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ENGINEERING ADVANTAGE

Fatigue Crack Formation Analysis

Fatigue crack formation analysis methods combine ANSYS finite element analysis to determine the stress and/or strain, distribution and separate fatigue analyses that relate the stress-strain to fatigue crack life of a specific material.

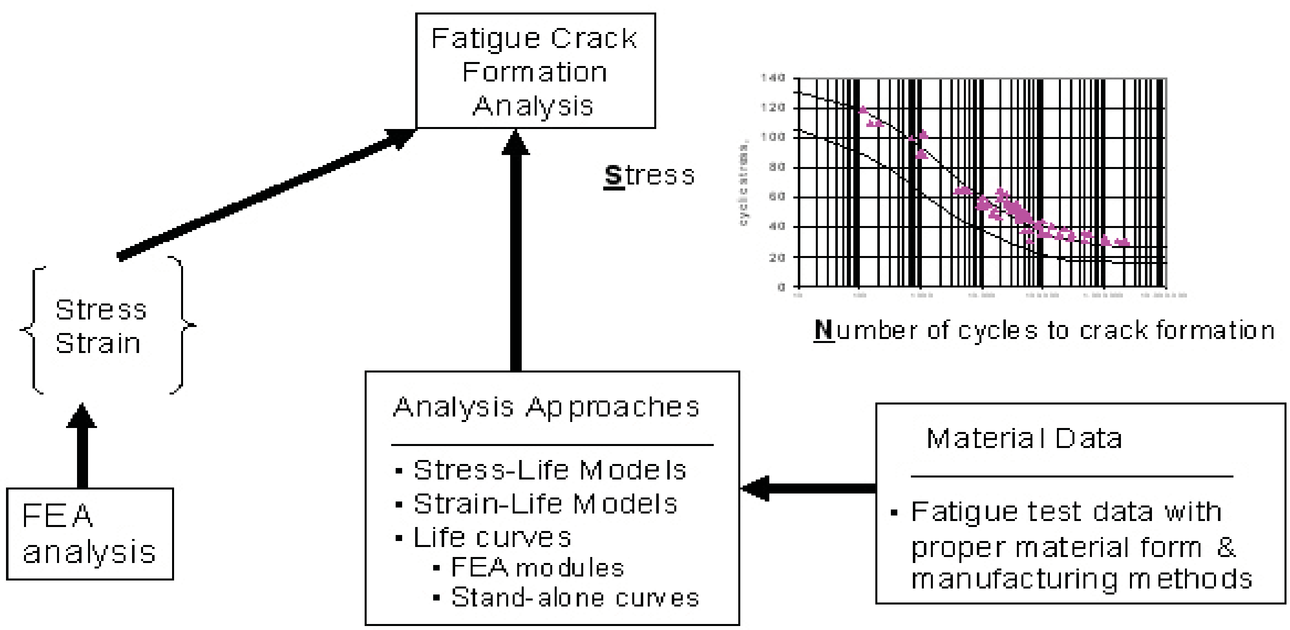

Figure 1. The roles of FEA and fatigue data in a Stress-Life fatigue analysis.

Fatigue cracks can form at stress levels well below the Ultimate Tensile Strength (UTS) or Yield Strength (YS). In these cases, an elastic material assumption in the finite element model is sufficient for obtaining stress and strain at the site of crack formation.

The Stress-Life method is the most common method used to relate the FEA stresses to the material's fatigue life, as illustrated in Figure 1. Fatigue crack formation depends upon the attributes of the material, including its internal structure (such as grain structure, particle types and size distribution) and the way it is manufactured (rolled, forged, heat treatment, milled, welded, shot peened, etc.). Because most fatigue cracks form at surfaces, the manufacturing process used to make the final surface is very important.

A significant amount of engineering judgment and experience must be employed to make meaningful predictions, especially if the available material database does not match all the relevant material attributes. For example, fatigue trends within low alloy steels

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can sometimes be normalized to the UTS of the steel, so that fatigue curves for one steel can be normalized and used as a surrogate for the particular steel of interest.

A typical fatigue analysis would develop appropriate fatigue life curves and use them as a subsequent process to the ANSYS stress analysis. ANSYS-nCode DesignLife provides the ability to input a fatigue life curve and track stress excursions in a complex loading schedule, thus enabling an accurate computation of fatigue life.

Some structures experience significant amounts of plasticity or creep. In this event,the finite element stress analysis must include material non-linearity and be used with more advanced fatigue life prediction methods. In these situations, there are very few publicly available fatigue databases. Instead, life prediction curves must be constructed from limited data. . Previous cracking experience of the part, or a similar part, can often be used to calibrate life prediction curves so that design improvements can be made.

There is significant scatter in fatigue capability of a material, as indicated in Figure 2. It is not uncommon for fatigue crack lives to vary by a factor of 10 or more at a single stress level. Therefore, a key element in a fatigue analysis is to properly account for the scatter in order to achieve an acceptably low number of cracks in the entire product line. . In some situations, the design / manufacturer must meet specified reliability levels such as 99% reliability with 95% confident level (the "99/95" or "A-basis").
Weibull, Log-Normal or Normal probability approaches are commonly used to achieve this requirement Figure 2 illustrates the "A-basis" limit established from a set of test observations.

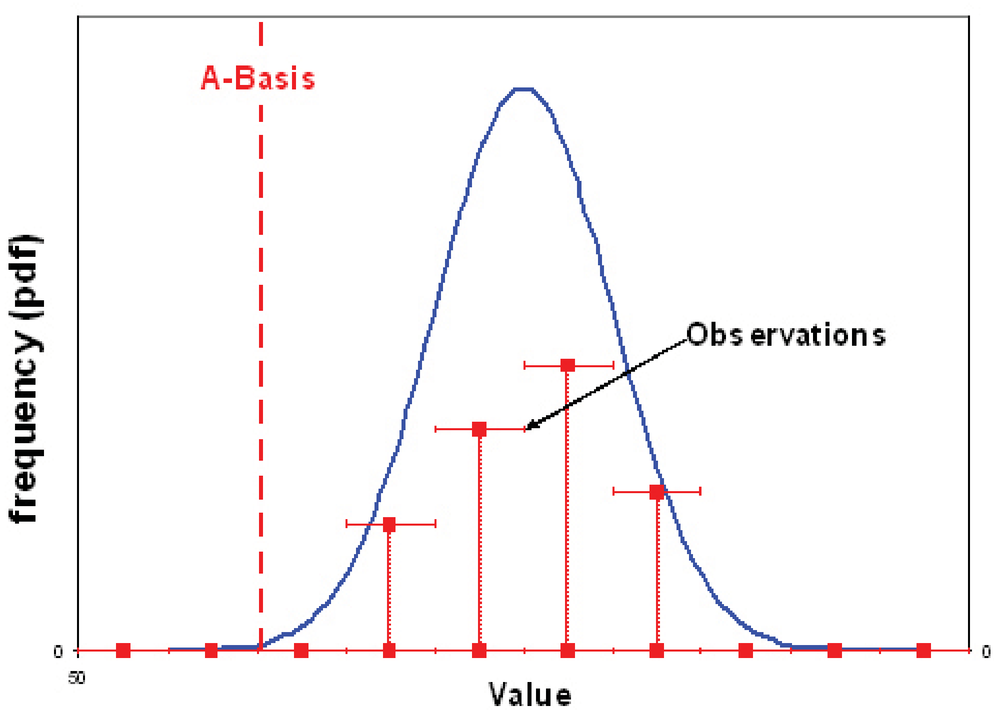

Figure 2. "A-basis" limit established from a set of test observations. The tests are idealized as a Normal distribution to establish the 99% reliability level with 95% confidence.

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