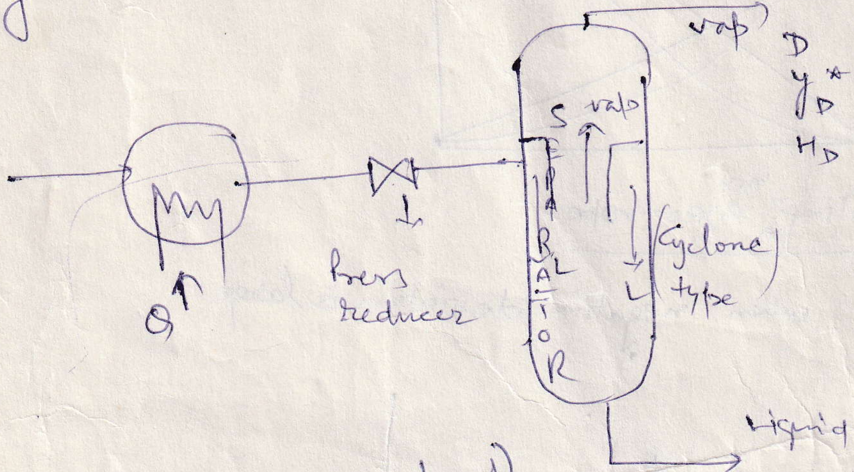
Single-stage operation – Flash vaporization

(equi^m distillation)

liq mix $\xrightarrow[\text{vap}]{\text{partially}}$ vap + liq. $\xrightarrow{\text{allowed}}$ ~~vap liq.~~ equi^m < separate: vap / liq.

It may be batch wise or continuous.

feed
mole/time F
Z_f
energy/mole = H_F



D
y_D^*
H_D

liquid
W
x_W
H_W

material balance (mole/time)

$$F = D + W \quad \text{—— (1)}$$

$\rightarrow$ $m_1 = m_1 + p_1 \, m_1$ (1)
$m_2 = m_2 + p_2 \, m_2$ (2)

(mole/time) Component balance.

$$F z_f = D y_D^* + W x_W \quad \text{—— (2)}$$

(energy/time) Enthalpy balance

$$F H_F + Q = D H_D + W H_W \quad \text{—— (3)}$$

$(x_1 + x_2) M_{av} = \dfrac{m_1 M_1 + m_2 M_2}{(m_1 + m_2)}$

$M_{avg} = \dfrac{p_1 m_1 + p_2 + m_2}{p_1 + p_2}$

$M_{av} = x_1 M_1 + x_2 M_2$

(2) By substituting (1)

$$(D + W) z_f = D y_D^* + W x_W$$

$$D [z_f - y_D^*] = W (x_W - z_f)$$

$$\frac{+W}{D} = \frac{z_f - y_D^*}{(x_W - z_f)} =$$

$$\boxed{-\frac{W}{D} = \frac{y_D^* - z_f}{x_W - z_f}}$$

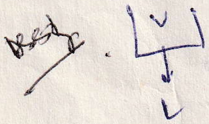
Same as $\dfrac{H_D - (H_F + Q/F)}{H_W - (H_F + Q/F)}$

(z_f, z_f) (y_D^*, x_W)

the composited distillate composition $y_{D\,avg}$ can be determined by simple material balance.

$$F x_F = D y_{D\,avg} + W x_W$$

<u>Differential Condensation</u> > vap feed is slowly condensed under equ^m conditions and condensate withdrawn as rapidly as it forms. Similarly, As above we can drive.



$$\ln \frac{F}{D} = \int_{y_F}^{y_D} \frac{dy}{(y - x^*)}$$

$-dD(y^* - x) = L\,dx$ ⟹

<u>Constant Relative Volatility</u> >

$$\ln \frac{F}{W} = \int_{x_W}^{x_F} \frac{dx}{y^* - x}$$ → Rayleigh eq^n ; $y = \frac{\alpha x}{1 + (\alpha - 1) x}$

and solve to get

$$\ln \frac{F}{W} = \frac{1}{\alpha - 1} \ln \frac{x_F (1 - x_W)}{x_W (1 - x_F)} + \ln \left[\frac{(1 - x_W)}{(1 - x_F)} \right]$$

$$\log \frac{F x_F}{W x_W} = \alpha \log \frac{F(1 - x_F)}{W(1 - x_W)}$$

ratio no. of moles A remaining in the residual $W x_W$ to B remaining $W(1 - x_W)$.

<u>Ex</u>. n- Heptane (A) 50 mole % } at P = 1atm
n - Octane (B) 50 mol % } → differential distillation / vap = 60 mol %.

$y_{D\,avg}$ * Composition of composite distillate and residue x_W = ?

<u>Basis</u> F = 100 mol   D = 60 mole
x_F = .50   W = 40 mole

for Composite distillate

$$F x_F = D y_{D\,avg} + W x_W$$

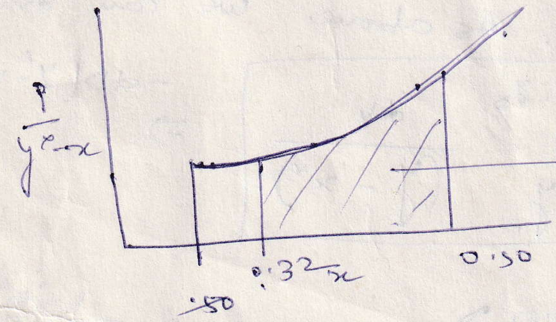
=

By eqn

$$\ln \frac{F}{W} = \int_{x_W}^{x_F} \frac{dx}{y^* - x} = \ln \frac{100}{40} = 0.916$$

eqm data is available.

x	0.50	0.46	0.42	0.38	0.34	0.32
y^*	0.689	0.648	—	—	—	—
$\frac{1}{(y^* - x)}$	5.29	5.32	5.35	5.50	5.685	



From this

$\Rightarrow x_W = 0.33,$

Now put in eqn

$$100 \times 0.50 = 60 \times y_{Davg} + 40(0.33)$$

$y_{Davg} = 0.614$ mole fraction of heptane

we can go by trial and error. Method also.

$$\log \frac{F}{W}\frac{x_F}{x_W} = \alpha \log \frac{F(1-x_F)}{W(1-x_W)}$$

$\alpha = 2.16$

$$\log \frac{100 \times 0.5}{40 \times x_W} = 2.16 \log \frac{100}{40}\frac{(1-0.5)}{(1-x_W)}$$

assume $x_W \Rightarrow$ L.H.S = R.H.S

$x_W = 0.333$. Ans