Paper / Subject Code: 52571 / Modelling Simulation and Optimization

14-May-2024 10:30 am - 01:30 pm 1T00538 - B.E.(Chemical Engineering)(SEM-VIII)(Choice Base Credit Grading System) (R- 19) (C Scheme) / 52571 - Modelling Simulation and Optimization
QP CODE: 10055156

(3 Hours) **Total Marks: 80**

N.B.

1. Question No. 1 is Compulsory.
2 Attempt any **Three** Questions from remaining **Five** Questions
3. Assume Suitable Data if needed and Justify the Same
4. Figures to the right indicate full marks.

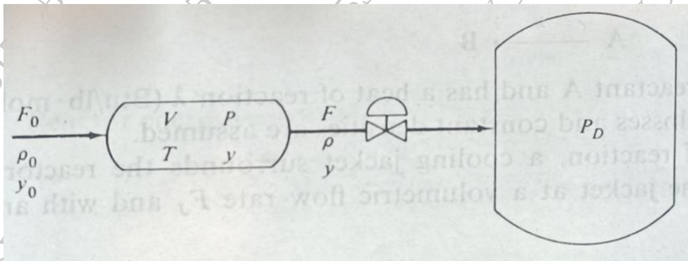
Que.1

a)	Explain classification of mathematical models	[05]
b)	Write applications and limitation of ANNs in Chemical Engineering	[05]
c)	Distinguish between Sequential Modular Approach and EquationOriented Approach	[05]
d)	Discuss principles of formulation of process models	[05]

Que.2

a) Derive mathematical model for describing the system, gas phase pressurized CSTR with reaction $2A \leftrightarrows B$ with k_1 and k_2 are rate constant of forward and backward reaction resp. The forward reaction is 1.5^{th} order in A; reverse reaction is first order in B. The mole fraction of reactant A in the reactor is y. The pressure inside the vessel is P (absolute). Both P and y can vary with time. The volume of the reactor V is constant. An isothermal system can be assumed. The flow of the reactor passes through a restriction (control valve) to another vessel which is held at a constant pressure P_D, (absolute). The outflow will vary with the pressure and the composition of the reactor. [10]

Assumptions : An isothermal system and perfect gases



b) The flow rate F (m^3/s) of oil passing through two perfectly mixed tanks in series is constant. The density ρ (kg/m^3) of the oil is constant. The volume of tank 1 is V_1 and that of thank 2 is V_2. The temperature of oil entering the first tank is T_o. The temperatures in the two tanks are T_1 and T_2. A heating coil in the first tank uses steam to heat the coil. Let Q_1 be the heat addition rate in the first tank. [10]

a. Derive the mathematical model for this system
b. Perform DOF for this system

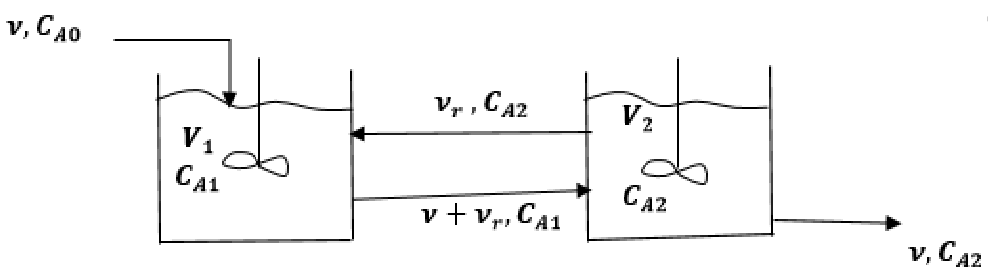
Que.3 Feed stream with pure species A and B are mixed with recycle stream enter CSTR, where following reactions take place [20]

$$A + B \rightarrow C$$
$$C + B \rightarrow P + E$$
$$P + C \rightarrow G$$

Here, C is an intermediate, P is main product, E is by product and G is oily waste. The plant consist of reactor, a heat exchanger to cool reactor effluent, a decanter to separate waste product G from reactants and other products and a distillation column to separate product P. Due to formation of an azeotrope some of product (equivalent to 15 wt% of mass flow rate of component E) is retained in the column bottom. Most of the bottom product is recycled to reactor and rest is purged. Construct a Williams-Otto flowsheet and develop the process equations.

Que.4

a) An isothermal irreversible reaction $A \xrightarrow{k_1} B$ takes place in a liquid phase constant volume reactor. The mixing is not perfect. Observation of flow patterns indicates that a two tank system with backmixing as shown in the sketch below. Assuming, v *and* v_r are constant, write the equations describing system. [10]



b) The model equation for a three CSTR in series is given below, At t=0, CA_0=1.8 kmol/m^3, $CA_1(0)$=0.4 kmol/m^3, $CA_2(0)$=0.2 kmol/m^3, $CA_3(0)$=0.1 kmol/m^3, τ=2, $k_1=k_2=k_3$=0.5, find concentration in all the reactor at t=0.2 using Runge Kutta-4th order method take the step size in time as 0.1? [10]

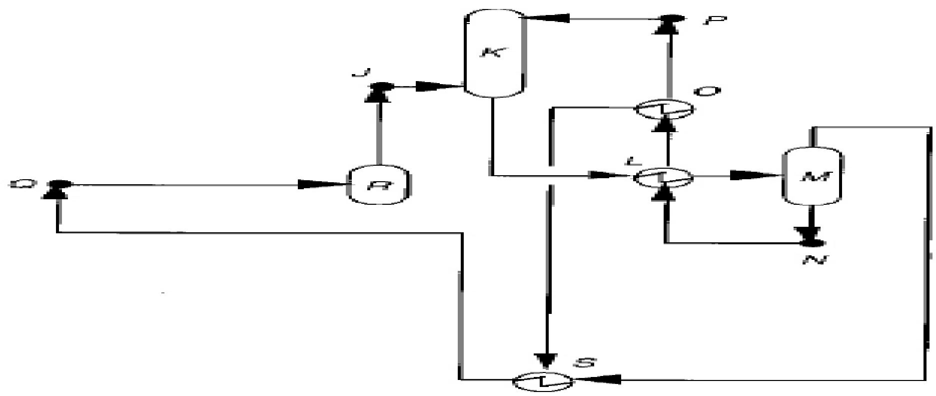
$$\frac{dC_{A1}}{dt} = \frac{1}{\tau}(C_{A0}) - \left(\frac{1}{\tau} + K_1\right)C_{A1}$$

$$\frac{dC_{A2}}{dt} = \frac{1}{\tau}(C_{A1}) - \left(\frac{1}{\tau} + K_2\right)C_{A2}$$

$$\frac{dC_{A3}}{dt} = \frac{1}{\tau}(C_{A2}) - \left(\frac{1}{\tau} + K_3\right)C_{A3}$$

Que.5

a) Determine the tear stream for the following flowsheet [10]

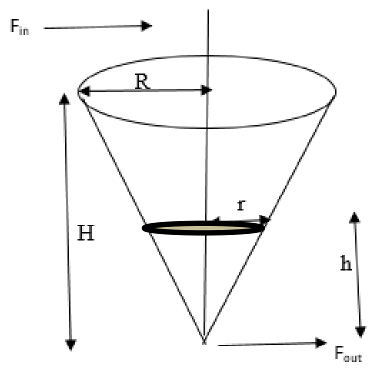


b) Solve the fixed point problem given by [10]

$$x_1 = 1 - 0.5\exp(0.7(1 - x_2))$$
$$x_2 = 2 - 0.3\exp(0.5(x_1 + x_2))$$

Using direct substitution method starting from $x_1 = 0.8$ *and* $x_2 = 0.8$

Q.6A A fluid of constant density ρ is pumped into a cone – shaped tank of total volume $V = \frac{H\pi R^2}{3}$. The flow out of the bottom of the tank is proportional to the square root of the height of liquid in the tank. Derive the relation describing the system. [10]



Q 6 B [10]

i. Solve the multivariable function $f(Y) = y_1^2 + y_1(1-y_2) + y_2^2 - y_2 y_3$. Comment whether the solution gives maxima or minima of the function 05

ii. What are artificial neural networks? How an artificial neuron model can be compared with biological neuron model 05
