AML 852 ENGG. FAILURE ANALYSIS & PREVENTION

MAJOR TEST (2007-08) Marks: 80
Time: 2 hrs

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1. (a) Give the salient features of Level 1 failure assessment for structural integrity under monotonic loading. (8)

(b) A long rectangular steel plate of cross section 20 mm (thickness) × 60 mm (width) contains a through thickness edge crack of length = 8 mm and is subjected to a load of 600 kN. Applying Level 1 assessment, find out whether it is fit for service or not considering avoidance of brittle fracture as well as plastic collapse. Given the yield strength, tensile strength and elastic modulus are 800 MPa, 1000 MPa and 200 GPa respectively. The fracture toughness of steel = 100 MPa$\sqrt{m}$. (12)

2. Answer the following questions:

(a) 'Etching with HF acid generally enhances the fracture strength of glass but sometimes the reverse is also noticed.' comment.

(b) What are the common causes for the failure of turbine blades? where does failure initiate and how does it propagate?

(c) Cracks were noticed in a weld joint after a few months in service. How would you check the susceptibility to cracking and how to prevent further recurrence of cracking?

(d) Give the characterizing features of H-induced cracking in steels and other alloys. (4×4)

3. A superheater tube in service was found to have failed prematurely. The outlet steam temperature was 540°C. How would you proceed to conduct the failure analysis for the same? what informations would you collect? (10)

4. (a) Differentiate between fatigue strength retardation factor (K_f) and the notch sensitivity factor in fatigue (q).

(b) How do the mean stress and the stress ratio affect the endurance fatigue strength? Explain. (10)

5. How is the cracking in creep condition characterized in presence of crack like defects? If the structure is also subjected to fatigue cycling along with creep, how would you analyse the final failure? Explain stepwise. (12)

6. You have been provided with a failed structural steel beam of cross section 15 mm thickness and 50 mm width with a yield strength = 450 MPa. The beam had been subjected to cantilever bending type loading and was found to initially contain a through thickness crack at the fixed end of depth = 5 mm. The loading was constant amplitude cyclic type with the minimum and maximum load being zero and 10 kN respectively. The distance (L) between the crack plane to the load point was 200 mm. The failed fracture surface was found to contain a smooth zone followed by a coarse, uneven greyish zone of depth = 30 mm. Find the fracture toughness of steel.

Given K_I for cantilever bending is expressed as

$$K_I = \frac{4.12\, M \left(\frac{1}{\alpha^3} - \alpha^3\right)^{\frac{1}{2}}}{B W^{3/2}}$$

where M = bending moment, $\alpha = \left(1 - \frac{a}{w}\right)$ where a, B and w have usual meanings. (12)

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