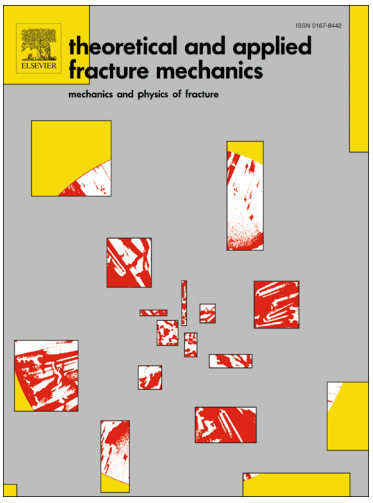
Accepted Manuscript



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PII: S0167-8442(18)30362-8
DOI: https://doi.org/10.1016/j.tafmec.2018.09.007
Reference: TAFMEC 2101

To appear in: *Theoretical and Applied Fracture Mechanics*

Received Date: 21 July 2018
Revised Date: 11 September 2018
Accepted Date: 11 September 2018

Please cite this article as: A.S. Chernyatin, P. Lopez-Crespo, B. Moreno, Yu.G. Matvienko, Multi-approach study of crack-tip mechanics on aluminium 2024 alloy, *Theoretical and Applied Fracture Mechanics* (2018), doi: https://doi.org/10.1016/j.tafmec.2018.09.007

MULTI-APPROACH STUDY OF CRACK-TIP MECHANICS ON ALUMINIUM 2024 ALLOY

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Abstract

This work presents a comprehensive study for characterising the crack-tip mechanics and fatigue crack propagation in an Aluminium 2024-T351 alloy. It combines information obtained from three different sources: full-field displacement information from digital image correlation, analytical modelling of the crack-tip field and SEM fractographies. The displacement data measured around the crack-tip are fitted to a Williams' series development in order to evaluate singular and non-singular terms of the crack-tip field. The procedures also allows rigid body motion to be corrected and the crack-tip coordinates and crack orientation to be estimated. Fatigue striations from the fracture surface were analysed with SEM in order to estimate the crack growth rate for different boundary conditions. Representation of all the results together with the Paris law data of the alloy allows the procedures to be cross-validated and to fit with a good agreement micro-scale measurements with continuum mechanics estimations.

Keywords

Fatigue crack growth; Al 2024-T351; Stress Intensity Factor; Digital Image Correlation; Scanning Electron Microscope;

Nomenclature

a – crack length;
W, Q – width and thickness of the Compact Tension specimen;
F – load applied to the specimen;
E, μ – Young's modulus and Poisson's ratio of material;
$X0Y$ – global coordinate system corresponding experimental measurements;
U, V – displacements of the specimen points in the global coordinate system;
$x0y$ – local coordinate system associated with the crack-tip;
r, θ – polar coordinates associated with $x0y$;
X_0, Y_0 – coordinates of the crack-tip in the global coordinate system before the loading;
α – angle of orientation of the crack plane before loading;
A, B – displacements of the crack-tip after loading;
φ – angle of rotation of the crack plane after loading;
u, v – displacements of the specimen points in the local coordinate system;

1. Introduction

Understanding crack-tip mechanics is key to improve fatigue life predictions of engineering materials. The important technological progress in the last 30 years has been extremely useful to improve our understanding of the different phenomena that take place at the crack-tip. For example, Scanning Electron Microscope (SEM) has been very useful to study different growth mechanisms in metals, such as growth on slip planes in a shearing mode or

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