ESTIMATION OF THE STRENGTH OF THE TIME-DEPENDENT HEAT SOURCE USING TEMPERATURE DISTRIBUTION AT A POINT

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ABSTRACT:

In contrast to the direct problems, the inverse heat conduction problems (IHCP) are defined as the estimation of initial/boundary conditions, properties of the system/material, sources or sink terms, shape, and governing equations from transient temperature measurements at one or several interior locations. The solution of inverse problems is much more difficult in comparison with direct problems due to instability in solution where these problems are called mathematically ill-posed. With the improvement of computer capability, inverse techniques have become a popular means of resolving heat transfer problems in the last decade. Important applications for inverse heat conduction problem solutions include, for example, controlled cooling of electronic components, estimation of jet-flow rate of cooling in machining or quenching, determination of conditions at the interface between the mold and metal during metal casting or rolling process, heat flux estimation in the surface of a wall subjected to fire or the inside surface of a combustion chamber and also in surfaces where ablation takes place or in surfaces going through welding process. Some other applications of the IHCP are prediction of the inner wall temperature of a reactor, determination of the heat transfer coefficient and outer surface conditions in the re-entry of a space vehicle and modeling of the temperature or heat flux at the tool-work interface of machine cutting and also in the transpiration cooling control. There are many different methods for solving the inverse heat conduction problems. Some of these methods will be listed here. For instance, the exact solution technique, the inversion of Duhamel's integral, Laplace transformation techniques, the control volume method, the use of Helmholtz equation, the finite difference method, the finite element approaches, the digital filtering method, Tikhonov regularization method, Alifannov iterative regularization, the conjugate gradient method, etc.

In this paper, the conjugate gradient method coupled with adjoint problem is used in order to solve the inverse heat conduction problem and estimation of the strength of the time-dependent heat source using the temperature distribution at a point in a three layer system. Also, the effect of noisy data on final solution is studied. The numerical solution of the governing equations is obtained by employing a finite-difference technique. For solving this problem the general coordinate method is used. We solve the inverse heat conduction problem of estimating the strength of the transient heat source, inside an irregular region. The irregular region in the physical domain (r, z) is transformed into a rectangle in the computational domain (ξ, η). The present formulation is general and can be applied to the solution of inverse heat conduction problems inside any region that can be mapped into a rectangle. The obtained results for few selected examples show the good accuracy of the presented method. Also the solutions have good stability even if the input data includes noise.