Computational fatigue crack propagation in arbitrary geometries including retardation effects

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To predict fatigue crack propagation in generic structural components, the stress intensity factor along the crack path must be calculated using a finite element global discretization, including appropriate crack tip elements, mesh generation schemes, and crack increment criteria. However, such numerical calculation just by itself is not efficient when the load is complex and crack retardation effects must be considered, requiring remeshing and time consuming recalculations in Finite Elements at each loading cycle.

On the other hand, the local approach based on the direct integration of the crack propagation rule can be efficiently used to calculate the crack increment at each load cycle, considering crack retardation effects if necessary [1]. However, this local approach requires as input the stress intensity expression for the crack, which may not be available for too intricate components.

Since the advantages of the two approaches are complementary, a reliable and cost effective two-phase methodology is introduced here to predict fatigue crack propagation in generic structural components under complex loading. First, an appropriate Finite Element software is used to calculate the generally curved crack path and its associated stress intensity factor, under **simple** loading. These values are then used as input to a local approach fatigue design software, where the actual **complex** loading can be efficiently treated cycle-by-cycle to predict the propagation fatigue life of the structure, considering load interaction effects such as overload-induced crack retardation, acceleration or arrest.

Two complementary software have been developed to implement this methodology in two-dimensional components [2]. The first software is an interactive graphical program for simulating 2D fracture processes based on a finite element self-adaptive mesh generation strategy. The second is a general-purpose local approach fatigue design software, developed to predict both initiation and propagation fatigue lives under complex loading by all classical design methods. In particular, its crack propagation module accepts any stress intensity factor equation or table, allowing it to be used with virtually any finite-element software. Experimental results show that the presented methodology and its software implementation can effectively predict the crack propagation path and fatigue life of an arbitrary 2D structural component.

References

[1] Broek, D., *The Practical Use of Fracture Mechanics*, Kluwer 1988.

[2] Miranda, A.C.O., Meggiolaro, M.A., Castro, J.T.P., Martha, L.F. and Bittencourt, T. N., "Fatigue Crack Propagation under Complex Loading in Arbitrary 2D Geometries," *Applications of Automation Technology in Fatigue and Fracture Testing and Analysis*: *Fourth Volume*, *ASTM STP 1411*, ASTM, West Conshohocken, PA, 2001.