Synopsis

Thesis Title : Development of Fatigue Crack Growth Model for Variable Amplitude Loading towards Damage Tolerant Philosophy

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Most components or structures experience in service a variety of cyclic stresses. In the case of cyclic constant amplitude loading the fatigue crack growth depends only on the crack, the component geometry and the applied loading. In the case of variable amplitude loading it also depends on the preceding cyclic loading history. Various types of load sequence (overloads, under-loads, or combination of them) may induce different load-interaction effects which can cause either acceleration or reduction of the fatigue crack growth rate.

A fatigue crack growth (FCG) model based on the analysis of the local stress-strain material behavior at the crack tip has been developed which could be used for fatigue crack growth analyses of cracked bodies subjected to an arbitrary variable amplitude loading (VAL). The model enables to correctly predict the effect of the applied compressive stress and tensile overloads by accounting for the existence of the residual stresses induced by the reversed cyclic plasticity around the crack tip. The model uses Creager and Paris solution for linear elastic stress field ahead of a blunt crack tip with a root radius. A procedure to obtain root radius is proposed and compared with values available in literature for various alloys of aluminum and steel. Actual elastic-plastic crack tip strains and stresses are determined from the Neuber rule for which the linear elastic stress data acts as input. Ramberg Osgood cyclic stress strain relation is used to get residual stress field after every cycle of loading. By using the weight function technique the effect of the resultant residual stress field is presented in terms of the instantaneous residual stress intensity factor and subsequently it is included into effective stress intensity factor range.

A set of prescripts are proposed for getting effective residual stress field after each load cycle. It allows modeling all effects of arbitrary load sequence on fatigue crack growth. The model uses a B-spline based fatigue crack growth relation which uses Collipriest crack driving force, D_c to account for stress ratio, R effects for fatigue crack growth rate (FCGr) under constant amplitude loading (CAL). The experimental verification of the proposed model is performed using data from literature.

Following are the contributions made in the project:

- An enhanced model is presented for modeling fatigue crack growth for CAL. The model is able to account for stress ratio effects efficiently.
- The whole of fatigue rate curve is descried using non uniform B-spline and the B-spline was represented as piecewise polynomial.
- Seven fatigue crack growth (FCG) models have been examined and performance of the crack driving force of these models in depicting stress ratio effects on fatigue crack growth.

- A new procedure has been proposed to estimate the root radius, ρ^* , which later used for describing linear elastic stress field ahead of crack tip.
- Prescripts are outlined to obtain the effective residual compressive stress from loading sequence and corrective residual stress intensity factor.

  One of the objectives of damage tolerant design (crack growth life versus crack length) is carried out.