**Example 3** / A continuous fractionating column is required to separate a mixture containing 0.695 mole fraction *n*-heptane *(*C7H16*)* and 0.305 mole fraction *n*-octane *(*C8H18*)* into products of 99 mole per cent purity. The column is to operate at 101.3 kN/m2 with a vapour velocity of 0.6 m/s. The feed is all liquid at its boiling-point, and this is supplied to the column at 1.25 kg/s. The boiling-point at the top of the column may be taken as 372 K, and the equilibrium data are:



Determine the minimum reflux ratio required. What diameter column would be required if the reflux used were twice the minimum possible?

**Solution**

The equilibrium curve is plotted in Figure blow. As the feed is at its boiling-point, the *q*-line is vertical and the minimum reflux ratio may be found by joining the point *(xd, xd )* with the intersection of the *q*-line and the equilibrium curve. This line when produced to the *y*-axis gives an intercept of 0.475.









Example 4 / A feed mixture composed of 42 mole% heptane and 58 mole % ethyl benzene is to be fractured at760 mmHg , to produce a distillate containing 97 mole % heptane and a residue 98mole % ethyl benzene . Find

1. The minimum reflux ratio .
2. The minimum number of equilibrium stage at the total reflux
3. The number of plates required in the design of distillation column operation at reflux ratio twice of the min. reflux ratio

Data :

X 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.9

y 0.26 0.44 0.566 0.65 0.73 0.79 0.85 0.956

1. Repeat (a),(b) , (c) if the feed enters the tower partially vaporized , so that 40 mole % liquid and 60 mole % vapour

**Solution**

Xd / rm+1 =0.44

E

0.97,0.97

1. Drawing the q-line from (xf,xf) at ( 0.47,47) until interaction the curve at point E
2. Drawing the line from ( 0.97,0.97) to point E and continued until the y-axis at point ( xd / Rm+1 , 0 ) , now this point equal to( 0.44,0)

Then 0.97 / Rm+1 = 0.44 Rm = 1.22

1. From the (Figure a,b) above the No.of stages = 8

No. of min. plate (N min) =7

1. = 2\* Rm = 2 \* 1.22 = 2.44

Top operating line : 1st point (xd, xd) = (0.97,0.97) , 2nd point (0,xd / R+1) =(0,0.97 / 2.44+1) = (0, 0.288)

q-line 1st point = (xf,xf) =(0.42,0.42) , 2nd point = (xf / q, 0)=(0.42 / 1 , 0) , q =1.0 the feed at bowling point

Bottom operating line : 1st point (xw,xw) = (0.02, 0.02) , 2nd point limited by intersection the end of q-line , from the (Figure c) 1- No.of stages =13 , 2- No.of plates = 13-1=12

1. Feed enters as 40% liquid and 60% vapour

Q=0.4 λ / 0.4 =0.4

q-line : 1st point (xf,xf)= (0.42,0.42) , 2nd point (xf / q ,0)= (0.42 / 0.4 ,0)= (1.05,0)

from (Figure d) xd / Rm+1 = 0.36 then Rm= 1.69

R = 2\* Rm = 2\* 1.69 = 3.38 then ( 0, xd/ Rm+1)= (0, 0.97 / 3.38+1) = 0, 0.22) then from figure the No.of stages =10 and No. of the plates =9