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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER M.TECH DEGREE EXAMINATION, JUNE / JULY, 2015

Mechanical Engineering

(Machine Design)

01ME6110 Fracture Mechanics

Max. Marks : 60 Duration: 3 Hours

(Answer any two from each module)
Unless otherwise specified material properties may be assumed appropriately.

Part - A

1(a) What kind of singularity describes a stress field near the vicinity of a crack tip in LEFM? What is Irwin's contribution related to crack tip? (3)

1(b) Why edge crack is more dangerous than centre crack of the same length a? Write down K_I for both edge crack and centre crack in an infinite plate. (3)

1(c) Determine the critical crack length in a centre cracked large size plate, loaded in Mode-I, if the critical stress intensity factor is 70MPa$(m)^{1/2}$ and applied stress is 100MPa (3)

2(a) Write down the values of strain energy density of a ductile material including plasticity and compare with that of brittle material. (3)

2(b) Draw an R- curve with crack length and explain why resistance of crack growth increases with increase in crack length? (3)

2(c) Stress function for mode –II, $\phi = -y\,\mathrm{Re}\bar{Z}$. Find out the second derivative of ϕ w.r.t y . (3)

3(a) Write down mode I stresses in an infinite plate with a centre crack (3)

3(b) A large plate of 36mm thickness with an edge crack of a = 26mm length is pulled very slowly under the displacements control loading. At the displacement of 4.8mm, when the recorded load is 2000N, the crack starts growing . At a = 38.4 mm, the crack is arrested and the load decreases to 1200N. Determine the critical energy release rate. (6)

Part - B

4(a) How does fatigue crack originates on a smooth surface ? (3)

4(b) Compare the plastic zone size between Irwin and Dugdale model. Write down the effective crack length using Irwin's model. (3)

4(c) Write down the relationship between J, strain energy release rate and CTOD (3)

5(a) Derive relationship between strain energy release rate and stress intensity factor for mode -I case. (4)

5(b) A cylindrical vessel with closed ends is made of steel with yield stress 350MPa and modulus 210GPa. The diameter of the pressure vessel is 1.2m and wall thickness is 20mm. The critical CTOD is known to be 0.075mm.Use the small scale yielding model to determine the maximum pressure the vessel can with stand if a through the thickness crack of 2a = 18mm is detected, parallel to the axis of the cylinder. (5)

6(a) Explain why fractured surface is inclined to the free surface in the case of plane stress for Mode-I loading. (3)

6(b) What are the conditions to be satisfied during J_{IC} test? Write down the expression J_{IC} in terms of flow stress and crack extension . (3)

6(c) Bring out the significance of Paris law. (3)

Part – C

7 (a) Derive the expression for velocity of crack propagation. (6)

7 (b) In a P- CMOD record of a single –edge- cracked bend specimen following details are obtained . Find the critical $CTOD_p$ corresponding to the plastic hinge. Arrive at the formula used.
P max =31000N, u_p = 1.15mm., beam span between the support =0.02m, beam depth, W= 0.05m, beam thickness, B= 0.025m, crack length a= 20mm, E= 210GPa. (6)

8 (a) Describe the influence of G-R variation in dynamic fracture behvaiour. (4)

8 (b) Explain the characteristic relationship between initial SIF and time –to-failure. (4)

8 (c) Describe the phenomenon of crack closure and how it improves the fracture toughness. (4)

9 (a) Why the texture of fatigue growth different from texture of fractured surface? What are the conditions on which the test of K_Q is rejected. (4)

9 (b) Describe how the major factors influencing environment- assisted fracture (4)

9 (c) Give relationship for dynamic fracture toughness and how crack propagation velocity varies with material toughness. (4)