Paper ID: 29105
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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Specialised Technologies, Including Nanotechnology (8)

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HIGHLY POROUS THERMAL PROTECTION MATERIALS: MODELING AND PREDICTION OF THE METHODICAL EXPERIMENTAL ERRORS

Abstract

Thermal modes of structures functioning in extreme temperature conditions always have a great research interest. Solution to such problems is connected with necessity in creation of methodology for properties detailed investigation of existing materials and, sometimes, in creation of the new materials. Detailed research on materials properties is related to the thermal experiment. That's why the creation of the new materials and optimization of existing ones connected not only with the development and application of advanced identification experimental methodology but with effective mathematical modeling tools. Creation of higly-porous composite materials is one of a new and promising direction of materials sciences. Meeting the challenges of multilevel properties identification of such materials, application of the inverse problems theory for their thermal characteristics reconstruction with respect to the results of an experimental study of non-stationary thermal state of the samples requires the reliable tools for thermal experiment. The contact temperature sensors, thermocouples, are often used in thermal tests. In this connection there is the task of developing the methodology for verification and prediction of thermocouple error. Developed in the frame of this work the experimental and theoretical methodology for complex data acquisition of unsteady thermal state of the sample of heat-shielding materials was proposed to test on a well-studied material TZMK, whose properties are close to the reticulated material. As part of these studies the continuum mathematical model of radiation-conductive heat transfer in a sample of partially transparent material was proposed. The combined grid numerical method of alternating directions with the implicit approximation at each fractional step is proposed and tested on the known analytical solutions and a simple three-step numerical method for solution to the kinetic problem of radiation transfer in a plane layer of the partially transparent material is developed. The comparison with analytical solutions and analysis of the behavior of the residual of kinetic equation confirm the high reliability and accuracy of the developed numerical methods. Thermal tests of TZMK samples using the original developed experimental and theoretical methods were carried out. According to the results of the comparative analysis of mathematical and experimental study the main mechanisms that affect the methodical errors of thermocouple are fined out and recommendations for their compensation are given.