Paper / Subject Code: 41953 / Process Dynamics & Control (PDC)

20-Nov-2019 1T00527 - B.E.(Chemical Engineering)(SEM-VII)(Choice Base) / 41953 - Process Dynamics & Control (PDC) 77378

(3 Hours) Total Marks: 80

N.B:

1) Question 1 is compulsory. Answer any three questions from the remaining.
2) Assume data if necessary and specify the assumptions clearly
3) Draw neat sketches wherever required
4) Answer to the sub-questions of an individual question should be grouped and written together.

Q.1.

a) A process of unknown transfer function is subjected to a unit impulse input. The output of the process is measured accurately and is found to be represented by the function $y(t) = te^{-t}$. Determine the unit step response of this process [05]

b) Explain Phase Margin and Gain Margin? [05]

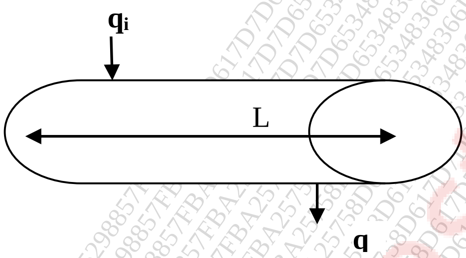
c) A second order system is found to have a peak amplitude ratio of 1.1547 at a frequency of 0.7071 *rad/min*. What are the values of natural period of oscillation and the damping coefficient of the system? [05]

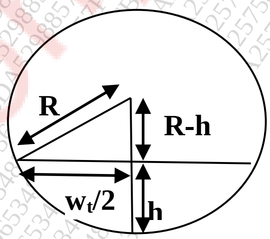
d) Write the degree of freedom equation and discuss the conditions to specify the process model. [05]

Q.2.

a) A horizontal cylindrical tank shown in Figure.A below is used to slow the propagation of liquid flow surges in a processing line. Figure.B illustrates an end view of the tank and w_t is the width of the liquid surface, which is a function of its height, both of which can vary with time. The model equation for the height of liquid h in the tank at any time with the inlet and outlet volumetric flow rates is given below. Linearize the given model equation assuming that the process initially is at steady state and that the liquid density ρ is constant.

$$\frac{dh}{dt} = \frac{q_i}{2L\sqrt{(D-h)h}} - \frac{C_v h^{0.5}}{2L\sqrt{(D-h)h}}$$





Derive the transfer function relating the changes in the liquid level **h** to the changes in the inlet flow rate q_i outlet flow rate is q. The Radius of cylinder is R and diameter of the tank is D, L is the length of cylinder and C_v is the constant of the valve in the outlet line. [10]

b) Two streams w_1 and w_2 each at a constant density of 900 kg/m^3, and carrying solute of mass fraction x_1 and x_2 respectively, enter a continuous stirred tank of 2m^3 capacity. At steady-state, w_{1s}=500 kg/min, w_{2s}=200 kg/min, x_{1s}=0.4, and x_{2s}=0.75. Suddenly the inlet flow rate w_2 decreases to 100 kg/min and remains there. Determine an expression for the mass fraction of the solute $x(t)$. Assume that liquid hold up is constant. [10]

Q.3.

a) The dynamic behaviour of a pressure sensor/transmitter can be expressed as a first-order transfer function (in deviation variables) that relates the measured value P_m to the actual pressure, P:

$$\frac{P_m(s)}{P(s)} = \frac{1}{30s+1}$$

Both $P_m(s)$ and $P(s)$ have units of psi and the time constant has units of seconds. Suppose that an alarm will sound if P_m exceeds 45 psi. If the process is initially at steady state, and then P step changes from 35 to 50 psi at 1:10PM, at what time will the alarm sound? [10]

b) The dynamic behaviour of the liquid level in each leg of a manometer tube, responding to a change in pressure, is given by where $h(t)$ is the level of fluid measured with respect to the initial steady-state value, $p(t)$ is the pressure change, and R, L, g, ρ, and μ are constants.

$$\frac{d^2h}{dt^2} + \frac{6\mu}{R^2\rho}\frac{dh}{dt} + \frac{3}{2}\frac{g}{L}h = \frac{3}{4\rho L}p(t)$$

(i) Rearrange this equation into standard gain-time constant form and find expressions for K, τ and ξ in terms of the physical constants.

(ii) For what values of the physical constants does the manometer response oscillate?

(iii) Would changing the manometer fluid so that ρ (density) is larger make its response more oscillatory, or less? [10]

Q.4.

a) Consider the following transfer function of a process: [10]

$$G_p(s) = \frac{5e^{-0.2s}}{(2s^2+s+1)}$$

Design a PI controller for the negative feedback loop of the process, based on the Zeigler and Nicholos tuning rules?

b) A first order process is controlled with a PI controller. For the system under study assume that

$G_p(s) = G_d(s) = \dfrac{1}{s+3}$ and $G_m(s) = G_f(s) = 1$. Find the values of the controller gain K_c and reset time τ_I that can satisfy, if possible, the below conditions:

(i) The decay ratio of the closed loop response is equal to 0.25

(ii) The closed loop gain to load changes is 10 [10]

Q.5.a) Using Routh Criteria determine the positive limits of K_c for the stability of the system with following open loop transfer function. $G_{OL}(s) = \dfrac{K_c(s+1)}{(s^4+2s^3+2s^2+(3+K_c)s+K_c)}$

(i) with K=6, will the output response be stable? [05]

(ii) Determine the limiting positive values of K for stability? [05]

Q.5.b) A unit feedback control system has: $G(s) = \dfrac{64(s+2)}{s(s+0.5)(s^2+3.2s+64)}$ Generate Bode plot and comment on the stability. Find the gain margin and phase margin. [10]

Q.6.

a) Following response was obtained from a dynamic system when a step of magnitude 0.2 was introduced.

Time(min)	Response
0	0.00
5	0.01757
10	0.025273
15	0.088674
20	0.178158
25	0.268563
30	0.343173
35	0.396964
40	0.432176
45	0.453617

Finally the response reaches a constant value of 0.4798 after a long time. Use the data to fit the First order plus dead time model to the system? [10]

b) Discuss Bode stability Criterion [5]

c) Differentiate between Negative and positive feedback control system [5]

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