B.Tech. Eighth Semester (Chemical Engineering) (CGS)

11676 : System Modelling : 8 CH 03

P. Pages : 4
Time : Three Hours

AW - 3494
Max. Marks : 80

Notes :
1. All question carry marks as indicated.
2. Answer **three** question from Section A and **three** question from Section B.
3. Due credit will be given to neatness and adequate dimensions.
4. Assume suitable data wherever necessary.
5. Diagrams and chemical equations should be given wherever necessary.
6. Illustrate your answer necessary with the help of neat sketches.
7. Use of cell phone is not allowed in the exam.
8. Use of pen Blue/Black ink/refill only for writing the answer book.

SECTION - A

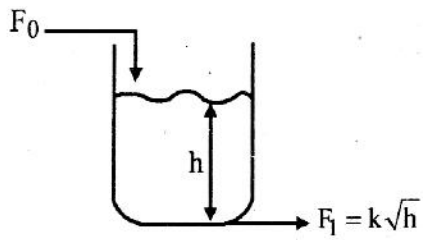
1. a) What do you mean by modelling of process/ system? Explain briefly with suitable examples the mathematical modelling and physical modelling. **6**

b) When is the system at steady state? Explain with example. **3**

c) Distinguish between deterministic models and probabilistic models. **5**

OR

2. Water enters at volumetric flow rate F_0 into a cylindrical tank with cross sectional area A. out flow rate F_1 of water from the tank depends upon the height of liquid as shown in figure. It is given by the equation $F_1 = K\sqrt{h}$



a) List the dependent variables, independent variables and constant parameters of the system. **3**

b) What fundamental law would you use to model the above process. **2**

c) Derive the mathematical model for the process. **5**

d) What type of model is it? Why? **2**

e) Is it possible to obtain the steady state model from the model you derived. If yes, how? **2**

3. A tank contains 20 m^3 of water. A stream of brine containing 2 kg/m^3 of salt is fed into a tank at a rate of 0.05 m^3/min. Liquid flows from the tank at a rate of 0.033 m^3/min. If tank is well agitated, what is the concentration of salt in the tank when the tank contains 30 m^3 of brine? 13

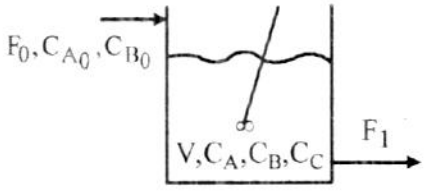
OR

4. Water containing 15 gm of pollutant/ litre flows through a treatment tank at the rate of 2 m^3/min. In the tank the treatment removes 2% of pollutant per minute and water is thoroughly stirred. The tank holds 40 m^3 of water. On the day the treatment plant opens, the tank is filled with pure water. Determine the concentration profile of the tank effluent. 13

5. Consider the following elementary reaction in series. 13

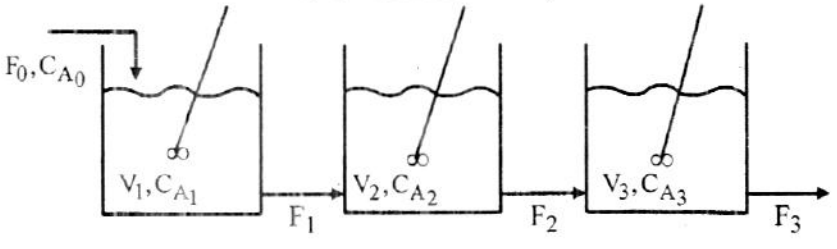
$A \xrightarrow{K_1} B \xrightarrow{K_2} C$

is taking place in isothermal CSTR. A feed containing A and B at concentration C_{A_0} and C_{B_0} respectively, enters into the tank at volumetric flow rate F_0 Product stream leaves the tank at volumetric flow rate $F_1 (F_0 \neq F_1)$ Assume constant density. List the various variables and constant parameters involved in the system. Model the system.



OR

6. Three CSTR are connected in series as shown figure. Reaction $A \rightarrow B$ is taking place in each reactor. Each reactor is maintained at different constant temperatures and rate constant in each reactor is K_1, K_2 and K_3. Volume of each reactor is V_1, V_2 and V_3 respectively. A reactant A is fed to the first reactor at concentration C_{A_0} and volumetric flow rate F_0 product is withdrawn from the last reactor at volumetric flow rate F_3 . Assume constant volume of each reaction and constant temperature in each reactor. Also assume constant density of fluid. Derive the mathematical model of the system. 13



SECTION - B

7. A supply of hot air is obtained by drawing cool air through a heated cylindrical pipe. The pipe is 0.1 m in diameter and 1.2 m long and is maintained at temperature of Tw = 300° C throughout its length. The average values of properties of air are as follows: heat capacity C_P = 1005 J/kg °C Thermal conductivity, K = 0.037 W/m^2 °C, density, $\rho = 0.809 kg/m^3$ Flow rate, $u = 8 \times 10^{-3} m^3$/sec. Inlet temperature = 21° C and overall heat transfer 14

coefficient $h = 52.3x^{(-1/2)}$ W/m^2 °C, where x is distance measured from the entrance of pipe inlet. Assuming heat transfer takes place by conduction with in the gas in the axial direction by mass flow of gas and by above mentioned variable heat transfer coefficient from the walls of tube, develop the mathematical model for temperature distribution in the axial direction in the form of differential equations for steady state conditions.

OR

8. G_{N+1} kg.mole / sec of wet gas containing Y_{N+1} mole of solute 1 kg mole of wet gas is fed into base of plate absorption column where the solute is to be stripped from the gas by absorption in L_0 kg mole/sec of lean oil which is fed at top of column. The solute in entering oil is X_0 kg mole/kg. mole of lean oil and the solute in exit gas is Y_1 kg. mole/ kg.mole of wet gas. The equilibrium constant Km is given as $K_m = Y_m / X_m$, where Y_m and X_m are mole fraction of solute in gas and liquid phases respectively. So that performance of the absorber can be expressed in terms of the absorption factor $A = (L_0 / K G_{N+1})$ and number of ideal stages (N) by Kremser - Brown Equation:- **14**

$$\frac{Y_{N+1} - Y_1}{Y_{N+1} - Y_0} = \frac{A^{N+1} - A}{A^{N+1} - 1}$$

9. The temperature distribution across a large concrete 50 cm thick slab heated from one side, as measured by thermocouples, approximates to the following relation: **13**

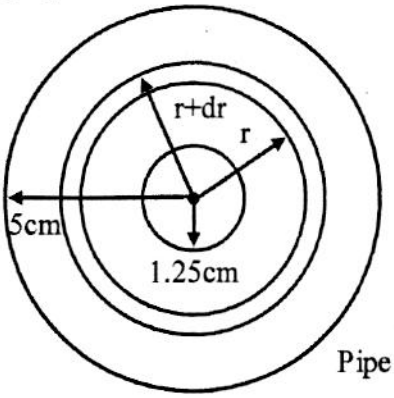
$T = 60 - 50x + 12x^2 + 20x^3 + 15x^4$ where, T is in °C and x is in metres. considering an area of 5 m^2. compute the following:-

a) A heat entering and leaving slab in unit time.
b) The heat energy stored unit time.
c) The rate of temperature change at both sides of slab.
d) The point at which rate of cooling or heating is maximum.

Take the following data for concrete:
Thermal conductivity, K = 1.2 w/m °C
Thermal diffusivity $\alpha = 1.77 \times 10^{-3}$ m^2 / sec

OR

10. Model the system for the heat loss through pipe flanges as shown in diagram below. Two thin wall metal pipes of 2.5 cm external diameter and joined by flanges 1.25 cm thick and 10 cm diameter are carrying steam at 120° C. If the conductivity of the flange metal K = 400 W/m °C and the exposed surfaces of the flanges lose heat to the surroundings at $T_1 = 15°C$ according to a heat transfer coefficient h = 12 W/m^2 °C determine the rate of heat loss from the pipe and the proportion which leaves the rim of the flange. **13**



Pipe Flange

11. The relationship between shear stress, τ and shear rate ' γ ' for pseudoplastic fluid can be expressed by equation 13

$\tau = \mu\gamma^n$ Following data are collected for certain pseudoplastic fluid.

Using the method of least squares estimates the values of parameters μ and n.

$\tau(N/m^2)$	5.99	7.45	8.56	9.15	11.30
$\gamma(1/s)$	55	75	100	120	140

OR

12. An investigator reported the data tabulated below. If is known that such a data can be modelled by following equation:- 13

$x = e^{(y-b)/a}$ where a and b are constant parameters Linearize this equation and employ linear regression to determine a and b. Based on your analysis predict y at x = 2.9.

x	1	2	3	4	5	6
y	0.6	1.9	3.1	3.8	5.2	7.9

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