Effect of Gross Plasticity on Fatigue Crack Propagation in Elliptically Notched Plates

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The fatige crack propagation occupies a major fraction of the useful fatigue life in many structural components. For the purposes of analysis and design, crack propagation rates have been sought by various researchers in terms of stresses and other variables of the component. Use of Stress Intensity factors to describe the rate of crack propagation seem to be the most rational of the present methods (1). This method, however, fails when the assumptions of linear fracture mechanics are violated. The present investigation is concerned with removing this restriction and extension of this approach to cases of crack propagation in components subjected to inelastic strains.

To describe inelastic stresses and strains in the vicinity of crack tips inelastic stress and strain intensity factors are proposed. As it is formidable to derive these factors in most cases a modified stress intensity factor is developed which indirectly incorporates these inelastic intensity factors (2). Using a recent hypothesis due to Neuber (3), this modified stress intensity factor ($\Delta K'$) is shown to be related to linear stress intensity factor (ΔK) as:

$$\Delta K' = \Delta K \left[1 + \frac{\Delta \epsilon_N^p}{\Delta \epsilon_N^e} \right]^{1/2} \qquad (1)$$

where $\Delta \epsilon_N^p$, $\Delta \epsilon_N^e$ are the nominal plastic and elastic strain ranges respectively.

Functional relations between crack propagation rates and the modified stress intensity factors are developed.

To illustrate and substantiate this procedure, about 50 experiments were conducted using thin mild steel and two aluminum alloy (7075-T6 and 2024-T3) plates with central elliptical holes. Plate specimens were subjected to constant amplitude nominal cyclic strains in a servo-controlled hydraulic closed loop testing system. Crack lengths at various number of cycles were measured using a travelling microscope, from which crack propagation rates were computed. For determination of modified stress intensity factors for these plates with cracks emanating from central elliptical holes, stresses recordet at various numbers of cycles were used. Relations between crack propagation rates and the stress intensity factor ($\Delta K'$) are given and discussed in the light of the existing relations and methods. Dependence of crack propagation on strain levels, crack length and material properties is given. Influence of local and gross plasticity on fatigue crack propagation rate is elaborated.

REFERENCES

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