AN ANALYSIS OF THE HIGH PRESSURE GAS TANK WITH INVERSE METHOD

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ABSTRACT

To broaden the application of inverse estimation, the purpose of this study is to estimate the unknown temperature boundary condition of the complex or irregular shape, like the high pressure gas tank. An inverse algorithm based on the sequential method and the concept of future time combined with the finite element method is proposed to solve the two dimensional irregular shape heat conduction problems. Special features about the proposed method are that the stiffness matrix of the irregular shape can be solved from the finite element method and used by the inverse algorithm. The estimated results are quite accurate with the consideration of future time in the different measured errors, the various sensor’s number and the sensor location. These results show that the proposed method is an accurate, sturdy, and efficient method for solving several realistic applications.

INTRODUCTION

In general, the inverse method is regularly used in the analysis of simple shapes. Nevertheless, an inverse algorithm based on the sequential method and the concept of future time combined with the finite element method is used to analyze the heat conduction problem with complex shape in this study.

It is an important issue to obtain the heat transfer phenomena in the complex shape in order to get the realistic conditions of the engineering problem. The realistic engineering problem will be disclosed when the temperature or the heat flux of the complex boundary can be detected. The safety of gas tank, oil pipe and the performance of the heat transfer component can be clarified.

In the inverse heat conduction problems, the surface conditions or the thermal properties of a material are estimated by utilizing the temperature measurements within the medium. These problems have received much attention and numerous papers have been devoted to this topic of research. The inverse problems are known as ill-posed, hence the estimation is very sensitive to the measured errors of the input data. To overcome the instability of the inverse problem, different methods have been developed. Several studies investigated the inverse heat transfer phenomena related to this topic [1-4].

The inverse method has been exhibited its potential for dealing with many kinds of heat problems. Indeed, a few researches have been solved the heat problems by the inverse method successfully. For example, Dong et al. [5] proposed a method of fundamental solutions for solving isotropic inverse heat conduction problems. The results of their study for several numerical examples are presented to demonstrate the efficiency of their proposed method. The maximum entropy method [6] is applied to estimate the surface temperature by Kim et al.. The inverse heat conduction problem is reformulated for MEM and a three-phase solution method using the successive quadratic programming. Chen et al. [7] presents an input estimation method to estimate the time-varying heat flux and the temperature of the inner wall in the chamber recursively. Their simulated results show that the proposed method exhibits a good estimation performance and promotes a practical implementation highly. Carvalho et al. estimate the temperature profile generated in the cutting processes by the finite volume method and the variation of the thermal properties [8]. In addition, Chen et al. [9] compare the performance between the application of the whole-domain function specification method and the sequential function specification method in the inverse problem of transient conjugate heat transfer of laminar forced convection in a circular pipe. The two inverse methods are used to estimate the time-dependent inlet temperature and the outer wall heat flux simultaneously on the basis of temperature measurements. Gao and He [10] present a new inverse analysis approach for identifying material properties and unknown geometry in the multi-region problems by using boundary element method. In their study, the material properties and coordinates of the unknown region boundary are taken as the optimize variables, and the sensitivity coefficients are computed by the complex variable differentiation method. In recent, the thermal properties and the heat flux are estimated by many different inverse methods as the development of this field [11-15].

However, the above approaches have some limits in the application, for example, an iterative process, an essential pre-select function, used in the nonlinear domain, or only specialized in the simple shape. Therefore, a sequential inverse algorithm [16] combined with finite element method [17, 18] is needed to solve the heat problems in order to release the above limitation.

The proposed method in this study is a numerical method that can estimate temperature boundary condition sequentially without the sensitivity analysis. A closed-form is derived from a numerical model to represent the unknown temperature boundary conditions.