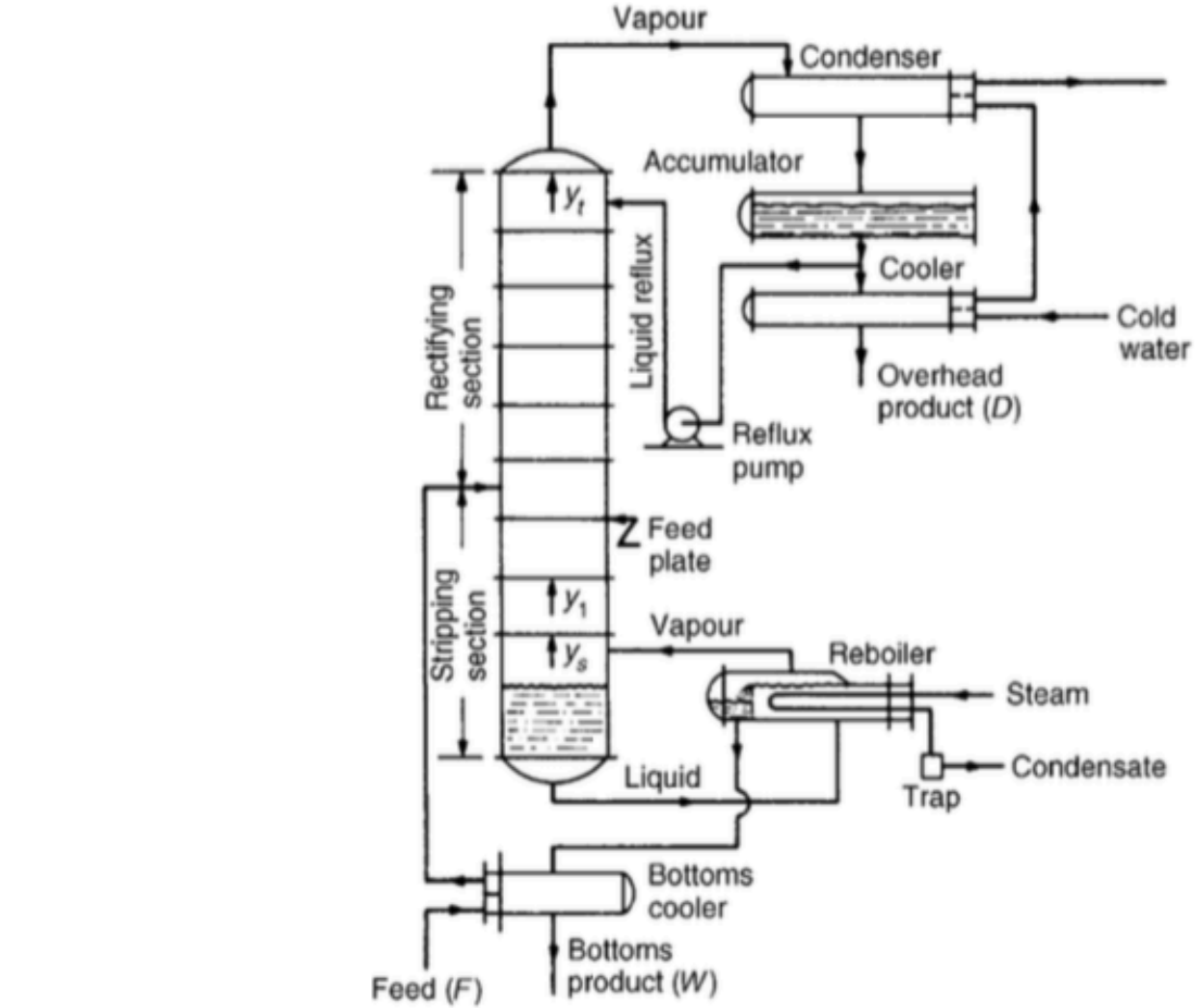
Design of Process Equipment-Distillation Column, CSTR and Adsorber

Design Algorithms

Distillation - Algorithm



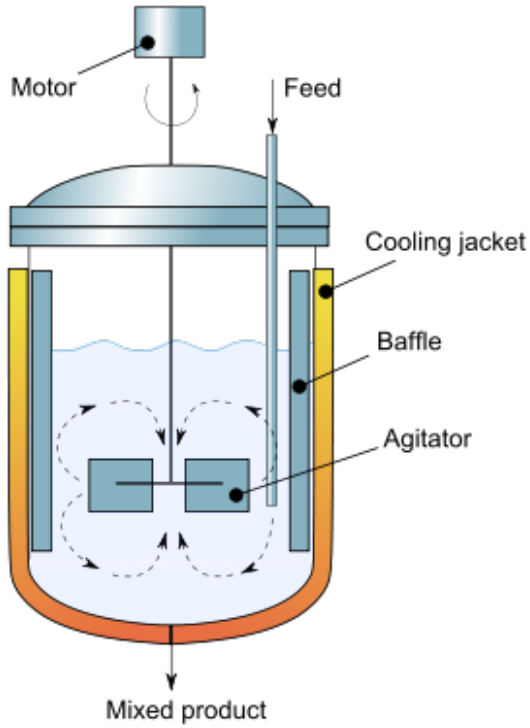
Distillation – Algorithm (Binary Mixture)

1. Perform a mass balance and determine number of theoretical stages
2. Estimate the physical properties of liquid and vapors using hand books (or literature)
3. Identify the column diameter based on flooding conditions
4. Find out the Plate spacing
5. Decide liquid flow arrangements inside the column
6. Make a provisional tray layout (including down comer area, active area perforated area, hole area and size, height and length of weir)
7. Decide plate layout (including calming zone and un perforated areas and hole pitch) if unsatisfactory go to step 6
8. Check for Weepage
9. Check for plate pressure drop
10. Determine back up liquid and down comer residence time.

CSTR – Algorithm

The design of an industrial chemical reactor must satisfy the following requirements:

1. Chemical factors
2. Mass Transfer factors
3. Heat transfer factors
4. The safety factors



Constant Stirred Tank Reactor

CSTR – Algorithm

1. Chemical factors

   The kinetics of reaction. The design must provide sufficient residence time for the desired reactor to proceed to the required degree of conversion

2. Mass transfer factors

   with heterogeneous reactions the reaction rate may be controlled by the rate of diffuion of reacting species; rather than the chemical reaction

CSTR – Algorithm

3. The heat transfer factors

   The removal or addition of the heat of reaction

4. The safety factors

   The confinement of hazardous reactants and products and the control of reactions and the process conditions.

CSTR – Algorithm

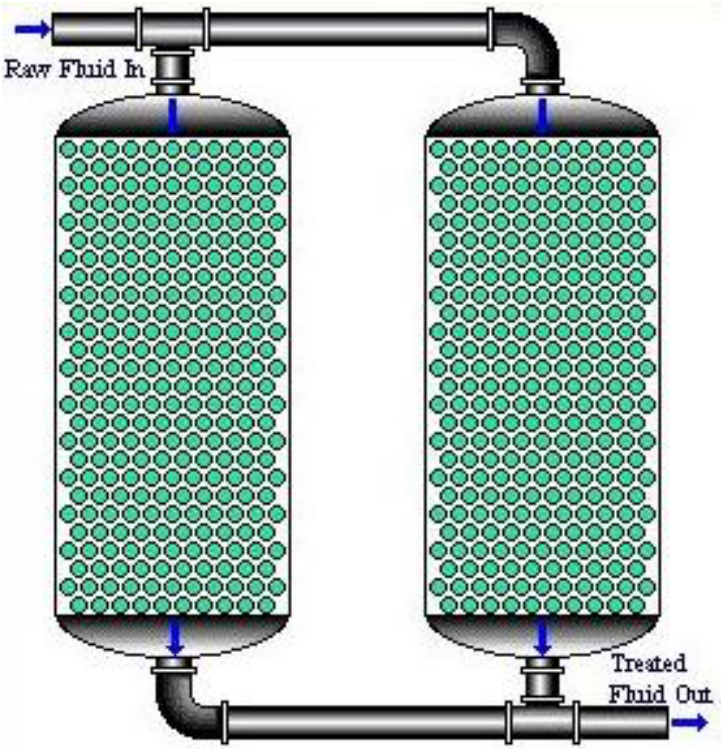
1. Collect together all kinetic data and thermodynamic data on the desired reaction and the side reaction. Note: Useful kinetic data will be carefully collected from the published literature or from laboratory and pilot plant study
2. Collect the physical properties data required for the design; either from the literature, by estimation or if necessary laboratory measurements
3. Identify the predominant rate-controlling mechanism (kinetic, mass or heat transfer)

CSTR – Algorithm

4. Choose a suitable type of a reactor, based on experience (from laboratory or pilot plant)
5. Make an initial size of reactor conditions to give desired conversion and yield
6. Size the reactor and estimate its performance
7. Select suitable or appropriate layout and material of construction
8. Make a preliminary mechanical design for the reactor : the vessel design, heat transfer surfaces, internals and general arrangements
9. Cost the proposed design, capital and operating and repeat steps 4 to 9 as necessary to optimize design

Adsorption – Process

The mixture to be separated is brought into contact with another insoluble phase, the solid adsorbent and the unequal distribution of the original constituents between the adsorbed phase on the solid surface and the bulk of the fluid then permits a separation to be made.



Adsorption – Process

Adsorption takes place in four basic steps:

(i) Bulk solution transport – in which movement of the organic material to be adsorbed through the bulk liquid to the boundary layer of the liquid surrounding the adsorbent

(ii) Film diffusion transport – involves the transport by diffusion of the organic material through the stagnant liquid film to the entrance of the pores of the adsorbent

Adsorption – Process

Adsorption takes place in four basic steps:

(iii) Pore transport – involves the transport of the material to be adsorbed through the pores by a combination of molecular diffusion through the pore liquid and or by diffusion along the surface of the adsorbent

(iv) Adsorption or Sorption - Involves the attachment of material to be removed at the available site.

Adsorption – Process

The pore sizes used in the adsorption process are defined as follows:

Macro pores > 25nm

Meso pores > 1nm and <25 nm

Micro pores <1nm

Adsorption – Process

Adsorption isotherms

The quantity of adsorbate that can be taken up by an adsorbent is a function of the absorbent characteristics and the temperature.

The characteristics of adsorbate that are of important includes: Solubility, molecular structure, molecular weight, polarity and hydrocarbon saturation.

Adsorption - Algorithm

Fixed bed activated carbon adsorption column design

1. Identify the granular activated carbon (GAC) for the separation of undesired component through mass balance
2. Determine the mass of activated carbon requires for given bed contact time
3. Determine the volume of water or solution to be treated for given contact time
4. Estimate the bed life
5. Identify the diameter and height of the adsorption column based on the volume of solution to be treated .

References

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