CHE 362 **Design Project** **Due 6/26/23**

Base Case Design #1 due 6/23/23 and #2 due 6/26/23

The goal of this project is to optimize the design of a distillation column to separate a binary mixture. The feed is to enter the column as a saturated liquid and a flow rate of 500 kmol/hr. The purity of the distillate and residue are listed on the assignment sheet. You can assume that the overall efficiency of the column in 75%. The trays should be designed for 75% flooding and 80% active area. The tray type is ***sieve trays***. The feed composition is listed on the assignment sheet.

Costs can be split between operating cost and capital (equipment) cost. Operating costs include steam for the reboiler and cooling water for the condenser. Capital costs include the cost of the shell and trays, and condenser and reboiler heat transfer area. Cost equations are outlined in the notes. For annualized capital cost, divide the total capital cost by 5 since the cost of equipment can be spread over 5 years. Cost should be calculated on an annual basis where the Equivalent Annual Operating Cost (EAOC) is the sum of the annual operating cost and annualized capital cost.

#1 Create a base case design of the column using a McCabe-Thiele diagram to estimate the number of stages and feed stage location. Use as your base case a reflux ratio of 1.2 times the minimum. Submit a copy of the McCabe-Thiele diagram. You may need to expand the graph at the top and bottom of the diagram to get an accurate estimate of the number of stages. Estimate the column diameter for the top tray. The trays should be designed for 75% flooding and 80% active area. Calculate the area of the condenser and reboiler. Use the assumptions for cooling water and steam listed below.

#2 Simulate your base case design using Aspen. Your Aspen model should meet the given specifications for your column. Use Aspen to calculate the column diameter. Using the heat duty for the condenser and reboiler and the distillate and reboiler temperatures reported by Aspen, estimate the heat transfer area for the reboiler and condenser. State any assumptions that you made in your calculations. Calculate the installed cost (C_{BM}) of the column shell, trays, condenser and reboiler. State any assumptions that you made. Calculate the annual operating cost for steam and cooling water. State any assumptions that you made. Calculate the EAOC for your base case. Show all of the details of your calculations. Include from Aspen copies of the stream table showing the mole fractions of the distillate and residue, the results of the tray sizing showing the column diameter and the block results showing condenser and reboiler heat duties in GJ/hr and the reflux ratio.

#3 Find the optimum column design based on the minimum EAOC. Include a spreadsheet for all cases that you tried sorted by increasing reflux ratio. Highlight the optimal design. Your spreadsheet should include the following columns: number of ideal stages, number of real trays, reflux ratio, column height in ft, column diameter in ft rounded up to the nearest half foot, condenser heat duty in GJ/hr, reboiler heat duty in GJ/hr, condenser heat transfer area in m^2, reboiler heat transfer area in m^2, cost of the shell, cost of the trays, cost of the condenser, cost of the reboiler, annual steam cost, annual cooling water cost, total capital cost, annual utility cost, EAOC. Assume the plant operates for 350 days/yr.

#4 Create a graph of EAOC vs reflux ratio to show your optimum design. Create a second graph that shows all of the following as a function of reflux ratio: the annual operating costs for steam and cooling water and the annualized cost (bare module cost/5) for the shell, trays, condenser and reboiler as a function of reflux ratio.

#5 Submit a copy of the detailed calculations for your optimum case. Include all work you did in Mathcad, Aspen and Excel.

Cost Information

Operating cost

50 psig steam = \$14.05/GJ
150 psig steam = \$14.83/GJ
600 psig steam = \$17.70/GJ

(maximum allowable ΔT in the reboiler is 30°C)

cooling water = \$0.354/GJ

Assume cooling water enters at 30 °C and is returned at no more than 45 °C

Assume the plant operates for 350 days/year.

EAOC = 0.2*Total Capital Cost + Annual Operating Cost

Total Capital Cost = Cost of (Tower Shell + Trays + Condenser + Reboiler)

Annual Operating Cost = Annual Cost of (Steam + Cooling Water)

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					P	xF	xB	xD
Muth	Walsh	Bradford	acetone	benzene		0.5	0.01	0.99
Brennan	Chisum		acetone	isopropanol		0.2	0.01	0.99
Prokop	Ross		benzene	chlorobenzene		0.1	0.01	0.99
Violette	Barth		benzene	ethyl benzene		0.2	0.01	0.99