GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

ENGINEERING FAILURE ANALYSIS

EMG 3202

SECOND SEMESTER SECOND SEGMENT EXAMINATION (2024)

This examination consists of 6 pages

INSTRUCTIONS

Time Allowed: 3 hours

Answer any 5 questions

Each question carries 20 marks

Total Marks: 100

SPECIAL REQUIREMENTS:

Graph paper

Scientific calculator

EXAMINERS: Dr L. Mugwagwa and Ms K.L Mahamba

Question 1

a. With the aid of an S-N curve explain the fatigue limit **[4]**

b. Explain the three stages a material undergoes during fatigue failure **[6]**

c. The fatigue data for a brass alloy is given as follows

Stress Amplitude (MPa)	*Cycles to Failure*
170	3.7×10^4
148	1.0×10^5
130	3.0×10^5
114	1.0×10^6
92	1.0×10^7
80	1.0×10^8
74	1.0×10^9

i. Plot an S-N graph (stress amplitude vs logarithm cycles to failure) using the data in the table. **[5]**

ii. Determine the fatigue strength at 4 x 10^6 cycles **[2]**

iii. Determine the fatigue life for a stress amplitude of 120 MPa **[3]**

Question 2

a. Explain how you can use the nitriding process to minimise fatigue failure of steel alloys **[4]**

b. Explain three factors that favour corrosion fatigue **[6]**

c. Give advantages and disadvantages of the following non-destructive testing methods

- Ultrasonic testing **[5]**
- Electromagnetic testing **[5]**

Question 3

Three identical fatigue specimens (denoted A, B, and C) are fabricated from a nonferrous alloy. Each is subjected to one of the maximum and minimum stress cycles listed below; the frequency is the same for all three tests.

Specimen	**σ_{max} (MPa)**	**σ_{min} (MPa)**
A	+450	-150
B	+300	-300
C	+500	-200

a. Rank the fatigue lifetimes of these three specimens from the longest to the shortest. **[4]**

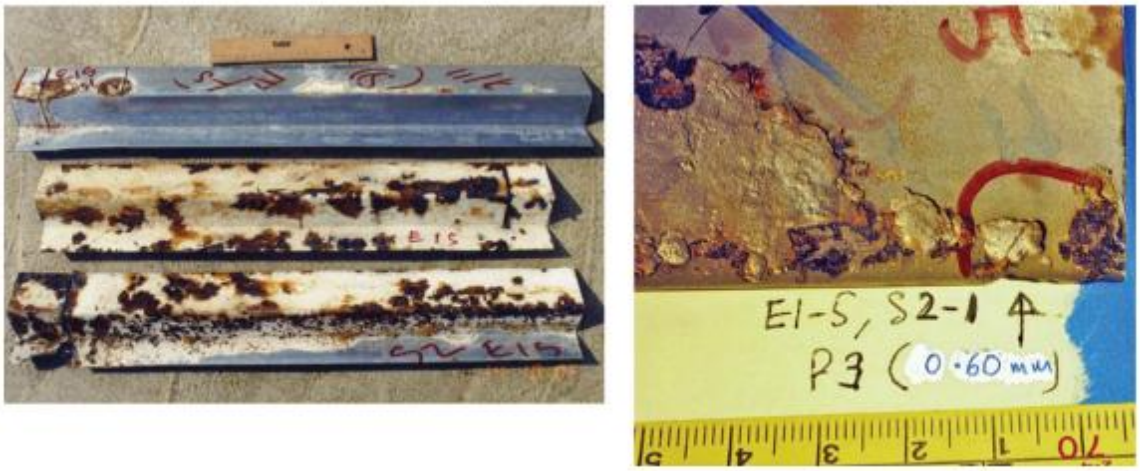
b. Now justify this ranking using a schematic *S*–*N* plot **[6]**

c. Explain how the following non- destructive testing methods are conducted, use diagrams were possible

i. Acoustic Emission **[5]**

ii. Eddy Current Testing **[5]**

Question 4



(a) (b)

The image above shows: **(a)** Corroded Z-spacers from rectified bay E1-5 and **(b)** localized corrosion and pitting attack on the corroded Z-spacer from bay E1-5.

From the given information above give full details on how you would carry out:

a) Site inspection. **[5]**

b) Metallurgical examination. **[5]**

c) Mechanical examination **[5]**

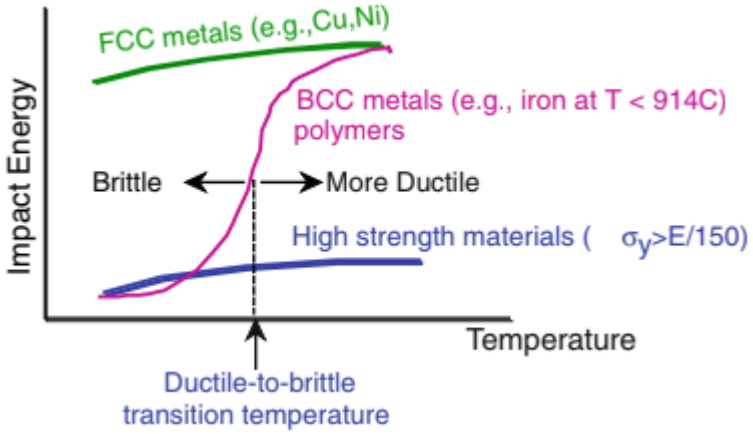
d) Chemical analysis **[5]**

Question 5

a) The properties of some materials are profoundly influenced by the presence of imperfections (flaws), give an account of how these flaws affect the operation of the part or component. **[5]**

b) Using diagrams explain interfacial defects of a part, giving the type of interface and its effects on that part. **[5]**

c) The diagram below shows a Ductile–brittle transition temperature curve



With the help of the diagram above explain the ductile-to-brittle phenomenon in engineering materials. **[10]**

Question 6

a. Describe the following, including what causes them and how they are harmful:

- **i.** Corrosion fatigue. **[1]**
- **ii.** Hydrogen embrittlement. **[2]**
- **iii.** Wear. **[1]**
- **iv.** Pitting**.** **[1]**
- **v.** Liquid metal embrittlement. **[2]**

b. List down the differences between ductile and brittle fracture. Support your answer with suitable diagrams. **[5]**

c. What are the applications of various welding processes in metallurgical engineering**.** **[8]**

Question 7

a. What effect does low temperature and elevated temperature have on mechanical properties of materials. **[5]**

b. What factors contribute to the fracture of a material. **[5]**

c. Boiler tubes made of austenitic stainless steels (ASSs) are known to be able to withstand higher temperature service than steels with ferritic, pearlitic, bainitic, or martensitic microstructures. What are the reasons for this? **[5]**

d. From your answers above, what do you think would be the basic principles in the metallurgical design of alloys with creep strengths higher than the basic ASS? **[5]**

END OF QUESTION PAPER!!!!