

# 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

# PHOTOMECHANICS 2008

## FULL PROGRAMME

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### SUNDAY 6<sup>TH</sup> JULY 2008

20:00 – 22:00 Registration

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### MONDAY 7<sup>TH</sup> JULY 2008

08:00 Registration and refreshments

08:45 Welcome address  
*James France Building, Loughborough University*

#### KEYNOTE LECTURE 1

*James France Lecture Theatre 1*

*Chair: J. M. Huntley, Loughborough University, UK*

09:00 ***Dynamic photoelastic studies of crack propagation in novel materials***  
A. Shukla, University of Rhode Island, USA

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#### Session 1 – FRACTURE MECHANICS

*James France Lecture Theatre 1*

*Chair: F. Pierron, ENSAM Châlons-en-Champagne, France*

09:45 ***Visualization and analysis of interactions between a dynamically growing crack and a stiff inclusion using coherent gradient sensing***  
H. Tippur and R. Kitey (USA)

10:05 ***Characterization of cracks during dynamic fatigue tests using the grid method***  
S. Vanlanduit, B. Belkassam, P. Guillaume and B. Ribbens (Belgium)

10:25 ***Analysis of elastic-plastic stress field near the crack-tip by digital image correlation and nonlinear intelligent hybrid method***  
K. Machida and G. Tanaka (Japan)

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10:45 Refreshments – **SPONSORED BY CEDIP FLIR**



#### Session 2 – 3D MEASUREMENTS

*James France Lecture Theatre 1*

*Chair: M. Sjödaahl, Lulea University of Technology, Sweden*

11:10 ***3D measurement of discontinuous displacement fields by extended volume correlation using X-ray microtomography***  
J. Réthoré, J. P. Tinnes, J.-Y. Buffière, S. Roux and F. Hild (France)

11:30 ***Characterisation of localised deformation in granular geomaterials using X-ray (micro)tomography and 3D-volumetric digital image correlation***  
S. A. Hall, N. Lenoir, Y. Pannier, J. Desrues, M. Bornert, G. Viggiani, P. Bésuelle, M. di Michiel (France) and J. Otani (Japan)

11:50 ***Deformation in wood exposed to three point bend: analysis by use of digital volume correlation applied to synchrotron radiation  $\mu$ CT data***  
F. Forsberg (Sweden), R. Mooser, E. Hack and P. Wyss (Switzerland)

12:10 ***Full 3D strain measurement by digital volume correlation and X-ray micro-computed tomography: accuracy and volume image defects***  
A. Germaneau, P. Doumalin and J. C. Dupré (France)

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12:30 Lunch

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## POSTER SESSION AND EXHIBITION

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### Posters

**1- Interference measurement of rough surface relief**

O. V. Angelsky, A. P. Maksimyak and P. P. Maksimyak (Ukraine)

**2- Object surface 3D dynamic measurement system based on Fourier interferometry**

L. Li and M. Wang (China)

**3- Who discovered the photoelastic effect?**

H. Aben (Estonia)

**4- A study on the development of photoelastic experimental hybrid method for small fringe orders**

J.-H. Nam, J.-S. Hawong and G. Kwon (Korea)

**5- A simple technique for correcting image distortion in fringe projection methods**

P. J. S. Tavares and M. A. P. Vaz (Portugal)

**6- Optimization of derivation regarding resolution and spatial resolution on strains**

J. Molimard and R. Bergé (France)

**7- Combined measurement uncertainty in phase-stepping methods**

E. Hack (Switzerland)

**8- Spatial phase wrapping of noisy wrapped map**

M. J. Huang and Y. L. Chen (Taiwan)

**9- An optimized filtering technique for wrapped phase data**

G. Petrucci (Italy)

**10- Strain measurement of flax fibre during tensile test by regressive spectral phase algorithm**

C. Pollâne (France)

**11- Sub-pixel level displacement field estimation using optical flow**

A. Sousa, V. Filipe, J. Morais and M. Vaz (Portugal)

**12- A space-time correlation algorithm for digital high-speed camera images**

J. Réthoré, D. Grégoire, H. Maigre and A. Combescure (France)

**13- Measurement of volume variation in elastomers by image correlation**

J.-B. Le Cam and E. Toussaint (France)

**14- Thermoelastic analysis of polymers in monotonic tensile tests**

D. Tscharnuter, M. Jerabek and Z. Major (Austria)

**15- Low density polyurethane foam properties characterisation by the virtual fields method and digital image correlation**

B. Guo and F. Pierron (France)

**16- Extension of the virtual fields method to combined isotropic and kinematic hardening laws**

V. The Tran, S. Avril and F. Pierron (France)

**17- An inverse method for material parameters determination of titanium samples under tensile loading**

T. Pottier, F. Toussaint and P. Vacher (France)

**18- Stress distribution measurement inside ball screw system using photoelasticity technique**

R. Bertolaso, F. Ronde-Oustau, M. Cheikh and F. Schmidt (France)

**19- Experimental study of stress repartition in aeronautical spherical plain bearing by 3d photoelasticity: validation of a numerical model**

A. Germaneau, F. Peyruseigt, S. Mistou, P. Doumalin and J.C. Dupré (France)

**20- The experimental analysis of stress for cylinder wall of small output 2 cycle engine using photoelastic method**

S. Sasaki, T. Ezumi and K. Satoh (Japan)

**21- Optical measurement of local strains development in finger-jointed wood subjected to static and sustained loads**

L. Muszyński (USA), B. Clouet and R. Pommier (France)

**22- Coupling advanced imaging analysis and morphology based modelling for integrated characterization of micro-mechanics of wood and wood-based composites**

L. Muszyński and J.A.Nairn (USA)

**23- 3D reconstruction of dental elements by optical technique**

C. Casavola (Italy), M. Kujawska (Poland), L. Lamberti, G. Pappalettera and C. Pappalettera (Italy)

**24- Strain fields adjacent to bone-implant interfaces: strain field analysis using digital image correlation techniques**

J. Ribeiro, J. Monteiro, H. R. Lopes, M. Vaz and R. M. Guedes (Portugal)

**25- Image correlation applied to wood painting**

H. Maigre and F. Morestin (France)

**26- Developments in the non-destructive evaluation of power plant main steam pipe: investigation and integration of DIC with ARCMAC**

C. Maharaj, A. Morris, A. Puri, M. Kourmpetis, I. Palmer and J. Dear (United Kingdom)

**27- TITL measurement result correction of out-of-plane deformation of a pipe under loaded by internal pressure E**

K. Kim, H. Jung, S. Jung, H. Kim, S. Na and H. Chang (Korea)

**28- Measuring of non-uniform residual stresses in depth with optical techniques**

J. Ribeiro, J. Monteiro, M. Vaz and H. Lopes (Portugal)

**29- Analysis of temperature measurement at lead/LiF interface under shock wave compression**

C. Chauvin, P. L. Hereil and F. Sinatti (France)

## **Exhibitors**

**Photron (Europe) Ltd**

**Professional Engineering Publishing**

**Dantec Dynamics**

**Cedip-FLIR**

**LAVision**

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

Ribeiro<sup>1</sup>, J., Monteiro<sup>2</sup>, J., Lopes<sup>1</sup>, H., Vaz<sup>3</sup>, M.

<sup>1</sup>ESTIG – Instituto Politécnico de Bragança; <sup>2</sup>INEGI – Instituto de Engenharia Mecânica e Gestão Industrial; <sup>3</sup>DEMEGI – Faculdade de Engenharia da Universidade do Porto  
Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal.

### INTRODUCTION

A method to measure residual stresses combining Moiré Interferometry and the incremental hole-drilling (integral method) was implemented in this work to measure non-uniform residual stresses in shot peening specimens. The calibration coefficients were obtained by numerical simulation with a FEM code generated in the ANSYS® programme. A mesh with 5525 parametric brick elements (SOLID185) was used to simulate the stress release evolution.

### RESULTS

The object grating (1200 l/mm in two orthogonal directions) was recorded on the object surface with epoxid resin being the master generated by laser interferometry with four collimated beams. Stresses were released by an incremental hole drilled with an air turbine (350.000 rpm). The strain relaxation was assessed by the Moiré interferometry. An image processing software was used to assess the in-plane displacement field.

A numerical model was implemented with a finite elements programme (ANSYS®) to calculate the calibration coefficients and simulated the stress release after drilling different hole increments.

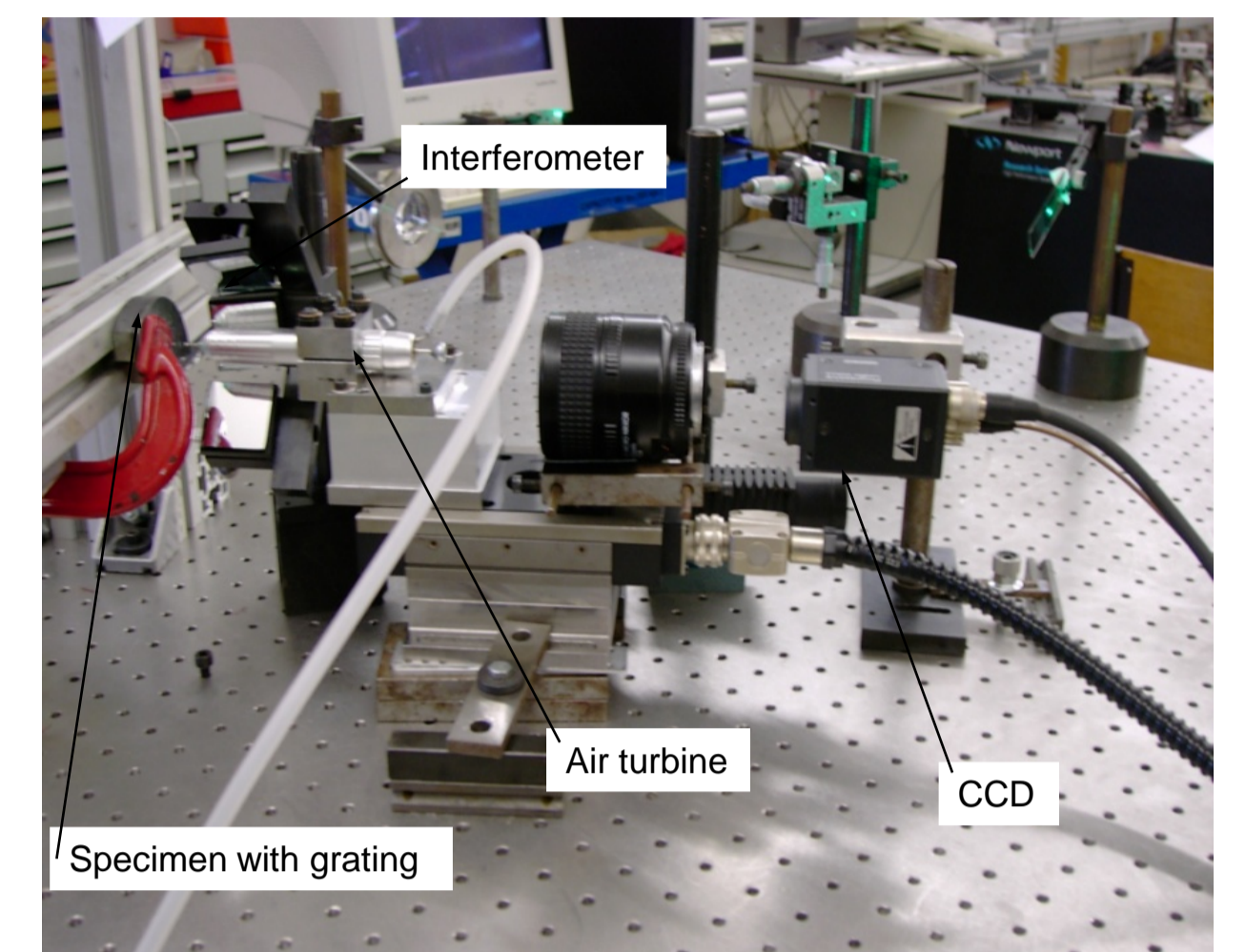


Figure 1. Apparatus of used set-up.

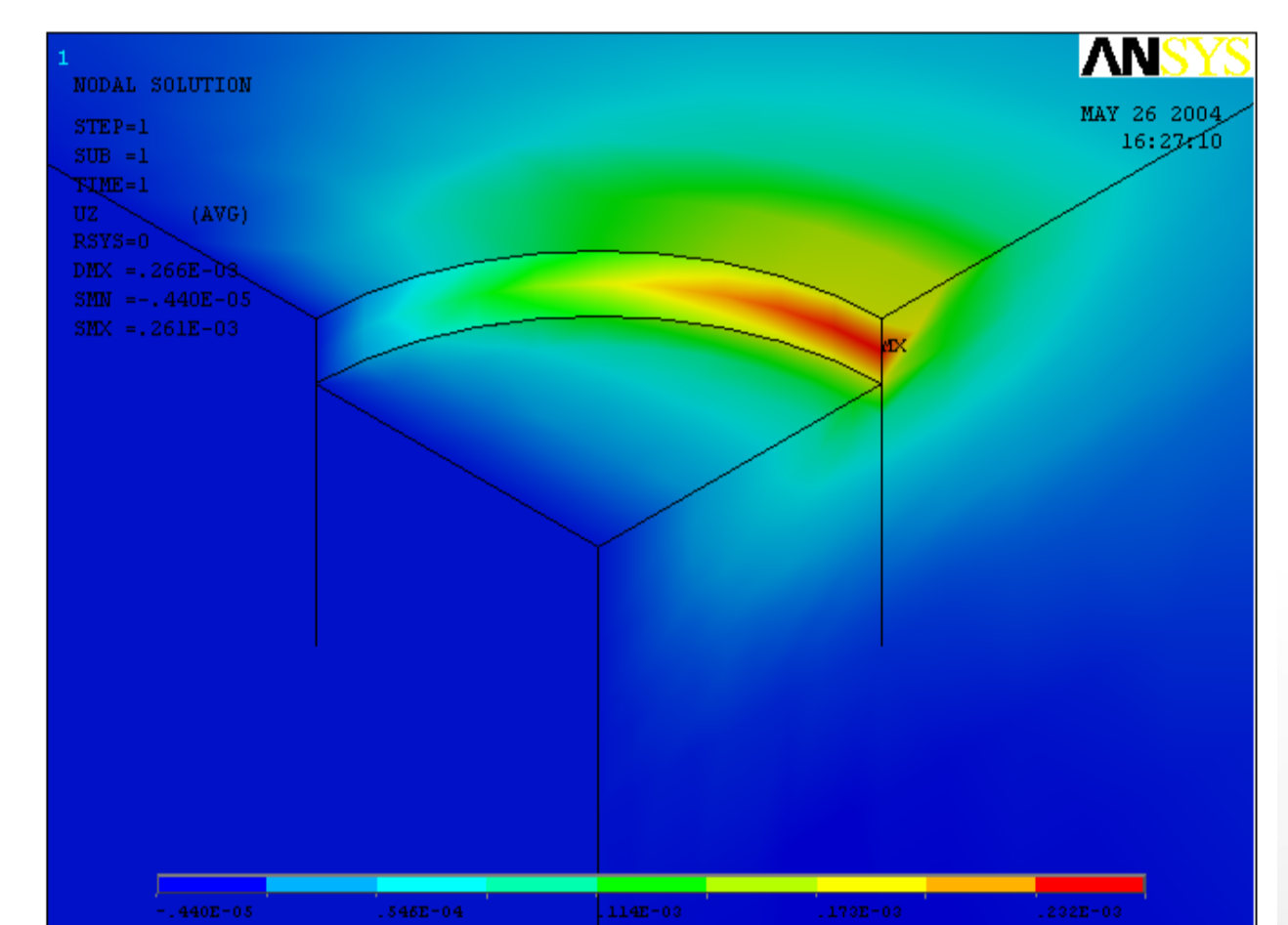


Figure 2. Simulation of incremental hole drilling.

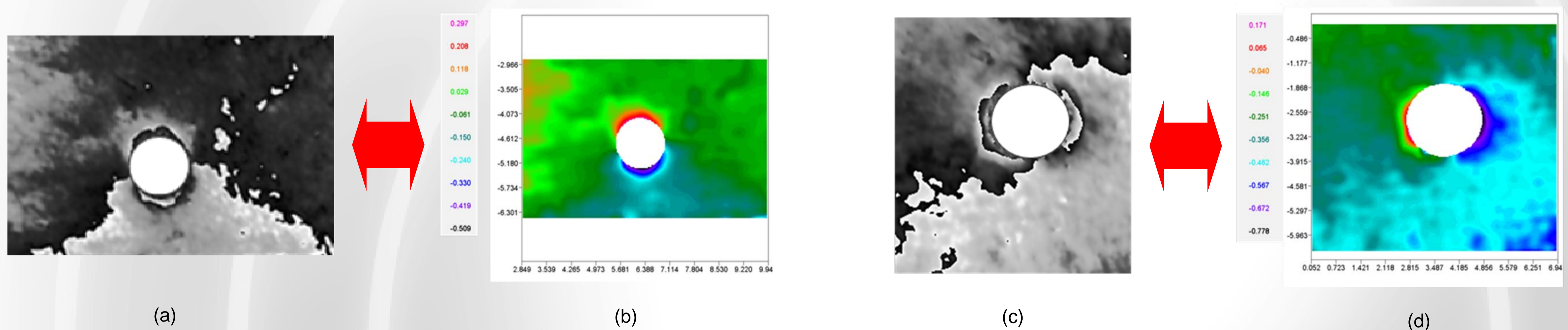


Figure 3. (a), (c) Phase map in u and v direction; (b), (d) Unwrapped phase map of displacement field in u and v direction (in  $\mu\text{m}$ ).

The results were compared with the ones obtained using different techniques and can be seen in figure 4.

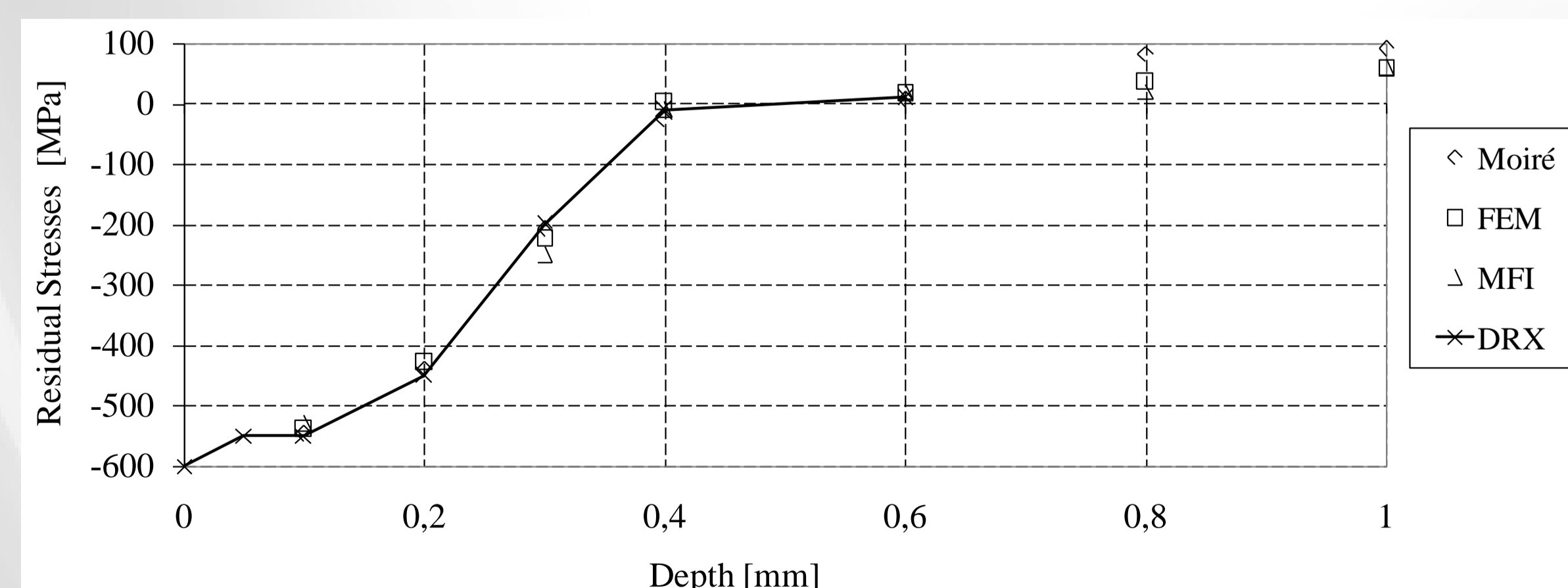


Figure 4. Residual stresses distribution in a AISI 4337 steel specimen. Comparison among Moiré Interferometry, FEM, MFI (integral method) and DRX (X-ray diffraction).

### CONCLUSIONS

The obtained results with Moiré Interferometry associated to the incremental hole drilling method are closer to the results measured with other traditional techniques used to measure residual stresses, therefore this optical technique is well adapted to measure non-uniform residual stresses in depth. This type of residual stresses are out of the scope ASTM E-837 standard and these measurements could be important to its reformulation.

Work founded by FCT – Fundação para a Ciência e Tecnologia, through Project POCI/EME/63236/2004.