Fatigue crack growth under large scale plasticity: A direct physical approach for single-valued correlation of fatigue crack growth data

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Abstract

The major challenge in the mechanics of elastic-plastic fatigue crack growth is to find a physically based driving force to correlate the crack growth rates under different loading conditions. Specifically, a parameter capable of providing a *single-valued* correlation of crack growth rate, regardless of applied fatigue stress/strain values, is needed. Approaches of the past used either cyclic strain (strain intensity factor) or nonlinear fracture mechanics based (cyclic J-integral, ΔJ) parameter, to correlate fatigue crack growth. The latter, however, requires experimental load-deflection curve after every crack length increment and geometry correction factors, which are complex. In the present work, it is shown that a new and physically based approach, on the basis of the *cumulative change in the cyclic strain energy of the net-section*, is used to successfully correlate fatigue crack growth in a variety of loading situations. The change in the cyclic strain energy is determined analytically from elastic-plastic behavior of material and from the relative sizes of cracked and uncracked sections in the crack plane. Load-deflection measurements, geometric correction factors, or numerical methods of fracture mechanics are not needed in the present approach. Remarkably, excellent correlations of fatigue crack growth in a variety of specimen geometries and stress/strain levels have been found in both *stress- or strain-controlled fatigue* conditions. This work, in conjunction with the author's earlier works, validates that the change in net-section strain energy is a fundamental quantity in the mechanics of fatigue crack growth.

Keywords: Fatigue, Crack growth, Net-section, Elastic-plastic, Yielding, Strain energy, Stress intensity factor