

CM2120 Fundamentals of Chemical Engineering 2
Department of Chemical Engineering
Michigan Technological University

Homework 5
Due 4 March 2009

1. Unisim Distillation Simulation: Binary (20 points)

a) Use Unisim to model a distillation column to separate n-heptane and n-octane. Set up the components as per the instructions of HW3.

You desire a liquid distillate composition of 90 mol% n-heptane (most important) and a bottoms liquid composition of 5 mol% n-heptane (if possible). The column has a total condenser and the external molar reflux ratio is 8 (saturated liquid). The column has a partial reboiler.

Set up a UniSim flowsheet with a feed stream, distillate and bottoms streams, and energy streams for the condenser and reboiler. Use “attach mode” to connect the streams to the column.

Double click on the feed stream to enter the feed of 1000 kgmol/h with composition of 50 mol% n-heptane (saturated liquid) at 101.325 kPa. (Use a vapor / phase fraction of 0.001 to estimate this).

Note that the condenser and reboiler pressure are the same as the rest of the column.

b) Perform an overall balance by hand to determine the distillate “specs” to enter into the column information under the design tab (when double clicking on the column).

c) You need to determine the number of stages. For now, just let UniSim automatically place the feed stage for you. When you make a change, you will have to select “Run”. You can click on the performance tab to view the compositions. Under this tab, you can also select the plots feature to print the composition as a function of stage number. Turn in this plot, indicating which line is for n-heptane. Compare your number of stages with the McCabe – Thiele analysis of HW4.

d) Click on the parameters tab and look at the liquid and vapor molar flow rates for each stage. Do you think “constant molal overflow” is a decent assumption?

2. Basics of Multicomponent Distillation (10 points).

Your company wants to distill 10000 kgmol/h of a feed that is 0.10 mole fraction methane, 0.15 mole fraction ethane, 0.25 mole fraction propane, 0.30 mole fraction n-butane, 0.20 mole fraction n-pentane. A fractional recovery of 94% propane is desired in the distillate and a fractional recovery of 96% n-butane is desired in the bottoms.

Identify the light nonkey, light key, heavy key, and heavy nonkey components and estimate the distillate and bottoms compositions and flow rates assuming nonkey compounds do not distribute.

3. Fenske, Underwood, and Gilliland (30 points)

Your company wants to distill 10000 kgmol/h of a feed that is 0.10 mole fraction methane, 0.15 mole fraction ethane, 0.25 mole fraction propane, 0.30 mole fraction n-butane, 0.20 mole fraction n-pentane. A fractional recovery of 94% propane is desired in the distillate and a fractional recovery of 96% n-butane is desired in the bottoms.

a) Use the Fenske equation to determine the minimum number of stages to achieve this separation. Also estimate the fractional recovery of nonkey components in the distillate.

Parameters are: $\alpha_{\text{methane-butane}} = 61.7$, $\alpha_{\text{ethane-butane}} = 10.8$, $\alpha_{\text{propane-butane}} = 3.5$, and $\alpha_{\text{pentane-butane}} = 0.30$.

b) Assuming nonkey elements do not distribute, use the Underwood equations to estimate $(L/D)_{\min}$. Assume the feed is saturated vapor.

c) For $L/D = 1.5 (L/D)_{\min}$, use the Gilliland correlation to determine the actual number of stages and feed stage.