At the point of intersection $y_{n+1} = y_{m+1}$

$x_n = x_m$

$$y G = L x + D x_D \quad \text{—— (3)}$$

$$y \bar{G} = \bar{L} x - W x_W \quad \text{—— (4)}$$

(4) − (3)

$$(\bar{G} - G) y = (\bar{L} - L) x - (W x_W + D x_D)$$

Overall balance

$$F z_F = D x_D + W x_W$$

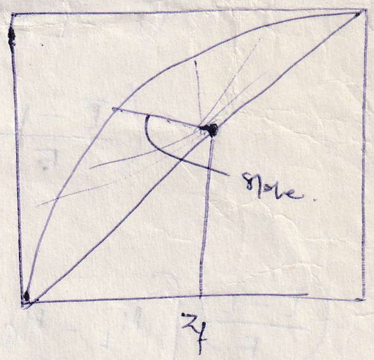
$$(\bar{G} - G) y = (\bar{L} - L) x - F z_f$$

$F(q-1) \quad y = F q \, x - F z_f$

$$y = \left(\frac{q}{q-1}\right) x - \frac{z_f}{q-1}$$ → operating line

↓ slope ↓ intersection.

when $x = z_F \Rightarrow y = z_f$.

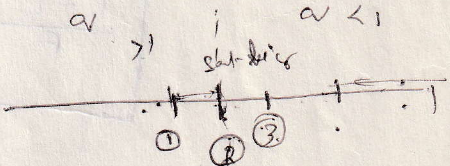


Case 1 liquid below bubble pt.

H_F — B.P. — H_L S.L — H_G S.V.

$q > 1$

$$q = \frac{(H_G - H_F)}{H_G - H_L} > 1 \Rightarrow \frac{q}{q-1} > 1$$



Case (2) (sat. liq)

$q = 1$ slope = ∞

Case (3) (liq + vap) $0 < q < 1$ slope < 0

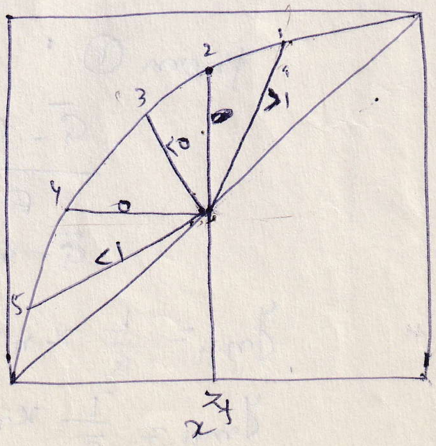
Case (4) Sat vap

$q = 0$ slope = 0

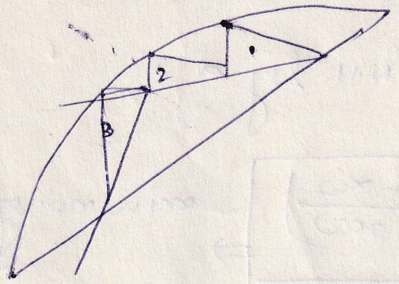
Case (5) superheated vap

$q < 0 \quad 1 > \frac{q}{q-1} > 0$ $(q < 1)$

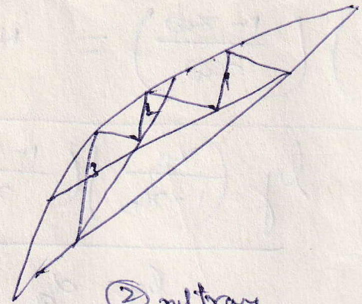
$-1/2 \quad \frac{-1/2}{-3/2} = 1/3$



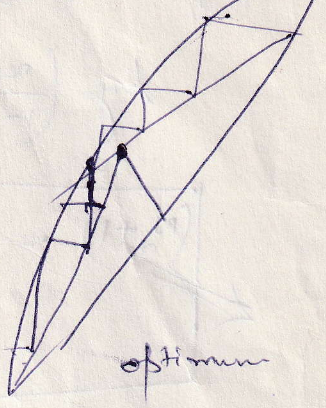
Location of the feed tray > ⇒ from which tray operating line change.
ex - 3



Feed tray (3)



(2) nd tray



optimum

Total Reflux or Infinite Reflux Ratio > (ex- rebols composition with Practical system) y = x at (each separation)

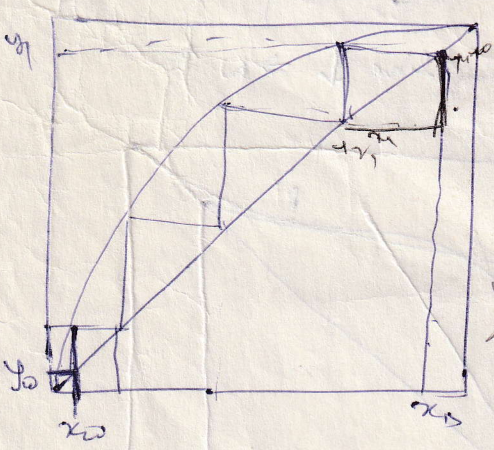
$R = \frac{L}{D}$; $G = L + D$

Total Reflux $L = G$. $D = 0$

G $\frac{L}{G} = 1$

operating line $y = \frac{L}{G}x + \frac{D x_D}{G}$

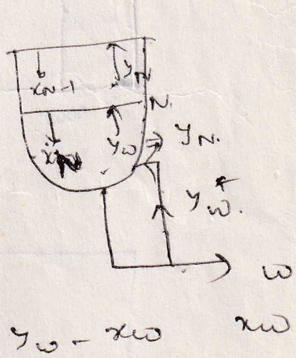
$y = x + \frac{D x_d}{G}$; $D = 0$, $y = x$



Such operating condition can be interpreted as requiring infinite reboiler heat and condenser cooling capacity.

⇒ operating line concide with diagonal (45°)
&
⇒ min no. of trays are required.

for. Constt Relative volatility



for. residue pdt.

$$\frac{y_w}{1-y_w} = \alpha_w \frac{x_w}{1-x_w} \quad \text{—} (1)$$

operating line

$y_w = x_{N_P}$

$y_w - x_w$
$y_w - x_N$
$\downarrow$
y_N
$\downarrow$
x_w

$$\frac{x_N}{1-x_N} = \alpha_w \frac{x_w}{1-x_w} \quad \text{—} (2)$$

for last tray

$$\frac{y_N}{1-y_N} = \alpha_N \frac{x_N}{1-x_N} \quad \text{—} (3)$$

Substitute (2) in (3) ⇒

$$\frac{y_N}{1-y_N} = \alpha_N \alpha_w \frac{x_w}{1-x_w}$$

$$\frac{y_1}{1-y_1} = \alpha_1 \cdots \alpha_N \alpha_W \frac{x_W}{1-x_W}$$

for total Condenser

$$\frac{y_{1,e}}{1-y_1} = \frac{x_D}{1-x_D} = \alpha_{av}^{N+1} \frac{x_W}{1-x_W}$$

$$\log\left(\frac{x_D}{1-x_D}\right)\left(\frac{1-x_W}{x_W}\right) = N+1 \log \alpha$$

including Reboiler

$$(N_m+1) = \frac{\log\left(\frac{x_D}{1-x_D}\right)\left(\frac{1-x_W}{x_W}\right)}{\log \alpha_{av}}$$

⇒ min no. of trays.

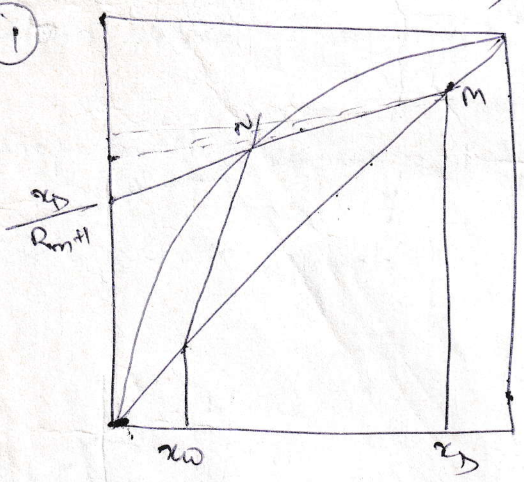
Fenske's eqn.

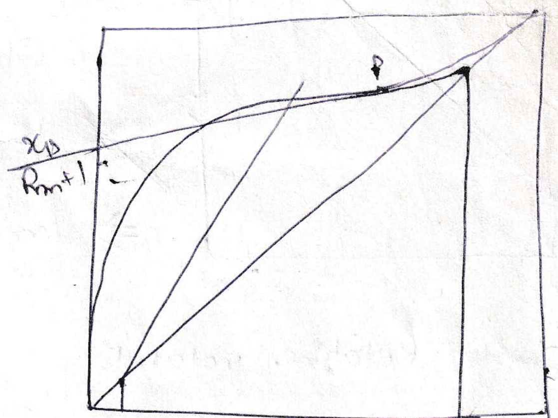
Co-relate this with composition (y = x) = ?

Minimum Reflux Ratio ⇒ R_m is the max ratio which will require an infinite no. of trays for the separation desired.

min reboiler heat and condenser cooling capacity for the separation.

as R_m ↓ ⇒ slope of operating line ↓ ⇒ N ↑

① 

② 

tangent to eqm curve.