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ABSTRACT: The estimation of crack growth under variable amplitude loading is complex due to interaction effects such as plasticity, crack tip blunting, residual stresses, crack tip closure and crack tip branching. Crack closure has been identified to be one of the main interaction effects. In order to study the effect of crack closure the authors have previously carried out experimental testing to obtain more accurate measurements of crack opening and closure (1, 2). They have also developed two dimensional plane stress Finite Element models utilising high mesh density whilst maintaining the ability to measure crack growth over long crack lengths (3). This initial work has been extended in this paper to examine the effects of single and block overloads and random spectrum loading on crack growth. The crack length distance that is affected by overloads and underloads measured experimentally and predicted numerically are shown to be very close when using cyclic hardening material properties and kinematic hardening. In addition the comparison of experimental and numerical crack growth versus crack length graphs shows good correlation of the crack growth acceleration and retardation after the applied overload which has not been seen previously. These comparisons seem to be a very useful tool to validate numerical models.

KEY WORDS: fatigue; crack growth; finite element, periodic loading; crack closure; overloads

1. Introduction

It is generally well recognised that there are interaction effects that modify the fatigue life of components when subject to variable amplitude loading. A key effect of the interactions on fatigue life is crack growth acceleration and retardation. There is though some debate about which interactions cause crack retardation and acceleration and several hypotheses have been proposed as a source of these phenomena. There have been several reviews about load interactions on fatigue crack growth (4-10) which suggest that the principal reasons are: crack closure (plasticity, roughness and oxide), residual stresses, crack tip blunting, crack tip sharpening, crack tip branching, strain hardening, crack deflexion, and change in rate of damage accumulation in the reversed plastic zone ahead of the crack tip. All these interaction mechanisms depend on stress/strain conditions, material quality, load type, environment and other specific conditions that depend on the application. Also some mechanisms are not totally independent of each other (5).
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