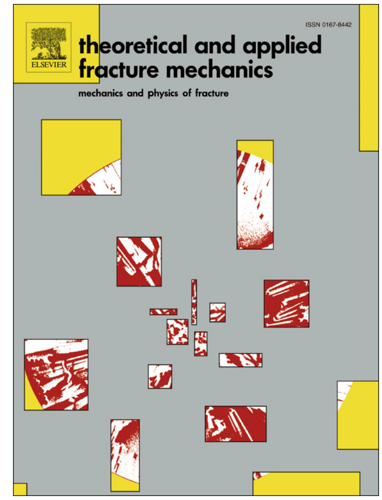

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Rui F. Martins, Luís Ferreira, Luís Reis, Paulo Chambel

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Fatigue crack growth under cyclic torsional loading

Rui F. Martins[a *], Luís Ferreira[a], Luís Reis[b], Paulo Chambel[a]

[a]UNIDEMI, Department of Mechanical and Industrial Engineering, Faculty of Science and Technology, Universidade Nova de Lisboa, *Campus* de Caparica, 2829-516 Monte de Caparica, Portugal

[b]IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1, 1049-001 Lisboa, Portugal

ABSTRACT

In the research herein presented, mode III and mode I fatigue loading tests were carried out on standard *compact tension* (CT) specimens using a bi-axial servo-hydraulic *Instron 8874* machine. Thin sheet CT specimens were made of two types of austenitic stainless steels, namely an AISI 316L stainless steel and a high-strength Cr-Mn stainless steel. Specimens were pre-cracked in mode I, at room temperature, and crack growth paths were experimentally determined. Fracture surfaces of rectangular sections were observed using optical devices and crack growth revealed to be higher at the external surfaces than at the mid plane of the specimens tested under mode III fatigue loading; in addition, smooth slant crack growth occurred, as well as crack branching. Fracture surfaces obtained under mode I loading revealed that crack grew flat, coplanar and normal to the tensile axis, as expected. Additionally, stress intensity factors present at tip of each branch crack loaded under mode III were calculated through finite element analyses (FEA). Hence, although an out-of-plane torsional loading was remotely applied, a mixture of modes was foreseen to be applied locally at crack tip during crack growth, namely mode I, mode III and mode II loading, in that order of relevance, and equivalent stress intensity factor values at the crack tip were calculated using Pook, Richard or Schöllmann *et al.* criterion.

Keywords: Cyclic torsional loading tests; Mixed-mode loading; Finite Element Analysis; Fatigue Crack Growth.

1. Introduction

Fatigue crack growth (FCG) can lead to non-expected fracture of components or structures [1-3], being important to continuously monitor crack propagation in order to avoid catastrophic failure. In general, any complex structure composed by components in which the primary load path is at an angle to crack-like defects or is subjected to variable bending, torsion and tension will experience mixed mode fatigue loading [4, 5]. From experimental observations, crack growth will depend, just among other variables, on type and magnitude of the loads applied, on the ratio among different loads, as well as on the initial crack length and on the initial crack tip condition, or on the environmental conditions that are applied to the crack during its propagation; they will also depend on the cyclic mechanical properties of the material in which a crack propagates, anisotropy, mean stress or on the residual stresses present in the structure or components [6]. In fact, detailed crack growth analysis for metallic materials can use complex and little-used methods that include plastic deformation in the crack tip region introduced by load history effects, as well as of crack closure and friction, which can be responsible for modifying the direction and kinetics of crack propagation [7, 8].

This paper analyses crack propagation effects of applying either mode III or mode I loading in an AISI 316L and in a Cr-Mn high-strength austenitic stainless steel [3, 9-10]. The AISI 316L is a stainless steel frequently

* Corresponding author: Tel.: +351-21-294-8567; fax: +351-21-294-8531
E-mail address: rfspm@fct.unl.pt