

AML 852 Engineering Failure Analysis & Prevention
Major Test (2006-07)

Marks 90
Time 2 hr

Answer all the questions. You may assume suitably any missing data.

1. (a) Even if Griffith stress is applied in an ideally brittle material (i.e. glass), fracture may not occur. Comment. 05

(b) During water quenching of a steel component, 30 mm in section, heat transfer calculations indicate that the stress generated is 130 MPa. The K_{IC} determined in the laboratory test was $30 \text{ MPa}\sqrt{\text{m}}$ and yield stress was 620 MPa. The maximum size of surface defect specified in production is 0.50 mm.
(i) Calculate the tolerable defect size given that the aspect ratio of the flaw $a/2c = 0.10$
(ii) What would be the situation if the generated stress approached the yield strength of material? 13
2. (a) Initiation of fatigue failure normally occurs at the surface. Comment. 04

(b) How do the following factors influence tendency of hydrogen induced cracking in steels and why? 07
(i) Presence of sulphide ion (ii) Austenitic microstructure
(iii) Weld joint (iv) Temperature

(c) Explain the mechanism of formation of typical fractographic features in 07
(i) ductile fractures (ii) low energy cleavage fracture (iii) fatigue fracture
3. A rotor had been in service for 15 years when inspection was proposed to be carried out to evaluate the extent of damage in the rotor. How will you ascertain the following **without using destructive methods**? 18
(a) Damage due to creep and steps to be taken (using microscopic technique)
(b) Degradation in rotor toughness (using microscopic technique)
(c) Remaining life assessment (by hardness measurement).
Supposedly the L-M diagram for the rotor is available.
4. A through thickness discontinuity of 30 mm length was present in the centre of a wide steel plate in the weld region. The plate was used as a structural member and was subjected to a stress of 300 MPa. If the width and thickness of plate are 300 mm and 15 mm respectively, examine using Level 1 approach whether the member was fit for service considering avoidance of brittle fracture as well as plastic collapse. The yield strength of steel = 450 MPa and tensile strength = 750 MPa. The steel has a fracture toughness = 0.12 mm in weld region and the weld region is stress relieved to a level of residual stress = 30% of yield strength. Elastic modulus of steel = 200 GPa. 18

5. (a) Steady state creep data taken for a steel at a stress level of 70 MPa is given as follows-

ϵ (s^{-1})	T (K)
1×10^{-5}	977
2.5×10^{-5}	1089

- If it is known that the value of stress exponent $n = 7.0$, compute steady state creep rate at 1250 K and at a stress level of 50 MPa. 06
- (b) What could be possible causes for failure of steam turbine blade? How would you proceed for conducting failure analysis of blade? 06
- (c) What are the materials specific factors which play dominant role in failure problems? Discuss briefly. 06