IDENTIFICATION AND VERIFICATION OF MATHEMATICAL MODELS IN THE PROCESS OF THERMAL DESIGN AND TESTING THE AEROSPACE VEHICLES (PLENARY LECTURE)

O.M. Alifanov

Moscow Aviation Institute (National Research University), Russian Federation, oleg.alifanov@mai.ru, mailing address: Volokolamskoe shosse, 4, Moscow, 125993

ABSTRACT

The lecture deals with various aspects of the theory and methodology of inverse heat transfer problems in relation to thermal design and testing of aerospace vehicles. The lecture includes the topics listed below.

A little about the history and formulation of inverse problems as identification and verification problems of mathematical models and diagnostics of heat transfer processes.

Generalized classification of inverse heat transfer problems.

The violation of the classical conditions of well-posedness in the formulation of inverse problems. Regularization of solutions of ill-posed inverse problems.

Brief theory of iterative regularization and construction of iterative algorithms for solving inverse heat transfer problems.

Identification and verification of mathematical models at different stages of the design life cycle.

Examples of the use of boundary heat transfer inverse problems for “the black box” research:

- Measurement of heat fluxes along the axis of the high-temperature free jet for testing heat-shielding materials in transient conditions.
- Investigation of heat transfer intensity in supersonic heterogeneous (two-phase) flows.
- Study of heat fluxes on the surface of models of aerospace vehicles during tests in the hypersonic wind tunnel with magnetogasdynamic flow acceleration.
- Study of reusable heat-shielding tiles during flight tests of the re-entry vehicle «Bor-4».

Examples of the use of boundary heat transfer inverse problems for “the gray box” research:

- Simulation of laminar, transient and turbulent flow regimes in one experiment.
- Identification of the heat balance equation on the body surface in a dusty gas stream.
- Study of thermal characteristics of ablating composite materials.

An overview of applications of inverse methods carried out in the Moscow Aviation Institute in 2013 – 2018:

- The study of the characteristics of high temperature carbon and ceramic materials.
- Identification of mathematical models of heat transfer in ablating heat shield materials.
- Experimental and theoretical study of heat transfer processes in porous materials.
- Mathematical modeling when creating a material. Research, prediction and optimization of foam-class structures of ultra-high porosity for application in specific operation conditions.
- Research of heat transfer in multilayer thermal insulation.
- The study of defects in flexible thermal protection materials by methods of inverse problems of nonlinear acoustics.
- Inverse problems of thermal protection optimization.
- Optimal design of thermal protection, taking into account the structure of highly porous materials.

Synergy of fundamental and applied research in the process of creating the theory and methodology for the identification of mathematical models of heat transfer based on the solution of inverse problems. Life cycle in digital simulation of thermal conditions.