11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

MODIFIED DYNAMIC OBSERVERS BASED ON GREEN FUNCTIONS METHOD TO SOLVE A 3D TRANSIENT IHCP

Priscila F. B. de Souza[1], Fernando Malheiros[2], Márcio B. da Silva[3] and Gilmar Guimaraes[4]

[1,2,3,4] Federal University of Uberlandia, School of Mechanical Engineering, 38400-902, www.posgrad.mecanica.ufu.br
[1,]priscila@mecanica.ufu.br, [,2] fernandomalheiros@gmail.com,
[3]mbacci@mecanica.ufu.br, [4]gguima@mecanica.ufu.br,

Key Words: *Inverse Heat Conduction, Dynamic Observers, Green Functions.*

The inverse problem can be found in a large area of science and engineering and can be applied in different ways. The great advantage of this technique is the ability of obtaining the solution of a physical problem that cannot be solved directly. Different techniques of the inverse heat conduction problem (IHCP) can be found in literature. In the dynamic observer technique, the IHCP solution algorithms are interpreted as filters passing low-frequency components of the true boundary heat flux signal while rejecting high-frequency components in order to avoid excessive amplification of measurement noise [1]. The dynamic observers technique proposed by Blum and Marquardt [1], focused on the one-dimensional linear case, is here extended to solve an inverse multidimensional heat conduction problem.

In order to deal with multidimensional thermal models, this work proposes an alternative way of obtaining the heat transfer function, G_H. The obtaining of this function represents an important role in the observer method and is crucial to allow that the technique be directly applied to three dimensional heat conduction problems. In this work, the heat conductor transfer function G_H is obtained by using the Green function concept. This new procedure allows flexibility and efficiency to solve multidimensional inverse problems.

The inverse heat conduction problem is represented by an unknown heat flux heat that is partially imposed at a front surface of a sample while the other surface is kept at constant temperature. The reminiscent surfaces are exposed to convective medium. The heat flux is then estimated by using the modified dynamic observer techniques and temperature data from a sensor located at the sample far from the heat source. The novelty is the procedure used to obtain the heat transfer function. This work uses a polynomial fitting of the transfer function model G_H in time domain instead the linear adjust method. The technique is compared with the well know sequential estimation with function specification method and with experimental results.

The inverse problem solution based on dynamic observers can be divided in two distinct steps: i) the obtaining of the transfer function model G_H; ii) the obtaining of the heat transfer functions G_Q and G_N and the building algorithm identification. A complete description of this technique can be found in the work of Blum and Marquardt [1] and Sousa [2].

Priscila F. B. de Souza, Fernando Malheiros and Gilmar Guimaes.

Heat flux estimation for a 3D-transient thermal model: simulated and experimental cases. 3D transient applications are analyzed. Three cases are studied: i) a simulated case; ii) an experimental case (laboratory) and iii) Cutting orthogonal application.

An experimental test was carried out in order to analyze the algorithm efficiency in a controlled test in laboratory.

An AISI304 stainless steel samples with thickness of 47 mm and lateral dimensions of 127 x 127 mm is used in this test. The sample initially in thermal equilibrium at T_0 is then submitted to a unidirectional and uniform heat flux. The heat flux is supplied by a 318 Ω electrical resistance heater, covered with silicone rubber, with lateral dimensions of 100 x 100 mm and thickness 0.3 mm.

In the cutting application, the tests involved dry machining of grey iron cylinders, using uncoated carbide tools. The temperatures of the insert were measured with five T-type 28 AWG thermocouples each. The thermocouples were attached using capacitive discharge welding at the insert. Figure 1 shows the positions of the thermocouples and some estimation results.

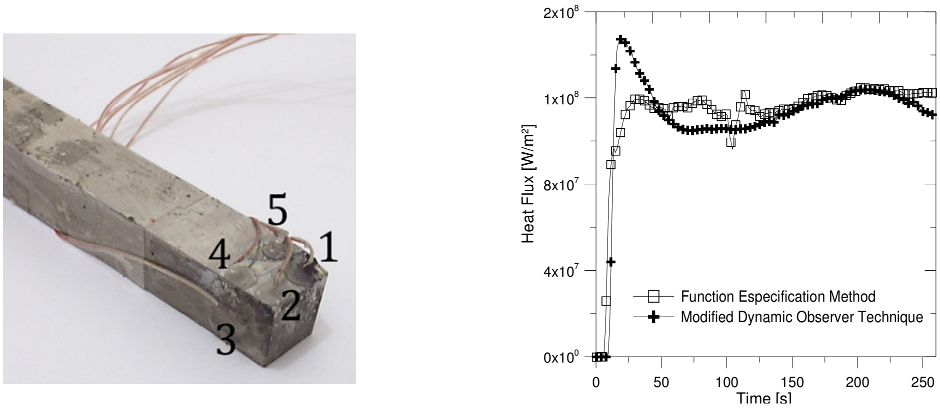

Fig. 1. Insert with five tthermocouples attached and comparison between the measured and estimated heat flux

It can be observed that the heat flux is recovered in both heating and cooling regions. However some oscillations can be observed. The great advantage of dynamic observer technique is the easy and fast numerical implementation for 3D model. The robustness and low computational cost and low error sensitivity give to this procedure a great potential in inverse techniques application.

REFERENCES

[1] J.W. Blum and W. Marquardt, An optimal solution to inverse heat conduction problems based on frequency-domain interpretation and observers", *Numerical Heat Transfer, Part B: Fundamentals,*Vol. **32**, pp.453 (1997)

[2] P. F. B. Souza, S. R. Carvalho,and G. Guimaraes, Dynamic observers based on Green's functions applied to 3D inverse thermal models. Inverse Problems in Science & Engineering (Print), VOL. 16, p. 743-761, 2008.