60

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE IN MECHANICAL AND INDUSTRIAL ENGINEERING

COURSE CODE: **MIE 421**

COURSE TITLE: **FRACTURE OF MATERIALS**

DATE: **11/12/2023** **TIME:** 8.00-10.00AM

INSTRUCTIONS TO CANDIDATES

1. This paper consists of **FOUR** questions
2. Answer Question **ONE (Compulsory)** and any other **TWO** Questions
3. All symbols have their usual meaning

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over

Question 1 **(30 Marks)**

a) (i) State any FOUR causes of materials failure **(2Marks)**

ii) With explanation, state any THREE factors that will make a ductile material to fail by cleavage **(3Marks)**

iii) Fatigue is one of the materials loadings that can easily lead to brittle fracture, write down any FOUR sources of fatigue cracks in materials **(4 Marks)**

b) Sketch the schematic representation of the standard linear solid creep experiment set up hence on the same axis sketch the strain-time curve representing each zone.

(4Marks)

c) With the use of **Fig Q1 (c),** determine the critical crack size for a central crack in a plate where the applied stress is 250MPa in tension and the plane strain fracture toughness is $600\text{MPa}\sqrt{m}$. Assume a ratio of crack length to plate width of 0.3

(5 marks)

d) Two bodies A and B are subjected to cyclic loadings. Body A is under completely reversed stress cycle while the body B is under completely tensile stress cycle.

i) Which of the two bodies is likely to fail first. Explain.

ii) Draw fully labeled stress –cycles curves for the two bodies A and B **(8 marks)**

e) State the Hall Petch's equation and using this equation, draw a curve relating the yield stress to the gran diameter. **(4 marks)**

Question 2 **(20 Marks)**

a) (i) Write down the equation for the cumulative damage Law. Explain each term used

(3Marks)

(ii) A machine part is used for carrying out two jobs A and B. Job A. If only doing Job A it will take it 60, 000 cycles to failure. If the machine is used for solely for job B it will do 120 000 cycles before failing. If the machine part does 5000cycles doing job A and 5000cycles of job B in a year. How Many years will it take before the machine part fails? **(5 marks)**

b) A wide plate of carbon steel is subjected to a uniform tensile load causing a stress of 120 MPa. The plane strain fracture toughness of the steel is 50 $\text{Pa}\sqrt{m}$. If the plate contains a crack of length 50mm at the center of the plate before it was subjected to cyclic stresses. Determine the number of cycles the plate would undergo wen final fracture occurs. It is given that the cyclic stresses range from a maximum of 120MPa tensile to a minimum of 30MPa compressive and that the Paris Law of crack propagation for the material is **(12marks)**

$$\frac{da}{dN} = 7 \times 10^{-10} (\Delta K)^3 \left(\text{MPa}\sqrt{\text{m}}\right)^3$$

where $\frac{da}{dN}$ is in m/cycle

Question 3 **(20 Marks)**

a) Define the following terms as used in fracture of materials **(4 marks)**

i) Stress intensity factor

ii) Plain strain fracture toughness

b) In an elastic-plastic material, it is given that r_{p-s} *and* r_{p-n} are the plastic zone size radius under plane stress and plane strain conditions respectively. Write an the expressions for r_{p-s} *and in* r_{p-n} in terms of the fracture toughness and the yield stress of the material. **(4 marks)**

c) Fig 3(c) shows the loading arrangement of a 4 point loading used for the determination of plane strain fracture toughness K_{IC}.

Show that the stress intensity factor can be given by the expression $K_I = \frac{3PY_1}{Bw^{\frac{1}{2}}}$

Where Y_1 is given by the expression

$$Y_1 = A\left(\frac{a}{W}\right)^{\frac{1}{2}} - B\left(\frac{a}{W}\right)^{\frac{3}{2}} + C\left(\frac{a}{W}\right)^{\frac{5}{2}} - D\left(\frac{a}{W}\right)^{\frac{7}{2}}$$

It is also given that

$$K = K_0[1.1 - 1.5\left(\frac{a}{W}\right) + 7.5\left(\frac{a}{W}\right)^2 - 13.4\left(\frac{a}{W}\right)^3$$

K_0 is defined as the uncorrected stress intensity factor given by the expression

$\sigma_0 = \sigma\sqrt{\pi a}$ **(12 marks)**

Question 4 **(20 Marks)**

a) (i) Differentiate between cyclic strain controlled fatigue as opposed to cyclic stress controlled fatigue.

(ii) Mention any TWO loading cases where the object will be said to be under strain controlled fatigue. **(4 marks)**

b) Two different metals A and B give very different behaviors under cyclic loading

Material A undergoes cyclic hardening

Material B undergoes cyclic softening

Sketch the stress strain curves for material A and B **(4 marks)**

c) A stainless steel materia is butt welded. If the yield strength of the plate is 600MPa and the Youngs Modulus is 200GPa. The component has a geometric concentratiob factor of 1,4. If the critical crack opening displacement for the steel is 0.25mm and the design stress is given as two thirds that of thje yield stress. It is also givn that the material of the plate and the weld are similar. What is the maximum allowable crack size in the component if

i) The weld plate was not stress relieved
ii) The weld plate was stress releved. **(12 marks)**

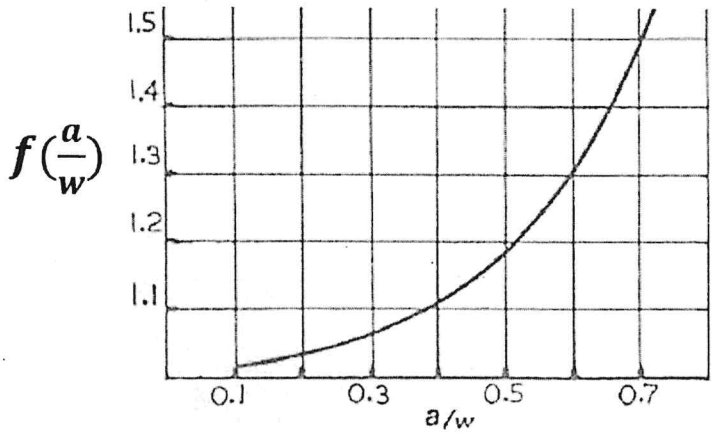

Fig Q1(c) Secant correction factor for a central crack in a finite plate.

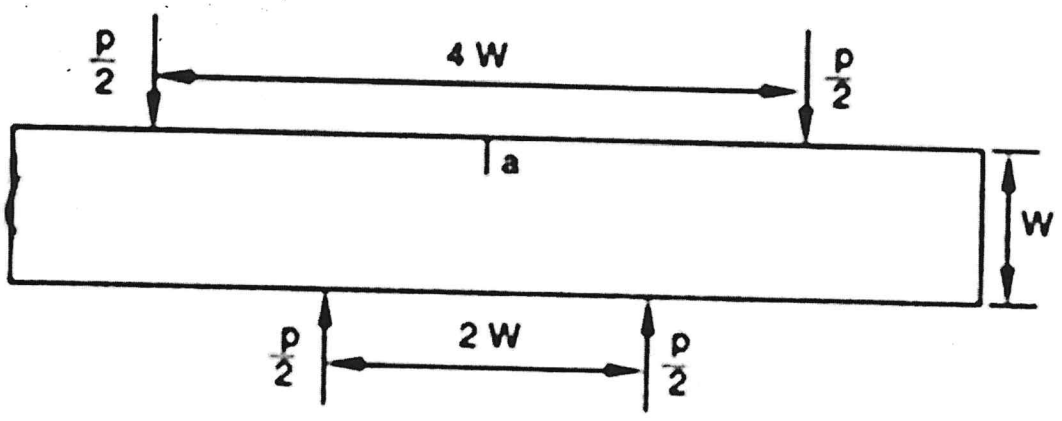

Fig 3 (c) A notched bar under a 4 ppint loading

This is the Last Printed Page