MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Specialised Technologies, Including Nanotechnology (8)

Author: Mr. Andrey V. Netelev
Moscow Aviation Institute (State Technical University), Russian Federation

Prof. Oleg Alifanov
Moscow Aviation Institute, Russian Federation
Mr. Sergey Budnik
Moscow Aviation Institute, Russian Federation
Prof. Aleksey V. Nenarokomov
Moscow Aviation Institute, Russian Federation

ESTIMATING OF EXTERNAL HEAT FLUX FOR ABLATIVE THERMAL PROTECTION OF SPACECRAFT BY INVERSE PROBLEMS TECHNIQUE

Abstract

In many practical situations it is impossible to measure directly heat fluxes at the external surfaces of thermal protection systems (TPS) of spacecraft, especially when the ablative materials are used as external layer of the TPS. The only way that can often be used to overcome these difficulties is indirect measurements. This type of measurements is usually formulated as the solution of inverse heat transfer problems. By solving such inverse problems, the boundary conditions and unsteady temperature field are reconstructed from interior temperature distribution in solids. Such problems are ill-posed in mathematical sense and their main feature shows itself in the solution instabilities. That is why special regularizing methods are needed to solve them. Presently, heat and mass transfer in ablative materials are being studied intensively. This interest is associated with the important practical applications of the results of these investigations in aerospace technology, chemical technology, and other fields. But traditional measurements of the heat flux made to solve this problem are currently based on the use of a calorimetric method or the thin-wall method. However, the basic deficiency of these methods in the considered conditions is the requirement of conservation of the calorimeter mass or the wall thickness in the course of the experiment. This significantly limits the measurement time, since with the prolonged action of a flow on a calorimeter or a thin wall ablation breakdown begins. As a result, these methods cannot easily take account of the influence on the heat transfer of factors such as internal decomposing of the materials. The goal of this paper is to estimate the heat flux at the external surface of TPS structure. Therefore it should combine the result of external convective and radiative heat fluxes, irradiation from the surface and thermal effect of external ablation of the material. Also the mathematical model of thermal kinetics is used for analysis of internal heat transfer in TPS. An algorithm and results of numerical-experimental study of heat transfer in a specimen of ablative materials are presented. The unknown heat fluxes at the external surface of specimen are determined by inverse problems of heat transfer technique using the iterative regularization method. The new technique under development is the combination of accurate enough measurements of thermal quantities which can be experimentally observable under real conditions and accurate data processing, which are based on the solutions of inverse heat transfer problems.