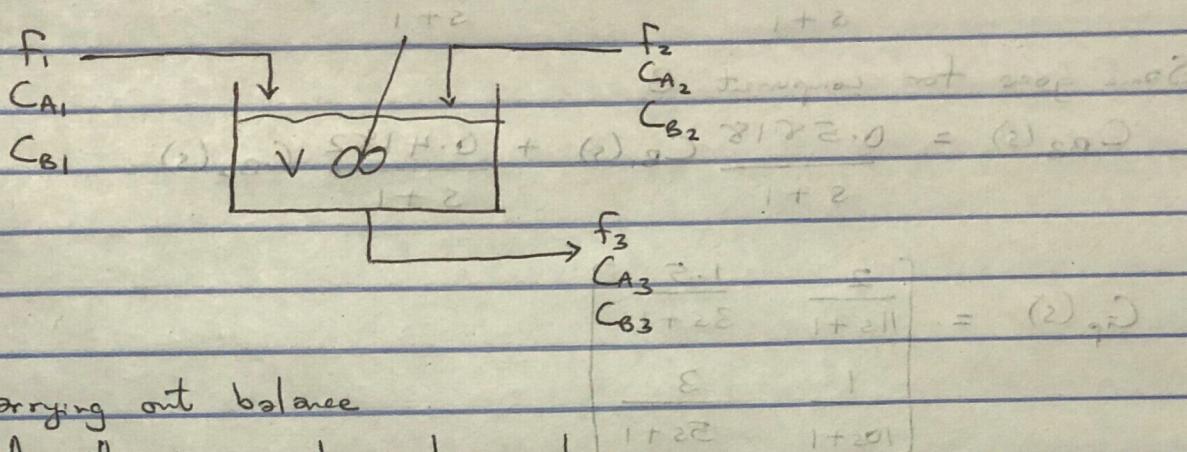


$$(z)_{in} \cdot 5814.0 + (z)_{out} \cdot 8182.0 = (1+z) \cdot (z)_{in}$$

$$\text{QUESTION } 1 (z)_{in} \cdot 5814.0 + (z)_{out} \cdot 8182.0 = (1+z) \cdot (z)_{in}$$



Carrying out balance

As there's no chemical reaction

$$\frac{dn}{dt} = n_{in} - n_{out}$$

$$\frac{d(C_{A3}V)}{dt} = f_1 C_{A1} + f_2 C_{B2} - (f_1 + f_2) C_{A3}$$

$$V \frac{dC_{A3}}{dt} = f_1 C_{A1} + f_2 C_{B2} - (f_1 + f_2) C_{A3}$$

$$V \frac{dC_{A3}}{dt} + (f_1 + f_2) C_{A3} = f_1 C_{A1} + f_2 C_{B2}$$

$$\frac{V}{f_1 + f_2} \frac{dC_{A3}}{dt} + C_{A3} = \frac{f_1}{f_1 + f_2} C_{A1} + \frac{f_2}{f_1 + f_2} C_{B2}$$

Do the same for component 'B'

$$\frac{V}{f_1 + f_2} \frac{dC_{B3}}{dt} + C_{B3} = \frac{f_1}{f_1 + f_2} C_{B1} + \frac{f_2}{f_1 + f_2} C_{A2}$$

N.B: No component is present in mixed stream initially

$$C_{A1} = 0.5 \frac{\text{mol}}{\text{m}^3}, C_{A2} = 0.35 \frac{\text{mol}}{\text{m}^3}, C_{B1} = 0.5 \frac{\text{mol}}{\text{m}^3}, C_{B2} = 0.65 \frac{\text{mol}}{\text{m}^3}$$

$$F_1 = 3.2 \frac{\text{m}^3}{\text{min}}, F_2 = 2.3 \frac{\text{m}^3}{\text{min}}, V = 5.5 \text{m}^3$$

$$\frac{5.5}{3.2 + 2.3} \frac{dC_{A3}}{dt} + C_{A3} = \frac{3.2}{3.2 + 2.3} C_{A1} + \frac{2.3}{3.2 + 2.3} C_{A2}$$

$$\frac{dC_{A3}}{dt} + C_{A3} = 0.5818 C_{A1} + 0.4182 C_{A2}$$

$$C_{A_3}(s) (s+1) = 0.5818 C_{A_1}(s) + 0.4182 C_{A_2}(s)$$

$$C_{A_3}(s) = \frac{0.5818}{s+1} C_{A_1}(s) + \frac{0.4182}{s+1} C_{A_2}(s)$$

Same goes for component B

$$C_{B_3}(s) = \frac{0.5818}{s+1} C_{B_1}(s) + \frac{0.4182}{s+1} C_{B_2}(s)$$

$$(b) G_p(s) = \begin{bmatrix} \frac{2}{11s+1} & \frac{1.5}{3s+1} \\ \frac{1}{10s+1} & \frac{3}{5s+1} \end{bmatrix}$$

(a) $\frac{1}{s+1}$ $\frac{1}{s+1}$ $\frac{1}{s+1}$

MATLAB code

Command window

clear

close

dc

num1 = 2;

deno1 = [11 1].

num2 = 1.5;

deno2 = [3 1];

$G_p1 = tf(num1, deno1);$

$G_p2 = tf(num2, deno2);$

$G_p3 = tf(num3, deno3);$

$G_p4 = tf(num4, deno4);$

$G_p = [G_p1 \quad G_p2; \quad G_p3 \quad G_p4]$

$step(G_p)$

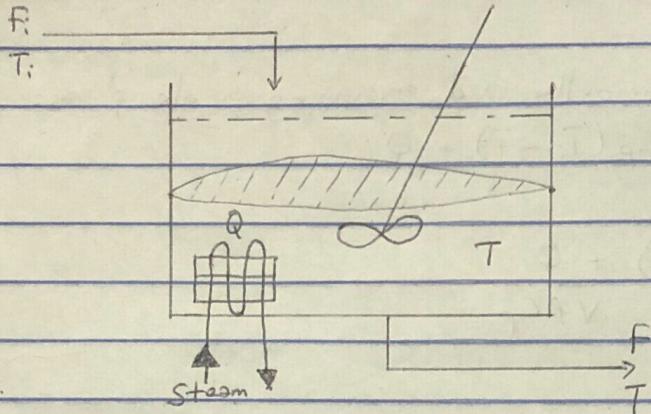
$GP = c2d(G_p, 1.5)$

$figure(2)$

$step(GP)$

$$GP = \begin{bmatrix} \frac{0.2549}{z-0.8725} & \frac{0.5902}{z-0.6065} \\ \frac{0.1393}{z-0.8607} & \frac{0.7775}{z-0.7408} \end{bmatrix}$$

QUESTION 2



(a.) Material Balance

At constant density ρ

$$\frac{dV\rho}{dt} = F_i\rho - F\rho$$

Constant tank hold up $\therefore \frac{dV}{dt} = 0$

$$F = F_i$$

Energy Balance

ACC. = IN - OUT + HEAT IN + WORK DONE

$$\frac{dT}{dt} = F\rho T_i - F\rho T + Q + W$$

Total work done on system = Shaft work + Energy added to system
+ Energy performed on surroundings

Written as

$$\frac{dU}{dt} = F\rho \left(\bar{u}_i + \frac{P_i}{\rho} \right) - F\rho \left(\bar{u} + \frac{P}{\rho} \right) + Q + W_s$$

$$H = U + PV$$

$$\frac{dH}{dt} - \frac{dPV}{dt} = F\rho \bar{H}_i - F\rho \bar{H} + Q + W_s$$

$$\frac{dPV}{dt} = V \frac{dP}{dt} + P \frac{dV}{dt}$$

But remember we have constant hold up (volume)

Also, since density is constant, mean pressure change is negligible

$$\frac{dT}{dt} = \dot{F}P\bar{H}_i - \dot{F}P\bar{H} + Q + W_s$$

Neglecting work done by impeller and assuming single phase:

$$\sqrt{\rho}C_p \frac{dT}{dt} = \dot{F}P C_p (\bar{T}_i - \bar{T}) + Q$$

$$\frac{dT}{dt} = \frac{F}{V} (\bar{T}_i - \bar{T}) + \frac{Q}{\sqrt{\rho} C_p}$$

$$Q = \dot{m}_s \lambda_s$$

$$\frac{dT}{dt} = \frac{F}{V} (\bar{T}_i - \bar{T}) + \frac{\dot{m}_s \lambda_s}{\sqrt{\rho} C_p}$$

$$\frac{V}{F} \frac{dT}{dt} + \bar{T} = \bar{T}_i + \frac{\lambda_s}{FC_p P} \dot{m}_s$$

$$\text{Data: } \rho = 1000 \frac{\text{kg}}{\text{m}^3}; C_p = 4.181 \frac{\text{kJ}}{\text{kg}^\circ\text{C}}; f_i = 0.15 \frac{\text{m}^3}{\text{mm}^2}; V = 3 \text{m}^3; \lambda_s = 2258 \frac{\text{kJ}}{\text{kg}}$$

$$\frac{3}{0.15} \frac{dT}{dt} + \bar{T} = \bar{T}_i + \frac{2258}{0.15 \times 4.181 \times 1000} \dot{m}_s$$

$$20 \frac{dT'}{dt} + \bar{T}' = \bar{T}'_i + 3.6004 \dot{m}'_s$$

$$20(s\bar{T}'(s) + \bar{T}'(0)) + \bar{T}'(s) = \bar{T}'_i(s) + 3.6004 \dot{m}'_s(s)$$

$$20s\bar{T}'(s) + \bar{T}'(s) = \bar{T}'_i(s) + 3.6004 \dot{m}'_s(s)$$

$$\bar{T}'(s)(20s + 1) = \bar{T}'_i(s) + 3.6004 \dot{m}'_s(s)$$

$$\bar{T}'(s) = \bar{T}'_i(s) \left(\frac{1}{20s+1} \right) + \left(\frac{3.6004}{20s+1} \right) \dot{m}'_s(s)$$