5-1

Multicomponent Distillation

Unfortunately, the Seader book does not cover the important cases of multicomponent distillation except to describe full blown rigorous mathematical models which require sophisticated simulators to solve. Students are directed to Ch 10 p 526-578 to become acquainted with the names of these methods.

Equation-Teaking Procedures
- Tridiagonal Matrix Algorithm (TMA)
- Bubble point method (BP)
- Sum Rate Methods (SR)

Simultaneous Correction Procedures
- Inside-Out Method
- MESH equations

Since we do not have convenient access to adequate computer facilities, we will look at the more traditional manual methods described in Wankat.

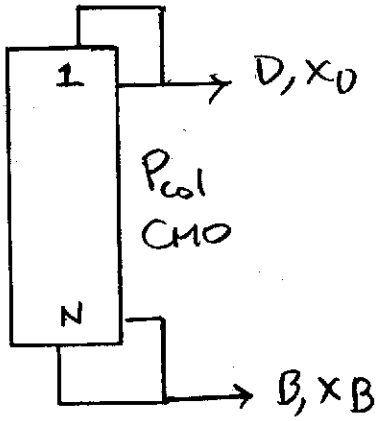
5-2

Binary distillation (especially for ideal cases – CMO) is straightforward.

In multicomponent distillation, we have significant additional complexity and loss of straightforwardness.

Calculation Difficulties

"BINARY"



$N = 2$
comp
DOF = 8

Typically
F
z
q_F
x_D
x_B
$L_o/D = R$
Use opt feed stage.

8 givens

With this information, we can employ the MT method. We can determine N_{stage}, all stage compositions (x_j, y_j), flowrates.

5-3

Consider $N_{comp} = 3$ DOF = 9

$F, (z_1, z_2), q_F, x_{D_i}, y_{D_i},$

$L_o/D = R$, opt feed

9 Givens

where $i = 1|2|3$

Problem: We have made all specifications possible (there is a solution) but we do not know the complete top or bottom composition necessary to begin stepping down or up.

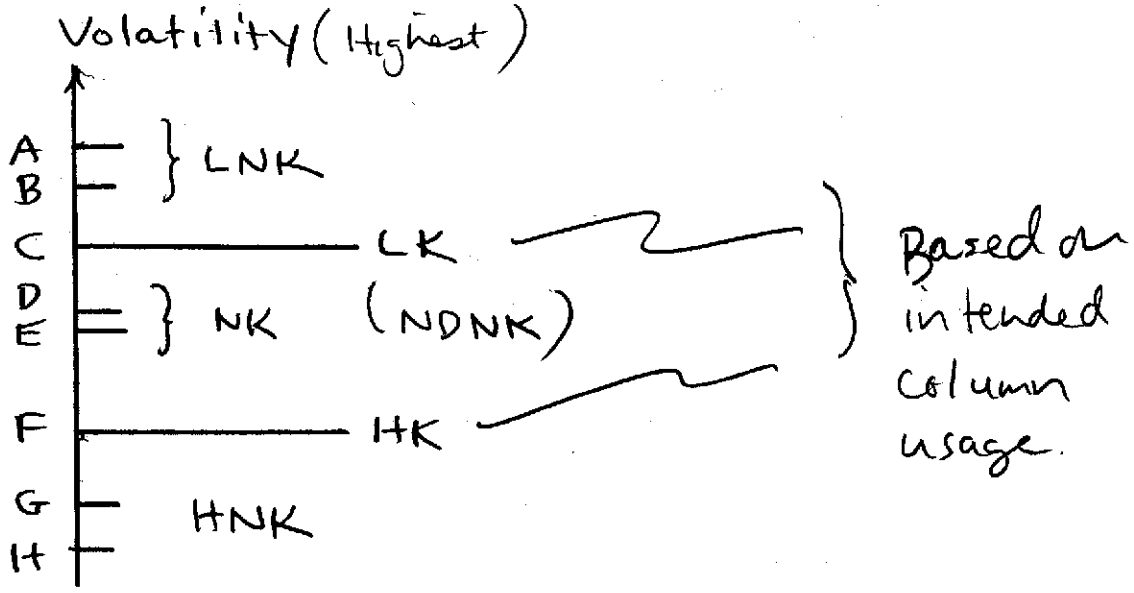
That is, if $i = 3$ we don't know

$$x_{D_1}, x_{D_2}, x_{B1}, x_{B2}$$

The solution? We must find a way (independent) to learn the values we need.

In order to learn the "behavior" of all remaining components, we resort to the concept of "key" components which we discussed earlier.

5-4



Principle Relationships Available

External Balances

$$F = B + D$$

$$Fz_i = BX_{B_i} + DX_{D_i} \qquad i = 1, 2, \ldots, c$$

Energy Balance

$$Fh_F + Q_C + Q_R = Bh_B + Dh_D$$

Stoic

$$\sum x_{D_i} = 1 \qquad \sum x_{B_i} = 1$$

Recall in Binary Distillation, we first performed an external balance to establish B & D. In multi component distillation, this is not possible (in complete knowledge of

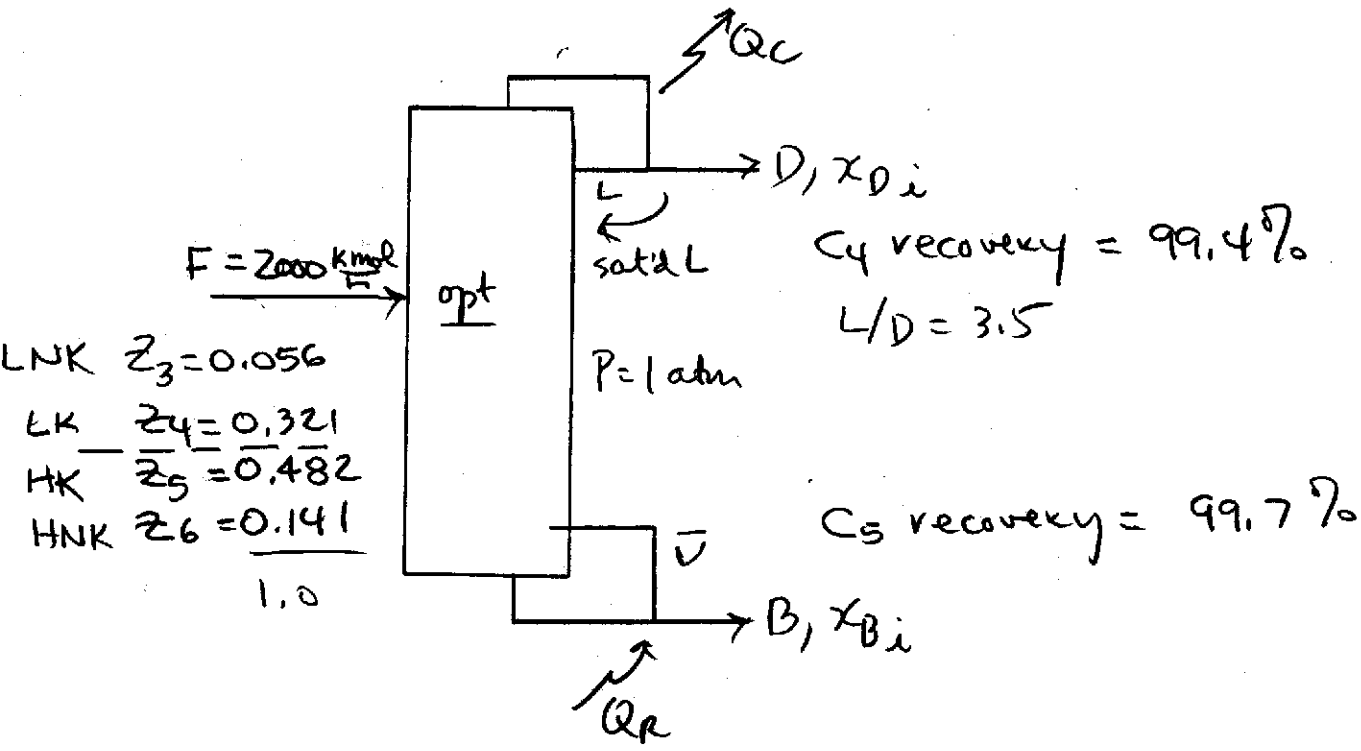
5-5

product stream compositions
(Difference # 1)

Difference #2 - to start MCD, we must assume a complete composition at one end of the column. The solution then involves trial and error (Difference #3) and a suitable condition must be established to check the assumed values.

Special cases. If only LNK's or HNK's are present (without NDNK's) the process is fairly straight forward. If this is not true, the rigorous methods from Ch 10 must be employed.

Example



5-6

Solution "A priori" we assume

all LNK goes to D
" HNK " " B.

"the sharper the separation between LK & HK, the more accurate this assumption is"

" Going to D we have

$DX_{D_3} = 2000(0.056) =$ 112 kmol/h "all"
$DX_{D_4} = 2000(0.321)(.994) =$ 638.5 " LK
$DX_{D_5} = 2000(0.482)(1-0.997) =$ 2.89 " HK
$DX_6 = 2000(0.141)(0) =$ 0 " "none"

$\Sigma = D =$ 753.39 kmol/h

Hence, compositions at top are:

$\frac{DX_{D_3}}{D} =$ 112/753.39 = 0.1487

$X_{D_4} =$ 0.8474
$X_{D_5} =$ 0.0038
$X_{D_6} =$ 0

$\Sigma = 0.9999$

5-7

Using techniques from BD

if TC:

$$x_{Di} = y_{1i}$$

$$x_{1i} = y_{1i} / K_{1i}$$ ← if independent of composition.

$$y_{2i} = \frac{L}{V} x_{1i} + \left(1 - \frac{L}{V}\right) x_{Di}$$

↖ TOL

$$x_{2i} = y_{2i} / K_{2i}$$

etc