimization of carbon-carbon composite material structure ensuring its maximum dimensional stability, the package with orientation of the group of thermononequilibrium layers of (0^o,45^o,90^o) has been investigated compared to analogs of carbon fiber reinforced plastic, which provides for high bearing capacity and service life thereof.

Pre-stress, thermal non-equilibrium state and shape stability of skins of panels made of carbon-carbon composite materials compared to analogs of carbon fiber reinforced plastic have been analyzed. It is found that pre-stress of skins of carbon-carbon composite materials both for various structures and for various thicknesses of monolayers is considerably lower compared with that of carbon fiber reinforced plastic.