FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF METARLLUGICAL ENGINEERING

METALLURGICAL PROCESS CONTROL

EMG 5103

Final Examination Paper

December 2024

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 20 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 5 printed pages

Additional requirements:

Calculator

QUESTION 1

With the aid of the diagram in Figure 1

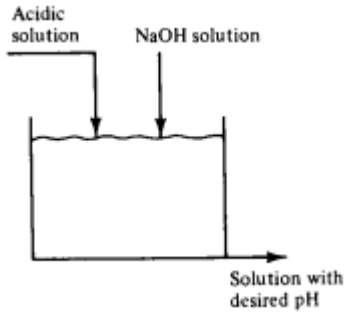
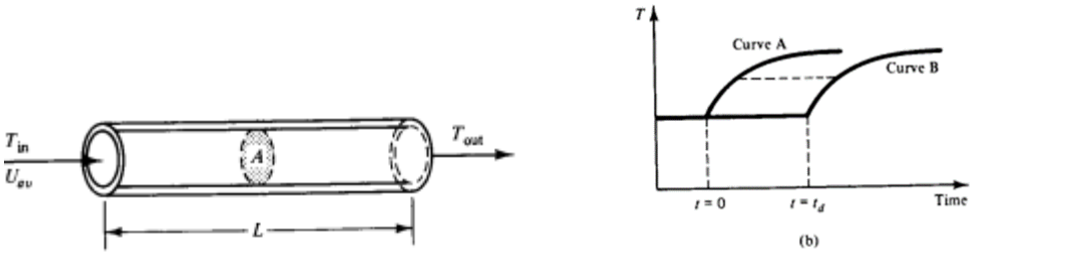


Fig 1

a) Describes the steps you would go through in designing a control system for maintaining the pH of a liquid in a stirred tank at a desired value?[8]
b) develop 2 different control systems that use both feedback and feedforward control system [6]
c) Determine the hardware elements required for feedback control system of the pH in the stir tank above [6]

QUESTION 2

Consider the flow of an incompressible, nonreacting liquid through a pipe. if the pipe is completely thermally insulated and the heat generated by the friction of the flowing fluid is negligible, it is easy to see that at steady state the temperature T_{out} of the outlet stream will be equal to that of the inlet T_{in}. Assuming starting at t=0 the temperature of the inlet changes as shown by the curve (b). the temperature at the outlet is delayed by t_d where t_d is the dead time



(a) Pipe flow of Example 4.9; (b) delayed response of exit

a) Describe the impact of dead time in mathematical modelling of metallurgy process design of effective controllers [5]
b) Determine the T_{out} equation?[4]
c) Determine la place transform?[6]
d) Show the relationship among normal function, delayed function and advanced function.[5]

QUESTION 3

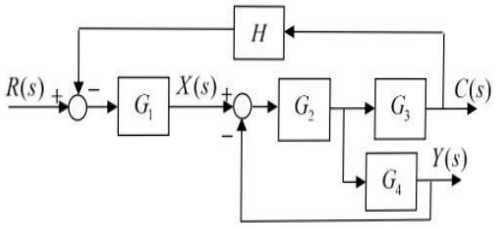
a) Define stability based on the roots of the characteristic equation. [2]

b) Give and explain four main advantages and disadvantage of cascade control system [4]

c) Name and describe a process in which you could employ cascade control. [4]

d) Explain how the SCADA system works in a processing plant of your choice. [4]

e) The closed-loop system shown in the block diagram has one input signal R (s) and two output signals C (s)and Y (s)).



Find the transfer functions Y/X(s), Y/R(s) and C/R(s) [6]

QUESTION 4

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 an engineering diagram of the system (e.g., a piping an instrumentation diagram) with all the relevant symbols**.** **[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 appropriates 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 5

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 to illustrate how the circuit control is going to be achieved and convert the PFD into a P and I diagram.[**15]**

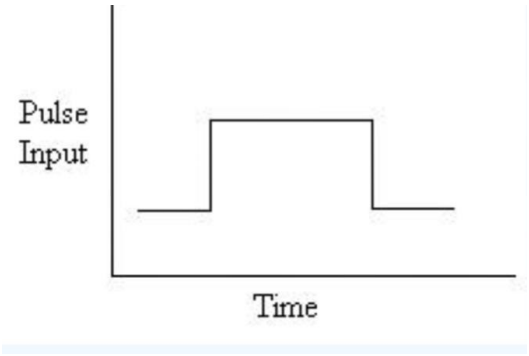
ii. Describe the three sources of systematic errors that you know**.[5]**

QUESTION 6

a) A metallurgical industry has put you in charge of one of their batch reactors to figure out a way to maintain a setpoint level inside a reactor it is extremely important that the level inside the reactor is at the set point. Discuss type of regulator controller that can be used.[4]

b) When the reactor start up, the controller initial received a step input. when the reactor achieved steady state the level in the reactor tends to fluctuate sending pulse inputs into the controller.

c) provide graphical presentation of the PID controller outputs. [16]



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