CL 312: Computer Aided Process Equipment Design Laboratory

Indian Institute of Technology, Guwahati.

Assignment-4

Use Aspen Plus V10 or V11 for process simulation.

Total Marks: 20

Mixtures of chemical components sometimes form azeotropes. An azeotropic mixture has both vapor and liquid phases that have identical compositions. It means that simple distillation cannot be used to achieve complete separation. The azeotrope can be either homogeneous or heterogeneous. Homogeneous azeotropes can be separated using Pressure swing distillation.

Pressure-swing distillation: If the composition of the azeotrope changes significantly with pressure, two columns operating at two different pressures can achieve separation. The basic idea is to operate one column at low pressure and the second column at high pressure.

Problem statement:
An equimolar mixture (540 kmol/hr) of acetone-methanol is available at 320 K and 1 atm. The mixture forms minimum boiling azeotrope at 1 atm containing 77.6 mol% acetone at 328 K while at 10 atm the azeotropic composition is 37.5 mol% acetone at 408 K, so pressure-swing separation is feasible.

Develop a process for the separation of acetone-methanol mixture using two distillation columns, one operating at 1 atm while another operating at 10 atm (no pressure drop inside the columns). In the low-pressure column, the bottoms composition specification is 99.5 mol% methanol while in the high-pressure column, the bottoms composition specification is 99.5 mol% acetone.

Few points to be noted while attempting the problem:

1) Use NRTL model as the thermodynamic base method.
2) Initially assume the number of stages as 40, specified molar reflux ratio as 6, total condenser and bottoms rate as 270 kmol/hr for the first column.
3) Similarly assume number of stages as 40, specified molar reflux ratio as 5, total condenser and bottoms rate (based on first column calculations results) for the second column.
4) You may add pressure (pumps, compressors, etc.) / temperature (heat exchangers) changing equipments wherever required.
5) You may use one or more design specs to solve the problem.

6) Column internals to be utilized as per *default* settings only (if required).
7) It is advisable to conduct ‘*one-on-one*’ (at a time) sensitivity analysis for any required analysis.
8) Your primary goal is to get answers based on the desired separation; also the secondary goal being able to obtain answers devoid of any errors (all blue ticks). Thus set your guess brackets, convergence criteria accordingly.

Solve the following:

a) Find the actual bottoms rate in the two distillation columns
b) Find the corresponding diameter of both the distillation columns
c) Find the minimum number of stages in each column that will minimize the reboiler duties of their respective columns (for the desired separation)
d) Find the optimum feed stage locations that will minimize the reboiler duties of their respective columns (for the desired separation)

Guidelines for submission of Assignment 4

1. All steams/equipment in the Aspen flowsheet must be labeled properly
2. All sorts of assumed data / input must be mentioned clearly in the report (if any)
3. Save the simulation file as Aspen Plus Compound (.apwz) file
4. Name of the files: Group(no.)_Assignment(no.) .apwz/.pdf
5. Report the following in **.pdf** file:
   a) Actual bottoms rate in the two distillation columns
   b) Distillation columns diameters
   c) Minimum number of stages in each column that will minimize the reboiler duties of their respective columns (for the desired separation)
   d) Optimum feed stage locations inside each column that will minimize the reboiler duties of their respective columns (for the desired separation)
   e) Snapshot of the final, well labeled Aspen flowsheet
6. Upload the following 2 files: .apwz and .pdf file on **Microsoft Teams** portal.

Last date of Assignment-4 submission: 9th April 2024, 11:59 p.m.