COLUMN: SPECIFICATION AND VARIABLES

Consider a column with N_T trays
N_C components

EQUATIONS:

1) Steady state mass balances for all components in all trays

$$L_{j-1}\, x_{j-1,i}-[(L_j+LD_j)x_{j,i}+(V_j+VD_j)y_{j,i}]+V_{j+1}y_{j+1,i}+F_jz_i=0 \qquad i=1,..,N_C \quad j=1,..., N_T$$

L= Liquid rates
LD= Liquid Draw rates
x= liquid compositions
z= feed composition

V= Vapor rates
VD= Vapor Draw rates
y=vapor compositions

2) Equilibrium Relations

$$y_{j,i}=K_{j,i,}(x_j, T_j, P_j)x_{j,i} \qquad i=1,..,N_C \quad j=1,..., N_T$$

3) Summation equations

$$\sum_{i=1}^{N_C} x_{j,i}= 1 \qquad j=1,..., N_T$$

$$\sum_{i=1}^{N_C} y_{j,i}= 1 \qquad j=1,..., N_T$$

3) Enthalpy balance in each tray

$$L_{j-1}\, h_{j-1}-[(L_j+LD_j)h_j+(V_j+VD_j)H_j]+V_{j+1}H_{j+1}+F_jH_F=0 \qquad j=1,..., N_T$$

h: liquid enthalpy
H_F: Enthalpy of feed

H: Vapor enthalpy

Total number of equations: $\mathbf{N_T(3+2N_C)}$

VARIABLES

1) For each tray (excluding condenser and reboiler):

T_j , L_j , V_j , $x_{j,i}$, $y_{j,i}$ Variables= $3(N_T -2) + 2 (N_T-2)(2 N_C)$

2) For the condenser (temperature, flows, compositions and duty)

T_1 , L_1 , D , $x_{1,i}$, $y_{1,i}$, Q_C Variables= $3+ 2 N_C+1$

3) For the reboiler (temperature, flows, compositions and duty)

T_{Nc} , V_{Nc} , B , $x_{Nc,i}$, $y_{Nc,i}$, Q_R Variables= $3+ 2 N_C+1$

***Total number of Variables*: $N_T(3+2N_C)+2$**

***Unknowns- equations* = 2**

Therefore two specifications are needed : Either through fixing some values

- **Temperature of trays**
- **Composition of products**
- **Flowrate of product streams**

or by adding some equations.

- **Flowrate of component A in top product/Flowrate of component A in Feed**
- **Reflux ratio**

TIPS FOR DISTILLATION COLUMN SETUP

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 ALL OF THEM AT THE BEGINNING. START WITH A FEW ABUNDANT COMPONENTS.**

3. **RUN AN ADIABATIC FLASH FIRST. IF THE FEED IS NOT TWO PHASE AT THE DESIRED PRESSURE, PUT AN ISOTHERMAL FLASH. CHANGE THE TEMPERATURE UNTIL YOU GET SOME SEPARATION IN THE DIRECTION YOU WANT.**

   To do this, list the components in increasing NBP and determine your key components. The light goes through the top and the heavy key component goes through the bottom

4. **REPLACE THE FLASH BY A COLUMN WITH THREE PLATES. USE BOTTOM SPEC SIMILAR (A LITTLE MORE TIGHT) TO THE GIVEN BY THE FLASH OUTLET STREAM OR USE RECOVERY RATIO. SPECIFY SOME REFLUX RATIO. Be careful with the use of a total condenser if you have inert or highly volatile compounds.**

5. **ADD MISSING COMPONENTS. INCREASE SLOWLY THEIR CONCENTRATION.**

6. **KEEP TIGHTENING THE BOTTOM SPEC AND ADJUSTING THE REFLUX RATIO AS WELL AS INCREASING THE NUMBER OF TRAYS SO YOU MEET THE SEPARATION YOU WANT WITH A REASONABLE REFLUX RATIO.**