Perancangan Proses Kimia

PERANCANGAN SISTEM/JARINGAN PEMISAH & RECYCLE

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Rancangan Kuliah Section 2

1. Dasar-dasar Penggunaan CHEMCAD/HYSYS
2. Perancangan Sistem/jaringan Reaktor
3. Tugas 1 dan Pembahasannya
4. **Perancangan Sistem/jaringan Separator & Recycle**
5. Tugas 2 dan Pembahasannya
6. Perancangan Sistem/jaringan Pemanas
7. Tugas 3 -- Studi Kasus
8. Ujian Section 2

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Heuristic of Separations

- **Heuristic 9**: Separate liquid mixtures using distillation, stripping, enhanced (exctractive, azeotropic, reactive) distillation, liquid-liquid extraction, crystallization, and/or absorption

- **Heuristic 10**: Attempt to condense or partially condense vapor mixtures with cooling water or a refrigerant. Then use Heuristic 9

- **Heuristic 11**: Separate vapor mixtures using partial condensation, cryogenic distillation, absorption, adsorption, membrane separation and/or desublimation
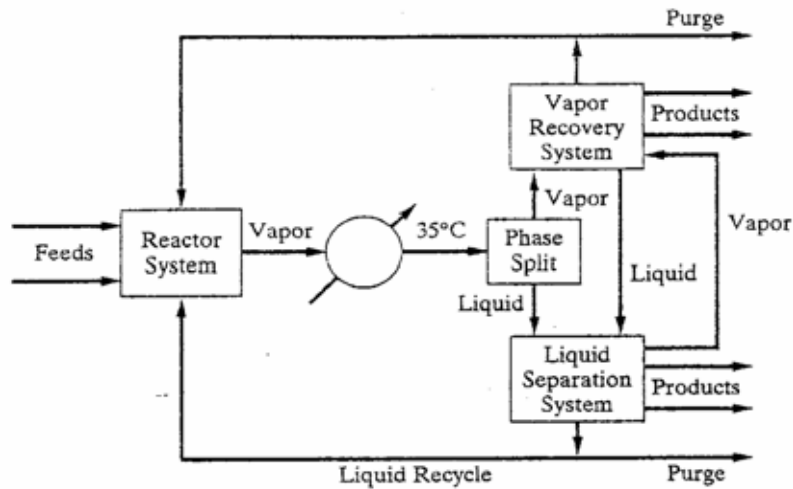
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Basic Configuration of Chemical Process

Feeds → [Reactor System] → Liquid → [Liquid Separation System] → Products

Liquid Recycle
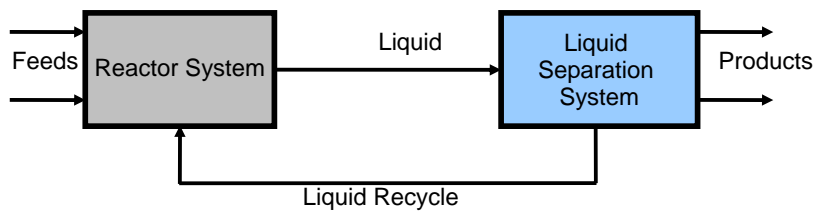
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Separation of Vapor Reactor Effluents


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- The liquid separation system involves one or more of the following separators:
  - distillation and enhanced distillation,
  - stripping,
  - liquid-liquid extraction,
  - and so on, with the unreacted chemicals recovered in a liquid phase and recycled to the reaction operation

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- For reaction products in the vapor phase, ==> partially condense them by cooling with cooling water or a refrigerant
- Cooling water can cool the reaction products typically to 35 ºC
- The usual objective is to obtain a liquid phase, which is easier to separate, without using refrigeration, which involves an expensive compression step.
- Unreacted chemicals are recycled to the reactor section and vapor products are removed
- A vapor purge is added when necessary to remove inerts that concentrate in the vapor and are not readily separated

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Separation of Vapor/Liquid Reactor Effluents

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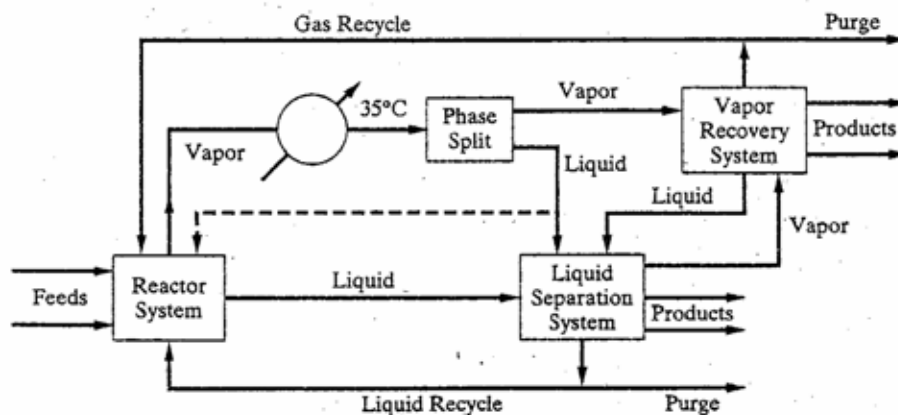
Heuristics

- Certain separation devices, i.e. membrane separators, are not considered for the separation of liquid
- To achieve a partial condensation, cooling water is utilized initially, rather than compression and refrigeration
- An attempt is made to partially condense the vapor products, but no attempts is made to partially vaporize the liquid products

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General Flowsheet for a Separation Process

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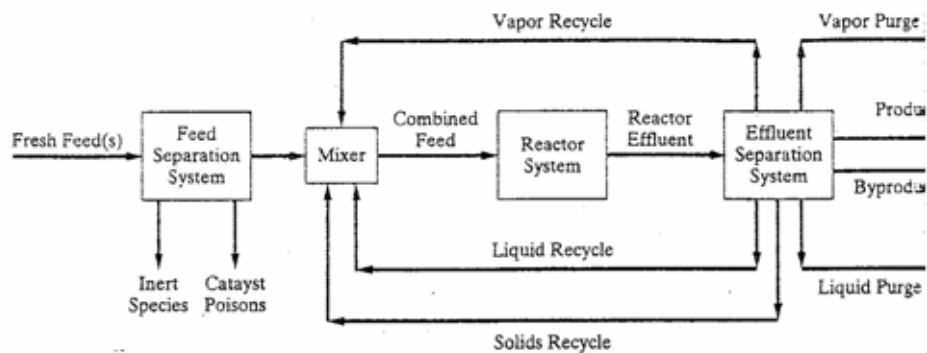
Phase Separation of Reacton Effluent

- Reactor effluent: homogeneous phase or heterogeneous phase
- Homogeneous phase ==> change Temperature and/or Pressure ==> to obtain partial separation of heterogeneous mixture
- Three-phase model considers the possibility that a vapor may also be present, together with two liquid phases
- If solids are present with one or two liquid phases, it is not possible to separate completely the solids from the liquid phase(s).
- Instead, a centrifuge of filter is used to deliver a wet cake of solids
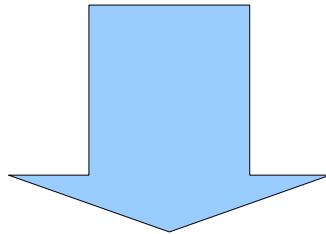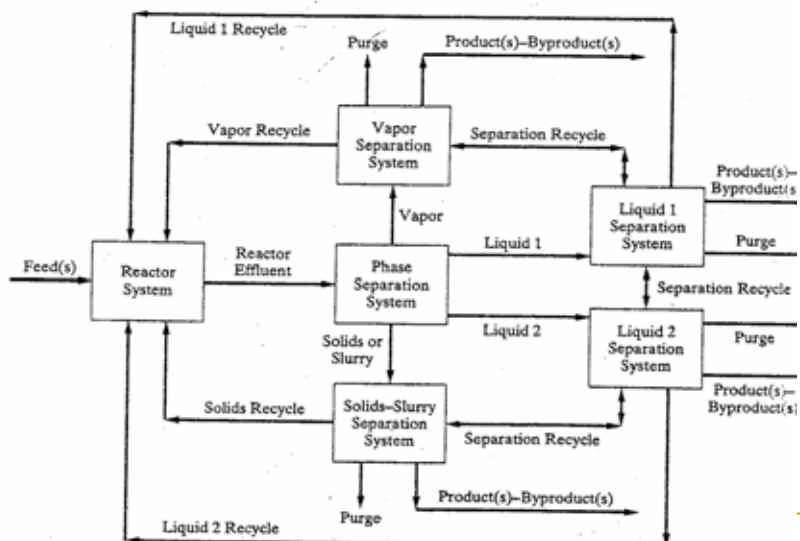
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Various Phase-Separation Devices

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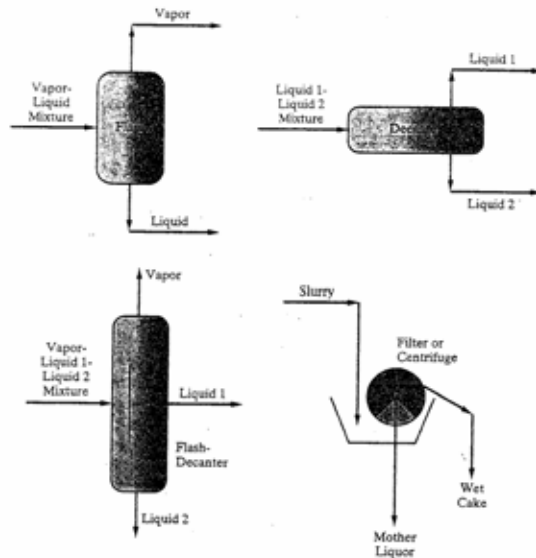
- Each exiting phase is either:
  - recycled to the reactor
  - purged from the system
  - sent to separate vapor, liquid, or slurry separation systems

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## Separate Separation Systems with Reactor-system and Separation-System Recycles

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- The effluents from these separation systems are:
  - products, which are sent to storage
  - byproducts, which leave the process
  - reactor-system recycle streams, which are sent back to the reactor
  - separation-system recycle streams, which are sent to one of the other separation systems
- Purges and byproducts are either additional valuable products, which are sent to storage
- Fuel byproducts, which are sent to a fuel supply or storage system
- Waste stream, which are sent to waste treatment, incineration, or landfill

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Example: hydrodealkylation of toluene to benzene

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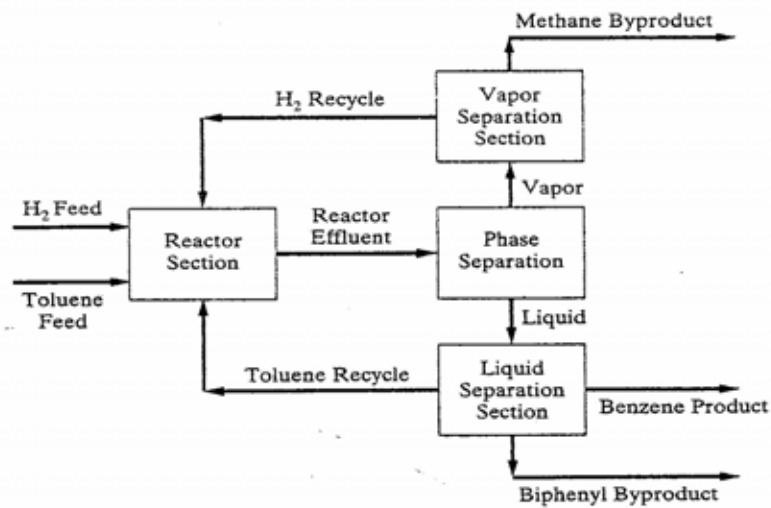
Factors for Separation Selection

- Phase condition of the feed
- Separation Factor (SF)

$$SF = y_1/x_1 / y_2/x_2 = K_1/K_2 = \alpha_{1,2}$$

- Reason for Separation
  - purification
  - removal of undesirable components
  - recovery

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Sequencing of Ordinary Distillation Columns

- The relative volatility between the two selected key components for the separation in each column is >1.05
- The reboiler duty is not excessive. (low relative volatility ==> high duty reboiler)
- The tower pressure does not cause the mixture to approach its critical temperature
- The overhead vapor can be at least partially condensed at the column pressure to provide reflux without excessive refrigeration requirements
- The bottoms temperature for the tower pressure is not so high that chemical decomposition occurs
- Azeotropes do not prevent the desired operation
- Column pressure drop is tolerable, particularly if operation is under vacuum

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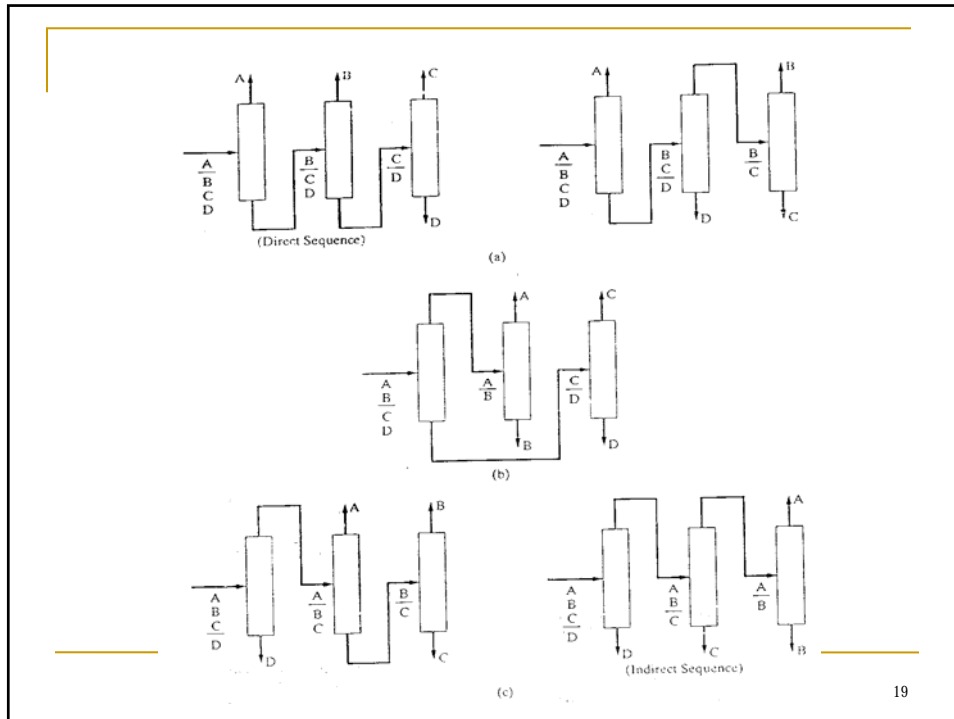
Heuristics for Determining Favorable Sequence ==> Economic

- Remove thermally unstable, corrosive, or chemically reactive components early in the sequence
- Remove final products one by one as distillates
- Sequence separation points to remove, early in the sequence, those components of greatest molar percentage in the feed
- Sequence separation points in the order of decreasing relative volatility so that the most difficult splits are made in the absence of other components
- Sequence separation points to leave last those separations that give the highest purity products
- Sequence separation points that favor near equimolar amounts of distillate and bottoms in each column
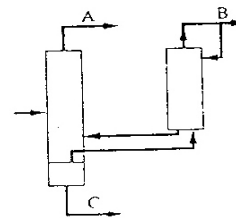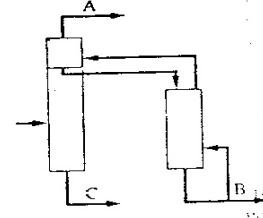
Configuration of Ternary Distillation
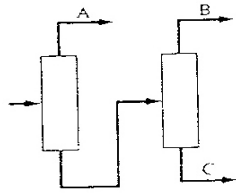
I. Direct Sequence
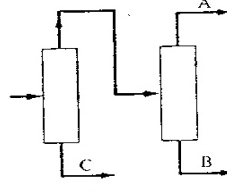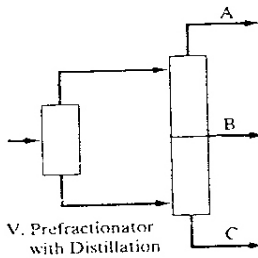
II. Indirect Sequence

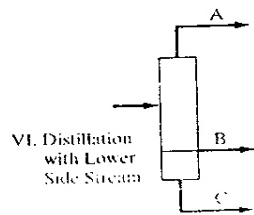III. Distillation with Vapor Side Stream Rectifier

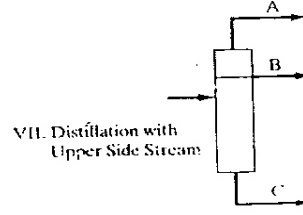IV. Distillation with Liquid Side Stream Stripper

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V. Prefractionator with Distillation

VI. Distillation with Lower Side Stream

VII. Distillation with Upper Side Stream

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- Example 5.2 Page 154-155

TUGAS KE-2
Perancangan Proses Kimia

- Mahasiswa dibagi menjadi 5 kelompok
- Tiap kelompok harus menyelesaikan tugas berikut ini menggunakan CHEMCAD:
    - Buatlah Perancangan sistem pemisahan untuk campuran multikomponen yang mengandung **bahan-bahan non-azeotrop dan azeotrop**
    - Setiap kelompok tidak boleh menampilkan campuran yang sama
    - Setiap kelompok diharapkan menampilkan sistem pemisahan yang berbeda-beda
    - Jelaskan analisis tentang: urut-urutan sistem pemisahan, target yang dapat dicapai, keunggulan dan kelemahan sistem pemisahan yang diusulkan
    - Buatlah dalam bentuk Laporan Kajian beserta hasil simulasinya