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# EXPERIMENTAL VALIDATION OF HEAT SOURCE FIELD ESTIMATIONS

H. Louche<sup>(1)</sup>, V. Delobelle<sup>(2)</sup> and D. Favier<sup>(2)</sup>

<sup>(1)</sup>Laboratoire de Mécanique et de Génie Civil (LMGC), Université Montpellier 2, CNRS, UMR5508  
cc048, Place E. Bataillon, 34095 Montpellier  
Téléphone : 04 67 14 96 34  
herve.louche@univ-montp2.fr

<sup>(2)</sup> Laboratoire 3SR, Université de Grenoble/CNRS  
BP 53, 38041 Grenoble Cedex 9.  
Téléphone : 04 76 82 51 85, Télécopie : 04 76 82 70 43  
vincent.delobelle@hmg.inpg.fr, Denis.Favier@hmg.inpg.fr

## 1. INTRODUCTION

Thermal field measurements are interesting tools to study thermomechanical couplings often associated with deformation of materials. Intensity and spatio-temporal distribution of the temperature variations are depending on the material behaviour (elasticity, plasticity, viscosity, damage, phase transformation,...) but also on the different characteristics of the thermal problem (geometry, thermal properties, boundary conditions, ...). Previous work [1] has shown the interest to study the local heat sources, causes of the temperature variations. Different methods have been proposed to get such heat source fields [2]. The method used in this work to estimate heat sources is based on approximations of derivative operators involved in the heat diffusion equation [1]. It was applied to study Lüders bands and necking in steels, PLC bands in AlMg alloys, plasticity in Al oligocrystals and stress induced phase transformation in Nickel-Titanium (NiTi) shape memory alloys [3]. Few works have been proposed to validate heat source field estimations. A first approach, qualified as “theoretical”, uses analytical or numerical examples of temperature and heat source distributions [1,3]. The objective of our presentation is to show a second approach, qualified as “experimental” and based on thermal induced phase transformation observed in a NiTi shape memory alloy.

After a description of the experimental benchmark, typical experimental results will be presented to discuss the validity of heat source estimations in homogeneous and one-dimensional cases.

## 2. METHODOLOGY

Fig. 1 shows the different steps of the method. An infrared camera observes the natural temperature decrease (or increase) at the surface of a NiTi sample. Depending on the boundary conditions the temperature distribution is homogeneous or axially heterogeneous (Fig. 2). Temperature variation fields are then processed to estimate the heat source fields qualified as local differential scanning calorimetry and noted  $DSC_{TFM}$  (TFM: Temperature Field Measurement). These  $DSC_{TFM}$  fields are then compared to a reference DSC obtained by standard DSC (noted  $DSC_{EXP}$ ) in order to evaluate the performance of the heat source estimations.

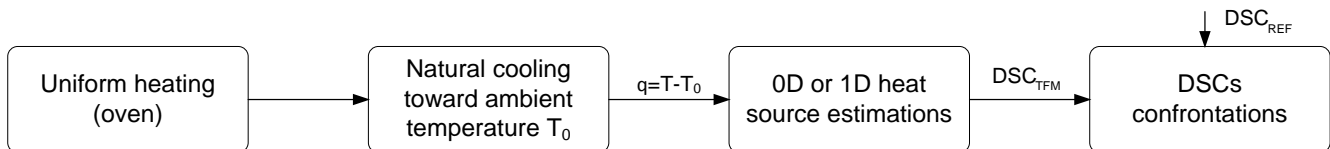


Figure 1: scheme showing the different steps of the experimental validation of heat source estimations

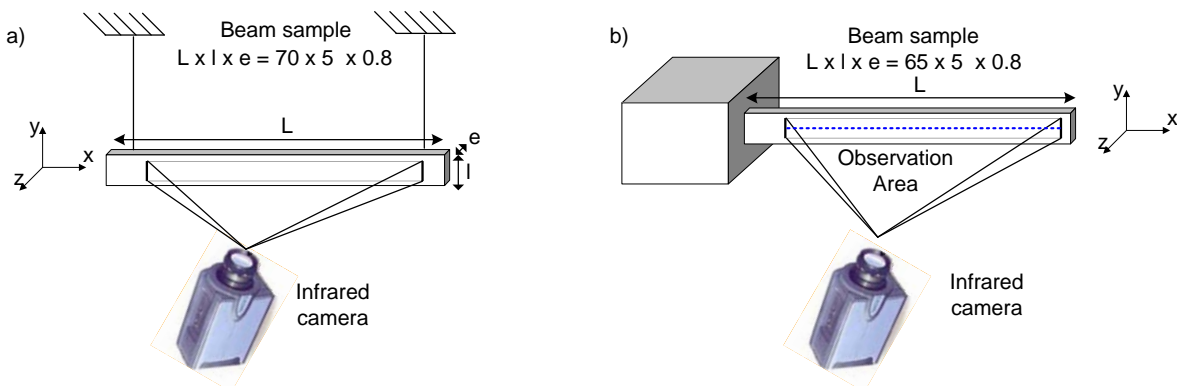
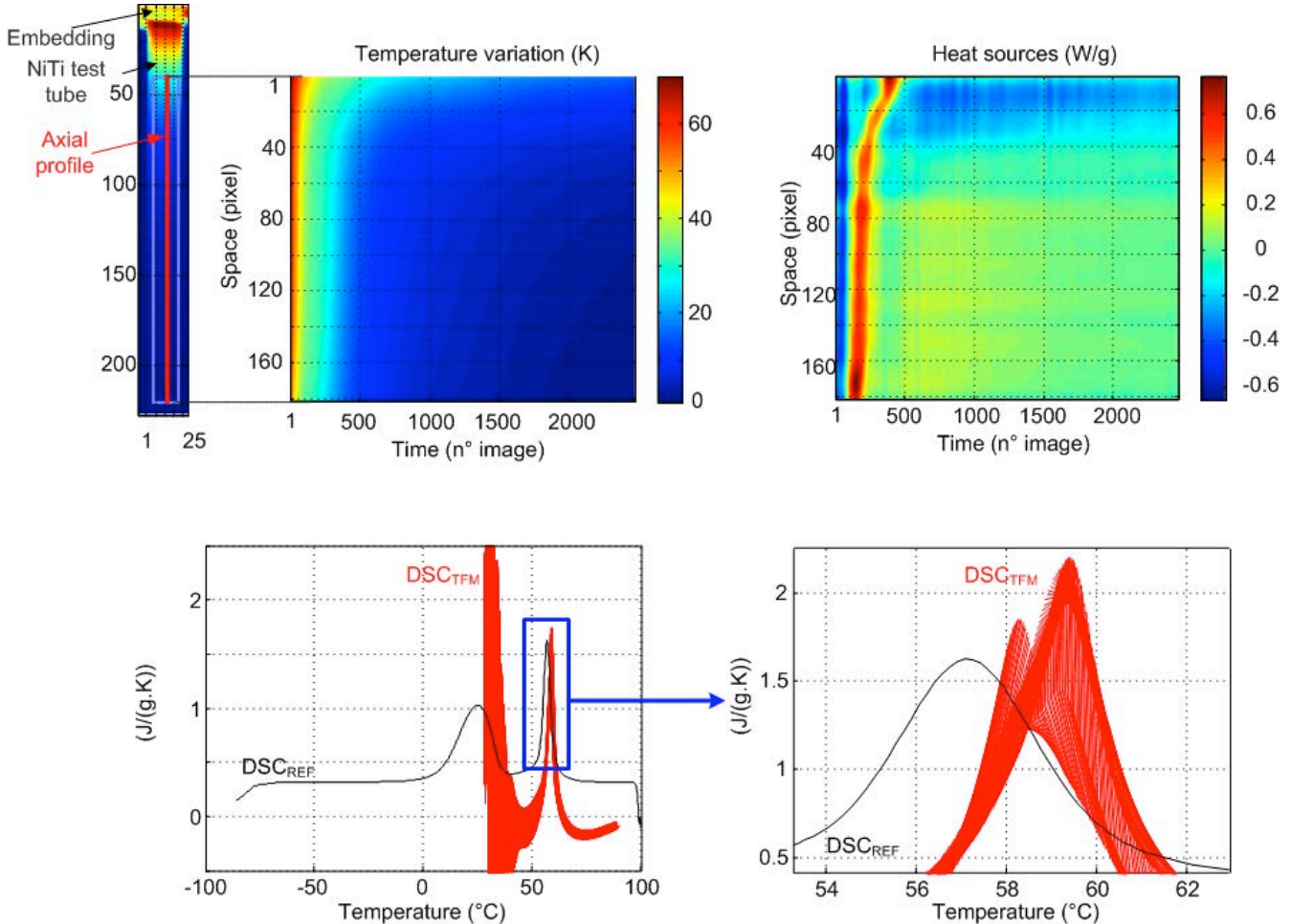


Figure 2: Experimental setup in the a) homogeneous and b) heterogeneous cases.

### 3. RESULTS

Typical spatio-temporal evolutions of temperature variations and heat source fields are plotted in Fig. 3.b and 3.c. Temperature evolution along the spatial direction (Fig. 3a) are diffused and heterogeneous. The axial distribution of the heat source shows clearly (Fig. 3c) a propagation of the phase transformation from the bottom to the top of the sample. Heat sources estimated in each point of an axial profile,  $DSC_{TFM}(x,t)$ , are finally compared with the reference  $DSC_{EXP}$  in Figs 3d,e.

These kinds of results will be analysed and discussed in regard to the validation of the method of heat source estimation.



**Figure 3: b) Spatio-temporal representation of the temperature variations along an axial profile plotted in Fig. a. c) Same representation for the specific heat sources (W/g). d) Local  $DSC_{TFM}$ , in each point (pixel) of the profile, compared with the reference ( $DSC_{EXP}$ ). e) Close-up around the second peak.**

### 4. REFERENCES

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