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Experimental study of crack growth under non-proportional loading along with first modeling attempts

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Abstract

For various configurations examined in a series of fatigue experiments on thin-walled tubes under tension and torsion, the experimental results (crack path and crack growth life) are measured. Additionally, crack opening and closure was observed applying surface deformation field measurements using digital image correlation. Due to the high applied load amplitudes considerable cyclic plastic deformation occurred especially ahead of the crack front. The material's cyclic plastic behavior was measured and a convenient plasticity model was used for its description. In the finite element analyses, actual geometries of cracked structures have been modeled. The non-linear nature of the cyclic deformation has been taken into account by applying the cyclic plasticity model. Plasticity-induced crack closure is captured by a contact formulation, actually however only for simple tension-compression loading. For the latter case, closure-free cyclic J-integrals were calculated. The crack growth rates measured in the experiments correlate well with the numerically determined cyclic J-integrals for the simple mode I case.

Keywords: Multiaxial fatigue; Mixed mode; Fatigue crack growth.

Nomenclature

$a_i, b_i, c^{(i)}$	material constants
$c_T, c_A, c_\chi^{(i)}$	material parameters
E	Young's modulus

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