



**FACULTY OF ENGINEERING AND THE ENVIRONMENT
DEPARTMENT OF METALLURGICAL ENGINEERING
ADVANCED MINERALS ENGINEERING**

EMG 5101

Final Examination Paper

DECEMBER 2024

This paper consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Examiner: C MAZEMO

INSTRUCTIONS

1. This paper contains ONE section with SIX questions.
2. Answer any FIVE questions.
3. Each question carries 25 marks.
4. Where a question contains subdivisions, the mark value of each subdivision is shown in brackets.
5. Illustrate your answer, where appropriate, with clearly labeled diagrams.
6. Started each question on a new page.
7. This paper comprises of 6 printed pages

Additional requirements:

Calculator

QUESTION 1

A rougher bank has 4 cells. The feed to the circuit has a mass rate of 1000 t/hr and a grade of 2% copper. The individual cells down the bank have the following grades and recoveries:

| | Cell 1 | Cell 2 | Cell 3 | Cell 4 |
|----------|--------|--------|--------|--------|
| Grade | 30 | 25 | 18 | 10 |
| Recovery | 35 | 30 | 25 | 20 |

- Calculate the cumulative down the bank grade recovery curve. (6)
- Flotation circuits typically consist of banks of cells, with a rougher, cleaner, scavenger arrangement being a commonly used one. Sketch a standard rougher, cleaner, scavenger circuit labelling the banks and streams. (3)
- A circuit with such a configuration achieves an 80% recovery over the rougher bank, a 50% recovery over the scavenger bank and a 60% recovery from the cleaner bank. What is the overall recovery of the circuit? (4)
- Assuming that we keep the operating conditions of the other banks constant, but increase the froth depth in the cleaner circuit. What would happen to the circuit recovery and concentrate grade? (1)
- What would happen to the feed rates and grades for each of the banks and why? (2)
- Typically, for a given feed rate and grade, the circuit recovery can only be increased at the expense of grade and vice versa. Assume that you have a typical smelter contract in which you are paid for a portion of the metal value and charged based on the mass of concentrate to be treated, and that the circuit is operating at the optimum trade-off between grade and recovery at the current metal price. How would you adjust your circuit's operation in response to an increase in the metal price and why? (3)
- List any mineral commodity mined in Zimbabwe which is not beneficiated using froth flotation. (1)

QUESTION 2

A tin concentrator treats a feed containing 1% tin, and three possible combinations of concentrate grade and recovery are:

- High grade. 63% tin at 62% recovery
- Medium grade 42% tin at 72% recovery
- Low grade 21% tin at 78% recovery

Separation efficiency = $R_m - R_g$ where, R_m (% recovery of valuable minerals)

$$R_m = \frac{100Cc}{f} \quad R_g (\% \text{recovery of gangue content}) = \frac{100C(m-c)}{(m-f)}$$

- a) Determine which of these combinations of grade and recovery produce the highest separation efficiency. [4]
- b) A slurry stream containing quartz (The density of quartz is 2650 kg/m^3) is diverted into a 1-litre density can. The time taken to fill the can is measured as 7 sec. The pulp density is measured by means of a calibrated balance, and is found to be 1400 kg/m^3 . Calculate the % solids by weight, and the mass flow rate of quartz within the slurry [4]
- c) A pump is fed by two slurry streams. One stream Has a flow rate of $5.0 \text{ m}^3/\text{h}$ and contains 40% solids By weight. The other stream has a flow rate of $3.4 \text{ m}^3/\text{h}$ and contains 55% solids. [4]

i) Calculate the Tonnage of dry solids pumped per hour. (Density of Solids is 3000 kg/m^3 .) [4]

ii) Calculate the % solids content of the slurry pumped from the sump [4]

$$x = \frac{100s(D - 1000)}{D(s - 1000)}, \quad M = FDx/100$$

, x - % solids by weigh, the volumetric flow rate ($F \text{ m}^3/\text{h}$), the pulp density ($D \text{ kg/m}^3$), and the density of solids ($s \text{ kg/m}^3$), the weight of slurry ($FD \text{ kg/h}$), and, of, the mass flow rate of dry solids in the slurry, $M \text{ kg/h}$:

QUESTION 3

- a) A sample of coal is floated in a small laboratory cell using a kerosene collector (HI) and a dithiophosphate promoter (DP) in combination with HI. Concentrates were collected at 0.5 minute intervals up to 3 minutes then a final concentrate at 7 minutes. The concentrates were dried, weighed and then assayed by ashing. From the data given below, calculate the flotation rate constant of the coal for the two reagents conditions.

| Collector H1 | | | Collector DP + H1 | | |
|--------------|---------|-------|-------------------|---------|-------|
| Time, min | Mass, g | Ash % | Time, min | Mass, g | Ash % |
| 0 | 461.8 | 58.5 | 0 | 456.4 | 58.7 |
| 0.5 | 43.6 | 13.2 | 0.5 | 56.5 | 21.2 |
| 1.0 | 18.3 | 15.1 | 1.0 | 30.9 | 26.0 |
| 1.5 | 11.9 | 16.1 | 1.5 | 30.3 | 25.7 |
| 2.0 | 10.3 | 14.7 | 2.0 | 23.6 | 26.8 |
| 2.5 | 5.4 | 15.0 | 2.5 | 17.3 | 28.6 |
| 3.0 | 4.7 | 13.7 | 3.0 | 13.3 | 27.3 |
| 7.0 | 17.5 | 12.8 | 7.0 | 21.1 | 31.0 |
| tail | 350.1 | 72.6 | tail | 263.3 | 83.1 |

Volume of cell = 250 mL

[10]

b) describe how do density based separation ,magnetic and electrostatic separation differ in terms of operational principles ,efficiency in separation materials based on density and suitability of various types of feed materials?[10]

QUESTION 4

A mill processes 15 000 t of a dry copper (Cu) ore per day. The grade for the feed is 4% Cu. The ore is coarsely ground and processed by a bank of rougher flotation cells. The Concentrate from the rougher cells is then regrind before being ed into the Cleaner/scavenger cells. 90% of the Cu in the feed is recovered to the final concentrate Assays for all.of the output streams are given in the table below

| Stream. | Cu assay (i.e. grade) (%) |
|------------------------------------|---------------------------|
| Rougher tails. | 0.25 |
| Cleaner/scavenger concentrattails. | 85.0 |
| Cleaner/scavenger tails. | 1.26 |

- Draw a flowsheet describing the process. You may simplify this by treating the bank of Roughers as one unit and the cleaner/scavenger cells as a second unit [4 marks].
- What is the purpose of the regrind step? [4 marks]
- What is the mass and recovery of Cu to each of the tailing streams? [4 marks]
- What is the minimum capacity of the regrind mill(h)? [4 marks]
- Knowing the mass flow of Cu in the circuit, suggest how the Cu recovery could be Improved further? [4 marks]

QUESTION 5

- in industry the entire filtering process consists of a cycle of four main steps.identify the steps involved in filtering process? (2)

b) Settling tests in a cylindrical tube was performed on a slurry containing 300 ppm solids. After a detention time of 80 minutes, the overflow fluid was found to contain 10 ppm solids. The overflow from the test data was found to be 8.2 m³/h. The classifier was required to achieve an overflow rate of 120 m³/h. Estimate:

1. The pool volume,
2. Pool area,
3. Pool depth,
4. Pool diameter. [8]

c) A nickel mineral of specific gravity 3091 kg/m³ was pulped using dilute sulphuric acid. The pulp contained 28% solids. After dissolving the soluble salts the pulp was filtered through a thin ceramic medium in the shape of a circular disk of area 0.178 m². The initial applied pressure was 10 kPa. The filtrate was collected after a step-wise increase in pressure at known intervals which gave a cake thickness of 12 mm and 12% moisture. The collected data are tabulated below. The temperature of the filtrate was 25°C. Determine the specific resistance of the deposited cake and medium.

$$(t-t_1) = \frac{K_1}{\Delta P}(V^2 - V_1^2) + \frac{K_2}{\Delta P}(V - V_1) \quad C_m = \frac{\rho m_F}{(1 - m m_F)}$$

$$\text{where } K_1 = \frac{\mu \alpha C_m}{2A^2} \text{ and } K_2 = \frac{\mu R_M}{A}$$

data:

| No | ΔP (x 10 ⁵ Pa) | Time, s | Filtrate Vol., m ³ |
|----|-----------------------------------|---------|-------------------------------|
| 1 | 0.1 | 72.4 | 0.072 |
| 2 | 0.4 | 130.0 | 0.079 |
| 3 | 0.6 | 823.0 | 0.112 |
| 4 | 0.8 | 1082.4 | 0.124 |
| 5 | 1.0 | 1370.0 | 0.138 |
| 6 | 1.2 | 1740.9 | 0.154 |
| 7 | 1.4 | 2400.0 | 0.180 |
| 8 | 1.4 | 3010.0 | 0.201 |
| 9 | 1.4 | 3640.0 | 0.221 |
| 10 | 1.4 | 4280.0 | 0.239 |
| 11 | 1.4 | 4820.0 | 0.253 |
| 12 | 1.4 | 5350.0 | 0.267 |
| 13 | 1.4 | 5800.0 | 0.278 |
| 14 | 1.4 | 6250.0 | 0.289 |
| 15 | 1.4 | 6700.0 | 0.299 |
| 16 | 1.4 | 7150.0 | 0.308 |

QUESTION 6

- a) A stainless steel woven wire screen with a square aperture had an aperture 3.18 mm square. The diameter of the wire was 1.2 mm. The mesh of a screen is defined by the relation $M = (L_A + d_w)^{-1}$ for measurements in inches or $M = 25.4 (L_A + d_w)^{-1}$ for measurements in millimetres. Given

$$A_O = \left(\frac{L_A}{L_A + d_w} \right)^2 \times 100$$

A_O = open area expressed as percent,

L_A = aperture, and

d_w = diameter of wire (or horizontal width of bar or plates, if used).

Determine:

1. The percent open area when the screen was operated in an horizontal position,
 2. The percent open area when the screen was operated at a slope of 20° ,
 3. The mesh size of the screen. [6]
- b) describe what determines the screen aperture to pass a specific size of particle [4]
- c) describe two criteria used to assess screen performance [6]
- d) Explain different solid-liquid separations in hydrometallurgy. (4)