



# UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: October 2019

Module Number: ME 3304

Module Name: Metallurgy for Engineers

[Three Hours]

[Answer all questions, each question carries 12 marks]

Q1. Failure of most of the metallic structures are due to the corrosion. Corrosion of metals in wet(liquid) environment proceeds due to the formation of an electrochemical cell.

a) Explain the mechanism of corrosion using suitable diagram.

[3.0 Marks]

b) Identify the type of corrosion in the following situations and explain your answer. (Use sketches whenever possible)

i) Corrosion in between two bolted steel plates fixed with steel nut and bolt with washers (same composition) as shown in Figure Q1.

[2.0 Marks]

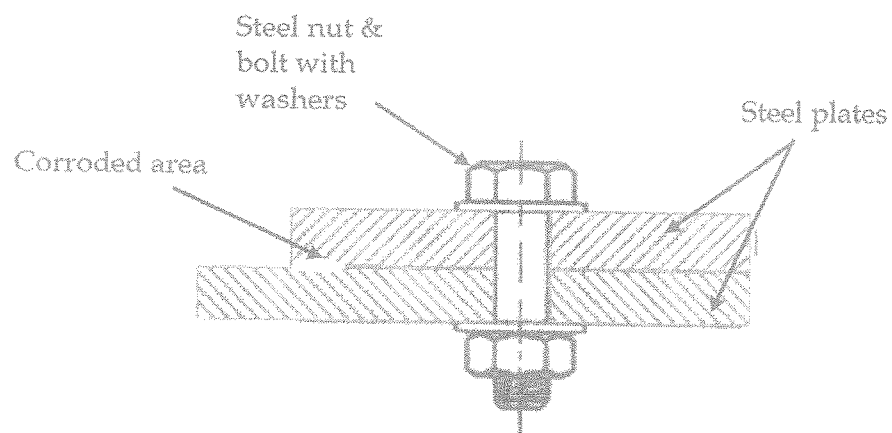


Figure Q1

ii) Failure of the metallic structure at costal area due to the formation of micro holes on the surface.

[2.0 Marks]

c) Compare the major differences between *Weld Decay* and *Knife Line Attack (KLA)*.

[2.0 Marks]

d) What do you mean by the cathodic protection? Explain briefly the terms "*sacrificial anodic protection*" and "*impressed current cathodic protection*".

[3.0 Marks]

Q2. Steels to be the most important engineering material due to their excellent mechanical properties.

a) Steels are produced using pig iron. List up the basic raw materials use in pig iron production.

[1.0 Mark]

b) Coke plays main role in pig iron production by supplying heat for the smelting process. Discuss the properties which determine the value of coke.

[3.0 Marks]

c) Electric arc furnace has extensively been used for manufacturing of steel. Name the main parts of the furnace indicated as A, B, C and D in Figure Q2 and describe briefly the process of steel making in electric arc furnace.

[4.0 Marks]

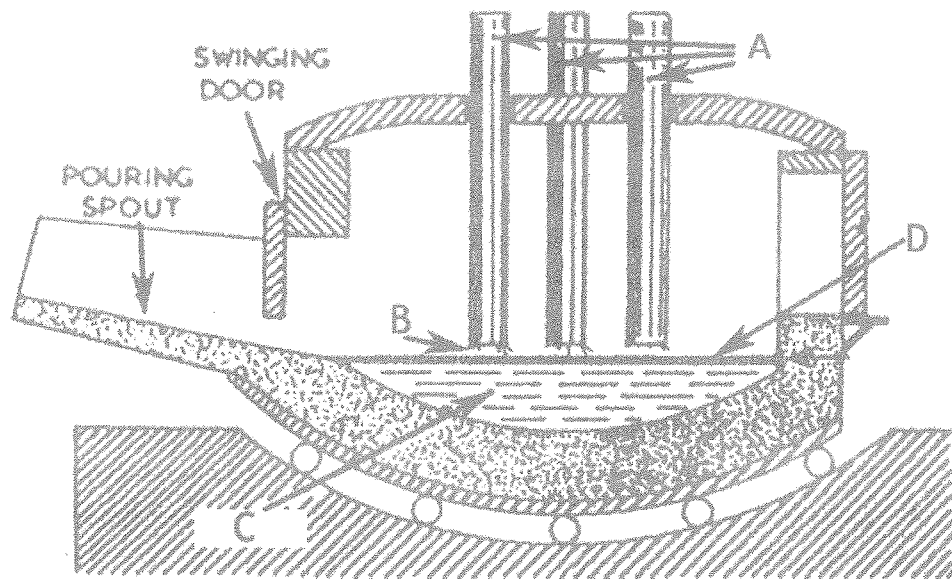


Figure Q2

d) Describe briefly the properties and applications of following stainless steels.

i) Austenitic stainless steel

ii) Martensitic stainless steel

[4.0 Marks]

Q3. Understanding the phase diagrams of alloy systems is extremely important because there is a strong correlation between microstructure and mechanical properties of alloys.

a) Phase diagrams can be classified according to the number of component/s exist. Name the main types of phase diagrams and give example for each?

[1.5 Marks]

- b) Cooling curves for the two components which are soluble in each other in all proportions in both liquid and solid states are given below. (Figure Q3)
- What are the melting points of metal A and metal B? [1.0 Mark]
  - Construct a phase diagram for above system using the data given in Figure Q3. Mark all the phase regions. (You may use a graph paper) [4.0 Marks]
  - In the above alloy system, an alloy contains 60% of metal B is cooled slowly from 1200°C to room temperature, maintaining equilibrium. Sketch the expected microstructures at 1000°C, 600°C and 400°C. Name all the phase/s. [1.5 Marks]
- c) Discuss briefly the effect of following alloying elements in Fe-Fe<sub>3</sub>C (steel) system.
- Manganese (Mn)
  - Nickel (Ni)
- [4.0 Marks]

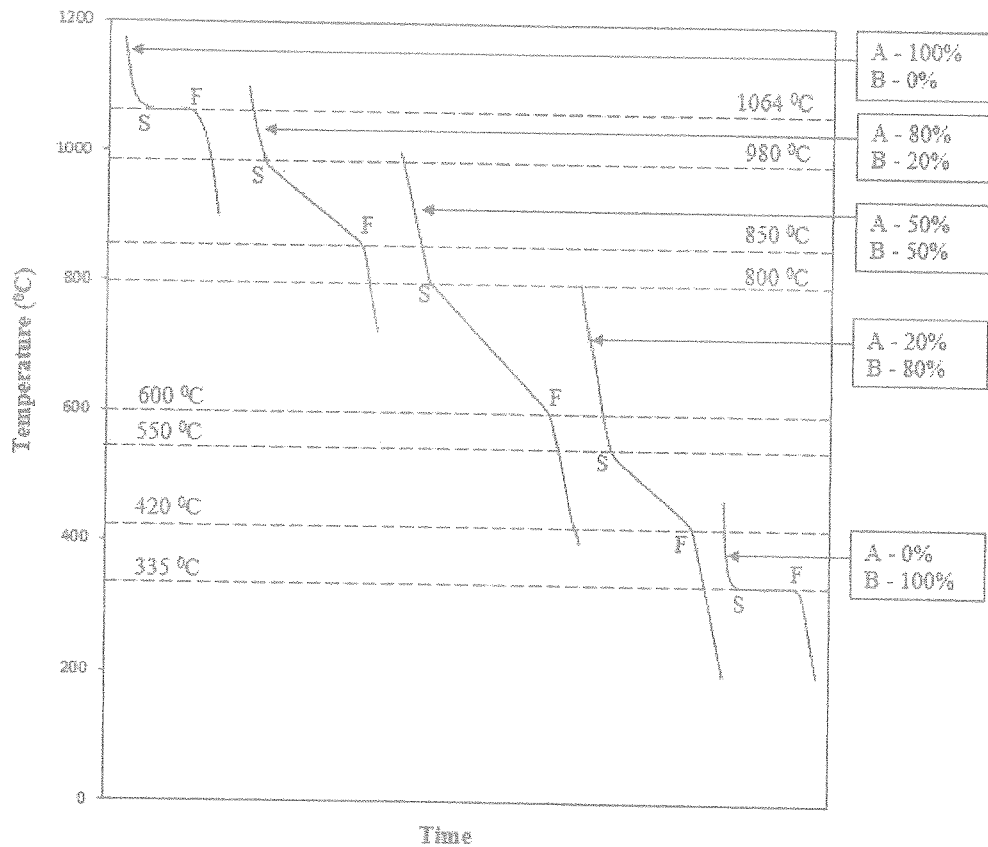


Figure Q3

- Q4. a) Metallic materials are deformed due to the applied loads. Deformation in metals can occur by elastic deformation and plastic deformation.
- i) Differentiate the elastic deformation and plastic deformation in metallic materials. [2.0 Marks]
  - ii) Define the terms *slip plan* and *slip systems*. [2.0 Marks]
  - iii) Compare the difference between *slip* and *twinning* process in metallic materials. [3.0 Marks]
- b) Explain why theoretical strength of metallic materials is higher than the strength measure by experimentally. [2.0 Marks]
- c) After cold-working process, metals need to be annealed for releasing internal stresses or enhancing the ductility for further cold-working. Discuss the microstructural changes during *recovery*, *recrystallization* and *grain growth* of cold- worked medium carbon steel sheet. [3.0 Marks]
- Q5. a) Strength of metallic materials can be achieved by changing their atomic arrangements. Describe briefly the following strengthening mechanisms.
- i) Strengthening by grain-size reduction [1.0 Mark]
  - ii) Strengthening by strain (work) hardening [1.0 Mark]
- b) Heat treatments are used to obtain the desirable properties of solid metallic materials by changing its microstructure.
- i) Write down the four major factors to be considered before conducting heat treatment of a ferrous alloys and discuss them briefly. [4.0 Marks]
  - ii) Discuss the main differences between the quenching and nitriding processes of steels. [2.0 Marks]
  - iii) Surface hardness of a medium carbon steel roller of 0.75 m in diameter (outer) and 2.5 m in length, need to be increased by using an appropriate heat treatment. Select the suitable heat treatment method to achieve this and justify your answer. [2.0 Marks]
- c) Write a short note on applications of copper and its alloys. [2.0 Marks]