

Fracture Mechanics Exam solutions

A. Problems:

1. $a/W = 55/100 = 0.55$, $f = 11.36$, $BEv/P = 47.85$
 - a) $K = (0.050)(11.36)/((0.025)\sqrt{0.1}) = 71.8 \text{ MPa}\sqrt{\text{m}}$
 - b) $P = (0.025)(210,000)(0.0005)/47.85 = 0.0549 \text{ MN}$
 $K = (0.0549)(11.36)/((0.025)(\sqrt{0.1})) = 78.8 \text{ MPa}\sqrt{\text{m}}$
2. $a/W = 0.5$, $f = 9.66$
 $K_Q = (0.05)(9.66)/0.025\sqrt{0.05} = 86.4 \text{ MPa}\sqrt{\text{m}}$
 $P_{\max}/P_Q = 54/50 = 1.08$; okay
 $a/W = 0.5$; okay
 $2.5(K_Q/\sigma_{ys})^2 = 2.5(86.4/900)^2 = 0.023 < a$, B; okay
 $K_Q = K_{Ic} = 86.4 \text{ MPa}\sqrt{\text{m}}$
 $R_{sc} = 2(0.054)(0.1 + 0.025)/(0.025)(0.025)^2(900) = 0.96 < 1$
3. a) $1 \times 10^{-11}(30)^3 \Delta K = 30$; $da/dN = 1 \times 10^{-11}(30)^3 = 2.7 \times 10^{-7} \text{ m/cyc}$
b) $da/dN = 1.0 \times 10^{-6} \text{ m/cyc} = 1 \times 10^{-11}(\Delta K)^3$, $\Delta K = 46.4 \text{ MPa}\sqrt{\text{m}}$
4. $\Delta\sigma = 250$, $\sigma_{\max} = 250$
 $a_f = (100/250)^2/\pi = 0.0509 \text{ m}$, $a_o = 0.002 \text{ m}$
 $da/dN = 1 \times 10^{-11}(250\sqrt{\pi a})^3 = 8.70 \times 10^{-4} a^{3/2}$

$$N_f = \frac{1}{8.70 \times 10^{-4}} \int_{0.002}^{0.0509} \frac{da}{a^{3/2}} = \frac{2}{8.70 \times 10^{-4}} \left[\frac{1}{\sqrt{0.002}} - \frac{1}{\sqrt{0.0509}} \right] = 4.12 \times 10^4 = 41,200$$

B. Short Answers

1. The three modes of fracture are:

Mode I: Opening

Mode II: Sliding

Mode III: Tearing

2. Griffith used an Energy approach to fracture

And Irwin introduced a Crack tip stress approach

3. The two main fracture toughness specimens used are:

Compact and 3 point bend bar

4. The metal alloy that shows a ductile to brittle transition with temperature change is:
Steel
5. Three categories of fatigue are:
High Cycle or stress life
Low cycle or strain life
 Da/DN vs ΔK
6. The fracture mechanics approach differs from a conventional stress based approach how?
The crack-like defect is considered
7. Region 2 fatigue crack growth can be expressed how analytically?
By a power law
8. Region 1 fatigue crack growth has what feature that helps in very high cycle applications:
Threshold ΔK , below which no da/DN
9. What three components are present in environmentally enhanced cracking:
Stress, Defect, Aggressive environment
10. For nonlinear fracture mechanics what two fracture parameters are most often used to characterize fracture?
 J and $CTOD$
11. What agency writes fracture mechanics test standards in the USA?
ASTM
12. Two ways to tell that linear elastic fracture mechanics no longer applies are:
Plastic Zone is too large compared with to the ligament size and
nonlinear load versus displacement curve
13. What three components go into a fracture mechanics analysis?
Stress, defect size and material properties
14. What three parameters are measured in a J_{Ic} test?
Load, load-line displacement, and crack length
15. K increases with crack extension with Constant load
and decreases with crack extension with Constant displacement

