1. **Bottom operating line**

the materials balance the blow number of plats (m) , Lm+1 = Lm

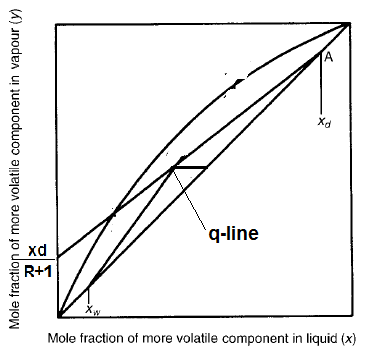
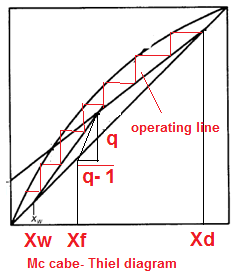
Lm = Vm +W , then Vm = Lm –W

ym Vm = Lm Xm+1 - W Xw ym = ( Lm / Vm) Xm+1 -( W / Vm ) Xw

**q- line equation yq = (q / q-1) Xq – Xf / q-1**

1. **First point (Xf,Xf) , 2- second point ( Xf / q) , 0))**

**For finding the q-line , drawing the line contact between the top operating line and bottom operating line**

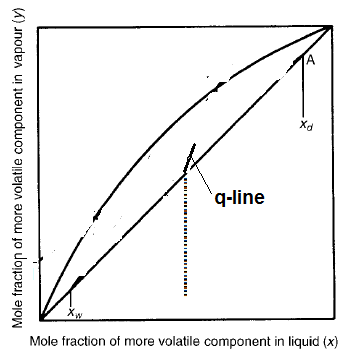
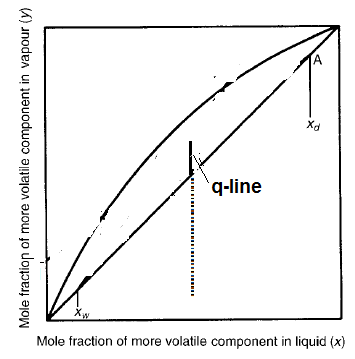
** **

**How to limited q**

1. If feed is sub cooled feed temperature (TF) less than boiling point (TB)

Q =( Cp(TB-TF ) + λ ) / λ q ˃ 1

1. The feed is liquid at it is boiling point ( X / Tf= TB ) q= λ / λ = 1

1 2

Lm = Ln + qF , Vm = Vn + F(q-1) or Vm= Lm –W

No. of stage -1 = No. of plates

1. q- line , q = heat required to vaporize 1 mole of feed / latent heat of feed , when the feed is partially vaporized , two phase ( vapour + liquid ) , for example the feed 20% liquid ad 80% vapour , and Xf=0.4 , then q=0.2 λ / λ =0.2

1st point ( 0.4,0.4), 2nd point (Xf / q , 0) = 0.4 / 0.2, 0 ) =( 2 ,0)

1. saturated vapour Tf= TB , q= 0 / λ =0
2. The feed is super-heated Tf ˃ TB , q= cp( TB-Tf ) / λ , q < 1

**Calculation the minimum Reflux Ratio (Rm)**

1. From equations [ , αAB = αA / α B= PA˚ / PB˚

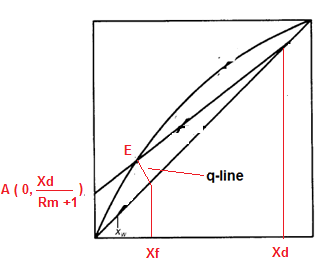
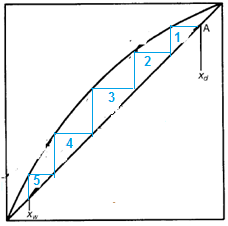
1. – from drawing

1-Drawing line from Xf (q-line) and interception the curve at point E ,

2- Drawing the line from Xd to interception the curve and y- axes at point A

A( 0, Xd / Rm+1) , example A= 0.6 then 0.6 = Xd / Rm+1 , 0.6 = 0.97 / Rm+1

Rm = 0.62

**Calculation of Minimum No. of plates (N min )**

1. By equations

The feed at its boiling point q=1 ( saturated liquid )

1. By drawing

**Example 1/** Abinary mixture of n-heptaine at its boiling point containg 70% mole percent of heptane is to be continuously distillated to give a top product of 98 % mole and bottom product of 1 mole% heptane. The reflux ratio is 3 and the vapour pressure of n- heptane is twice the vapour pressure of octane at the same temp.

1. Obtain the number of theoretical plate required .
2. Calculate the min-number of theoretical plate (Nm)
3. Calculate the min- reflux ratio (Rm)

**Solution**

αAB = αA / α B= PA˚ / PB˚ = 2 PB˚ / PB˚  =2 , A = n-heptane

yA = αAB XA / ( 1+ XA (αAB -1)) = 2 XA / 1+(2-1) XA = 2 XA / 1+ XA

XA  0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

yA 0 0.18 0.33 0.46 0.57 0.66 0.75 0.82 0.88 0.95 1

Overall material balance

F = D+W 100= D+W (1)

Material balance on the top

F Xf = DXd + WXw , 0.7 (100)= 0.98 D+ 0.1 W 70 = 0.98 D+0.1W (2)

W= 31.82 and D= 68.18

Top operating line

,R= , Ln = 3 \*68.1=204.3 kmole , Vn=Ln+D = 204.3+68.1=272.4 kmole then

yn= 0.75 Xn+1 + 0.245 operating line , can drawing this line between two points

(0,(D/ Vn)Xd)) ( Xd,Xd)  (0,0.245) and (0.98,0.98)

Bottom operating line : , Lm= Ln + qF , q=1 since the feed is at its boiling point

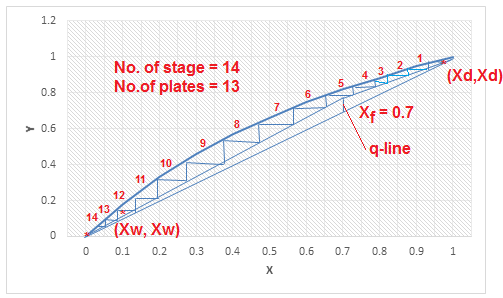
Lm= Ln+F  Lm = 100+204.3= 304.3 Kmole

Vm = Lm-W = 304.3 -3189= 272.41 kmole

 Bottom operating line

First point ( Xw, Xw)= (0.1,0.1) , if X= 0.5 then ym = 1.117(0.5) – 0.0117 = 0.54

Second point (0.5, 0.54)



From the diagram , No.of stage =14 , No,of plate =13

1. = ≈ 9

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