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«Carbon-carbon composite material based on pitch matrices with improved physical and mechanical characteristics»

Abstract

Relevance of the research topic. Due the high rate of modern development of science and technology its need to create multifunctional materials with a high level of properties and performance characteristics.

Carbon-carbon composite materials are the most promising materials that are used in almost all industries and various fields of technology. It is possible to obtain carbon-carbon composite materials with different properties by changing the technological operations and their sequence, as well as using different types of raw materials.

The use of carbon-carbon composite materials is economically advantageous, since products made from these materials, having high performance characteristics in wide temperature ranges, also have a lower specific gravity.

Experience in the production and use of carbon-carbon composite materials shows that the use of pitches as a matrix allows for changes and control of the properties of the composite. It seems promising to study the dynamics of changes in the properties and structure of carbon-carbon composite materials on pitch matrices after passing through technological stages of production and, based on the results obtained, to determine the possibility of ensuring higher and more stable physical, mechanical and thermal characteristics than in traditionally used technological modes.

The aim of the work is production of carbon-carbon composite material based on pitch matrices and a carbon fiber frame, characterized by higher and more stable physical, mechanical and thermal physical characteristics than the material obtained using traditional technology

Tasks:

1) identify the main technological stages of production of carbon-carbon composite material that have the greatest impact on their structure and properties;

2) evaluate and propose the most suitable non-destructive testing methods for carbon-carbon composite material based on pitch matrices and a reinforcing frame made of carbon fiber;

3) establish technological modes of production of carbon-carbon composite material based on pitch matrices and a reinforcing frame made of carbon fiber that ensure their high and stable physical, mechanical and thermal characteristics;

4) evaluate the degree of impact on the structure and properties of the material under consideration of additional cycles of compaction with pyrolytic carbon.

Scientific novelty:

1) for the considered material based on a carbon fiber framework and a pitch matrix, the main contribution to the formation of the structure is determined not by the interaction of fiber crystallites and the matrix mesophase, but by the modes of technological processes: impregnation and carbonization under pressure and subsequent high-temperature treatment;

2) for the considered carbon-carbon composite material based on a fibrous framework and a pitch matrix, the influence of the contribution of the properties of the fiber-matrix interface on the strength characteristics was identified and substantiated;

3) a kinetic model of the deposition rate of the pyrocarbon layer on the surface of the carbon fiber was obtained, describing the change in the mass and thickness of the layer in a wide range of variation of the deposition duration.

Theoretical and practical significance:

1) a mode of impregnation and carbonization under pressure has been developed and patented, allowing to obtain a material matrix with a smaller number of microdefects;

2) a choice of the finishing temperature of high-temperature treatment of carbon-carbon composite material based on a carbon fiber frame and a pitch matrix has been substantiated, allowing to obtain blanks with increased strength characteristics;

3) a method of non-destructive testing of a product for indirect determination of the strength characteristics of the material by measuring its hardness has been proposed;

4) a method of monitoring the degree of improvement of the structure of the carbon-carbon composite material under consideration using Raman spectroscopy has been proposed;

5) The database of information on the relationship between the properties of the material and the technological conditions of carbon-carbon composite material production has been expanded, which makes it possible to predict the structure and physicochemical properties of the material.

Statements submitted for defense:

- a method for selecting the temperature of the final high-temperature treatment to ensure higher and more stable physical and mechanical characteristics;

- application of Raman spectroscopy as a method for recording deviations in the technological mode of carbon-carbon composite material production, in particular, determining the temperature of the final heat treatment based on structural changes in the material;

- the mode of impregnation and carbonization under pressure of carbon-carbon material based on a carbon fiber frame and pitch matrix;

- a kinetic model of pyrolytic carbon deposition on the surface of carbon fiber.