

BITS PILANI, DUBAI CAMPUS
 Dubai International Academic City, Dubai, UAE
 Semester II 2012-2013
 COMPREHENSIVE EXAMINATION (Closed Book)
 BE (Hons) IV year EIE/ III CHEM

Course No : INSTR C451

Course Title : PROCESS CONTROL

Date : 08.06.13

Time: 3Hours

M.M = 80 (40%)

- NOTE:** 1. All the symbols and words carry their usual meanings, unless otherwise stated.
 2. Total No of Pages. 2, No of Questions. 7
 3. Answer all the questions sequentially

1. Find the total no of variables, total no of equations & the degrees of freedom for the binary distillation column shown in Figure 1. [12M]

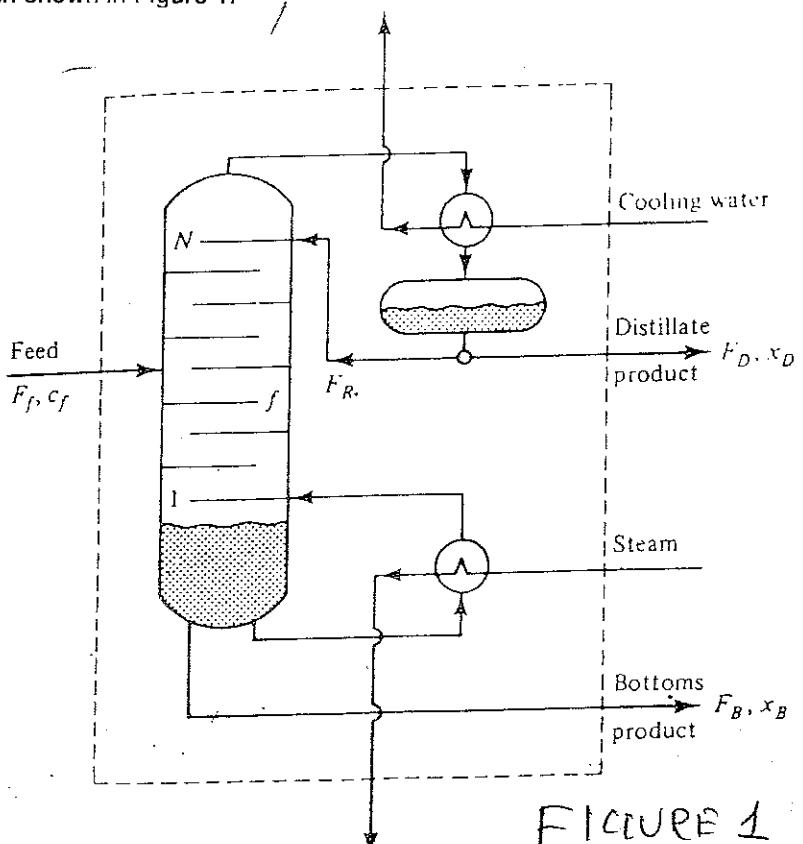


FIGURE 1

2. Draw the Bode plot (in the graph sheet) for the open loop transfer function with the following dynamic components:

$$G_p(s) = \frac{50}{s(1+0.2s)(1+0.1s)} ; G_r(s) = 1$$

and determine (1) gain cross over frequency (2) phase cross over frequency.
 (Assume Lower frequency = 0.1 rad/sec; Higher frequency = 20 rad/sec)

[12M]

3. A first order system with a transfer function $G_p(s) = 5 / 0.1s + 1$ is controlled with a feedback PI controller $G_c(s) = K_c(1 + 1/\tau_1 s)$. Assuming that the final control element has a transfer $G_f = 1$ and that the transfer function of the measuring device is $G_m(s) = K_m / \tau_{m1} s + 1$. Do the following,

- Set $K_m = 1$, $\tau_{m1} = 1$, and using the Routh criterion, find a pair of values K_c and τ_1 which yield stable closed loop response.
- Using the values of K_c and τ_1 found in part (a), examine the effect of changing K_m on the stability of the closed loop response.
- Do the same with τ_{m1} .
- Based on the results above, discuss the effect that measurement dynamics have on the stability of the closed loop response. [12M]

4. Consider the tanks shown in Figure 2. Find the overall transfer function for a unit step input. [12M]

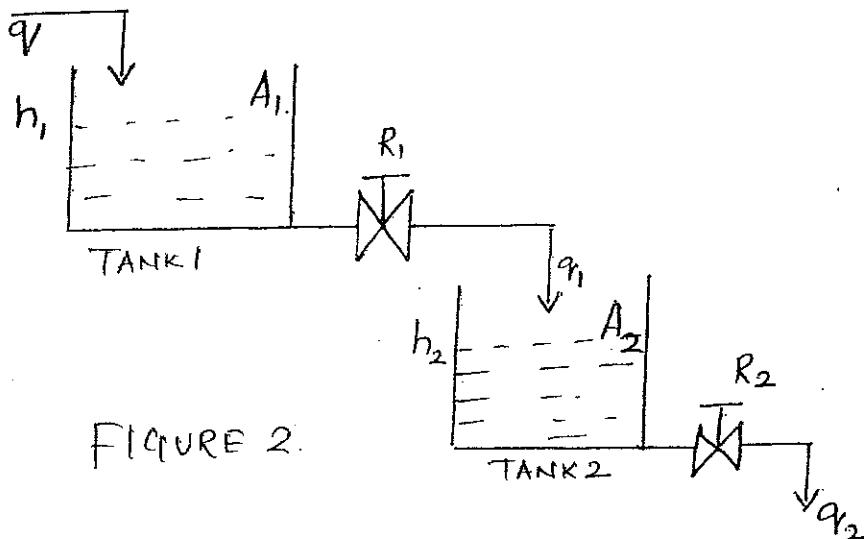


FIGURE 2.

5. The open loop transfer function of a unity feedback system is $G(s) = \frac{K}{s(s+10)}$.

Determine the gain K so that the system will have a damping ratio of 0.5. For this value of K determine the settling times, peak overshoot, decay ratio and time to peak overshoot for a unit step input. [12M]

- Under what condition we should select FFC + FBC system?
- Mention any four major differences between FFC and FBC
- What is meant by cascade control system?
- What is meant by inferential complex control?
- What are the types of model based controllers? [5*2=10M]

7A. Compare the parameters overshoot & settling times for the P, I and D controllers.

7B. Mention the different methods of tuning for conventional controllers.

7C. What are the classification of control valve according to the flow lift characteristics? Explain.

7D. Explain the flapper nozzle system in pneumatic controllers.

7E. What is the transfer function of pure capacitive process? [5*2=10M]

ALL THE BEST

II] CHEM/ IV EIB → PROCESS, CONTROL

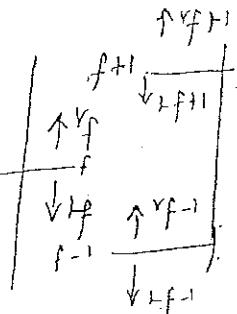
① Binary distillation column

I Feed tray:

$$d(M_f) = F_f - V_f - L_f + L_{f+1} + V_{f+1}$$

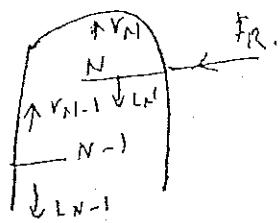
$$= F_f - L_f + L_{f+1}$$

$$\frac{d(M_f x_f)}{dt} = F_f x_f - L_f x_f + L_{f+1} x_{f+1} - V_f y_f + V_{f+1} y_{f+1}$$



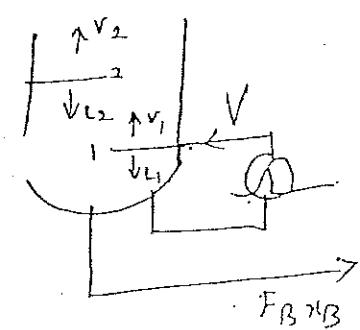
II Top tray: (n^{th} tray)

$$\frac{d(M_n)}{dt} = F_R - V_n - L_n + V_{n-1}$$



$$\frac{d(M_n x_n)}{dt} = F_R x_D - V_n y_n - L_n x_n + V_{n-1} y_{n-1}$$

Bottom section: (1st tray)



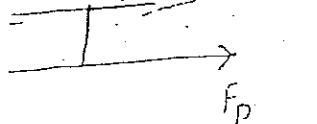
$$\frac{d(M_1)}{dt} = V - V_i - L_1 + L_2$$

$$\frac{d(M_1 x_1)}{dt} = V y_B - V_i y_i - L_1 x_1 + L_2 x_2$$

Reflux column:

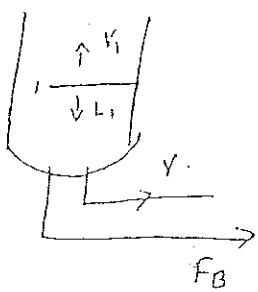
$$\frac{d(M_{RD})}{dt} = V_n - F_R - F_D$$

$$\frac{d(M_{RD} x_D)}{dt} = V_n y_n - F_R x_D - F_D x_D$$



(1)

I Column base:



$$\frac{d(m_B)}{dt} = L_i - Y - F_B$$

$$\frac{d(N_B x_B)}{dt} = L_i x_i - Y y_B - F_B x_B$$

(7)

a. There are $2N+4$ diff eqn.

$$2N \rightarrow N \text{ trays}$$

$$2 \rightarrow \text{reflux drum}$$

$$2 \rightarrow \text{column base}$$

b. Equilibrium eqn (Referring x_i and y_i)

$$y_i = \frac{\alpha x_i}{1 + (\alpha - 1)x_i} \quad i = 1, 2, \dots, N, B$$

c. Relative volatility.

$\alpha_{i+1} \rightarrow$ equilibrium eqn.

N - For N trays

1 - Column base

c. Hydraulic eqn: (Relationship with L_i and m_i)

$$L_i = f(m_i) \quad i = 1, \dots, N$$

N - Hydraulic eqn's

f0

$2N+4$

$N+1$

$\frac{N}{L+N+5}$

Total

diff eqn's

No. of Variables:

χ_i $i = 1, 2, \dots, N, B, D$ $N+2$
(Liquid drop)

γ_i $i = 1, 2, \dots, N, B$ $N+1$
(Vapor temp)

M_i $i = 1, 2, \dots, N, R_D, B$ $N+2$
(Liquid Liquid)

L_i $i = 1, 2, \dots, N$
(Liquid flows)

Independent variables $F_f, \alpha_f, F_D, F_B, F_R, V$

Total No. of variables

$$\frac{6}{\overline{4N+11}} = 1$$

$$\underline{\underline{4N+11}} \quad \underline{\underline{1}}$$

$$(IM)$$

Degrees of freedom = Total No. of variables - Total No. of eqn's

$$= 4N+11 - 4N+5$$

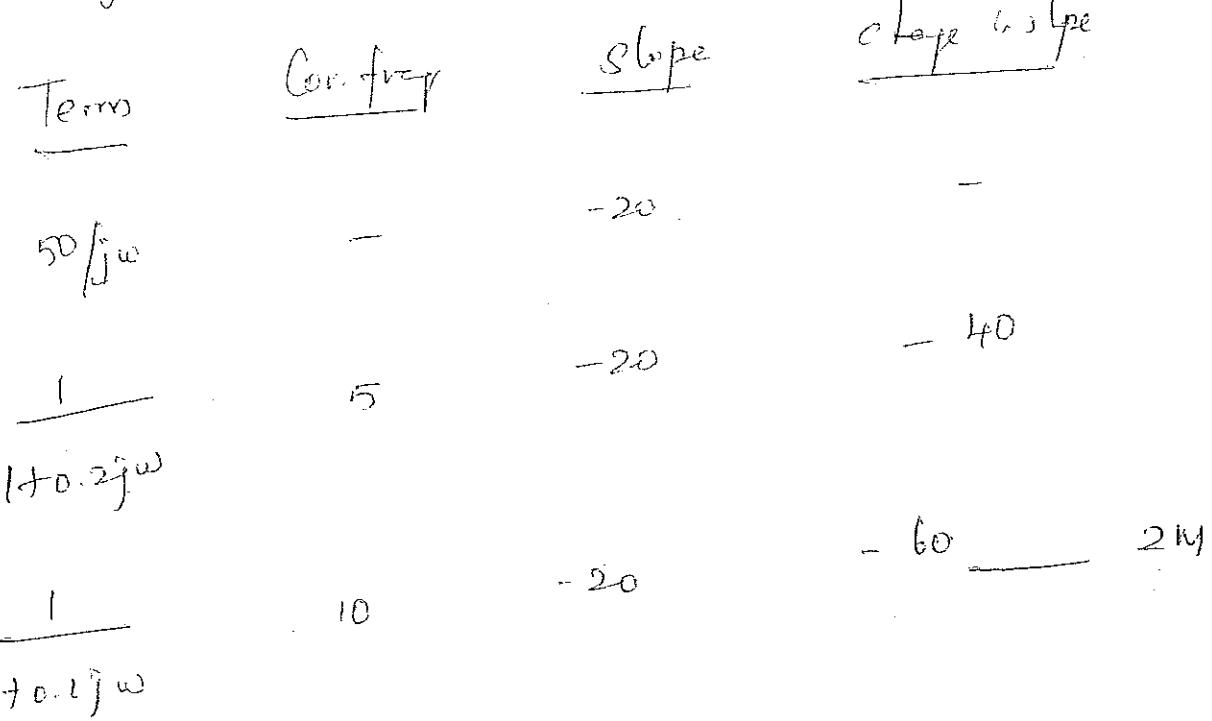
$$= 6 \longrightarrow (\textcircled{2})^N$$

(3)

$$2. \quad G(s) = \frac{50}{s(1+0.2s)(1+0.1s)} \quad \textcircled{A}$$

$$G(j\omega) = \frac{50}{j\omega(1+0.1j\omega)(1+0.2j\omega)}$$

Magnitude plot



$$\omega_l = 0.1, \quad \omega_h = 20$$

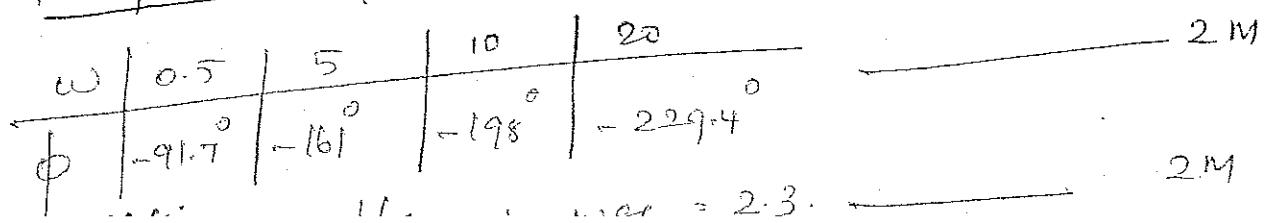
$$\omega = \omega_l \Rightarrow A = 20 \log \left| \frac{50}{j\omega} \right| = 20 \log \left| \frac{50}{0.1} \right| = \approx 54 \text{ dB}$$

$$\omega = \omega_{C_1} \Rightarrow A = 20 \text{ dB}$$

$$\omega = \omega_{C_2} \Rightarrow A = 8 \text{ dB} \quad \text{2M}$$

$$\omega = \omega_{C_3} \Rightarrow A = -10 \text{ dB}$$

Phase plot: $\phi = -90^\circ - \frac{1}{0.2\omega} - \frac{1}{0.1\omega} = 2$



~~8B. Adv.: One to one linear relationship
discr. offset.~~

(3) The char. eqn $1 + \frac{5}{0.1s+1} \cdot k_c \cdot \frac{(e_I s+1)}{e_I s} \cdot \frac{k_m}{e_m s+1}$

$$\frac{(0.1s+1)(e_I s)(e_m s+1) + 5k_c(e_I s+1)k_m}{(0.1s+1)(e_I s)(e_m s+1)}$$

$$(0.1e_I e_m)s^3 + e_I(e_m + 0.1)s^2 + e_I(1 + 5k_c k_m)s + 5k_c k_m \quad 2M$$

(a) Set $k_m = e_m = 1$

$$0.1e_I s^3 + 1.1e_I s^2 + e_I(1 + 5k_c)s + 5k_c = 0$$

$$\frac{0.1e_I}{1.1e_I} \quad \frac{e_I(1 + 5k_c)}{5k_c} \quad \left. \begin{array}{l} 1.1e_I^2(1 + 5k_c) - 0.5e_I k_c > 0 \\ \text{and is satisfied for} \\ k_c = 1.0 \Rightarrow e_I = 0.1 \end{array} \right\}$$

$$\frac{1.1e_I^2(1 + 5k_c) - 0.5e_I k_c}{1.1e_I} \quad 0 \quad \frac{5k_c}{-} \quad 3.33M$$

(b) Set $k_c = 1.0$; $e_I = 0.1$

$$0.01e_m s^3 + 0.1(e_m + 0.1)s^2 + (1 + 5k_m)0.1s + 5k_m = 0$$

$$\frac{0.01e_m}{0.1e_m} \quad \frac{0.1(1 + 5k_m)}{5k_m} \quad \left. \begin{array}{l} (e_m + 0.1)(1 + 5k_m) \\ - 5.65 e_m k_m > 0 \end{array} \right\}$$

$$\frac{0.1(e_m + 0.1)}{0.1(e_m + 0.1)} \quad 0 \quad \left. \begin{array}{l} \text{For } e_m = 1 \text{ is stable.} \\ \text{If } k_m > -2.2 \text{ for all} \\ \text{relax 3 km} \end{array} \right\}$$

$$\frac{5k_m}{-} \quad \approx \quad \left. \begin{array}{l} \text{since } k_m > 0 \end{array} \right\}$$

c. Set $k_c = 1.0$ and $T_I = 0.1$ and $k_m = 1$

Then from input by the system is stable

If $T_m > 0.6$ is for all value of $T_m = 2 M$

d. T_m and k_m have no effect on the stability
of no closed loop response. $= 2 M$

c.A. When load variable change by a large
amount and when process lag is more
then we have to go for $FF + FB$. $= 2$

6B. FBC

Not sensitive to
process parameter

Account model is
not needed

Cross check of CV

May become unstable

FFC

Sensitive

Needed

No cross check of CV.

May become unstable. $= 2$

6C. Two controllers connected in series - one is called
as primary controller and other is the secondary
controller. Output of the primary decides the setpoint if
the secondary controller. $= 2$

6D. Some systems the actual CV's are not
measurable. We measure the sec. measurement

and infer the value of CV. This is called inferred CV. $= 2$

7

6. Model based control

Model Ref. adaptive Ctr.

1. Adaptive Ctr.

Model identification adaptive
Ctr.

2. optimum "

(STR)

5.

$$G(s) = \frac{K}{s + 10}$$

$$\frac{C(s)}{R(s)} = \frac{G}{1+G} = \frac{\frac{K}{s^2 + 10s + K}}{s^2 + 2\xi\omega_n s + \omega_n^2} = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$$\omega_n^2 = K ; \quad 2\xi\omega_n = 10$$

$$\omega_n = \sqrt{K} \quad 2 \times 0.5 \times \omega_n = 10$$

$$\omega_n = 10$$

$$K = \omega_n^2 = 10^2 = 100$$

$$\text{Safety time } 5\% \quad t_s = \frac{4}{\xi\omega_n} = \frac{4}{0.5 \times 10} = 0.8 \text{ s}$$

$$2\% \quad t_s = \frac{3}{\xi\omega_n} = \frac{3}{0.5 \times 10} = 0.6 \text{ s}$$

$$M_p = e^{-\xi\pi/\sqrt{1-\xi^2}} = 0.163 \text{ m}$$

$$\gamma_{Mp} = 16.3\%$$

$$\text{decay ratio} = (0.163)^2 = 0.0265 \text{ m}$$

$$t_p = \frac{\pi}{\omega_d} = 0.363 \text{ sec.}$$

(8)

on-offSettling Time

8A.

P



small change

T



D



2

8B.

Tuning

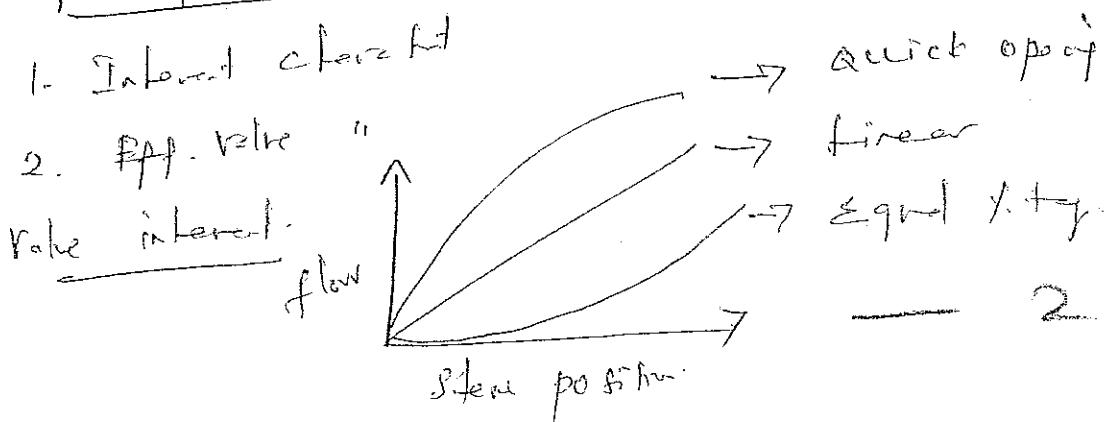
1. open loop transient response
2. Ziegler - Nicols method
3. continuous cycling method
4. FR. Response method.

2

8C

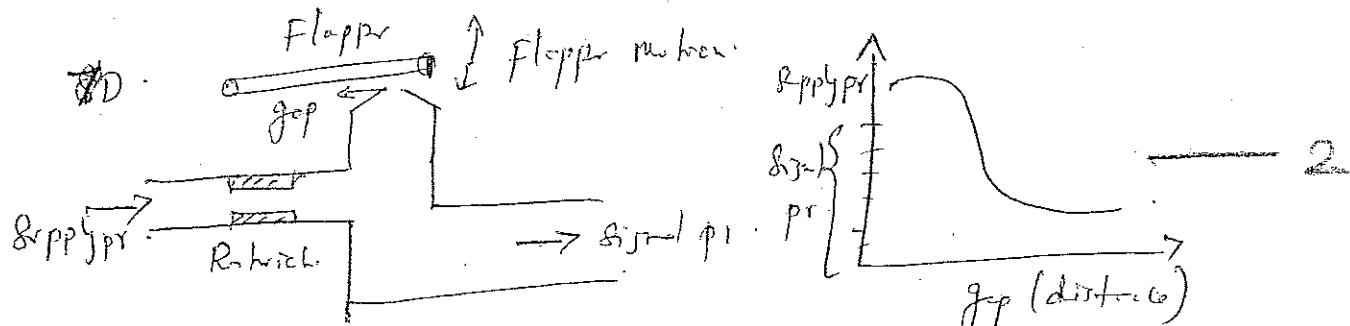
Flow lift characteristics

1. Inherent characteristic



2

8D.



2

Flapper close the nozzle; $p_{pp} = p_1$ flapper move up \rightarrow gap is producedGap \uparrow \rightarrow ; $p_1 \downarrow$

$$\left. \begin{array}{l} \text{No. of intervals} \\ q_1 = q_2 + t_2 \frac{dh}{dt} \\ q_1 = h/R_1; q_2 = h_2/R_2 \end{array} \right\} \quad \begin{array}{l} q = q_1 + A_1 \frac{dh}{dt} \\ q_1 = h/R_1 \\ H_1(s) = \omega(s) + \frac{R_1}{1+t_1 s} \end{array} \quad (5)$$

Taking LT

$$H_2(s) = \frac{H_1(s)}{R_1} \times \frac{R_2}{1+t_2 s}$$

rb $H_1(s)$

$$H_1(s) = \omega(s) \times \frac{s^2}{(1+t_1 s)(1+t_2 s)}$$

$$\text{Overall TF} = \frac{H_2(s)}{\omega(s)} = \frac{s^2}{(1+t_1 s)(1+t_2 s)}$$

Step unit step $r(t) = 1$; $\omega(s) = 1/s$

$$H_2(s) = \frac{s^2}{s(t_1 s+1)(t_2 s+1)} + \frac{c}{t_2 s+1} = 1$$

By partial fraction $\frac{A}{s} + \frac{B}{t_1 s+1} + \frac{c}{t_2 s+1}$

$$s=0 \Rightarrow A=1$$

$$s=-1/t_1 \Rightarrow B = t_1^2 / (t_2 - t_1)$$

$$s=-1/t_2 \Rightarrow c = t_2^2 / (t_1 - t_2)$$

$$H_2(t) = R_2 \left[\frac{1}{s} + \frac{t_1^2}{t_2 - t_1} \cdot \frac{1}{t_1 s + 1} + \frac{t_2^2}{t_1 - t_2} \cdot \frac{1}{t_2 s + 1} \right]$$

$$H_2(t) = R_2 \left[1 + \frac{t_1}{t_2 - t_1} e^{-t/t_1} + \frac{t_2}{t_1 - t_2} e^{-t/t_2} \right]$$

(6)

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Semester II 2012-2013
TEST II / (Open Book)
BE (Hons) IV year EIE / III YEAR CHEM

Course No : INSTR C451 / CHE C441
Course Title : PROCESS CONTROL
Date : 06.05.2013 Time: 50 Minutes M.M = 20 (20%)

NOTE: 1. All the symbols and words carry their usual meanings, unless otherwise stated.
2. Answer all the questions.

1. A transient disturbances test is run on a process loop. The results of 9% controlling variable change gives a process reaction graph as shown in Fig 1. Find the settings for three mode actions.
[5M]

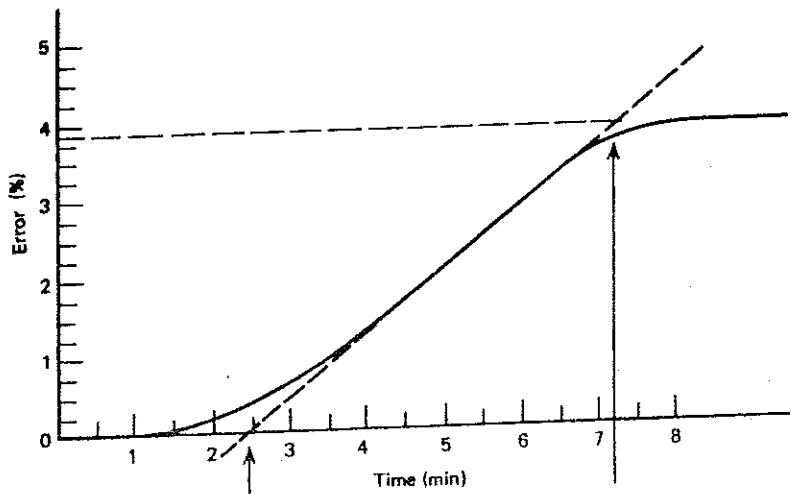


FIG1. PROCESS REACTION GRAPH

2. Consider a unity feedback control system has an open loop transfer function $G(s) = \frac{10}{s(s+2)}$.
Find the rise time, the percentage overshoot, peak time, decay ratio for a step input applied. [5M]

3. Why is the controller design of process with dead time a particularly sensitive and difficult problem? Explain. [3M]

4. Draw the response for the step input to P, I, D, PI , PD & PID controllers. [3M]

5. Non interacting capacities always result in an over damped or critically damped second order system and never in an under damped system. Why? [2M]

6. For the second order system given below, if we introduce a unit step change in the input then what will be the percentage overshoot of the response?

$$G(s) = \frac{1}{s^2 + s + 1} \quad [2M]$$

ALL THE BEST

PROCESS CONTROL / T2 OPEN BOOK.

6/5/13

$$1. \quad \text{From graph: } \begin{cases} L = 2.4 \text{ min} \\ T = 4.8 \text{ min} \end{cases} \quad \text{1M}$$

$$N = \frac{\Delta \varphi}{T} = \frac{3.9 \text{ y.}}{4.8} = 0.8125 \text{ y./min.}$$

← 1M

$$K_p = 1.2 \frac{\Delta P}{NL} = 1.2 \frac{97.1}{(0.8125)(2.4)}$$

$$K_p = 5.54$$

$$T_I = 2L = 2(2.4) = 4.8 \text{ min} \quad \text{in}$$

$$T_D = 0.5L = 0.5(2.4) = 1.2 \text{ min} \quad \longrightarrow 1M$$

$$2. \quad G_1 = \frac{10}{s(s+2)}$$

$$\frac{C}{R} = \frac{G_f}{1+G_f} = \frac{10}{s^2 + 2s + 10}$$

Comp the geno for with

$$2 \notin w_n = 2 ; \quad ; \quad w_n^2 = 10$$

$$\omega_n = 3 \cdot 16^2$$

$$\varepsilon = \gamma_{wn}$$

$$\xi = 0.316 \quad w_n = 3.162 \quad |M|$$

$$t_r = \frac{\pi - \phi}{\omega_d}$$

$$= \frac{\pi - \frac{1 - \sqrt{1 - q^2}}{q}}{\omega_d}$$

$$; t_r = \frac{\pi - \frac{1 - \sqrt{0.999}}{2.99}}{2.99}$$

$$\omega_d = \omega_n \sqrt{1 - q^2} = 2.99.$$

$$\boxed{t_r = 0.633 \text{ sec}}$$

1M

$$\gamma. M_p = e^{-\frac{q\pi}{N}\sqrt{1-q^2}} \times 100$$

$$\boxed{\gamma. M_p = 35.12}$$

1M

$$t_p = \frac{\pi}{\omega_d} = \frac{3.14}{2.99} = 1.050$$

$$\boxed{t_p = 1.050}$$

1M

$$\text{degrads} = (\text{overshot})^2$$

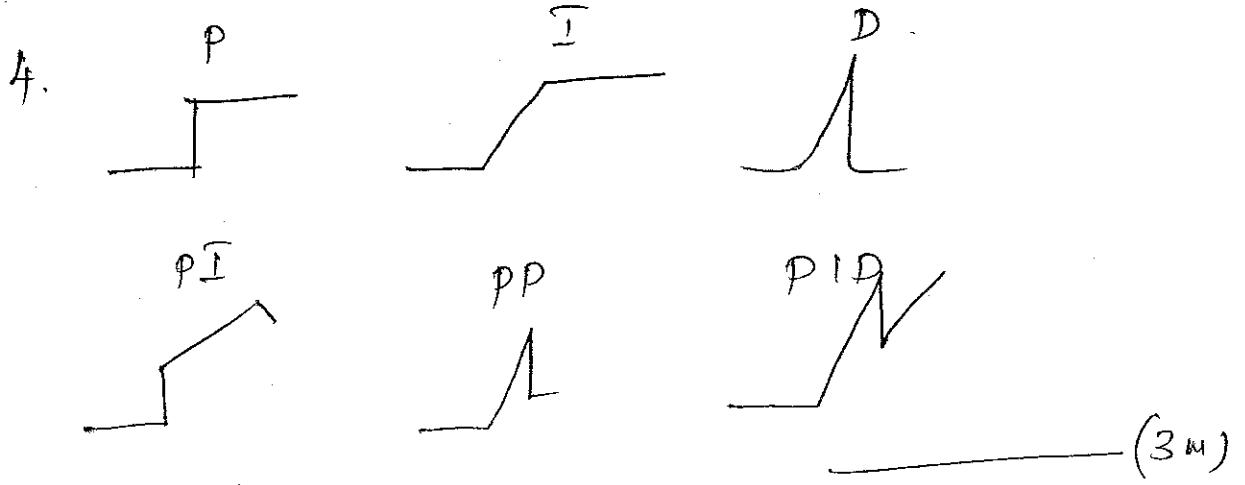
$$M_p = 0.35$$

$$\boxed{\text{degrads} = (0.35)^2 = 0.1225}$$

1M.

3. 1. Disturbance entering the process will not be detected.
2. Control action will be taken based on the test measurement.
3. Control action will also take some time to make its effect

————— (3m)



5. The non interacting roots will be real and may be equal. It cannot be imaginary. Hence it is ~~not~~ cannot be underdamped.

— (2m)

6. $G_1(s) = \frac{1}{s^2 + s + 1}$

$$2\zeta\omega_n = 1 ; \omega_n^2 = 1$$

$$\zeta = 0.5$$

$$e^{-\zeta\pi/\sqrt{1-\zeta^2}} = \underline{0.1630} \quad — (2m)$$

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Semester II 2012-2013
TEST I / (Closed Book)
BE (Hons) IV year EIE / III YEAR CHEM

Course No : INSTR C451 / CHE C441

Course Title : PROCESS CONTROL

Date : 24.03.2012

Time: 50 Minutes

M.M = 20 (20%)

NOTE: 1. All the symbols and words carry their usual meanings, unless otherwise stated.

2. Answer all the questions.

1. Develop the mathematical model for the system shown in Figure 1. What are the state variables for this system and what type of balance equations have you used? All the flow rates are volumetric and the cross sectional areas of the three tanks are A_1 , A_2 and A_3 (ft^2) respectively. The flow rate F_5 is constant and doesn't depend on h_3 , while all other effluent flow rates are proportional to the corresponding hydrostatic liquid pressures that cause the flow. [6M]

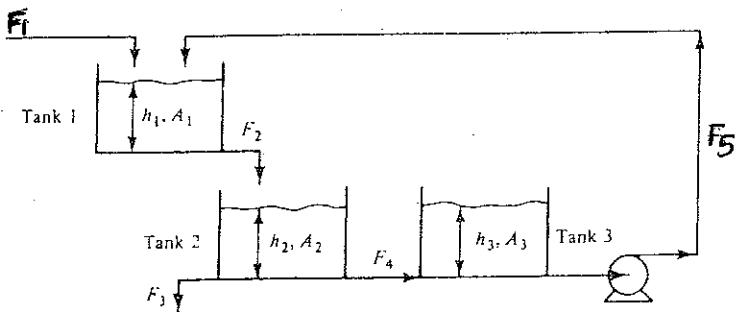


FIGURE 1

2. For Fig 2, Find the transfer function of the given process in terms of deviation variable. And also identify what is the order of the given process. [5M]

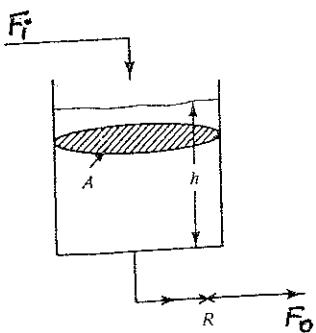


FIGURE 2

3. Find the mathematical model (in time domain) of a process for the block diagram shown in Fig 3. [3M]

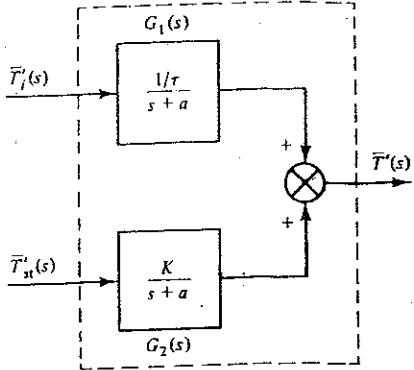


FIGURE 3

4. Derive the state equations and find the degree of freedom for the stirred tank heater shown in figure 4. [6M]

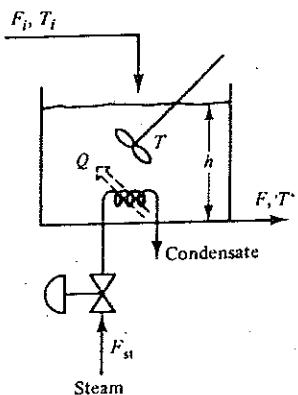


FIGURE 4.

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TEST I / IV YEAR EIE / II CHEM

① state variables : h, h_2, h_3] — 1M
 Batocig egn : material balance

Tank I :

$$A_1 \frac{dh_1}{dt} = F_1 + F_5 - F_2$$

$$F_2 = \alpha_1 h_1$$

$$A_1 \frac{dh_1}{dt} = F_1 + F_5 - \alpha_1 h_1 \quad \text{—— } 1\frac{1}{2} \text{ M}$$

Tank 2

$$A_2 \frac{dh_2}{dt} = F_2 - F_3 - F_4$$

$$F_3 = \alpha_2 h_2 ; \quad F_4 = \alpha_3 (h_2 - h_3)$$

$$A_2 \frac{dh_2}{dt} = F_2 - \alpha_2 h_2 - \alpha_3 (h_2 - h_3) \quad 2 \text{ M}$$

Tank 3

$$A_3 \frac{dh_3}{dt} = F_4 - F_5$$

$$= \alpha_3 (h_2 - h_3) - F_5 \quad \text{—— } \frac{11}{2} \text{ M}$$

②

$$F_i = F_0 + A \frac{dh}{dt}$$

$$F_i - F_0 = A \frac{dh}{dt}$$

$$F_i - h_0/R = A \frac{dh}{dt}$$

$$f_i = A \frac{dh}{dt} + \frac{h_0}{R} \quad \text{--- (1)}$$

At steady state

$$f_{is} = A \frac{dh_s}{dt} + \frac{h_0}{R} \quad \text{--- (2)}$$

$$(1) - (2)$$

$$A \frac{d}{dt} (h - h_s) + \frac{h - h_s}{R} = f_i - f_{is}$$

$$A R \frac{d}{dt} (h - h_s) + h - h_s = (f_i - f_{is}) R$$

$$A R \frac{d}{dt} (h') + h' = f_i' R$$

$$A R s h'(s) + h'(s) = f_i' R(s)$$

$$TF = \frac{h'}{f_i'} = \frac{R}{A R (s+1)}$$

$$= \frac{k_p}{e_p (s+1)}$$

If it is a first order system. — 1M

$$3. T'(s) = \frac{\gamma_e}{s+a} T_i'(s) + \frac{k}{s+a} T_{st}'(s)$$

$$(s+a) T'(s) = \frac{1}{\epsilon} T_i'(s) + k T_{st}'(s)$$

$$\frac{dT'}{dt} + a T' = \frac{1}{\epsilon} T_i'(s) + k T_{st}'(s)$$

— 3M

$$4. \quad \rho_r = \rho A h \quad \text{--- } ①$$

$$E = U + k + P$$

$$\frac{dE}{dt} = \frac{dP}{dt} = 0$$

$$\frac{dE}{dt} = \frac{du}{dt}$$

$$\frac{du}{dt} \approx \frac{dT}{dt}$$

$$H = \rho r c_p (T - T_{ref})$$

$$H = \rho A h c_p (T - T_{ref}).$$

8 total eqn's

$$1. \quad \frac{d}{dt} (\rho A h) = \rho F_i - \rho F \quad \text{--- } ① \quad 2M$$

$$\frac{d}{dt} (Ah) = f_i - F \quad ① \quad 2M$$

$$2. \quad \frac{d (\rho A h c_p (T - T_{ref}))}{dt} = \rho F_i c_p (T_i - T_{ref}) - \rho F c_p (T - T_{ref}) + \alpha.$$

$$T_{ref} = 0 \quad + \quad \frac{dF}{dt} \\ A h \frac{dT}{dt} = F_i (T_i - T) + \frac{\alpha}{\rho c_p} - ② \quad 2M$$

$$DOF = 2$$

$$\text{No. of eqn} = 2$$

$$\text{No. of memb} = 6 \quad (h, T, F_i, F, T_i, \alpha) \quad \text{--- } 1M$$

Name:

ID No:

BITS, PILANI - DUBAI
Dubai International Academic City, Dubai, UAE
Semester II 2012-2013
QUIZ I / (Closed Book)
BE (Hons) IV year EIE / III YEAR CHEM

Course No : INSTR C451 / CHE C441
Course Title : PROCESS CONTROL
Date : 12.03.2013

Time: 20 Minutes M.M = 10 (10%)

NOTE: 1. All the symbols and words carry their usual meanings, unless otherwise stated.
2. Answer all the questions.

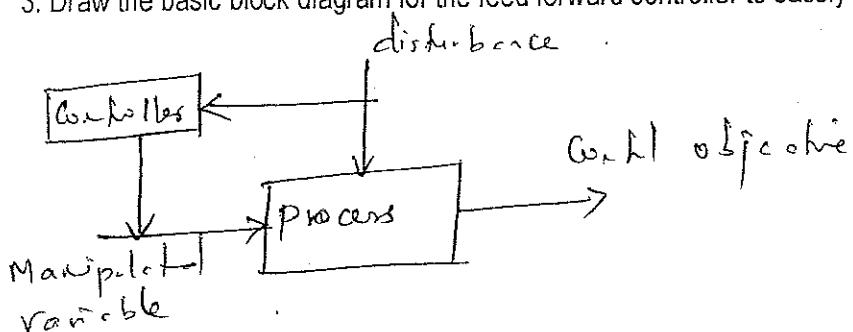
1. Mention the basic needs that the control system has to classify.

1. Suppressing the influence of external disturbance
2. Ensuring the stability
3. Optimizing the performance of a chemical process

2. Mention the design elements of a process control system

defining the control objective, select measurement
select manipulated variable, select anti configuration
control aspects etc..

3. Draw the basic block diagram for the feed forward controller to satisfy the control objective.



4. Mention the equilibrium equation for distillation column.

$$y_i = \frac{\alpha x_i}{(1 + (\alpha - 1)x_i)} \quad \alpha = \text{Relative volatility}$$

5. Write the mass balance equation for the bottom section of distillation column.

Ans $\frac{dM}{dt} = V - V_1 - L_1 + L_2$

6. 12 psig process signal is equal to 16 mA in electronic signal.

Consider the air heating system used to regulate the temperature in a house (Fig 1). The heat is supplied from the combustion of fuel oil. Refer the figure 1 to answer question no 7 to 10.

7. Identify the control objective & the available measurements.

↓
To keep the temp in the house at the
desired level
Available meas. house temp, fuel oil flow rate

8. Is this a SISO system? Also identify the external disturbances.

If it is SISO, there is only one control objective.

Ext. dist.: Ext. temp, amount of heat losses,
fuel oil flow rate, desired house temp.

9. Develop a feed back control configuration to achieve your control objective.

Loop b/w house temp & fuel oil flow rate

10. Is feed forward control configuration possible for achieving your control objective?

Yes. Measure ext. temp and manip. b/w
fuel oil flow rate. Assume negligible heat
loss.

ALL THE BEST