DISTILLATION/ABSORPTION COLUMN DESIGN

1800 or earlier

Now
DISTILLATION/ABSORPTION COLUMN DESIGN

Distillation

Absorption

ChE 4253 - Design I
DISTILLATION/ABSORPTION COLUMN DESIGN

Packed Tower

Tray tower

ChE 4253 - Design I
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

- Vapor Compression (VC)
- Mechanical Vapor Recompression (MVR)
- Thermal Vapor Recompression (TVR)
- Absorption Heat Pump (AHP)
- Compression-Resorption Heat Pump (CRHP)
- Thermo-Acoustic Heat Pump (TAHP)
- Heat Integrated Distillation Column (HIDIC)
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

Heat Integrated Distillation Columns (HIDiC)
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

Petroleum Fractionation
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

Pervaporation distillation
Complex Columns

Double Effect
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

Pressure Swing Distillation

![Diagram of Pressure Swing Distillation process]

- Pressure $P_1$ and $P_2$
- Flow rates $F$, $F_1$, $F_2$
- Products $D_1$, $D_2$
- Pure A and Pure B

$p_1 < p_2$
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns Multicomponent cases

Simple Sequences
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns Multicomponent cases

Simple Sequences
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns

Petlyuk Columns (circa 1960)                      Divided wall column

Prefractionator

Main shell
DISTILLATION/ABSORPTION COLUMN DESIGN

Complex Columns Multicomponent cases

Complex Sequences
Absorber/stripper typical arrangement.
Distillation Control

[Diagram of a distillation column with control valves, temperature sensors, and process streams indicating feed flow, reflux, control temperatures, steam, bottom impurities, and top impurities leading to top and bottom products.]
DISTILLATION/ABSORPTION COLUMN DESIGN

BINARY SYSTEMS: Use McCabe Thiele

Given \( x_B \) and \( x_D \) \( \Rightarrow \) calculate RR, #trays, Feed tray, D, B \( \Rightarrow \) Design
Given \( x_D \) and RR (for fixed #trays and feed tray) \( \Rightarrow \) \( x_B \), D, B \( \Rightarrow \) Operations
Given 2 operating values (for fixed #trays and feed tray) \( \Rightarrow \) the rest \( \Rightarrow \) Operations
MULTICOMPONENT SYSTEMS: Use Computers!!!

Degree of Freedom = Number of unknowns – Number of equations

One per each condenser, reboiler or draw. See notes.
DISTILLATION/ABSORPTION COLUMN DESIGN

MULTICOMPONENT SYSTEMS: Use Pro II

Case 2: You know number of trays and feed tray location

You need to fix variables or add equations.

- Add Equations (The easiest), e.g. Reflux ratio and Recovery ratio
- Fix variables, e.g. Compositions, temperatures, flows, etc.
MULTICOMPONENT SYSTEMS:

Case 2: You know nothing, not even the number of trays needed.

Use Fenske-Underwood Gilliland (see Separation Class Book) to get an idea

\[ N = \frac{\log \left( \frac{x_d}{1-x_d} \right) \left( \frac{1-x_b}{x_b} \right)}{\log \alpha_{\text{avg}}} \]

Pro II has this shortcut

.... or if you are too lazy use Pro II as follows

1. Do not try blindly specs and number of trays. it won’t work most of the time.
2. If you have many components do not include them all at the beginning. start with a few of the most abundant components.
3. Put an adiabatic flash first. if the feed is not two phase at the desired pressure, use an isothermal flash. Change the temperature until you get some separation in the direction you want.

To do this list the components in increasing boiling point and determine key components. Light key goes mostly to the top. Heavy key goes mostly to bottom.

Continues in next slide...
Case 2: You know nothing, not even the number of trays needed.

Continued...

4. Replace the flash by a three plates column, with similar specs as those given by the flash outlet streams. It should not be a big problem to get it.

5. Add the components that are missing. Do it slowly, increasing their concentration until you reach the desired values.

6. Keep tightening the specs and increasing the number of plates accordingly, so that you meet the separation you want.