PAPER REF: 4740

A NOVEL GRAZING ILLUMINATION SYSTEM FOR FATIGUE CRACK GROWTH MEASUREMENT

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ABSTRACT

This letter reports on the development of a dedicated illumination system for fatigue crack growth measurement system. The system uses darkfield lighting with a led ring system and a reflector for Central Crack Test (CCT) specimen illumination. Numerical ray-tracing optimization was employed for the specific specimen limitations, such as size and reflectivity properties as well as the requirement for uniform field illumination.

Keywords: fatigue testing, illumination systems, optical metrology, crack-tip growth.

INTRODUCTION

Traditional illumination systems for fatigue crack growth testing shows a severe limitation in contrast and a rather low detection capability for narrow crack opening. Furthermore, the discernment between the crack opening and other superficial artifacts prevents the correct identification of the crack-tip position and total length. Although these are not severe problems for the traditional crack-tip position measurement with a travelling microscope, they become very significant when trying to use image methods as an alternative. An important image processing rule is to start with the best possible image, or otherwise, statistical and morphological data processing will hardly be able to remove all unnecessary clutter.

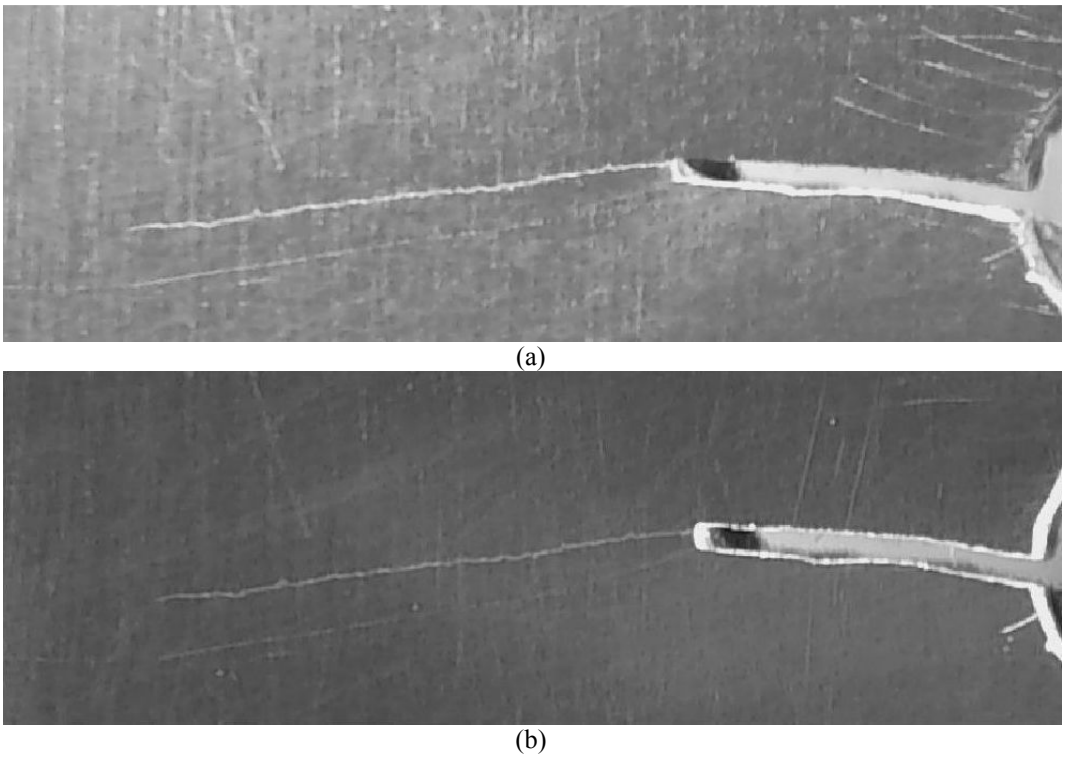
Developing an illumination system involves a correct specification of the test specimen geometry and physical properties as well as the envisaged feature characteristics. For the CCT test specimens and crack detection this implies a diffuse tangential illumination to increase the contrast of the crack relatively to the surface. It also requires a suitable wavelength for the specific detection sensor (Tian, 2007; Ortner, 2012). In this project, a cold LED lighting was used with an appropriate wavelength distribution and a special geometry for darkfield illumination was designed and optimized trough numerical ray-tracing.

RESULTS AND CONCLUSIONS

The initial testing shows very promising results with increased crack-tip detection capability with the LOME dedicated image processing system.

The images acquired with the grazing illumination system show a higher contrast and an increased S/N ratio. The required number of statistical and morphological imaging processing operations is considerably reduced for these images, increasing the processing efficiency and improving the final result.

A comparison of the images acquired with and without the grazing illumination can be seen in Fig. 1.



(a)

(b)

Fig. 1 - Imaged acquired with (a) no illumination and with (b) grazing illumination system

ACKNOWLEDGMENTS

The authors gratefully acknowledge INEGI - Instituto de Engenharia Mecânica e Gestão Industrial - for supporting the current work. Dr. Pedro 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 authors also acknowledge the support of FCT through project grant PTDC/EME-TME/120331/2010 - Combined Experimental-numerical methodology for SIF determination.

REFERENCES

[1]-Gui Yun Tian, Rong Sheng Lu, Duke Gledhill. Surface measurement using active vision and light scattering. Optics and Lasers in Engineering, 2007, 45, p. 131-139.

[2]-Ortner, A, Gräff, O, Stelzl, M, Macherey, F, Neubecker, R. 'Edge-light': combination of sensitive crack detection and luminescence measurements. 2012. Prog. Photovolt: Res. Appl.. doi: 10.1002/pip.2275.