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Author: Mr. Yang Tianyang
Moscow Aviation Institute (National Research University, MAI), Russian Federation,
orange.tianyang@gmail.com

Prof. Oleg Alifanov
Moscow Aviation Institute, Russian Federation, o.alifanov@yandex.ru

IDENTIFYING NON-LINEAR HEAT TRANSFER STATES OF A SPACECRAFT'S HEAT SHIELD DURING ITS ENTRY INTO THE ATMOSPHERE BY USING THE COMPARATIVE TEST METHOD

Abstract

When a space vehicle enters the Earth's atmosphere at hypersonic speeds, its intensive braking occurs, as a result of which large aerodynamic heat fluxes act on its surface. In order to correctly and reliably design the thermal protection system (TPS) of the space vehicle, it is advisable to identify the design mathematical models of heat exchange on the surface and inside the heat shielding materials during the relevant ground experiments and tests. In the most critical cases, the study of the thermal properties of the prototype TPS by flight tests is carried out. When conducting flight tests, in order to obtain information on the functional characteristics of TPS under actual conditions of descent in the atmosphere, it is necessary to monitor changes on a number of thermophysical parameters in the largest possible part of the descent trajectory. Since the velocity and altitude of the space vehicle during flight tests are unsteady and sometimes significantly variable, changes in the parameters of heat transfer and thermal properties of materials will also change intensively and non-linearly during descent in the atmosphere. To monitor the parameters that determine the heat transfer process on the surface of a space vehicle, such as the coefficients of convective and radiation heat transfer, as well as the surface catalytic activity of TPS, the comparative test method based on the solution of the boundary inverse heat conduction problem can be effectively used. Based on the results of last year's research, the solution of the problem by using comparative test method in the case of a non-linear thermal conductivity model is further discussed to determine the changes of the most significant parameters mentioned above. In this case, the non-linear heat transfer model should correspond to the conditions of the actual flight tests of the space vehicle. This paper also deals with the non-linear two-dimensional inverse boundary heat transfer problems for some relatively simple cases, which have been successfully applied to reconstruct boundary heat fluxes. These calculations will allow designers to obtain the necessary heat transfer parameters in some special areas of the space vehicle, such as the area of the leading edge of the wing, and this issue will be discussed in detail in the next article.