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A two-phase approach to estimate fatigue crack initiation and propagation lives of notched structural components

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Abstract Total fatigue lives of notched structural components are considered as a summation of crack initiation and propagation phases and a two-phase approach to fatigue life prediction is presented. The local strain approach and fracture mechanics-based approach are used to predict the lives spent in the two phases. A strain-life curve corresponding to the transition crack size where the two phases are divided is formulated based on the equivalence between the Coffin-Manson law and a simple Elastic-Plastic Fracture Mechanics crack growth law in the low cycle fatigue regime. A crack growth model that includes the short crack behaviour is used to predict the crack propagation life. The transition crack size, related to the average grain size of the material, is chosen in such a way that the proposed approach can be appropriately adopted in both phases, considering the stress gradient and microstructure effects. The proposed approach is applied to predict fatigue lives of various notched specimens. The three-dimensional effect is considered in the assessment. The predictions are in good agreement with the experimental results.

Keywords: Crack initiation; Crack propagation; Notch; Small cracks; Fatigue life prediction.

Nomenclature

a	crack size
a_d	size of defect
a_i, a_f	initial crack size, crack size at failure
a_t	transition crack size dividing the crack initiation and propagation phases
a_0	El Haddad intrinsic crack size
a^*	an additional parameter in the threshold model
A, n	parameters in the short crack propagation law
C, m	parameters in the crack propagation law for high strain fatigue loading
d, r, θ, t, w	geometrical parameters for the micro-notched specimen
D, R, t, W	geometrical parameters for the central-hole-notched specimen
E, ν, μ	Young's modulus, Poisson's ratio, generalized Poisson´s ratio
ESED	Equivalent Strain Energy Density
FE, FEM	finite element, finite element method
g	average grain size
HB	Brinell hardness
K', n'	cyclic strength coefficient, cyclic strain hardening exponent
K_t	stress concentration factor
LCF, HCF	low cycle fatigue, high cycle fatigue
LEFM, EPFM	Linear Elastic Fracture Mechanics, Elastic-Plastic Fracture Mechanics
N, N_i, N_f	fatigue life, fatigue crack initiation life, total fatigue life
NSIF	Notch Stress Intensity Factor

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