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Initial Composition of feed:

weight of methanol = 1.5 kg
weight of ethanol = 0.75 kg
weight of butanol = 0.75 kg

moles of methanol = $\frac{1.5}{32.04}$ = 46.816 mol

moles of ethanol = $\frac{0.75}{46.07}$ = 16.273 mol

moles of Butanol = $\frac{0.75}{74.121}$ = 10.118 moles

Total moles = 73.213 mole

mole fraction of methanol = 0.639
mole fraction of ethanol = 0.222
mole fraction of Butanol = 0.139

mole fractions:→

1) Total Reflux
1.1) methanol →
Distillate

Area ratio = Area of methanol / Area of cyclohexane
(AR) = 10.54/75.95

= 0.14

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Calibration curve ⇒ $y = 1.293x + 0.1829$

Weight ratio $= 1.293 \times 0.14 + 0.1829$
$= 0.36$

weight of methanol = Weight ratio × weight of cyclohe

$= 0.36 \times 5.008$
$= 1.81$

1.2) Ethanol

	Area ratio ethanol	weight ratio ethanol	weight of ethanol	mole fraction ethanol
Distillate	0.176	0.316	~~0.372~~ 1.58	0.6372
Bottom	0.183	0.327	~~0.318~~ 1.63	0.0316

1.3) Butanol

	Area ratio Butanol	weight ratio Butanol	weight of Butanol	mole fraction Butanol
Distillate	0.00197	0.018	0.09	0.013
Bottom	0.266	0.285	1.42	0.17

Sample Calcution for Distillate →

$$\text{mole fraction of methanol} = \frac{\frac{1.81}{32.04}}{\frac{1.81}{32.04} + \frac{1.58}{46.07} + \frac{0.09}{79.121}} = 0.64$$

~~2) Ref~~	Total Reflux	R = 1.9	R = 1
P_{sat}-methanol-top	0.9509 atm	1.0089 atm	1.0452 atm
P_{sat}-methanol-bottom	1.5766 atm	1.7443 atm	1.9332 atm
P_{sat}-ethanol-top	0.5342 atm	0.5703 atm	0.5930 atm
P_{sat}-ethanol-bottom	0.9336 atm	1.0437 atm	1.1689 atm
P_{sat}-butanol-top	0.0948 atm	0.1025 atm	0.1074 atm
P_{sat}-butanol-bottom	0.1841 atm	0.2100 atm	0.2401 atm

Relative Volatility :-

$\alpha_{methanol-ethanol-top}$	1.7802	1.7691	1.7625
$\alpha_{methanol-ethanol-bottom}$	1.6887	1.6712	1.6538
$\alpha_{methanol-butanol-top}$	10.0329	9.8447	9.7348
$\alpha_{methanol-butanol-bottom}$	8.5644	8.3053	8.0322
$\alpha_{ethanol-butanol-top}$	5.6359	5.5649	5.5233
$\alpha_{ethanol-butanol-bottom}$	5.0717	4.9695	4.8689

Minimum Number of Trays :

Fenske Eqn :

$$N = \frac{\log\left[\left(\frac{x_d}{1-x_d}\right)\left(\frac{1-x_b}{x_b}\right)\right]}{\log(\alpha_{avg})}$$

x_d = mole fraction of light key in distillate
x_b = mole fraction of heavy key component at bottom

α_{avg} = mean of relative volatilities at top and bottom of the column

$\therefore \alpha_{avg} = \sqrt{\alpha_t \alpha_b} = \sqrt{10.0329 \times 8.5644}$

$= 9.27$

$\alpha_t = \alpha_{MB-top} = 10.0329$
$\alpha_b = \alpha_{MB-bottom} = 8.5644$

$$N = \frac{\log\left[\frac{0.61}{1-0.61} \times \frac{1-\cancel{0.81}\ 0.17}{\cancel{0.81}\ 0.17}\right]}{\log(9.27)} = 0.912$$

$\therefore$ We need Minimum of $\underline{\underline{1}}$ tray.

Minimum Reflux ratio :

by Underwood eqn :

$$\sum \left(\frac{\alpha_i z_{i,f}}{\alpha_{i} - \theta} \right) = 1 - q$$

$$\sum \left(\frac{\alpha_i z_{i,f}}{\alpha_i - \theta} \right) = 1 + R_{min}$$

Saturated liq. ⇒ q = 1

∴ substituting values,

$$\frac{9.8447 \times 0.639}{9.8447 - \theta} + \frac{5.649 \times 0.222}{5.649 - \theta} + \frac{1 \times 0.139}{1 - \theta} = 0$$

This gives θ = 1.14 or 6.365

θ = 1.14 gives Rmin as negative

θ = ~~6.36~~ given

$$1 + R_{min} = \frac{9.8447 \times 0.71}{9.8447 - 1.14} + \frac{5.649 \times 0.29}{5.649 - 1.14} + \frac{0.005 \times 1}{1 - 1.14}$$

$R_{min} = 0.12$

θ = 6.36 gives

$R_{min} = -ve$

∴ $R_{min} = 0.12$