# Homework #8 Multicomponent Distillation

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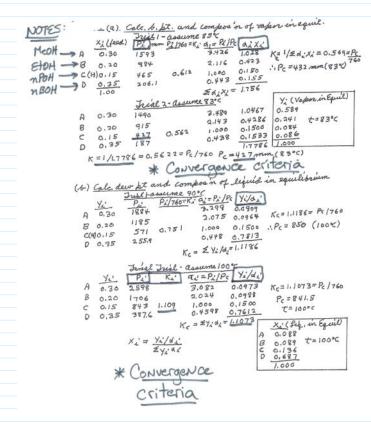
#### 1) Vaporization of Multicomponent Alcohol Mixtures

The vapor-pressure at 101.325 kPa (760 mm Hg) is available for several alcohols:

T (°C)	Vapor Pressure (mm Hg)			
	Methanol (MeOH)	Ethanol (EtOH)	n-Propanol (nPOH)	n-Butanol (nBOH)
50	415	220.0	88.9	33.7
60	629	351.5	148.9	59.2
65	767	438	190.1	77.7
70	929	542	240.6	99.6
75	1119	665	301.9	131.3
80	1339	812	376	165.0
85	1593	984	465	206.1
90	1884	1185	571	225.9
100	2598	1706	843	387.6

An alcohol feed mixture at 101.325kPa (760 mmHg) consisting of 30 % methanol, 20% ethanol, 15% n-propyl alcohol and 35% n-butyl alcohol is to be fed to a distillation column. Calculate the following assuming the mixture follows Raoult's Law:

- a) The boiling point and composition of the vapor in equilibrium.
- b) The dew point and composition of the liquid in equilibrium.
- c) The temperature and composition of both phases when 40% of the feed is vaporized in a flash distillation (single 'stage' vapor-liquid separation)



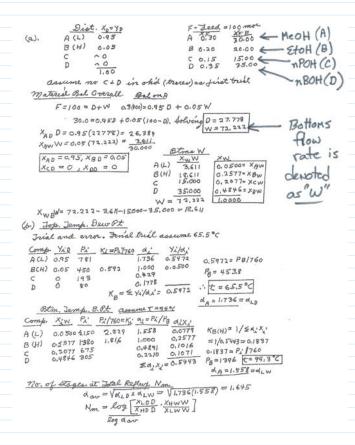
# Equilibrium And Flash Distillation Calculation Validation

#### 2) Multicomponent Alcohol Distillation

An alcohol feed mixture at 101.325kPa (760 mmHg) consisting of 30 % methanol, 20% ethanol, 15% n-propyl alcohol and 35% n-butyl alcohol is distilled so that 95% of the methanol along with a residue of 5% methanol and other trace components is recovered in the distillate. The feed is below the boiling point, so that q=1.10. The operating reflux ratio is 3.0. Assume Raoult's Law applies.

#### Determine the following:

- a) Composition and amounts of the distillate and bottoms streams for a feed of 100 mole/hr.
- b) Top and bottom temperatures and the number of stages at total reflux.
- c) The distribution of components at the conditions determined in part (b).
- d) The minimum reflux ratio, and number of stages when R=3.0.
- e) The feed tray location.



Multicomponent Fractional Distillation Calculation Validation

# $N_{m} = log \begin{bmatrix} \frac{0.95(27,778)}{0.05(27,778)}, \frac{0.2577272.222}{0.05000272.222} \end{bmatrix}$ Nm = 9.21 theoret stages 3 istribution of trace componente (+D in Bit, Btma XXWW = (XX, err) XHDD XHWW $\frac{Component C}{X_{CD}D} = (0.458)^{9.21} \left( \frac{0.0582.7.78}{0.0582.7.732} \right) = 5.628810^{-5}$ Mail of C XCFF = XCD + XCWW, 15.00=5.6=8x10 XCWW+1.0 XCW Solving, Xew W = 14.999155, XCD D = 0.000845=8.45x10-4 Component D & D, ev = V0.1778x0.2210=0.1982 $\frac{\chi_{DD}D}{\chi_{DW}M} = \left(0.1992\right)^{9.21} \left(\frac{0.05 \times 2.778}{0.257 \% 72.222}\right) = 2.51 \times 10^{-9}$ mate. balof D XDFF = XDD D + XDWW, 35.0 = XDD D + XDD O = 8 solving, X 00 D = 8.79 × 10 -7, X 0 W = 35.00 New compositions of D and W including traces (c) Minimum Reflex Rom T<sub>acr</sub> = (65.5+94.3)/2 = 79.9°C (80°C) P<sub>A</sub> | 339 mm | 1.649 P<sub>B</sub> 814 | 1,000 P<sub>C</sub> 276 | 0.463 P<sub>D</sub> 165 | 0.2632 Eq.(11.7-19) $1-q=\frac{\sum d_{\perp} \times_{\perp F}}{d_{\parallel}-\theta}$ Trial and even. $1 - 1, 1 = -0.700 = \frac{1.649 \times 0.30}{1.649 - 0} + \frac{1.000 \times 0.20}{1.000 - 0} + \frac{0.463 \times 0.15}{0.463 - 0} + \frac{0.2032 \times 0.35}{0.2032 - 0}$ assumed 8 1.649-0 + 0.2000 + 0.06945 + 0.07112 0.463-0 + 0.2032-0 -0.0941 -0.0713 -0.0697 -0.0949 -0.0717 -0.1026 -0.0947 -0.0714 -0.0944 1.200 1.1018 1.195 1.0896 1.196 1.0921 1.1018 Hence, use 6 = 1,1955 Rm +1 = \( \frac{a\_1 \times 1}{a\_1 - \theta} \) $R_{m1} + I = \frac{1.649 \times 0.95}{1.649 - 1.1955} + \frac{1.000 \times 0.050}{1.000 - 1.1955} + \frac{0.203 \times 0.050}{0.463 - 1.1955} + \frac{0.203 \times 3.16 \times 10^{10}}{0.2032 - 1.1955}$ Rm = 2.199 Rm = 2.20 Use operating R= 3.00 $\frac{R}{R+1} = \frac{3}{3+1} = 0.75$ $\frac{R_{opt}}{R_{opt}} = \frac{2.70}{2.20+1} = 0.6875$ Nm/N = 0.57 9.21/N = 0.57 N = 16.2 theoretical stages Kirkbride Fred Fray Socation $log \frac{Nz}{Ns} = 0.206 log \left[ \frac{X_{HF}}{X_{LF}} \right] \frac{W}{D} \left( \frac{X_{LW}}{X_{HD}} \right)^{2}$ $= 0.206 \log \frac{100}{1000} = 0.04921$ = 0.04921 = 0.04921

N2/N6=1.1199 N2+N2=16.2 Solving, N2=8.6 (Feed on stage 8.6 from top)

# Multicomponent Fractional Distillation Calculation Validation Continued