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NUMERICAL ANALYSIS OF PLASTICITY INDUCED CRACK CLOSURE BASED ON AN IRREVERSIBLE COHESIVE ZONE MODEL

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ABSTRACT

During the last years different numerical models based on node to node crack growth scheme have been employed to study the effect of plasticity induced crack closure (PICC). This paper presents a numerical analysis of PICC based on a cohesive zone model (CZM) ith with irreversible damage that employs a crack growth method coupled with cyclic plasticity at crack tip and phenomenological fracture. The CZM produces a plastic wake from volumetric plastic strain that is different than that generated in uncoupled methods. Thus, the proposed model generates a high deviatoric plastic strain, allowing the closure study without strain ratcheting at first node behind the crack tip. Results obtained from the proposed numerical analysis are compared with those obtained from experimental fatigue tests conducted on a 2024-T3 aluminum alloy compact-tension specimens (CT). Numerical results show an excellent correlation with those obtained experimentally highlighting the ability of the proposed CZM to capture the influence of crack tip plasticity in the evaluation of crack closure phenomenon..

Keywords: Plasticity induced crack closure, cohesive zone model, strain ratcheting, process zone, finite element analysis, fatigue damage.

NOMENCLATURE

T= Effective cohesive traction.
NLC= Number of load cycles.
COD= Crack opening displacement.
E= Young Modulus.
$P\varepsilon_{xx}$, $P\varepsilon_{yy}$, $P\varepsilon_{xy}$= Logarithmic plastic strain components at bulk material.
P= Load applied.
P_{max}= Maximum load.
P_{min}=Minimum load.
P_{op}=Opening load.
k= Damage variable.
K_{com}= Cohesive stiffness during compression situations.
K_{coh}= Initial cohesive stiffness.
dy= Crack profile displacement.
δ= Effective cohesive separation.
δ_c= Cohesive critical separation.
δ_E= Cohesive failure separation.
σ_c= Initial maximum cohesive traction.
α= Rate of damage evolution.
γ=Damage healing.
β=Damage threshold.
σ_{ys}= Yield stress.
σ_0= Remote stress.
σ_{xx}, σ_{yy}, σ_{xy}= Bulk material stress tensor components.
σ_{11}, σ_{22}, σ_{12}= Cohesive stress tensor components.
ε_{xx}, ε_{yy}, ε_{xy}= Logarithmic strain components at bulk material.