THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION OF THE DEGREE OF B.E.

3586 MATERIALS SELECTION AND FAILURE ANALYSIS

NOVEMBER 1999

TIME : TWO HOURS

[In addition, candidates are allowed 10 minutes before the examination begins, to read the paper.]

[The use of notes, textbooks and calculating devices is permitted in the examination room.]

[Appropriate engineering assumptions may be made for inadequate data.]

Answer ONLY 4 (four) questions.

Question 1.

For ONLY 3 (three) of the engineering products listed below.

i) Describe the operating and environmental conditions to which they are exposed, and the properties of candidate materials required to fulfil the necessary function, and

ii) Suggest suitable materials and manufacturing processes.

a). The casing of an electric motor. [8 marks]

b). Small gear wheels. [8 marks]

c). Pipelines for carrying natural gas. [8 marks]

d). An impeller blade to pump seawater. [8 marks]

Question 2.

For ONLY 4 (FOUR) of the following (a-e):

i). Describe typical conditions to which the following products are subjected in their normal use.

ii). Discuss the trade-offs involved in choosing between the two materials or manufacturing processes in each case.

a). Steel versus plastic *paper clips*. [6 marks]

b). Forged versus cast *crankshafts*. [6 marks]

c). Glass versus metal *water jugs*. [6 marks]

d). Wood versus metal *handles for hammers*. [6 marks]

e). Shape rolled or welded *I-beams*. [6 marks]

Question 3.

Answer ONLY 4 (FOUR) of the following.

a). Describe the difference between creep and stress relaxation, giving an example of each as they relate to engineering applications. [6 marks]

b). Discuss the difference in fatigue behaviour between ferrous and non-ferrous metals. [6 marks]

c). How is Miner's rule used to provide an estimate of the remaining life of a component subject to fatigue loading? [6 marks]

d). Explain in detail what is meant by the "leak-before-break" criterion. [6 marks]

e). In steels, what determines the hardness and the hardenability? Why are these particularly important in welding? [6 marks]

Question 4.

Answer ONLY 3 (three) of the following.

a). Industrial sledgehammer heads were made from an AISI 1060 plain carbon steel. To reduce tool replacement costs, heavily deformed regions of the heads were periodically removed by grinding.
In subsequent use a reground head struck a metal plate. A chip flew off a corner of the head and blinded a worker, resulting in litigation.
New hammers have a bulk hardness of R_c 44-55, while the chip had a hardness of R_c 65.

What do you suspect is the problem?
What recommendations would you make to eliminate its occurrence, yet minimise expense?

[8 marks]

b). The frame of a bicycle was made from cold-drawn alloy steel tubing. As a result of excessive abuse, the frame was broken and repaired using conventional arc welding. The repair seemed adequate, but shortly afterwards the frame broke again, this time adjacent to the repair weld. The break appeared ductile in nature, with evidence of plastic deformation prior to fracture.

What was the probable cause of the second failure? [8 marks]

c). The propeller of a cabin cruiser has been cast from a nickel-aluminium bronze alloy, and is designed for both fresh- and salt water use. One of the blades struck a rock and was badly bent. A replacement propeller is expensive and cannot be obtained for some time. The owner therefore wishes to repair the damaged component.

Can the blade simply be hammered back into shape?
Would you recommend any additional processing either before or after repair?
Explain your recommendations.

[8 marks]

d). The left hand rear wheel of a car was badly damaged when the car left the road and hit a tree. The driver claimed that the wheel came off while travelling straight along the road, causing him to lose control and crash.
Examination showed that the axle had broken just inside the outer axle housing with most of the axle remaining inside and attached to the differential unit at the other end. The fracture surface revealed mostly ductile tearing, and inspection of the remaining portion of the axle showed it was no longer straight.

Do you believe the account of the driver, and why? [8 marks]

Question 5.

In relation to the construction and failure of offshore structures, answer **ALL** the following sections.

a). Why are additional mechanical property requirements demanded for materials used in the manufacture of nodal joints?

[4 marks]

b). How have these superior properties been achieved?

[4 marks]

c). How might the welding problems of nodal joints be eliminated?

[4 marks]

d). What is "cold cracking"?

[4 marks]

e). Discuss the principal types of corrosion failure common in offshore production platforms, with particular reference to mechanisms and materials selection.

[8 marks]

END OF EXAMINATION PAPER.