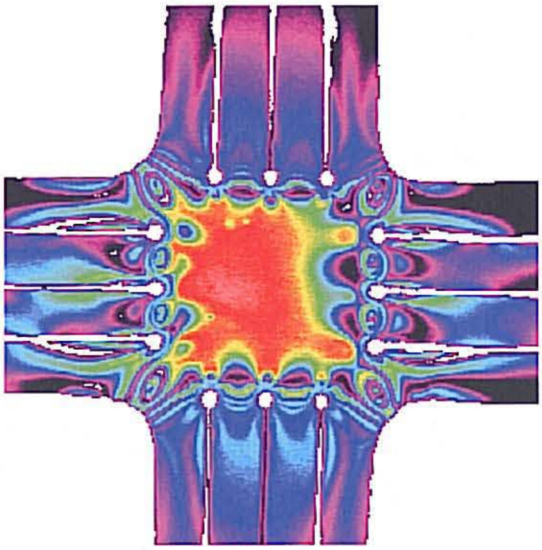

PHOTOMECHANICS 2008

7-9 July 2008
Loughborough, UK

International conference on full-field measurement techniques and their applications in experimental solid mechanics

Book of Abstracts
Edited by Jonathan Huntley and Michel Grédiac

Loughborough University

FOREWORD

We would like to welcome you to Loughborough and the *Photomechanics 2008* conference.

The main objective of this conference is to provide an international forum to promote the new possibilities offered by full-field measurement techniques and to discuss their impact on the mechanical characterization of materials and structures.

Photomechanics 2008 is the second international version of a French series of conferences named *Photomécanique* launched in 1995 by Prof. Berthaud. Based on the increasing success of these national conferences, it was decided in 2004 to launch an international edition, *Photomechanics 2006,* which was held in Clermont-Ferrand, France. *Photomechanics 2008* is the first in this long line of conferences to be held outside France. The 84 abstracts received from 20 different countries clearly indicate the success of this initiative.

Such a large number is mainly due to the patronage of different international associations and to the support of various institutions and companies. We would like to thank all of them for their effective advertising of the conference and for their much appreciated financial contributions.

The authors of some abstracts were invited to contribute full-length papers to *Strain, an International Journal for Experimental Mechanics* edited by the *European Association of Experimental Mechanics*. We would like to take this opportunity to thank Emmanuel Gdoutos and Bob Mines for their confidence in the scientific level of the conference.

We are also very grateful to the 34 members of the scientific committee who reviewed the abstracts received and to the 6 members of the local organizing committee for their tireless work. The conference could not have been organized without their contributions.

Finally, we hope you will enjoy your stay in Loughborough!

Jonathan Huntley and Michel Grédiac
Co-Chairmen of *Photomechanics 2008*

PHOTOMECHANICS 2008

Loughborough, United Kingdom

7th – 9th July 2008

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MEASURING OF NON-UNIFORM RESIDUAL STRESSES IN DEPTH WITH OPTICAL TECHNIQUES

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ABSTRACT: The goal of this work is the development of optical experimental techniques to measure non-uniform residual stresses in depth, as alternative to the hole-drilling method with strain gages. The proposed hybrid techniques are based on Moiré Interferometry and in-plane Electronic Speckle Pattern Interferometry (ESPI) and used the integral method for stress assement. In this work a shot peening specimen was used to compare the results obtained with different techniques: X ray diffraction, hole drilling with strain gages, finite elements method simulation and the referred optical techniques.

1. INTRODUCTION

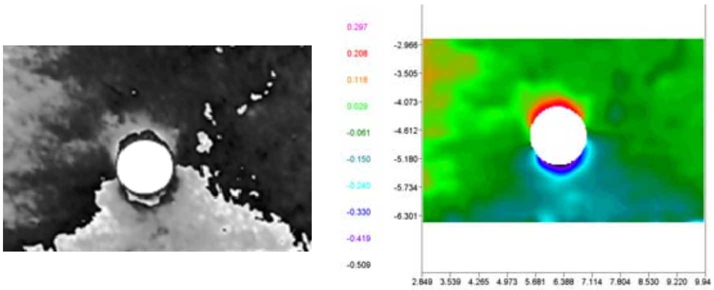
There are many techniques to measure residual stresses like, hole drilling, X ray diffraction, neutron diffraction, magnetic, ultrasonic, Raman and others [1]. All of them have advantages and disadvantages. The most used technique is the hole drilling with strain gages [2] due to the fact that it is the less expensive and more versatile. However, some drawbacks are associated to this technique like, the punctual measurement, the difficulty to define the plastic region and the measurement is limited to the area of the strain gages. To avoid these limitations, in this work is proposed the use of the hole drilling technique associated with an optical method, Moiré Interferometry and ESPI. Both are field techniques allowing the assessment of in-plane displacements without contact and high resolution. Grating replication techniques were developed to record high quality diffraction gratings onto the specimen's surfaces. An optical set-up of laser interferometry was developed to generate the master grating (virtual). An in-plane ESPI set-up was also designed and implemented to measure displacements in one direction. The stress relaxation was promoted by the blind hole-drilling and the obtained fringe patterns (Moiré and speckle) were video recorded. Image processing techniques were applied to assess the in-plane strain field. A finite elements code (ANSYS®) was used to simulate the stresses relaxation process whose values were compared with the experimental data and to calculate the hole-drilling calibration constants.
To compute the values of residual stresses measured with optical techniques associated with hole drilling method was used the expression defined by Wu [3]:

$$\left[u^i\left(x_k,y_k\right) \quad v^i\left(x_k,y_k\right)\right]\begin{bmatrix}\cos\theta_k\\ \sin\theta_k\end{bmatrix}=\sum_{j=1}^{i}\begin{bmatrix}A^{ij}+B^{ij}\cos 2\theta_k\\ A^{ij}-B^{ij}\cos 2\theta_k\\ 2B^{ij}\sin 2\theta_k\end{bmatrix}^{-1}\begin{bmatrix}\sigma^j{}_{xx}\\ \sigma^j{}_{yy}\\ \tau^j{}_{xy}\end{bmatrix} \tag{1}$$

Where *i*=1,2, …, *n*; being *n* the total number of increments; A^{ij} and B^{ij} are the calibration coefficients of the *j* layer after the increment i; $u^i(x_k,y_k)$ and $v^i(x_k,y_k)$ are the measured displacements with the referred optical techniques on three points after the increment *i*; $\sigma^j{}_{xx}$, $\sigma^j{}_{yy}$ e $\tau^j{}_{xy}$ are the tree components of the residual stresses for the layer *j*. The calibration coefficients were numerically calculated using a finite elements program (Ansys®), with which the incremental hole drilling was simulated. The hole drilling method with strain gages was used to compare the results obtained with optical techniques. In this case the new proposed ASTM E837 standard was used [4].

2. RESULTS

With the obtained images, for each increment, image processing routines were used to obtain the displacements in two orthogonal directions (*u*,*v*), around the hole, due to the stress relaxation. In figure 1, phase map and the unwrapped phase map in *v* direction, for the second increment are presented [5]:



(a) (b)

Fig. 1 – (a) phase map in *v* direction; (b) unwrapped phase map in *v* direction (in µm).

The obtained results with the different techniques for the residual stresses are presented in figure 2.

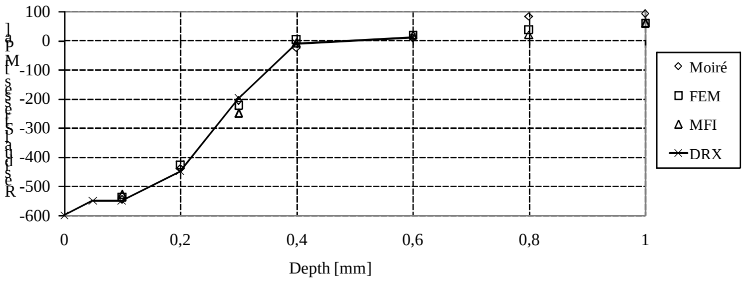


Fig. 2 – Residual stresses distribution in a AISI 4337 steel specimen. Comparison among Moiré Interferometry, FEM, MFI (integral method) and DRX (X-ray diffraction).

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