Review quiz

You are carrying out 3 component distillation involving methanol, ethanol, and octanol. Ethanol composition in distillate is 70%. Octanol composition in bottom is 90%. Which one is non-key

A. Methanol

B. Ethanol

C. Butanol

C. All are keys

Review quiz

You are carrying out 3 component distillation involving methanol, ethanol, and octanol. Ethanol composition in distillate is 70%. Octanol composition in bottom is 90%. Fractional recovery of ethanol in distillate is 90%. What is fractional recovery of ethanol in bottom.

A. 70%

B. 90%

C. 10%

C. 50%

Review quiz

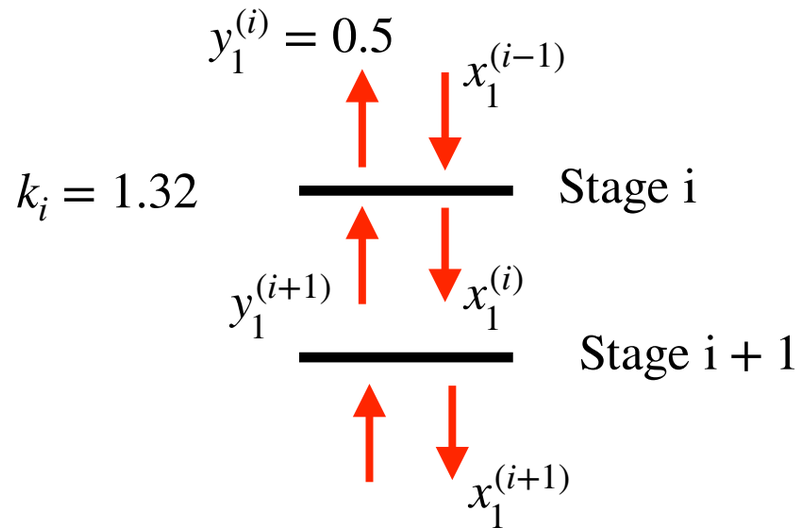
In the case of minimized number of stages, what would be $y_1^{(i+1)}$. Equilibrium relationship for component 1 for stage i (k_i) is 1.32.

A. 0.45

B. 0.38

C. 0.35

D. 0.5



Review quiz

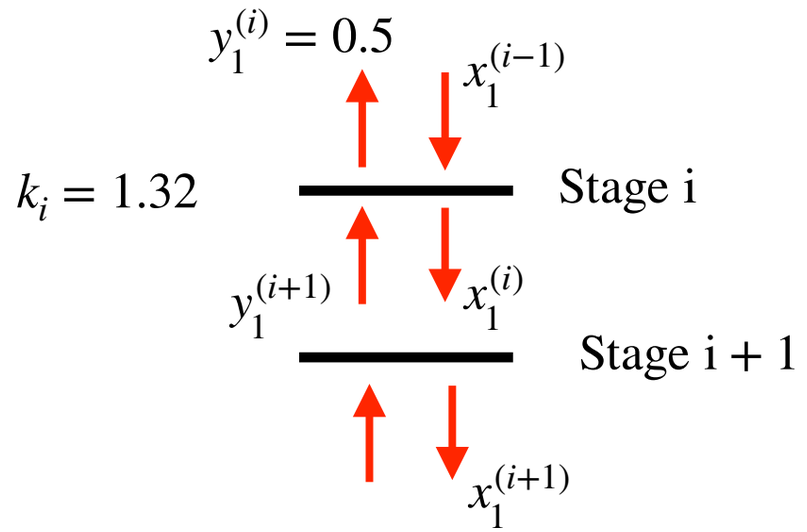
In the case of minimized reflux ratio, what would be y_1^{i+1} near the pinch point (stage i is at the pinch point). Equilibrium relationship for component 1 for stage i (k_i) is 1.32.

A. 0.45

B. 0.38

C. 0.35

D. 0.5



In-class exercise problem

A three component feed (100 mole/hr, saturated vapor feed) containing three species (#1, #2, #3) are to be separated by distillation. Feed composition is as following:
#1: 20%, #2: 40%, #3: 40%

Desired recovery for #2 in distillate is 95%. Assume constant relative volatility. NK does not go to bottom.

$$\alpha^{12} = 2 \qquad \alpha^{31} = 0.25 \qquad x_D^{(HK)} = 0.1$$

1. Identify light key (LK), heavy key (HK), and non-key (NK).
2. Calculate B and D flow rates.
3. Calculate compositions of distillate and bottom (all three components).
4. Calculate minimum number of stages by the Fenske method.

Solution

A three component feed (100 mole/hr, saturated vapor feed) containing three species (#1, #2, #3) are to be separated by distillation. Feed composition is as following:
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1. Identify light key (LK), heavy key (HK), and non-key (NK).
2. Calculate B and D flow rates.
3. Calculate compositions of distillate and bottom (all three components).
4. Calculate minimum number of stages by the Fenske method.

1. Lets look at volatility based on α: #1 is the most volatile, #3 is least volatile

#2 is specified and goes predominantly to the distillate. This makes #2 as LK.

HK seems to be only 10% in distillate. It can not be #1 which does not partition. So #3 is HK.

This makes #1 as LNK

A three component feed (100 mole/hr, saturated vapor feed) containing three species (#1, #2, #3) are to be separated by distillation. Feed composition is as following:
#1: 20%, #2: 40%, #3: 40%

Desired recovery for #2 in distillate is 95%. Assume constant relative volatility. NK does not go to bottom.

$$\alpha^{12} = 2 \qquad \alpha^{31} = 0.25 \qquad x_D^{(HK)} = 0.1$$

2. Lets write the equations for fractional recovery

#1 It does not partition. Fractional recovery in distillate is 1.

$$1 = \frac{Dx_D^1}{Fz_1} \qquad \Rightarrow Dx_D^1 = 1Fz_1 = 100 * 0.2 = 20$$

#2 $$0.95 = \frac{Dx_D^2}{Fz_2} \qquad \Rightarrow Dx_D^2 = 0.95Fz_2 = 0.95 * 100 * 0.4 = 38$$

#3 $$x_D^3 = 0.1 \qquad \Rightarrow Dx_D^3 = 0.1D$$

Adding above three, we get $Dx_D^1 + Dx_D^2 + Dx_D^3 = 58 + 0.1D \qquad \Rightarrow D(x_D^1 + x_D^2 + x_D^3) = 58 + 0.1D$

$\Rightarrow D = 58 + 0.1D \qquad \Rightarrow D = 64.4$

$\Rightarrow B = F - D = 35.6$

EPFL

3. Composition

$$Dx_D^1 = 20 \qquad \Rightarrow x_D^1 = 20/D = 0.31 \qquad x_D^3 = 0.1$$

$$\Rightarrow x_D^2 = 1 - 0.31 - 0.1 = 0.59$$

fractional recovery of #2 in bottom is 100-95 = 5%

$$\Rightarrow 0.05 = \frac{Bx_B^2}{Fz_2} \qquad \Rightarrow x_B^2 = 0.05Fz_2/B = 0.05 * 100 * 0.4/35.6 = 0.056$$

Since #1 does not partition, rest in bottom is #3

$$\Rightarrow x_B^3 = 1 - x_B^2 = 0.944$$

3. Fractional recovery of 3 in bottom = $\frac{Bx_B^3}{Fz_3} = \frac{35.6 * 0.944}{40} = 84\,\%$

$$N_{min} = \frac{\ln\left[\left(\frac{FR_D^2}{1-FR_D^2}\right)\left(\frac{FR_B^3}{1-FR_B^3}\right)\right]}{\ln \alpha^{23}} \qquad \alpha^{12} = 2 \qquad \alpha^{31} = 0.25 \qquad \alpha^{23} = 1/\alpha^{12} * 1/\alpha^{31} = 1/2 * 1/0.25 = 2$$

$$N_{min} = \frac{\ln\left[\left(\frac{0.95}{0.05}\right)\left(\frac{0.84}{0.16}\right)\right]}{\ln 2} = 6.6$$

~7 stages