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HIGH-POROUS AEROSPACE MATERIALS: IDENTIFICATION AND PREDICTION OF PHYSICAL PROPERTIES

Abstract

Light high-porous materials are widely used in thermal protection systems of spacecraft and other aerospace applications. Usually, the study of their properties is provided through corresponded physical experiments. Such an approach is possible only with the existed material's specimens. In doing so the potentiality to determine and predict of many properties of a material under development is critically limited or even eliminated without the mathematical simulation methods. The main purpose of this study was to confirm operability and effectiveness of the complex methods developed for theoretical prediction and experimental-computational determining physical, in particular, thermal properties of modern high porous materials. The physical and mathematical models of heat transfer processes in the experimental specimens of high-porous material are presented. Irregularity, local heterogeneity and anisotropy of materials essentially constrict a choice of possible approaches to mathematical simulation of their structure and properties. The basis for the method proposed is the direct mathematical simulation for global structure of the complex irregular systems each being determined by the property of local regularity. The characteristics of global and local models have been developed for such materials. In the framework of this approach a number of direct statistic models were developed on the basis of orthogonal local regular random heterogeneous system both for the fiber high porous materials and light-weight foamed carbon materials. Particularly, our study revealed that these models make possible to obtain and to predict such effective material's properties as radiation and molecular thermal conductivities, energy accommodation coefficient, complex refractive index, scattering indicatrix, scattering and absorption factors, etc. In the proposed approach these properties are determined both from direct simulation and inverse problems solving. An experimental-computational system for study of the thermal properties of composite materials by methods of inverse heat transfer problems is also considered. The most promising direction in further development of methods for non-destructive diagnostics of high-porous materials using the procedure of inverse problems is the simultaneous determination of a combination of thermal properties. The general method of iterative regularization is concerned with application to the estimation of materials properties. Such problems are of great practical importance in the study of material properties used as non-charring thermal protection shields in objects of space engineering, power engineering, etc.