Workshop 4

Fracture and Fatigue Applications

Bolt Load Problem

- A bolt loaded compact K_{IEAC} specimens is tested as follows:
- W = 50 mm, B = 25 mm, a_o = 20 mm in, E = 210 GPa

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- a) The K_{Iscc} specimen is loaded with the load line displacement v_{ll} = 0.25 mm and placed in an environmental test chamber. The crack grows to 40 mm and arrests. Find the K_{Iscc} assuming that the load line displacement was remaining constant.

Critical Defect Problem

- For the SI K_{Ic} result in Workshop 2 and $\sigma_{ys} = 700$ Mpa

-    a) What is the critical defect size for a plate that is 100 mm wide and 25 mm thick with an edge defect and loaded in tension to 1.0 MN.

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-    b) What is the critical defect size if the K_{ic} is doubled and the yield stress halved

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Cyclic Life Problem

- Use the result of the da/dN vs ΔK test in prob 6 to predict the fatigue life for a semi-infinite SENT geometry with

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- a_o = 0.1 in, K_{Ic} = 100 ksi√in

- and stress range is 10 to 40 ksi

Fracture Mechanics Used in Fractography

1. Use fracture surface as a guide to the behavior of the component

2. Stages in failure

    i) Crack initiation (or pre-existing crack)

    ii) Crack Propagation, fatigue crack growth, stress corrosion cracking

    iii) Final Failure
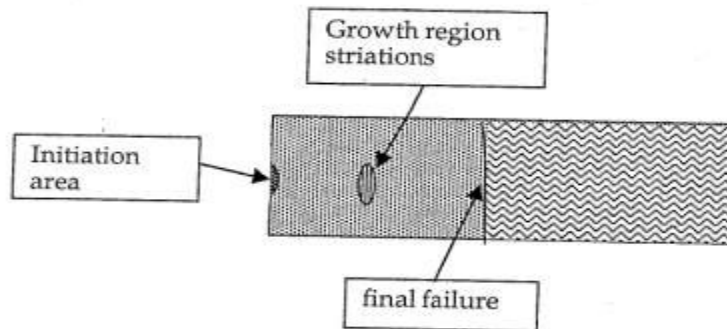
3. Examples of calculations of behavior

    i) Initiation, S-N or, ε-N

    ii) Growth, da/dN vs ΔK

    iii) Failure, K_{Ic}

Failure Problem

- A tension strut from a lifting devise has a 1x5 in. cross-section. It is rated to carry 75 kips maximum. The lifting devise picks up loads about 5 times an hour during operation. It had a design life of 25 years.

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- A failure of the strut occurred after about 7 years of operation. Examination of the fracture surface revealed the following:

- i) A small area on the edge was discolored (about 0.02x0.1 in). This appeared to be the initiation point of the failure.

- ii) The area around this looks like fatigue

Material Properties

- Assume properties of the material:

-    a) Generic da/dN vs ΔK generic for steel
  $$da/dN = 6.6 \times 10^{-9} \Delta K^{2.25}$$

- b) ΔK_{TH} is about 6.0 ksi $\sqrt{in}$

- c) K_{Ic} is about 120 ksi $\sqrt{in}$

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- Do an evaluation of this failure using the principles from the course. Consider evidence from each of the observations on the fracture surface.

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Fracture Surface

0.02x0.1 in area

final failure

1.75 in