GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

CORROSION AND WEAR

EMR 5203

Part V Examination Paper

April 2024

This examination paper consists of 3 printed pages

Time Allowed: 3 hours

Total Marks: 100

Examiner : Mrs Siqiniselo Maphosa

INSTRUCTIONS

1. Answer any 4 questions

2. Each question carries 25 marks

3. Use of calculators is permissible.

Question 1

a) LIST five differences between wet and dry theories of corrosion [5]
b) Describe the following forms of corrosion giving associated preventative and control measures
   I. Crevice corrosion [10]
   II. Pitting corrosion [10]

Question 2

a) Predict giving reasons whether or not galvanic corrosion will cause the following alloys to be subjected to leaching: (i) carbon and carbon steel alloys in an oxidizing atmosphere, (ii) steel rivets in aluminium drain gutters, (iii) copper-nickel alloy in refinery condenser tubes, (iv) graphite fiber-reinforced aluminium composites, (v) brass in water, (vi) iron-chromium alloys, and (vii) carbon steel pipe in contact with the weld to stainless steel pipe. [15]
b) A sample of zinc corrodes uniformly with a current density of 4.2 x 10-6 A/cm2 in an aqueous solution. (a) What is the corrosion rate of zinc in mg/dm2 (b)What is the corrosion rate of zinc in mm/year? [10]

Question 3

In operation of a ball mill the best milling efficiency is obtained when the mill balls are of near equal diameter. A small scale mine two tonnes per hour capacity ball mill uses 40mm diameter forged steel balls with a wear rate time constant of 1.35 E-03 hr-1. The mill balls cost $800 per tonne.

$$T = \frac{6.9}{k} \log_{10}\left(\frac{D_a}{D_b}\right)$$

$$R = kW$$

where T – Time in hours for change in diameter from Da to Db in mm

k – wear time constant in hr-1 R- rate of wear of a ball of weight W kg

a) What size of balls will need to be added after one full day of operation to maintain equal ball diameter? [6]
b) How many of these balls are to be added if the load of balls is to be maintained to the initial loading? [3]

c) What is the ball cost per tonne of ore milled? [3]
d) Different mill balls, high chromium cast iron, are proposed to be used. Their wear rate time constant is 8.4E-03hr-1 and cost of $1000/ton. What is will be the saving or loss per day in cost of mill balls used if changed to high chromium cast iron? [9]
e) What two factors can accelerate mill ball wear in ball mills?[4]

Question 4

a) Wear is surface failure resulting from dynamic contact between two surfaces such as abrasion and erosion. List and discuss two mechanochemical factors that would enhance corrosive wear [6]
b) Define and discuss the following wear mechanisms including prevention and control and give one example of each:
   i. Fretting [7]
   ii. Surface fatigue wear [6]
   iii. Adhesion [6]

Question 5

a) Iron is corroding in seawater at a current density of 1.69×10^{-4} A/cm^2 . Determine the corrosion rate in (a) mdd (milligrams per decimeter2 day) (b) ipy (inches per year) (density for Iron = 7.86) [10]
b) Describe an electrochemical test procedure that could be used to assess either general corrosion or an organic coating. Produce a fully labelled diagram of the test equipment and corrosion cell [15]