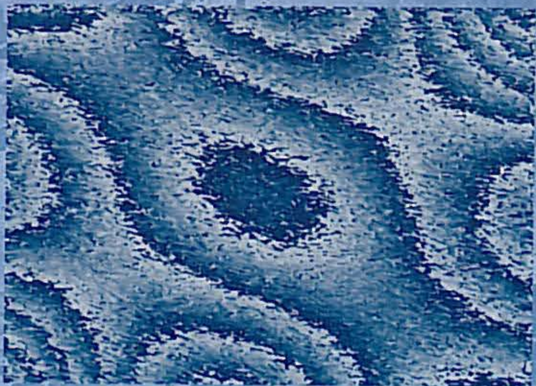
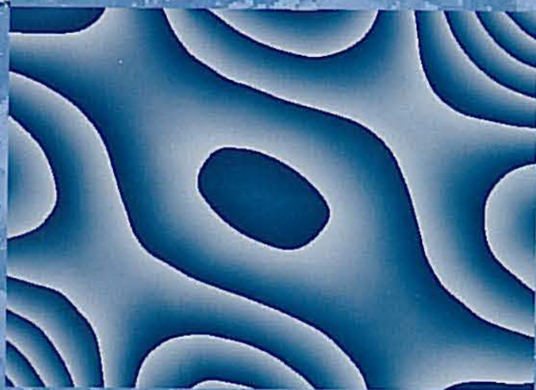
EXPERIMENTAL MECHANICS
New Trends and Perspectives

J.F. Silva Gomes, Mário A.P. Vaz
Editors





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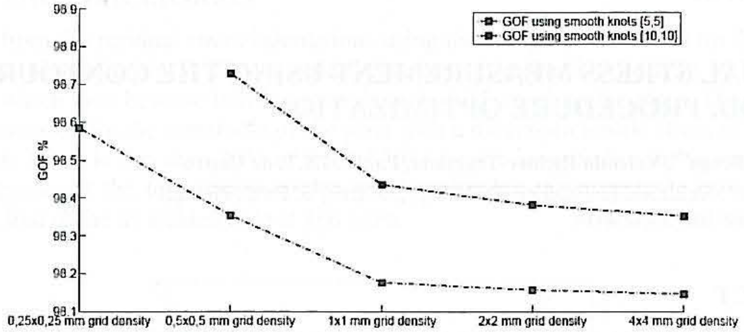

Figure 1 - Goodness of fit for different smoothing parameters

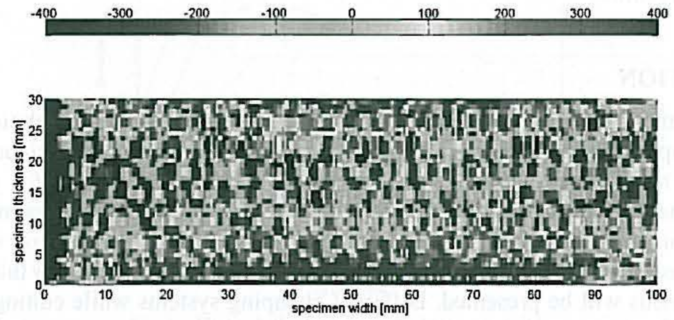

Figure 2 - Residual stress map obtained by the contour method for the maximum value of GOF

It was concluded that the optimum results are obtained with an interpolation grid density equal to the CMM measurement grid density. Concerning the number of smoothing knots it was concluded that its value may only be fully tuned by trial and error but engineering judgment can help to obtain near optimum parameters.

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PAPER REF: 2851

NEW METHODOLOGY TO MEASURE RESIDUAL STRESSES BASED ON FBG SENSORS

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ABSTRACT

Residual stresses are locked-in stresses which exist in a structural part without the application of any service or other external loads. The effects of residual stress may be either beneficial or detrimental, depending upon the magnitude, sign, and distribution of the stress with respect to the in service applied loads. In most cases, residual stresses arise from the production process.

In order to measure residual stress mechanically, the locked-in stress must be relieved so that a sensor can register the change in strain caused by the relaxation of the stress. One of the most common methods to measure residual stresses is the hole drilling method, which can be considered almost non-destructive due to the hole small diameter. Electrical strain gage rosettes are the sensors commonly used in this method. This type of sensor can be problematic when used on industrial environments. In order to eliminate this drawback the present study is focused on the development of a new methodology to replace these electrical sensors with fiber optic Bragg sensors. The results obtained, particularly with the 3.2mm length grating sensors, were encouraging. The residual stress profile is in agreement with the one obtained for the electrical sensors.

INTRODUCTION

Today, due to weight and cost reduction policies there is an increasing pressure to better understand the effect of residual stresses on the mechanical properties of a component/structure. Its failure can be due to external loading conjugated with locked-in residual stresses. In most cases, residual stresses are created due to mechanically induced plasticity or by thermal effects (Withers and Bhadeshia, 2001). Quantitative estimation of residual stresses is important for a safe performance of structural components, (Venkitakrishnan et al., 2007).

In order to measure residual stress mechanically, the locked-in stress must be relieved so that a sensor can register the change in strain caused by the relaxation of the stress. One of the most common methods to measure residual stresses is the hole drilling method, which can be considered almost non-destructive due to the hole small diameter (Mathar 1934). This method, technique widely accepted for measuring residual stresses, involves drilling a small hole into the surface of a component at the centre of a special strain gage rosette and measuring the relieved strains. This type of sensor can be problematic when used on industrial environments, mainly due to electrical noise and magnetic fields. In order to eliminate this drawback, this study is focused on the development of a new methodology to replace the electrical sensors with fiber optic sensors, fiber Bragg grating (FBG) sensors. After installation and residual stress measurements, this new type of sensors can also be used to monitor the strain loading of the component during service.

RESULTS

A MIG welded plate was used as a component containing residual stresses. Two fiber optic rosettes, with 1.6 and 3.2mm gratings, were developed and tested. For comparison, two similar electric strain gage rosettes were also used. A detail of a FBG rosette is presented in Figure 1. The results obtained for the 3.2mm sensor length, for the case of an electrical and a FBG rosette, are presented in Figure 2.

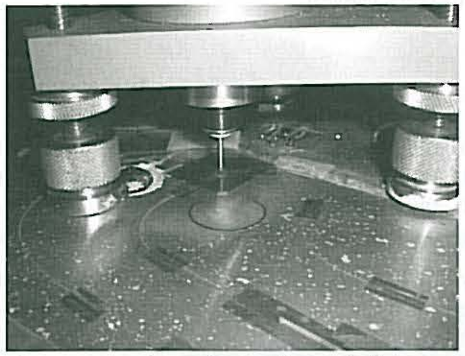

Figure 1 - Experimental setup, fiber optical rosette.

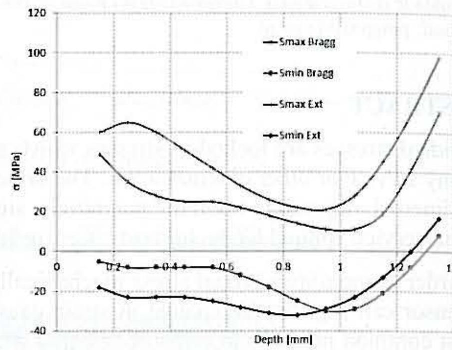

Figure 2 - Residual stress field, 3.2mm length sensors.

CONCLUSIONS

The results obtained, particularly with the 3.2mm length grating sensors, were encouraging. The residual stress profile is in agreement with the one obtained with electrical sensors. New developments are being performed in order to improve the methodology already developed.

ACKNOWLEDGMENTS

P. Moreira acknowledges POPH (Programa Operacional Potencial Humano) QREN (Quadro de Referência Estratégico Nacional) - Tipologia 4.2 promotion of scientific employment funded by the ESF (European Social Fund) and MCTES (Ministério da Ciência, Tecnologia e Ensino Superior). The support of Universidade do Porto Pluridisciplinar projects program is also acknowledge. The FBG sensors were kindly supplied by FiberSensing.

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PAPER REF: 2843

ULTRASONIC MEASUREMENT OF RESIDUAL STRESSES IN WELDED ELEMENTS AND STRUCTURES

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ABSTRACT

The objective of the study described in this paper is to identify the residual stress distribution and relaxation in standard welded specimens, large-scale welded panel imitating critical, from the fatigue point of view, zones of welded structure. The RS were measured after welding and in the process of fatigue loading of welded elements by the UltraMARS system that is based on using ultrasound.

INTRODUCTION

The residual stresses (RS) are one of the main factors determining the fatigue strength of materials, parts and welded elements and this factor should be taken into account during the design and manufacturing of different products (Trufyakov, 1995). Although certain progress has been achieved in the development of different experimental techniques, a considerable effort is still required to develop efficient and cost-effective methods of residual stress analysis (Kudryavtsev, 2008). The application of an ultrasonic non-destructive method for residual stress measurements had shown that, in many cases, this technique is very efficient and allows measuring the residual stresses both in laboratory conditions and in real structures in field for a wide range of materials (Kudryavtsev, 1985).

RESULTS AND CONCLUSIONS

The measurements of welding residual stress were performed for 8 and 15 mm thick specimens with longitudinal attachments welded from both sides and a large-scale welded panel. The main plate dimensions are 700x115mm and 600x70mm for 15mm and 8mm thick specimens, respectively. The process of residual stress measurement in 15 mm thick specimen by using the UltraMARS system is presented in Figure 1.

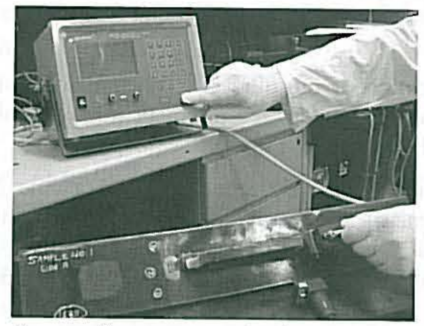

Figure 1 - Process of measurement of residual stresses in a welded specimen using the UltraMARS-7 system