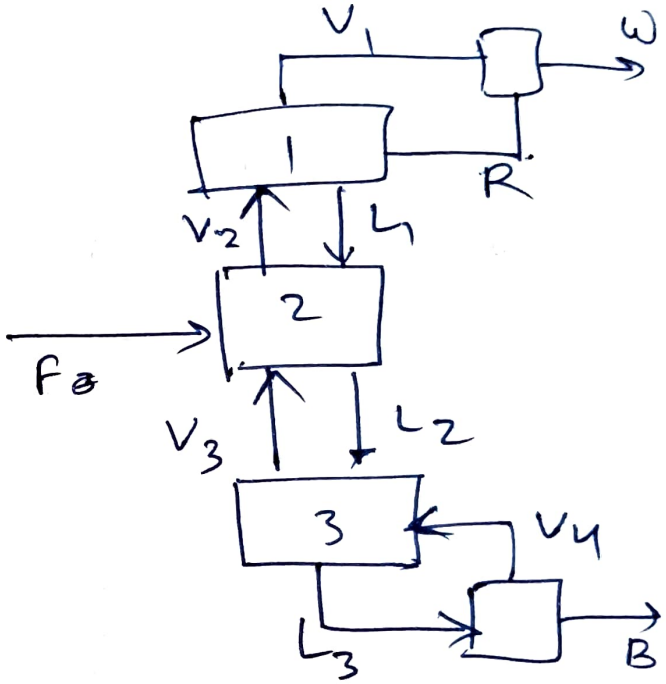
Part(a) Bubble point method multicomponent multistage distillation

$F = 1000$ Kmol/h

0.6 methanol (normal boiling pt 65°C)

0.2 Ethanol (" " " 98°C)

0.2 propanol (" " " 97°C)



W ⇒ 600 Kmol/h.

B ⇒ 400 Kmol/h.

At bottom stage:

$400 + A + A_2$

at distillate tray

$V_1 + D + R$

$R = 2000$ Kmol/h

$D = 600$ Kmol/h.

So, $V_1 = 2600$ Kmol/h

now at tray 1 :-

$V_1 + L_1 = V_2 + R$

$\boxed{L_1 = 2000}$

at tray - 2 :-

$F + L_1 + V_3 = L_2 + V_2$

$\boxed{L_2 = 3000}$

at tray 3 :-

$L_3 - 400 \Rightarrow V_4$

$L_3 \Rightarrow$

column pressure = 1 atm

Temperature of distillation column = 100°C

Stage j	T_j	V_j
1	65	2600
2	81.5	2600
3	98	2600

$$K_i = P_i^S / P$$

$$P^S \Rightarrow \exp\left[C_1 + \frac{C_2}{T} + C_3 \ln T + C_4 T^{C_5}\right]$$

K_{ij}	1	2	3
methanol	1.034	3.317	3.212
Ethanol	0.585	2.095	2.024
Propanol	0.307	1.226	1.181

$$A_j = L_{j-1} = V_j + \sum_{m=1}^{j-1} (F_m - U_m - W_m)$$

$A_1 = 0$

$A_2 = L_1 = 2000$

$A_3 = L_2 = 3000$

$$B_{i,j} = -[(V_j + U_j^0) K_{ij} + L_j + V_j]$$

$$B_1 = -[2600 \times 1.034 + 2000 + (-600)]$$

$$= -4088.481$$

$$B_2 = -[V_2 K_{12} + L_2 - V_1] = -10751.237$$

$$B_3 = -10752.234$$

$C_{ij} \Rightarrow V_{j+1} K_{i,j+1}$

$C_1 = 8624.26$

$C_2 = 8351.28$

$C_3 =$ does not exist

Applying Thomas method :-

$$\begin{bmatrix} -4088.4 & 8624.2 & 0 \\ 2000 & -11024.2 & 8351.28 \\ 0 & 3000 & -10751.2 \end{bmatrix} \begin{bmatrix} X_{11} \\ X_{12} \\ X_{13} \end{bmatrix} = \begin{bmatrix} 0 \\ -7.1F.F \\ 0 \end{bmatrix}$$

$X_{13} = 0.03721$

$X_{12} = 0.13333$

$X_{11} = 0.28125$

for ethanol :-

$A_2 = 2000, \quad A_3 = 3000$

$B_1 = -2921.91, B_2 = -7847.1, B_3 = -7662.42$

$C_1 = 5447.2, \quad C_2 = 5262.42$

Similarly by thomas Algorithm :-

$x_{23} = 0.1212$

$x_{22} = 0.2671$

$x_{21} = 0.4987$

for propanol :-

$A_2 = 2000, \quad A_3 = 3000$

$B_1 = -2198.21, B_2 = -5587.621, B_3 = -5470.62$

$C_1 = +3187.6, \quad C_2 = 3070.6$

Similarly, by thomas Algorithm →

$x_{33} = 0.1084$

$x_{32} = 0.1987$

$x_{31} = 0.2881$

Stages	1	2	3
methanol	0.2812	0.1332	0.0371
Ethanol	0.1831	0.0971	0.0387
Propanol	0.202	0.4991	0.1083
$\Sigma x_{i,4}$	0.75	0.43	0.18

normalise $\bar{x}_{iy} = \frac{x_{i,y}}{\sum_{1}^{3} x_{i,y}}$

Stage	1	2	3
methanol	0.3741	0.3092	0.203
ethanol	0.2942	0.2261	0.212
Propanol	0.3842	0.4628	0.608

for first iteration.

Antoine Coeff :-

	A	B	C
methanol	5.20	+1581.34	-33.5
ethanol	5.32	+1670.40	-40.19
Propanol	5.31	+1690.8	-51.80

$\sum K_{ij} x_{i,j} \Rightarrow P_T$ — for T_j

and M.E. for V_j.

Solving.