GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

EMR 3203 PYROMETALLURGY – NON FERROUS

Part III Second Semester Examination Paper

AUGUST 2022

This examination paper consists of 4 printed pages

Time Allowed: **3 hours**

Total Marks: **100**

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INSTRUCTIONS

1. Answer ALL questions in section A and any 2 from section B
2. Use of calculators is permissible

Additional Requirements

MARK ALLOCATION

Section A	50 Marks
Section B	50 Marks
Part Questions	As shown in each part question
Total Attainable	100

SECTION A (50 MARKS)

ANSWER ALL QUESTIONS

1. Matabeleland South Province is home to one of the largest national cement clinker production plant, PPC Colleen Bawn. Clinker production is one of the major contributors to the world CO_2 emissions, 8% in 2020.

   The plant produces clinker at a rate of 6.944kg/s. A rotary kiln is used to produce clinker from limestone and montmorillonite clay. Coal is used as fuel to heat up the kiln to the clinker formation temperature of 1450°C. Exhaust gases have CO_2 from combustion of coal and decomposition of $CaCO_3$ to CaO.

   Assuming steady state conditions in the kiln, complete decomposition of $CaCO_3$ and with the data below estimate the
   a. minimum amount of coal to be charged to the kiln [20]
   b. and the amount of CO_2 generated per tonne of clinker produced. [20]
   c. In what ways can the amount of coal required by the kiln be reduced? [10]

Inputs	Outputs
Limestone ($CaCO_3$) - 1.65 tonnes	Clinker - 1 tonne
montmorillonite ($(Na,Ca)_{0.33}(Al, Mg)_2(Si_4O_{10})$ $(OH)_2.nH_2O$) - 0.4 tonnes	Exhaust gases
Coal	

	Limestone and Montmorillonite	Coal	Clinker	Exhaust Gases
$CaCO_3$	75.34%			
CaO			64.58%	
C		80%		
CO_2				60%

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Element	Atomic mass
Ca	40 g/mol
C	12 g/mol
O	16 g/mol

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Heat Inputs	Heat Outputs
Coal Combustion $Q=m_cH_c$ where $H_c=30600$ kJ/Kg°C and m_c is the mass of coal in kg	Sensible heat of coal is 1.15KJ/kg°C fed at 25°C
	Sensible heat of limestone mixed with montmorillonite is 0.86KJ/kg°C
	Endothermic clinker formation heat is 1795kJ/kg-clinker
	Heat lost in exhaust gases $Q=m_{eg}C_{eg}T_{eg}$ Where $C_{eg}=1.071$kJ/kg°C $T_{eg}=315$°C m_{eg} is the mass of exhaust gases
	Heat loss from the kiln surface to the surroundings $Q=\sigma\varepsilon A_{kiln}(T^4_s-T^4_\infty)/(1000m_{clinker})$ Where $\sigma=5.67\times10^{-8}$W/m^{2}K^4 $\varepsilon=0.78$ $A_{kiln}=565$m^2 $T_s=581$K $T_\infty=300$K $m_{clinker}=6.944$kg/s

SECTION B (50 MARKS)

ANSWER ANY TWO QUESTIONS

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2. Mhangura Mine copper ores have the metal in the minerals, bornite (Cu_5FeS_4), chalcopyrite ($CuFeS_2$) and chalcocite (Cu_2S). The gangue material is mainly, haematite (Fe_2O_3), silica (SiO_2) and calcite ($CaCO_3$). You are a metallurgist assigned to the rejuvenation of the mine processing plant. Shareholders suggest the current plant is deteriorated and will finance a fresh start up.

   a. Suggest two different process flow sheet routes for this type of ore. Include chemical reactions that would result in production of a sellable copper product. [20]
   b. Of the two, select one you would prefer and highlight its pros over the other. [5]

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3. Zimbabwe is the third largest producer of platinum in the world. As part of beneficiation and value addition efforts platinum mines are erecting and enlarging their concentrate smelting furnaces.
    a. Discuss factors you will consider in selection of a furnace type to smelt platinum concentrates. [7]
    b. What would you consider in selection of refractory lining material for a platinum concentrate smelter? [6]
    c. ZimPlats furnace in 1996, just after commissioning, had overheating challenges. Explain why a platinum smelting furnace would require a cooling mechanism yet using electric power to heat it up. [6]
    d. Platinum smelter matte is forwarded to a converter. Why is smelting and converting done separately and why would it be undesirable to combine the two steps in one furnace? [6]

4. There is a drive to find substitutes to the use of mercury by small scale miners. Direct smelting of gravity concentrates is one of the most suggested ways to eliminate the use of environmentally unfriendly mercury amalgamation. Smelting energy costs and overall gold recovery are important in determining the adoption of this technology by small scale miners.
    a. Discuss ways that can be used to reduce the energy costs in the direct smelting of gold concentrates. [6]
    b. What are the desirable properties of slag that will result in increased recovery of gold? [6]
    c. Which additives can be used to remove impurities such as Fe, Cu, Al and Si from the gold dore? [3]
    d. What type of flux can be used in the smelting of gold concentrates? [4]
    e. State the role of the flux you suggested above [6]

END OF QUESTION PAPER

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