Simutech Project IIT Kanpur

Distillation Column Design

Mentors:

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End-Term Report :
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Project Objectives

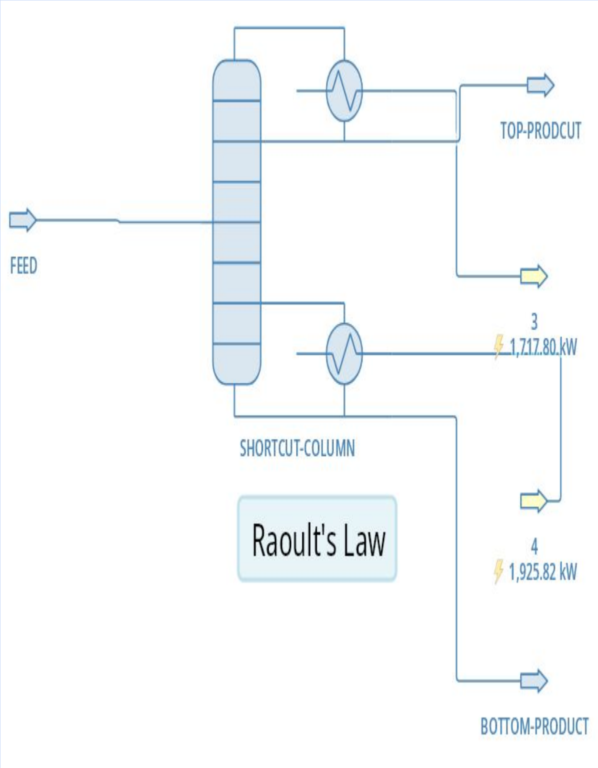
- Using Python/MATLAB, optimise a Continuous Distillation Column for a binary mixture.

- Outline a binary distillation column in Python/MATLAB, utilise the McCabe Thiele process to investigate the column, and derive conclusions from the process.

- Understand Azeotropic mixtures.

- Automate the Inspection pipelines to determine the minimal and real number of stages required to accomplish the desired separation, as well as the Minimum Reflux Ratio, utilising Graph-based Visualisations.

- Simulating the construction of a distillation column using simulation tools such as DWSIM or Aspen.

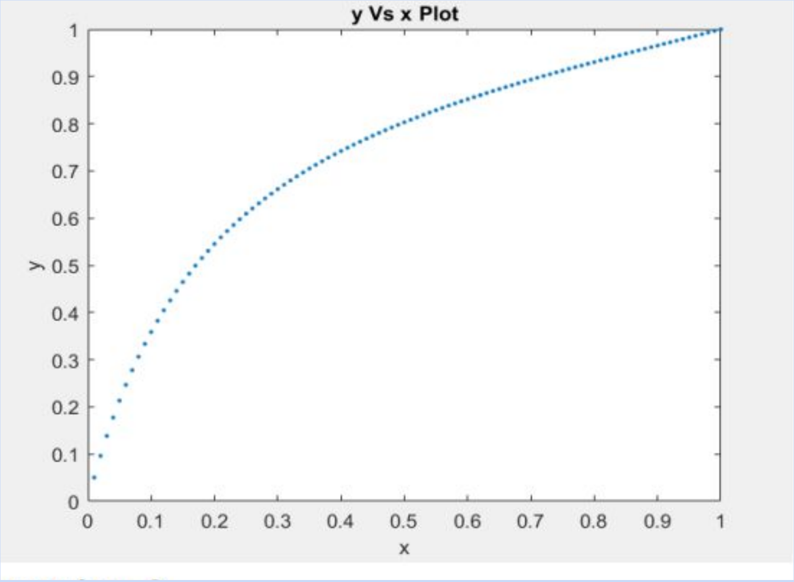


- Learning different distillation techniques.
  1. Extractive Distillation
  2. Azeotropic Distillation
  3. Pressure Swing Distillation

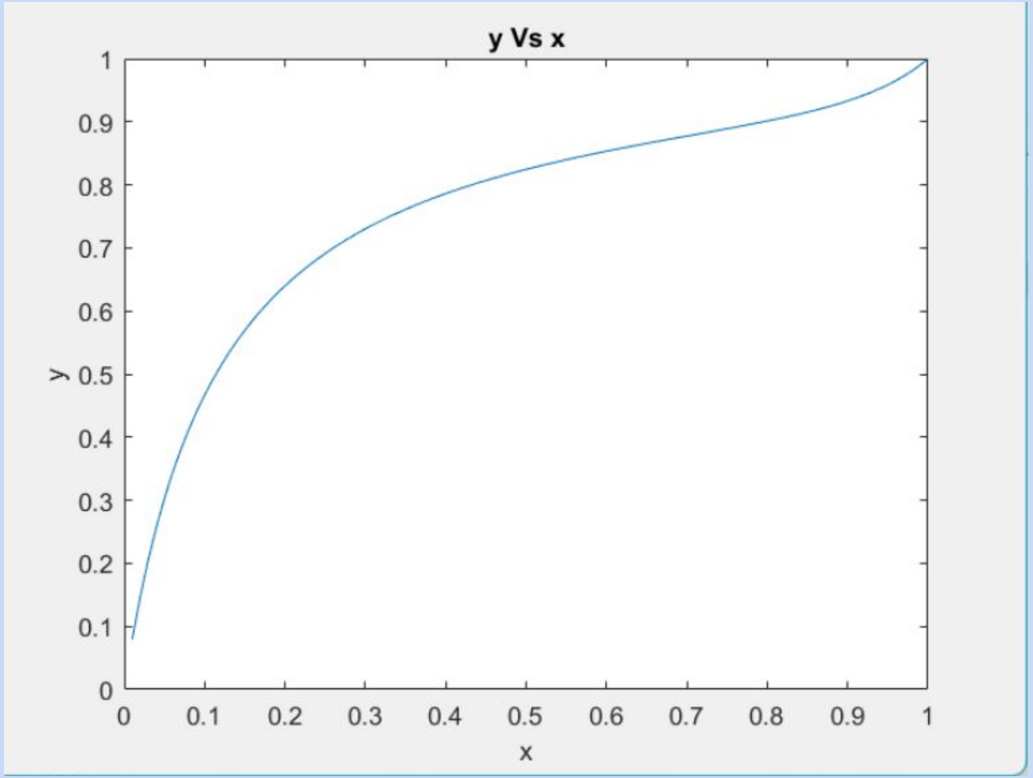
As part of this project on the design of distillation columns, we were tasked with completing three separate assignments.

ASSIGNMENT 1

Assignment 1 focused mostly on studying the fundamentals of Raoult's law and various activity coefficient models. Using MATLAB code to implement Raoult's Law and one activity coefficient model for the binary azeotropic system.



y Vs x Plot Using Raoult’s Law



y Vs x plot using Van Laar Coefficient Model

ASSIGNMENT 2

In this assignment, we computed

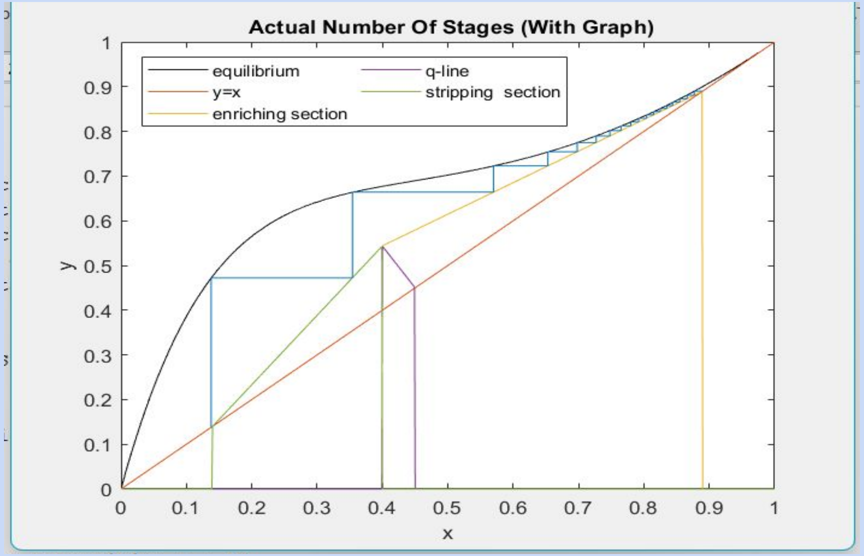
1. ACTUAL NUMBER OF STAGES
2. MINIMUM NUMBER OF STAGES
3. MINIMUM REFLUX RATIO

in a distillation column for

1. Non-ideal solution (using Van Laar's Method)
2. Ideal solution

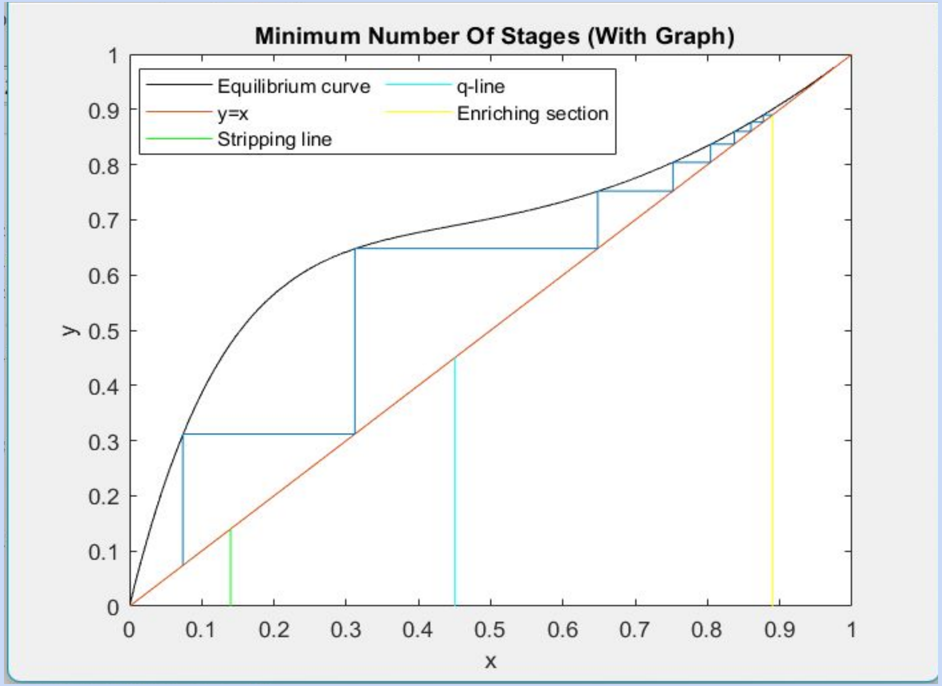
Here we have listed the respective methods of how we computed the above mentioned quantities :

1. We calculated ACTUAL NUMBER OF STAGES by first finding the point where q-line, enriching section line and stripping section line intersects and then constructed the triangles to commute the actual number of stages.



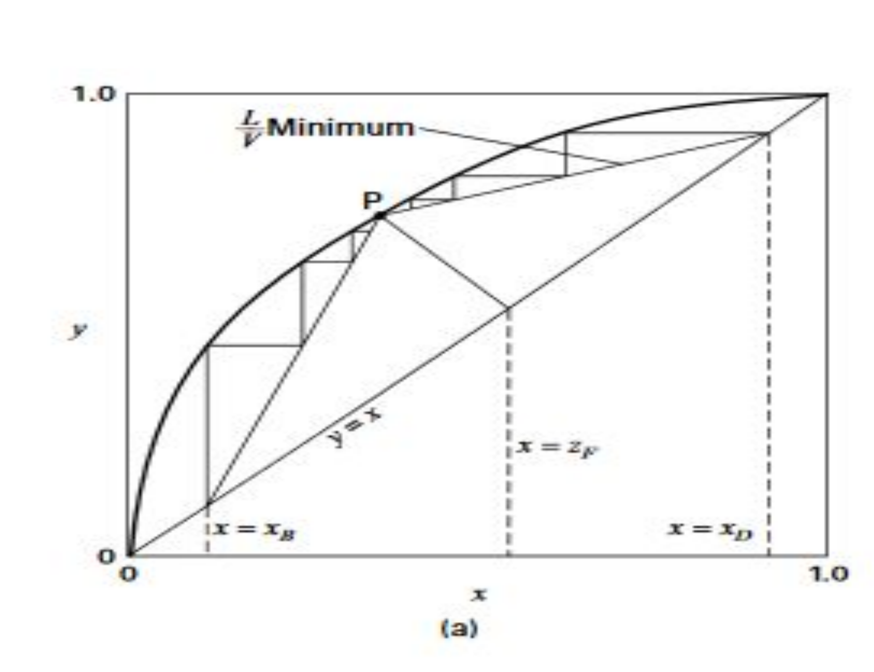
Calculating actual number of stages in non-ideal case

2. To calculate MINIMUM NUMBER OF STAGES, the point of intersection of above three lines comes on y=x line and thus constructing the triangles gives us the minimum number of stages.



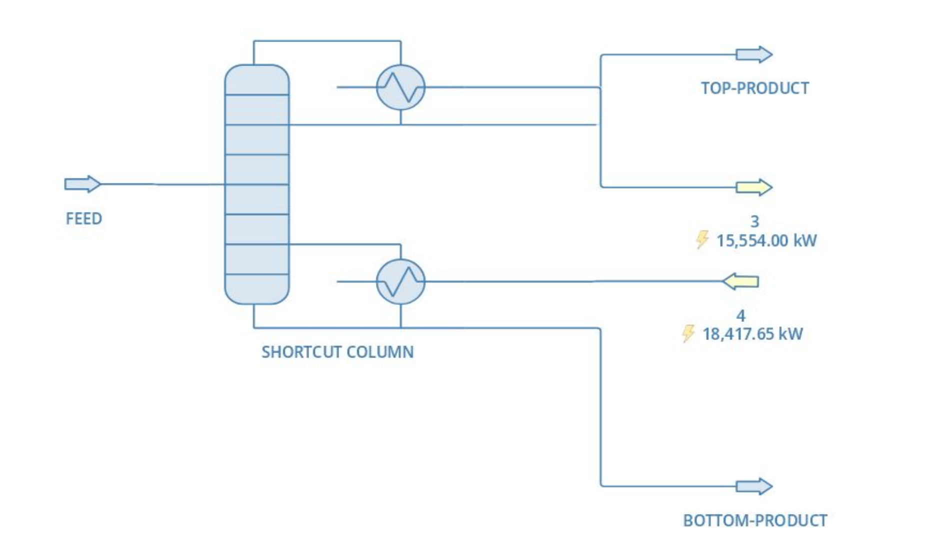
Calculating minimum number of stages

3. To calculate MINIMUM REFLUX RATIO, we first calculated point of intersection of q-line and equilibrium cure. Then we extrapolated the enriching section line from this point to intersect on the y-axis. We used this y-intercept to calculate the minimum reflux ratio.



ASSIGNMENT 3

In this assignment we firstly simulated a distillation column & verified the results of the Python/MATLAB code through the DWSIM software for the system of ethanol and water.



Flow Sheet using Shortcut column

By performing the simulations on DWSIM software using Shortcut Column , the results matched with MATLAB code results which proves the accuracy of the code and method for both ideal and non-ideal solution.

DWSIM RESULTS

Results

Property	Value	Units
Minimum Reflux Ratio	1.93179	
Minimum Number of Stages	9.22109	
Actual Number of Stages	19.699	
Optimal Feed Stage	5.57856	
Stripping Liquid	560.135	mol/s
Rectify Liquid	282.357	mol/s
Stripping Vapor	400.015	mol/s
Rectify Vapor	400.006	mol/s
Condenser Duty	15554	kW
Reboiler Duty	18417.6	kW

MATLAB CODE RESULTS

```
Actual Number Of Stages(Trays) :
    18

Minimum Number Of Stages(Trays) :
     8

Minimum Reflux Ratio :
1.974
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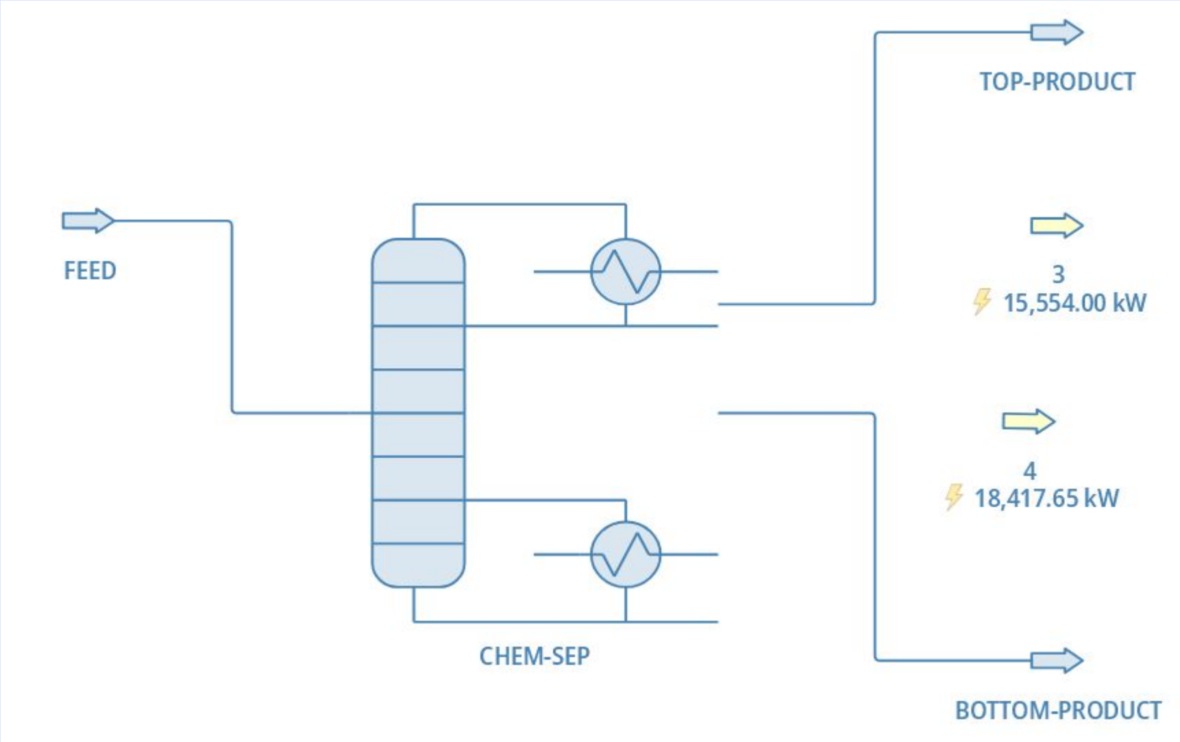
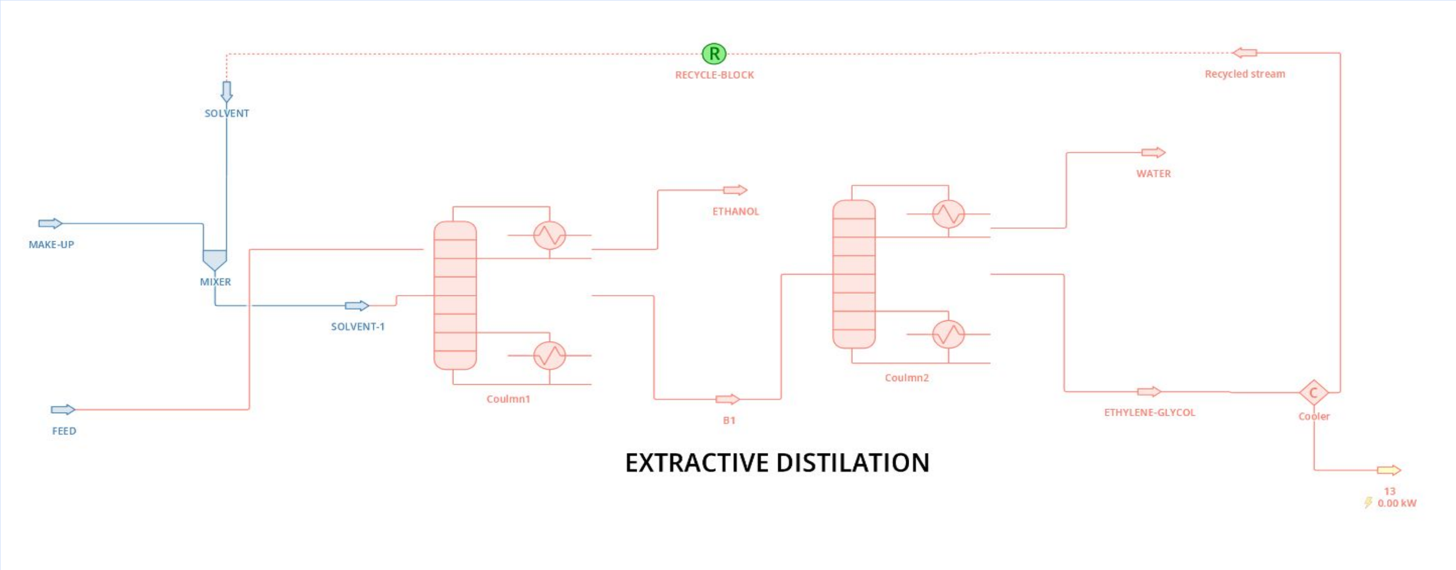


Chem-sep Column Design

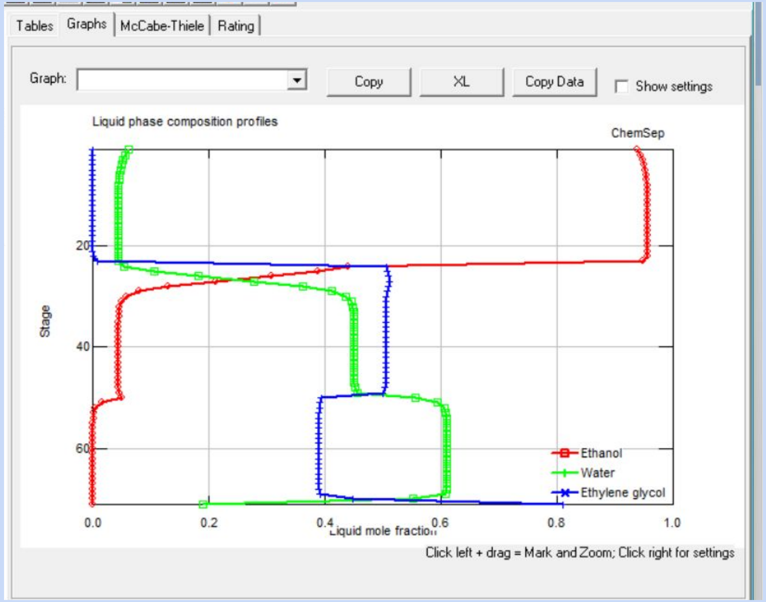
2.We did Separation of Azeotropic mixture by Extractive Distillation using DWSIM software for the system of ethanol and water.

Extractive Distillation

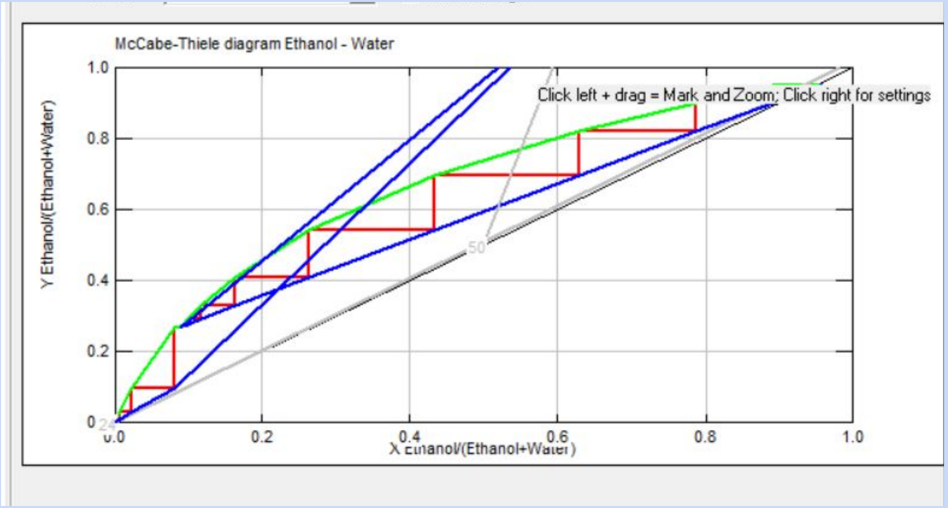
Extractive distillation separates a binary mixture by adding a third component. The third component is less volatile and doesn't evaporate during distillation. Or, raise the boiling point



Composition of Ethanol,Ethylene Glycol & Water at each stage in Chem-Sep Column 1



McCabe-Thiele Diagram (Column 1)



3.Performed Pressure Swing Distillation Through DWSIM Software.

Pressure Swing Distillation

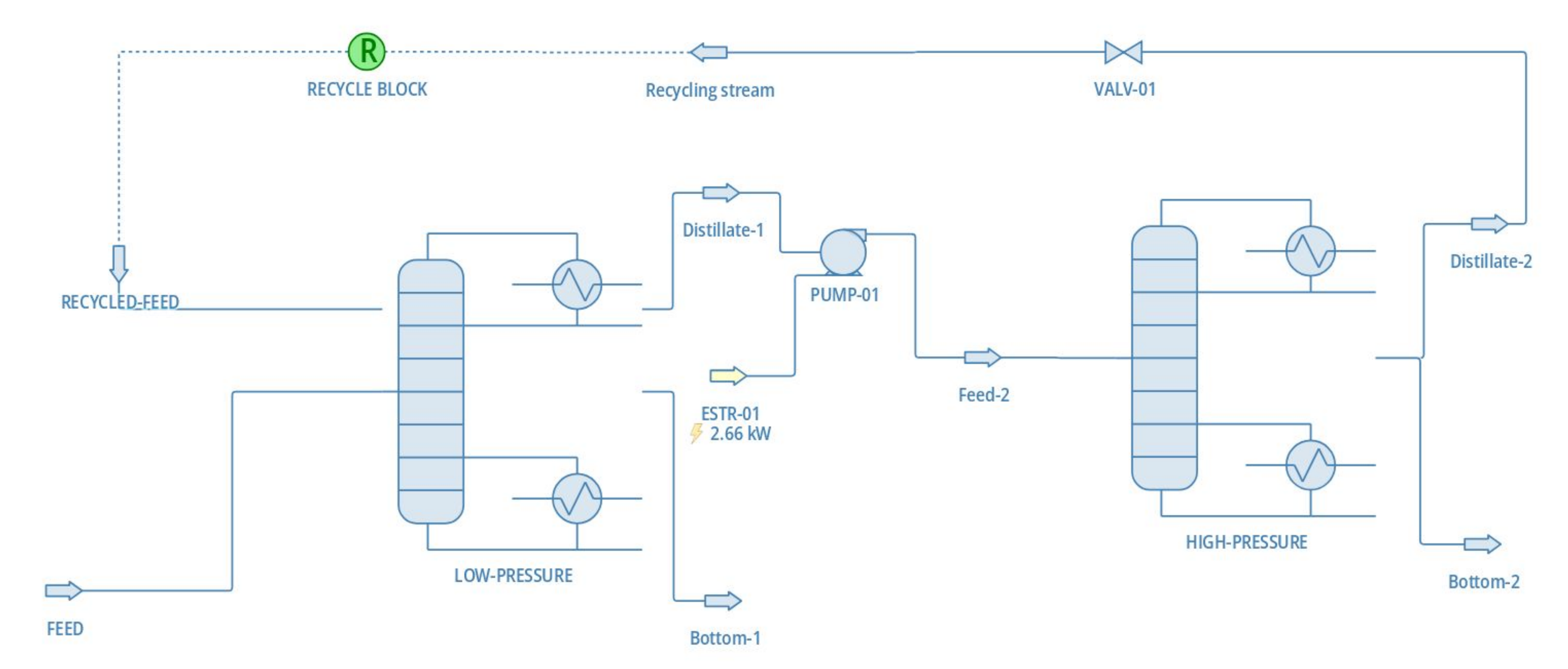
Process and chemical industries use pressure swing distillation to extract azeotropes. Azeotropes are liquid mixes that do not separate when boiling, meaning the gas and liquid phases are identical.

Principle Of Pressure Swing Distillation

At constant pressure, azeotrope mixes may contain more than one azeotropy point, but this is uncommon.

When pressure fluctuates, the azeotropy point moves. At different pressures, the same liquid combination forms a distinct azeotrope.

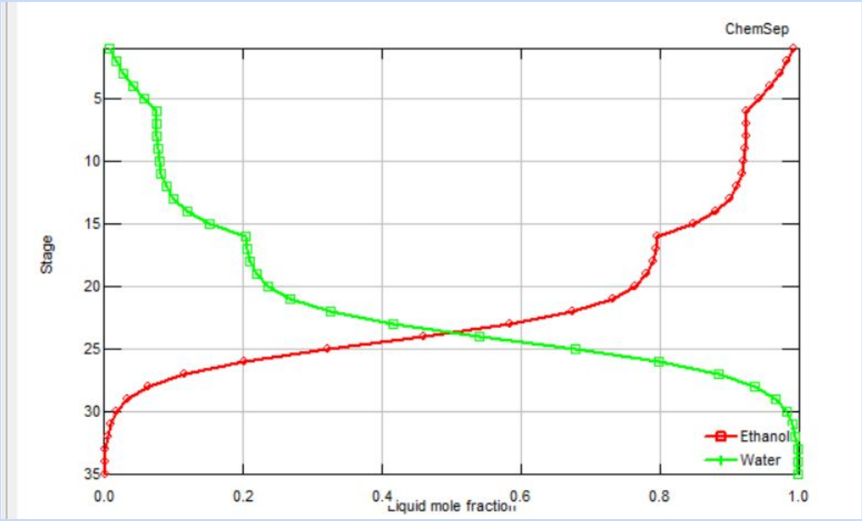
Since pressure can vary the relative volatility of a liquid combination, many azeotropes lose their azeotropy when the pressure is raised to a specific degree. A distillation column can separate the azeotropic system.



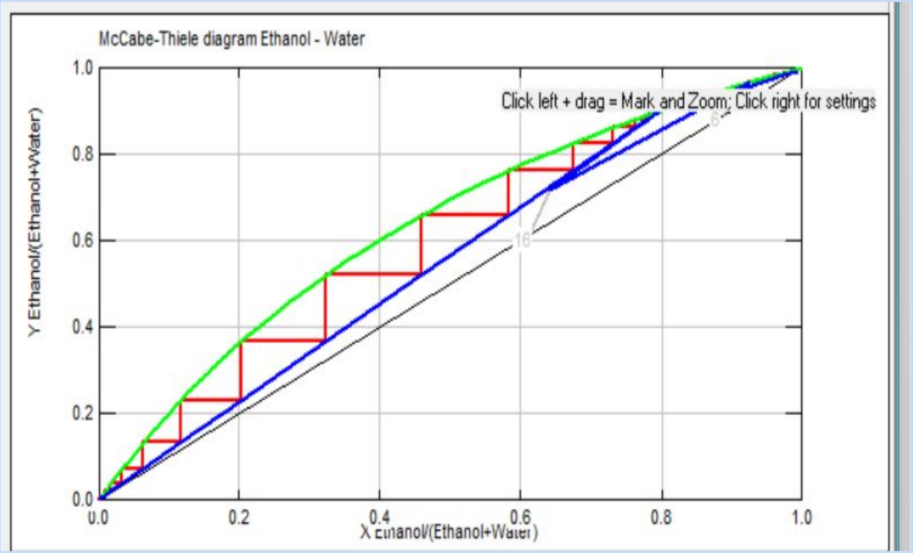
Flow Sheet showing Pressure Swing Distillation

Results from Low-Pressure Column

Compositions of Ethanol and Water

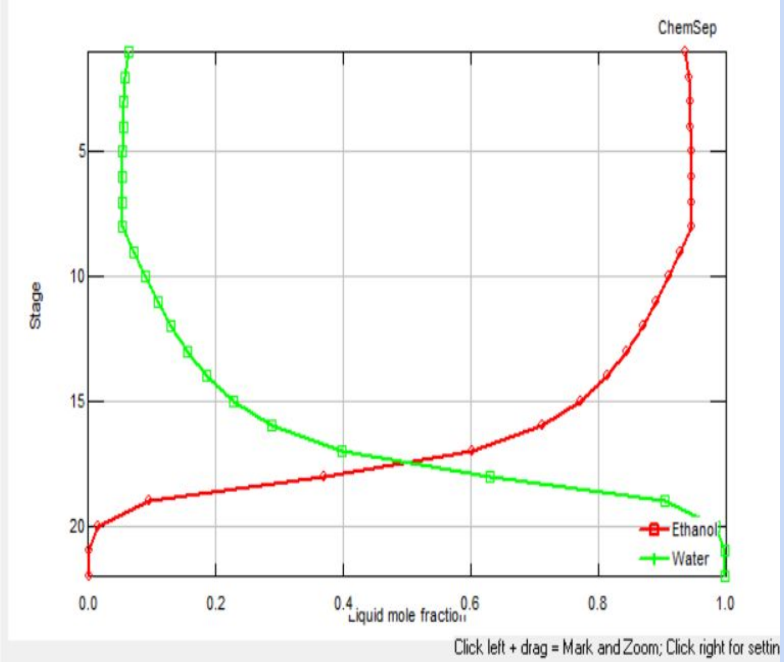


McCabe thiele Diagram

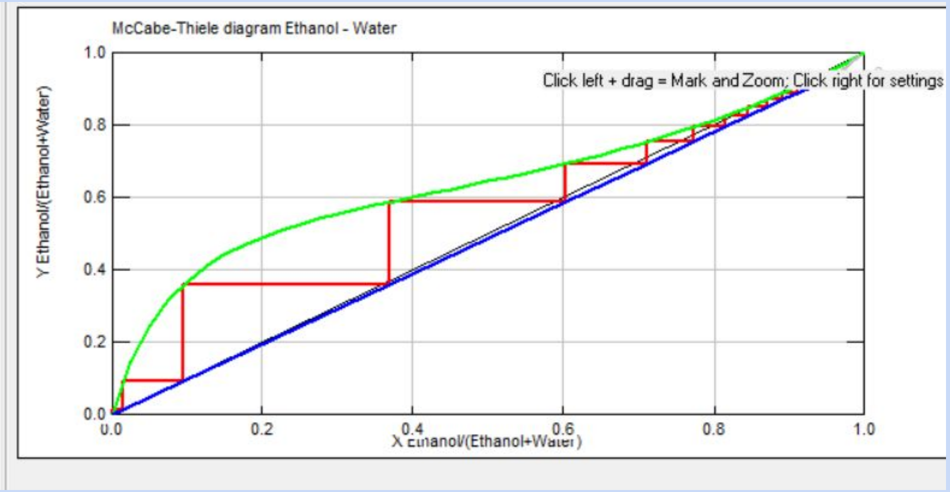


Results from High-Pressure Column

Composition Of Ethanol and Water



McCabe-Thiele Diagram



THANK YOU!!!

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