Published in the QIRT Journal, Volume 1, Issue 1

Analysis of thermoelastic and dissipative effects related to fatigue of aluminium alloys

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Keywords: aluminium, fatigue, infrared thermography, thermomechanical couplings, dissipation

The traditional methods used for characterizing the fatigue behaviour of materials require several tests which are time-consuming and expensive.

The problem is even more delicate for aluminium alloys as the associated Wöhler curves do not present any asymptote allowing an assessment of the fatigue limit. Consequently there is an increasing interest in experimental approaches which may provide more rapidly fatigue behaviour characteristics.

Among these methodologies there are the thermal methods based on the analysis of the warming of the specimen during a stepwise loading fatigue test. The remarkable variation of the warming regime at a certain stress range was empirically related to the fatigue limit of material [1]. These methodologies already provided reliable fatigue limit values for some steels [1-3]. Conversely, the results are more questionable for aluminium alloys, particularly because of the high thermal diffusivity of these materials [4].

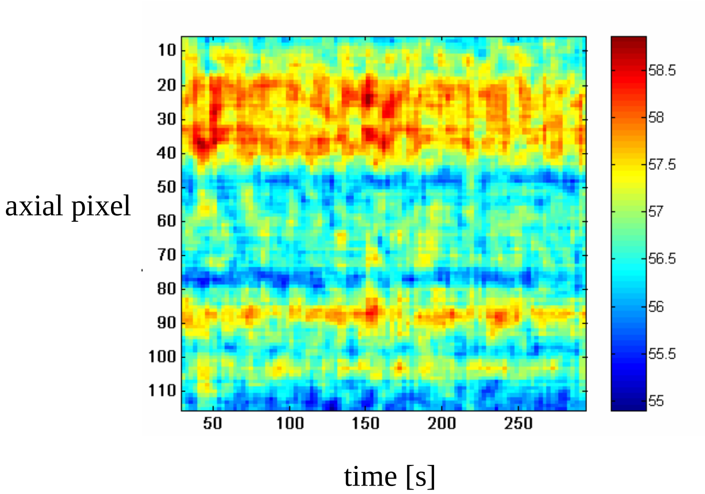
Considering the thermal increase as an indicator of fatigue damage may be problematic since it does not reveal the intrinsic behaviour of material. Actually it depends on the diffusion properties (material effect) but also on thermal boundary conditions and on the intensity and the distribution of heat sources (structure effect) [2-6].

In this work it is chosen to estimate the different heat sources accompanying the fatigue test using infrared thermal data and a local form of the heat equation.

In order to define the heat sources related to fatigue phenomena a thermomechanical framework is necessary: in this paper the Thermodynamics of Irreversible Processes is used. It permits to introduce the heat diffusion equation and to interpret the experimental results.

By means of this theory two energy-indicators are identified: the intrinsic dissipation and the thermoelastic source. They can be useful in order to predict the critical zones for the nucleation of fatigue damage.

For example in the following figure the axial profile of the thermoelastic source range (expressed in [°C/s]) is represented as a function of time. As it is possible to observe some localization phenomena are present. It will be shown that these phenomena are evident since the beginning of the stepwise loading fatigue test. Moreover they are placed in good agreement with the axial position of failure section.



Bibliography

[1] **G. La Rosa, A. Risitano** "Thermographic methodology for rapid determination of the fatigue limit of materials and mechanical components", International Journal of Fatigue, 22, 2000.

[2] **V.Dattoma, U.Galietti, A.E. Morabito,** "Analisi energetica del danneggiamento a fatica con tecnica termografica", Atti del XXX Convegno AIAS, Alghero 12-15 Settembre 2001.

[3] **V.Dattoma, U.Galietti, A.E. Morabito,** "Energy-Analysis of fatigue damage by thermographic technique" XXIV Thermosense Conference: 4710, Maldague, *et al.*, 2002, pp. 460-467

[4] **C. Mabru, A. Chrysochoos** "Dissipation et couplages accompagnant la fatigue de matériaux métalliques", Photomecanique 2001: Y. Berthaud, *et al.*, 2001, pp.375-382.

[5] **A. Chrysochoos, H. Louche,** "An infrared image processing to analyse the calorific effects accompanyng strain localisation", International Journal of Engineering Science, pp. 1759-1788, 38, (2000).

[6] **T. Boulanger, A. Chrysochoos, C. Mabru, A. Galtier** "Calorimetric analysis of dissipative and thermoelastic effects associated with the fatigue behaviour of steel": submitted to Int. J. of Fatigue.