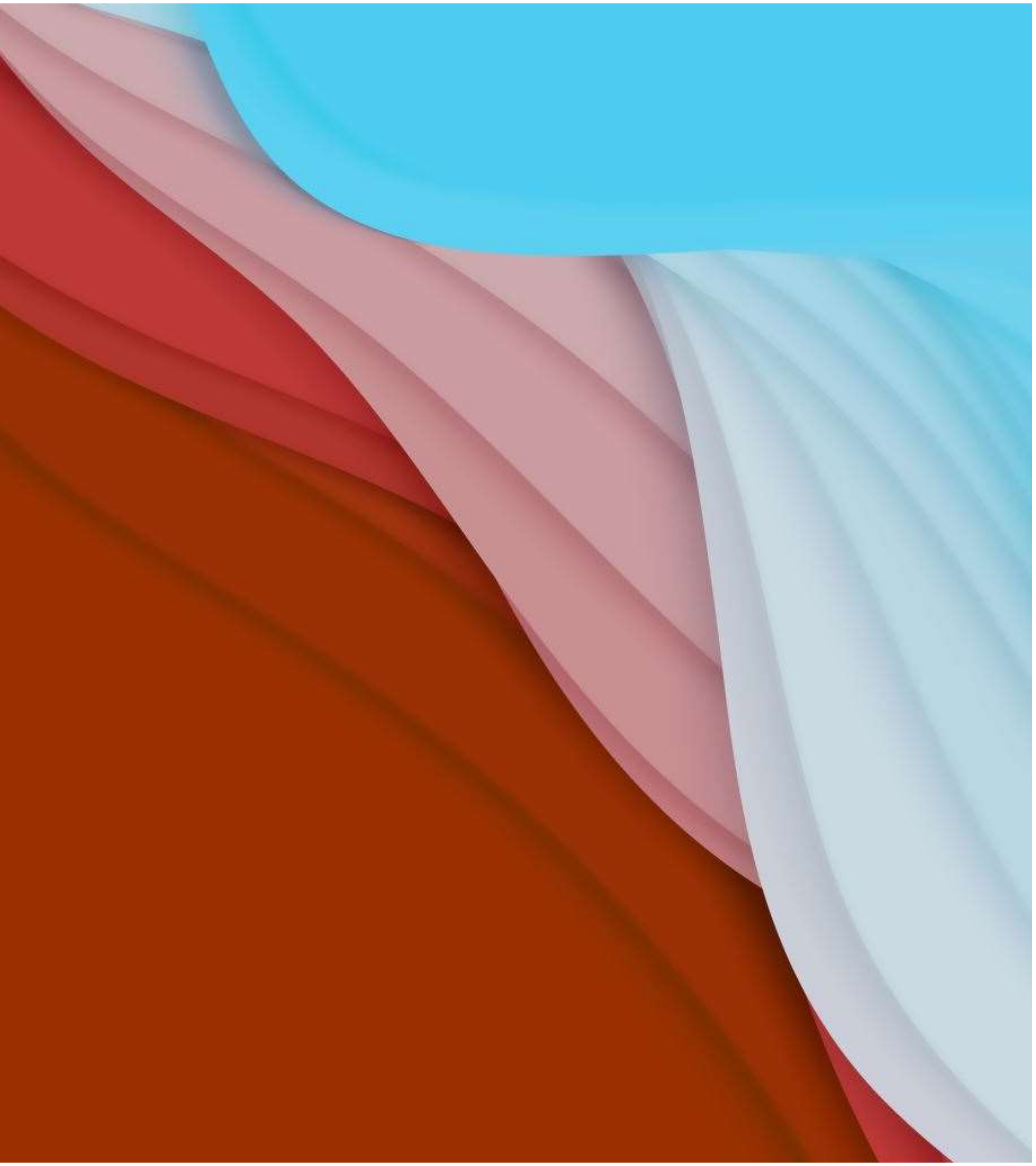

CEN416
PROCESS DESIGN II

“Short-cut" Methods

The short-cut methods available can be divided into two classes:

1. **Simplifications of the rigorous stage-by-stage procedures** to enable the calculations to be done using hand calculators, or graphically.

2. **Empirical methods**, which are based on the performance of operating columns, or the results of rigorous designs.

“Key” Components

The **light key** will be the component that it is desired to keep out of the bottom product, and the heavy key the component to be kept out of the top product.

The keys are known as "adjacent keys" if they are "adjacent" in a listing of the components in order of volatility, and "split keys" if some other component lies between them in the order; they will usually be adjacent.

Heuristic rules for optimum sequencing

1. *Remove the components one at a time.*

2. Remove any components that are present in large excess early in the sequence.

3. With difficult separations, involving close boiling components, postpone the most difficult separation to late in the sequence.

Hengstebeck's method

For any component *i* the Lewis-Sorel material balance equations and equilibrium relationship can be written in terms of the individual component molar flow rates; in place of the component composition:

Rectifying section

$$v_{n+1,i} = l_{n,i} + d_i$$

$$v_{n,i} = K_{n,i} \frac{V}{L} l_{n,i}$$

Stripping section

$$l'_{n+1,i} = v'_{n,i} + b_i$$

$$v'_{n,i} = K_{n,i} \frac{V'}{L'} l'_{n,i}$$

where $l_{n,i}$ = the liquid flow rate of any component i from stage n,
$v_{n,i}$ = the vapour flow rate of any component i from stage n,
d_i = the flow rate of component i in the tops,
b_i = the flow rate of component i in the bottoms,
$K_{n,i}$ = the equilibrium constant for component i at stage n.

Hengstebeck's method

The method used to estimate the limiting flow-rates is that proposed by Jenny (1939). The equations are:

Rectifying section

$$\underline{l_i} = \frac{d_i}{\alpha_i - 1} \quad (11.50)$$

$$\underline{v_i} = l_i + d_i \quad (11.51)$$

Stripping section

$$\underline{v'_i} = \frac{\alpha_i b_i}{\alpha_{LK} - \alpha_i} \quad (11.52)$$

$$\underline{l'_i} = v'_i + b_i \quad (11.53)$$

where α_i = relative volatility of component i, relative to the heavy key (HK),
α_{LK} = relative volatility of the light key (LK), relative to the heavy key.

Bubble and Dew Point Calculations

Equilibrium relationships

$$\begin{cases} y_i = K_i x_i \\ \sum_{i=1}^{c} y_i = 1 \qquad (i = 1, 2, \ldots, c) \\ \sum_{i=1}^{c} x_i = 1 \end{cases}$$

Bubble point temperature (x_i known):

$$\sum K_i(T)x_i = 1 \quad \Rightarrow \quad f(T) = \sum_{i=1} K_i(T)x_i - 1$$

Dew point temperature (y_i known):

$$\sum_{i=1}^{c} y_i \Big/ K_i(T) = 1 \quad \Rightarrow \quad f(T) = \sum_{i=1}^{c} y_i \Big/ K_i(T) - 1$$

REFERENCES

1. Sinnot, R.K. 1999, Coulson's & Richardson's Chemical Engineering, Volume 6, Chemical Engineering Design, ButterWorth Heinemann, Oxford.

2. Turton R., Bailie R.C., Whitin W.C., Shaeiwitz J.A. 1998, Analysis, Synthesis and Design of Chemical Processes, Prentice Hall, New Jersey.