**CBE 333: Chemical and Biological Engineering Lab I**

**Distillation Post-Lab Assignment**

**Fall 2016**

**Problems:**

1. Using the RI calibration data you took last week, prepare a plot of **mole fraction** of isopropanol in the liquid sample versus the Refractive Index reading. Fit the resulting calibration curve (at concentrations below the azeotrope) with an appropriate equation or equations.
2. Submit your analysis of the total reflux run made by L02 – Team 4 from last week.
   1. Construct a McCabe-Thiele diagram. The diagram must be correctly labeled and have the following features:
      1. Reference line, given by y = x.
      2. Vapor-liquid equilibrium curve for isopropanol/water mixtures at a pressure of 0.9 atm.
      3. Distillate and bottoms compositions from the RI readings.
      4. Ideal steps showing the minimum number of stages, Nmin, that should be needed for the separation observed.
   2. Construct a second McCabe-Thiele diagram for this run.
      1. Like the first, it should be correctly labeled and have the reference line and the VLE curve for a pressure of 0.9 atm. But now use the measured compositions of the liquid in the boiler, Trays 1 to 6 and the distillate. At each of the 8 liquid compositions, start at the reference line and construct vertical lines and horizontal lines. The points of intersection to the left of the reference line show an estimate of the actual composition of the vapor leaving each stage.
      2. Calculate the Murphree efficiency, , of each stage by comparing the actual composition of the vapor at that stage to the value predicted by the VLE curve,



* + 1. Calculate the average Murphree efficiency of all 7 stages (ie – 6 trays and the partial reboiler).
  1. Run analysis:
     1. Plot the temperature profile for the column. (Include the temperature of the bottoms still and the reflux stream as well as the temperature at each tray.) How does the temperature vary with tray number?
     2. Plot the composition profile for the column. (Include the composition of the bottoms and the reflux as well as the composition at each tray.) How does the composition vary with tray number?
     3. Compare the minimum number of stages found with the McCabe-Thiele method in 2a-iv with the value given by the Fenske equation.
     4. Determine the overall stage efficiency, , of the column by comparing the minimum number of stages required (found in 1d) to the number of stages actually present,



* + 1. Compare the overall stage efficiency and average Murphree efficiency.
  1. Calculate the separation factor defined as



* 1. From an energy balance around the column (including the condenser and the reboiler), calculate the heat loss from the system. Note that the cooling water rotameter gives readings in [L/min].

**3) Run Comparisons (Use the ASPEN simulation for this part!):**

a) For two reflux ratios (0.5 and 1) simulate the performance of a 7 stage column (ie – 6 trays plus a partial reboiler), for feed introduced at Tray #5 from top and Tray #2 from top. Calculate the separation factor as previously defined. Complete table 1 listing the reflux ratios, feed tray location, tray liquid-compositions and the separation factors obtained.

b) Compare these results with the total reflux run to determine the effect of reflux ratio and feed tray location on the separation achieved.

c) What effect does changing the feed composition have on the distillation tower design and operation?

**Table 1**

|  |  |  |  |
| --- | --- | --- | --- |
| Feed Tray Location | | 5 from top | 2 from top |
| Condition | Feed  Reflux | Sat’d liq  Sat’d liq | Sat’d liq  Sat’d liq |
| R=0.5 | XD  X6  X1  XF  XB  ∆X6-1  SF |  |  |
| R=1 | XD  X6  X1  XF  XB  ∆X6-1  SF |  |  |