CAE ASSOCIATES
ENGINEERING ADVANTAGE

Fatigue Crack Growth Analysis

Fatigue crack growth analysis methods combine finite element analysis (FEA) to determine stress, and/or strain, with separate fracture mechanics analyses for specific materials of interest as indicated in Figure 1. The most common application of these types of analyses is during a Damage Tolerance (DT) analysis of a structure.

Even though a structure is not put into service with a known crack, the concept of DT is to suppose that a crack could inadvertently be present. The DT analysis determines how many fatigue cycles will grow the crack to the point of structural failure, or until an undesired condition exists (for example: a leak in a pipe). This analysis can then be used to set proper inspection intervals or remove the part from service, before the hypothetical crack can grow to the undesired condition.

Fatigue Crack Growth analyses are also used to evaluate the remaining life when an unexpected crack has been discovered in a structure. The methods used to predict crack growth are quite different from those used to predict crack formation. ANSYS finite element analyses are used to understand the local stress and strain cycles in the vicinity of the crack site. Fracture mechanics principles are used to relate the stress fields in the part to the Stress Intensity at the tip of the crack. The Stress Intensity Factor (SIF) is then related to the cyclic growth rate of the crack as illustrated above. Stand-alone computer codes such as ANSYS nCode DesignLife,

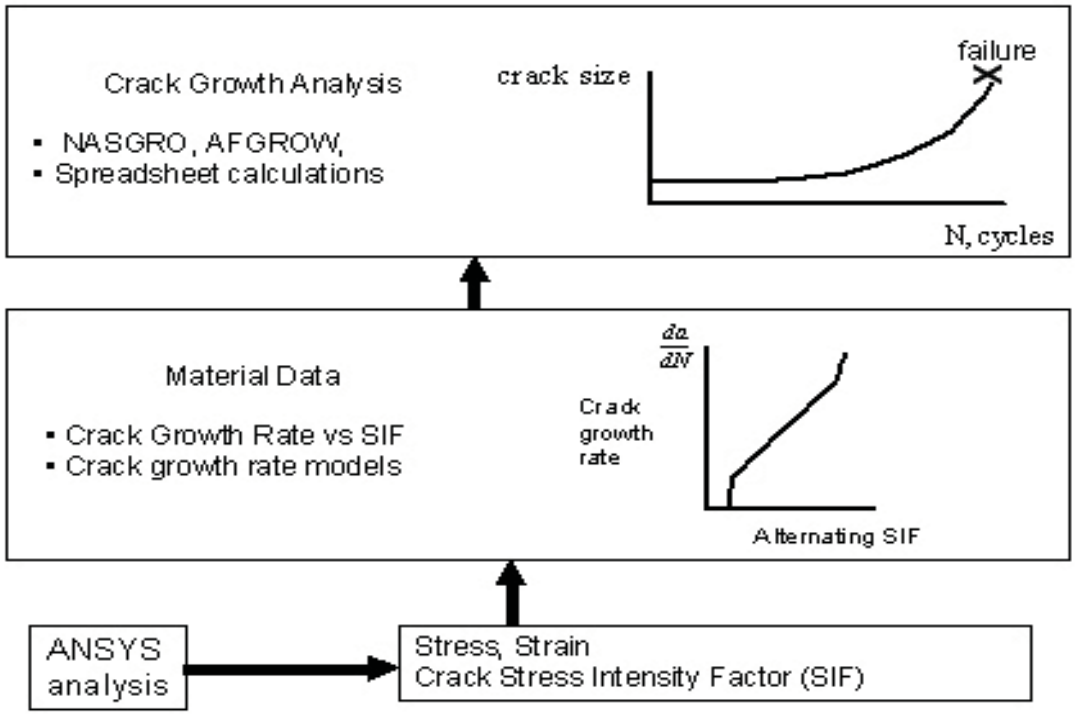

Figure 1. Elements of a fatigue crack growth analysis.

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or separate spreadsheet-based codes are used to integrate the crack growth rate curve to predict total crack life.

Stress Intensity Factors have been determined for many standard machine elements such as holes and simple plates, and are included in libraries in some crack growth codes. If the geometry of interest is equivalent to one of these standard geometries, then the standard SIFs can be used directly with the stress output from the finite element analysis.

It is not usually necessary to include the actual crack in the finite element analysis unless standard SIF solutions have not been developed for the geometry and loading of the part. For these special situations, CAE Associates uses a variety of fracture mechanics methods, such as special crack tip elements or J-integral calculations to determine the SIF. A proprietary algorithm has been developed by CAE Associates to determine the SIF of a crack as it grows through the part, accounting for the compliance and load changes due to the growth of the crack., as shown in Figure 2.

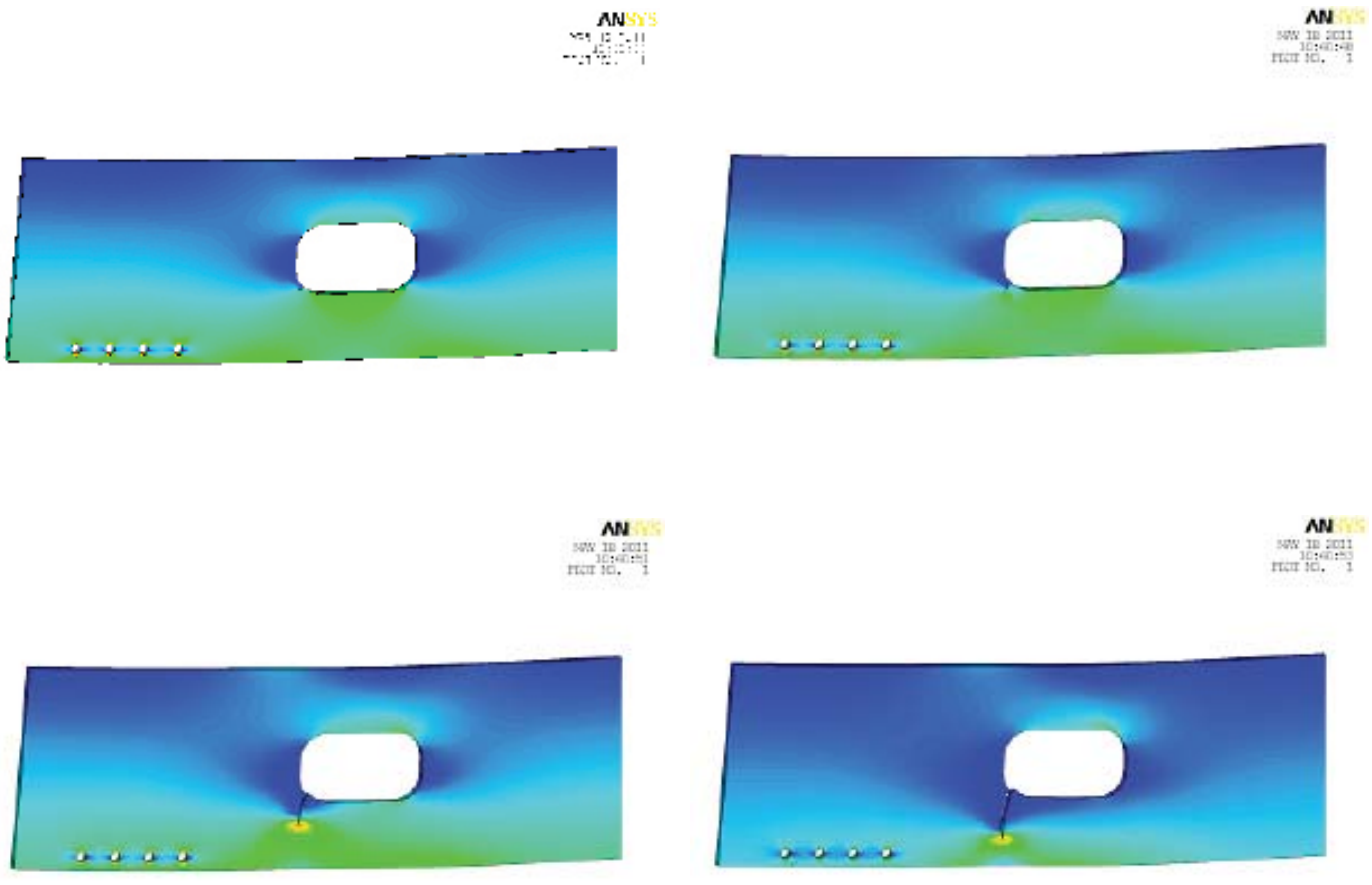

Figure 2: Automated crack growth analysis using mesh-morphing routines.

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