Synopsis

Thesis Title : Fracture analysis of structural components with multi – site damage

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Multi-site damage (MSD) has been a challenging issue to the aircraft and construction industry for a long period. In real life situation, components develop cracks at more than one location and these cracks propagate in a completely different manner from the case of a specimen with a single crack. Unlike components with a single crack, where mostly the cracks take a self-similar growth pattern, these components show a curvilinear crack path, which is difficult to predict. When two cracks approach one another, their stress fields influence each other and produce enhancing or shielding effect depending on the position and orientation of the cracks. There are no generalized analytical methods/formulae for predicting their stress fields and the remaining life of components with MSD. In the present study, a model has been developed in MATLAB for the evaluation of strain energy release rates and stress intensity factors (SIF) for multiple cracks by using the modified virtual crack closure technique. Numerical investigations have been carried out on collinear cracks by varying the secondary crack width and spacing between the crack tips. The crack tip spacing is found to influence SIF in an exponential way. Numerous cases of non-aligned cracks have also been solved by varying the crack tip spacing and the vertical offset. By using a curve fit in MATLAB based on least squares minimization, interaction factors and expressions for SIF have been arrived at for the case of collinear cracks and non-aligned straight cracks. Experimental studies have been carried out on cold formed steel specimen, in order to study its fracture behavior and for evaluation of the crack growth constants. Tension coupon tests have been conducted as per ASTM standards on cold form steel (CR5 grade). Fatigue crack growth tests have been conducted on C(T) specimen as per ASTM E-647 in order to obtain crack growth constants and the fracture toughness of the material. Remaining life has also been computed for several plates with multiple cracks. It is found that the vertical offset and edge distance are very crucial parameters that influence the remaining life. Hence, it is recommended that edge distance is also a primary parameter to be considered, while analyzing multiple cracked components.