GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND ENVIRONMENT

DEPARTMENT OF METALLURGICAL ENGINEERING

METALLURGICAL PROCESS CONTROL

EMR 5103

November 2023 Examinations

This examination consists of 5 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Graph paper and a scientific calculator

Examiner's Name: K.L Mahamba

INSTRUCTIONS

1. Answer any 5 questions

2. Each question in section B carries 20 marks

QUESTION ONE

a) List the desirable properties of a thermocouple. **[2]**

b) List the objectives of chemical process control. **[3]**

c) What variables should be measured to monitor the operational performance of a plant? **[2]**

d) Define Laplace transform. Using the definition, find the Laplace transform of exponential function. **[3]**

e) Define stability based on the roots of the characteristic equation. **[2]**

f) With the help of a block diagram, explain various elements in a typical negative feedback control system**.** **[3]**

g) Solve the Laplace transform

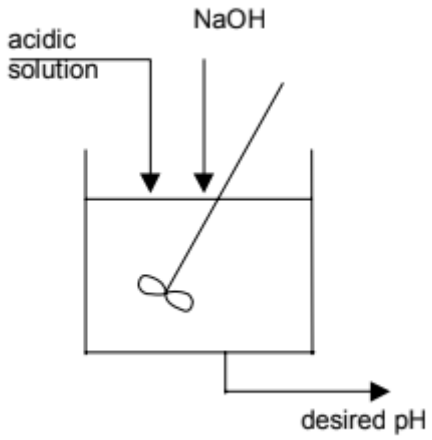
$$\frac{d^2x}{dt^2} + 3\frac{dx}{dt} + 6x = 0,\ x(0) = 0,\ x'(0) = 3.$$

e) Explain how the SCADA system works in a processing plant of your choice. **[5]**

QUESTION TWO

a) Briefly explain four reasons why automation systems are important to mineral processing operations. **[8]**

(b) With the aid of the diagram in Figure 1



Discuss how you would control pH. In your discussion clearly state the following:

(i) Control Objectives

(ii) Measurements

(iii) Manipulated Variables

(iv) Final Control Element. **[12]**

QUESTION THREE

An exothermic stirred tank reactor has an inlet feed, given by flow F. The outlet temperature, T_{out} shows a first order dynamic response when increasing this flow.

Downstream from the reactor is a heat exchanger, but the pipe connection from the stirred tank to the heat exchanger has approximately θ seconds of delay. The heat exchanger operates by using chilled water, which enters at a constant flow rate of q. The hot stream from the reactor enters the heat exchanger and then this exits with temperature, T. The dynamics relating the hot stream inlet temperature to the outlet temperature, T, are also first order.

i)Draw a Piping and Instrumentation diagram of the system with all the relevant symbols used to represent the components in the system**.** **[5]**

ii) Draw a block diagram of the system, using one block per unit operation, starting from the feed flow rate F as the input, up to the exiting temperature, T. In your block diagram enter all the transfer function and dynamic information you know, using appropriate symbolic representation. **[8]**

iii) Write a single symbolic transfer function relating the incoming flow, F to the exiting temperature, T. **[2]**

iv) What will be the order of the transfer function in part iii? **[1]**

b) You are working at a leaching section of the plant, and the operator is complaining that the amount of oxygen in the pulp (dissolved oxygen level) is too low, below the required amount. He thinks that the feedback control system is broken and needs to be fixed.

List instructions you would give to your operator to investigate whether the control system is broken. **[4]**

QUESTION FOUR

You work at a foundry where the temperature of the molten metal is measured by dipping a resistance temperature detector on the cupola spout when the molten is being poured into the ladle. There have been many instances where workers have been burnt using the current system. The company engineer assigns you to design a new system which is safer.

i. What instruments are you going to use? **[5]**

ii. With the aid of diagrams explain how the measurement system will function. **[15]**

QUESTION FIVE

A certain Gold small scale mine is experiencing problems in its mineral processing plant which include spillages in the crushing circuit and milling circuit.

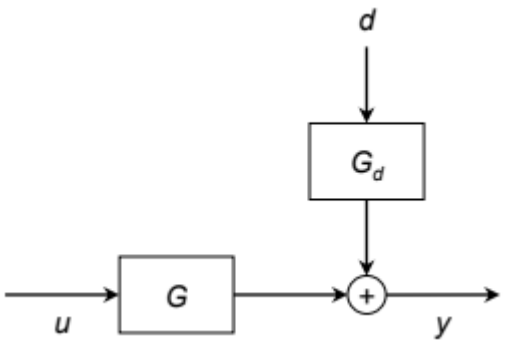
i. Design a process flow diagram that to illustrate how the circuit. control is going to be achieved and convert the PFD into a Pand I diagram.[**15]**

ii. Describe the three sources of systematic errors that you know**.[5]**

QUESTION SIX

Feedforward control is frequently used in process control. It may however lead to problems if the model is wrong.

a) Make a block diagram with the feedforward controller Cff included for the following case:



b) In which situation is it advisable to use feedforward control? Also consider possible measurement delays associated with d and y in question(a). **[3]**

c) What is the transfer function for the perfect feedforward controller, Cff, ideal? Why can you not always realize a perfect feedforward controller? **[3]**

d) Design a feedforward controller when the process models are G = 5 and Gd = 3/(5s+1). **[8]**

e) Sketch the response in y to a step in d (d=1) for the following three cases

i. No control (u=0) **[2]**

ii. With the feedforward controller from part d and no model error. **[2]**

iii. With the feedforward controller from part d and the real plant has G = 8 and Gd = 2/(5s+1). **[2]**

END OF QUESTION