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Simultaneous identification of the spatio-temporal dependent heat transfer coefficient and spatially dependent heat flux using a MCGM in a parabolic system☆

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Abstract

This paper aims to simultaneously identify the spatio-temporal dependent heat transfer coefficient $\gamma(\mathbf{x}, t)$ and spatially dependent heat flux $q(\mathbf{x})$ in a parabolic system. The simultaneous identification problem is formulated as a constrained minimization problem using the output least squares method with Tikhonov regularization. The differentiability of the solution and adjoint equations are investigated to obtain the gradient formulas and determine the step lengths, respectively. To illustrate the efficiency, accuracy, and robustness of the proposed algorithm numerical results are investigated using the modified conjugate gradient method (MCGM).

Keywords: Simultaneous identification, Numerical reconstruction, Heat transfer coefficient and heat flux, Tikhonov regularization, MCGM.

1. Introduction

This paper presents an inverse problem of reconstructing spatio-temporal dependent heat transfer coefficient and spatially dependent heat flux from the noisy measurements of the solution on three parts of the boundary. The heat transfer coefficient represents the convection between the conducting body and the ambient environment Lienhard (2013). Robin conditions appearing in all transfer phenomena are very important in engineering particularly focusing on the dynamics of the interface between two different materials, such as the boundary of a solid particle submerged in a fluid Aichmayer (2011). According to Zhou et al. (2010) the boundary heat flux of a solid cannot be measured directly. For example, during the heating process in a reheating furnace a sensor cannot be attached to a slab surface to measure the heat flux Weisz-Patrault et al. (2014). This can be also found in determining the aerodynamic heat Nakamura et al. (2014) on the surface of the thermal protection system of a hypersonic vehicle. Under these circumstances, the boundary heat flux can be reconstructed indirectly by solving an inverse heat conduction problem. Furthermore, the values of Robin coefficient and heat flux have significant practical interest in thermal and diffusion

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