Inverse Identification of the Time-Varying Shape of a Phase Change Bank in a High Temperature Melting Furnace

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The time-varying shape of the phase change bank on the inside surface of a refractory brick wall of a high temperature melting furnace is investigated (Fig. 1). This bank is created as the molten material comes into contact with the cooled surface of the wall and undergoes a solidification process. Maintaining this bank is essential in order to protect the wall against the corrosive molten material. Probing the shape of the bank with sensors submerged into the molten bath is however impractical. A promising alternative, proposed here, is to appeal to an inverse method. In this case, temperatures are recorded by sensors embedded inside the brick wall (Fig.1).

The phase-change problem is handled with a finite-difference general source-based enthalpy method[1] while the inverse method rests on the Levenberg-Marquard least-square minimisation technique. The inverse heat transfer procedure is validated and thoroughly tested for typical phase change conditions that prevail inside industrial facilities. The effect of the number of sensors, of their location and of the measurement noise on the accuracy of the predicted bank is then investigated.

As an example, Fig. 2 compares the predicted and the exact time-varying shape of the bank for a typical 2D phase-change process. In this example, a steady-state heat flux that increases linearly with x is imposed on the Ω_4 boundary (Fig.1). The motion of the

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[1] V. R. Voller, and C. R. Swaminathan, General source-based method for solidification phase change, Numerical Heat Transfer, Part B (Fundamentals), vol. 19, n. 2, pp. 175-89, 1991.

solidification front is estimated by an inverse method using the transient readings of three sensors distributed on the outside surface of the brick wall (Ω_3 boundary). Examination of Fig.2 reveals that the discrepancy between the predictions and the exact solution increases with bank thickness. This behavior is due to the fact that the sensitivity coefficients diminish with solid phase thickness. Embedding the sensors deeper inside the wall does indeed improve the accuracy of the predictions but, from an industrial point of view, it complicates matters. The accuracy of the proposed inverse method is investigated in terms (1) of the physical properties of the bank (thermal diffusivity and thickness) and (2) of the magnitude of the heat flux.

Further results illustrating the features of the present inverse heat transfer procedure will be presented at the conference.

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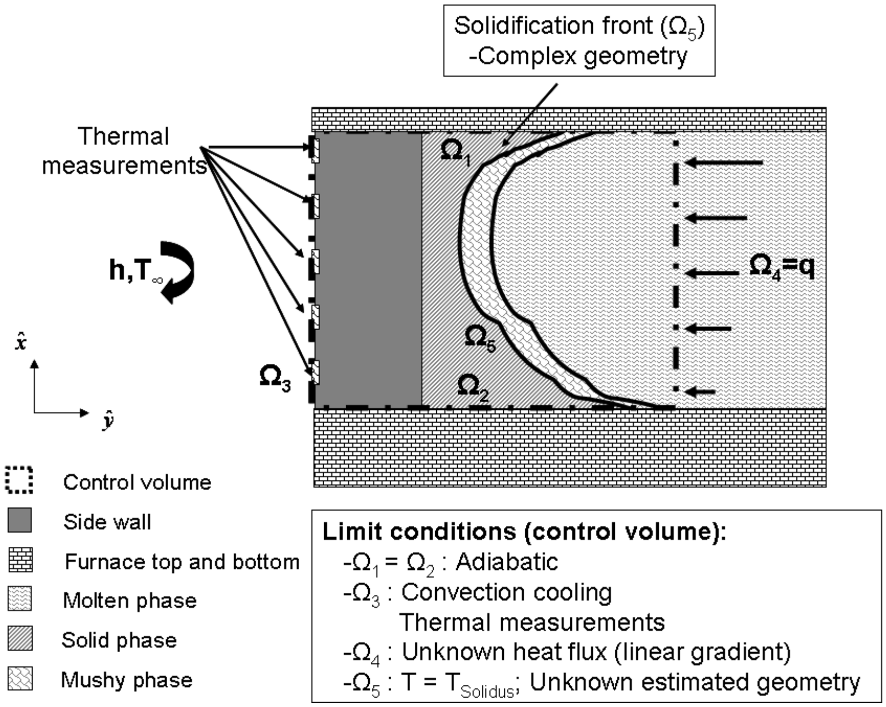

Figure 1 : The inverse problem : temperature sensors are embedded inside the wall.

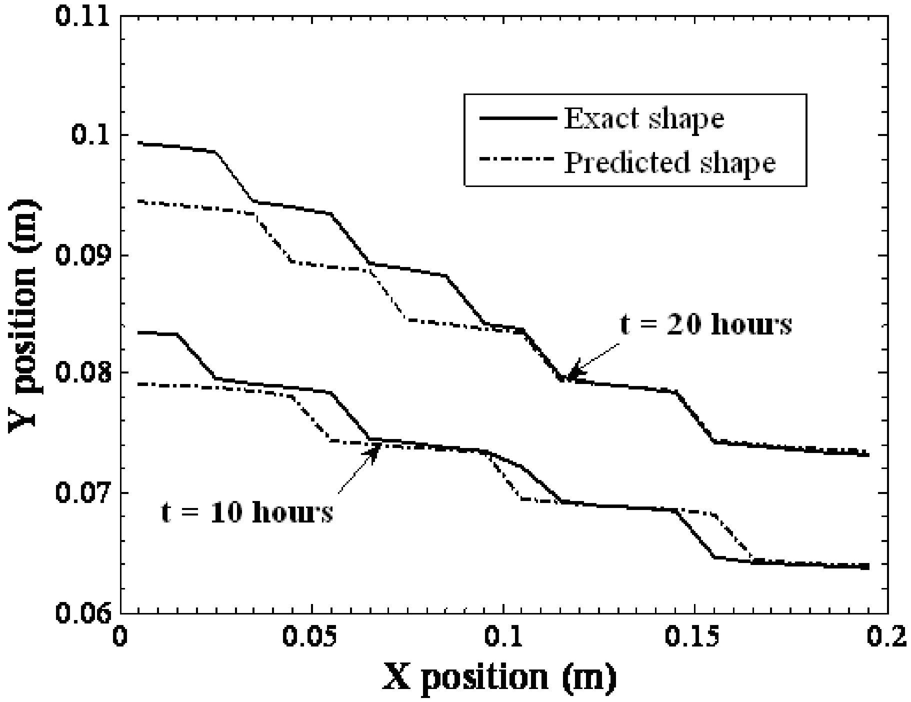

Figure 2 : Progression of the time-varying shape of the bank for a typical 2D phase-change process.