Mass Transfer Operations
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Module - 4
Absorption
Lecture -6
Tray Tower Design and Introduction to Multicomponant System

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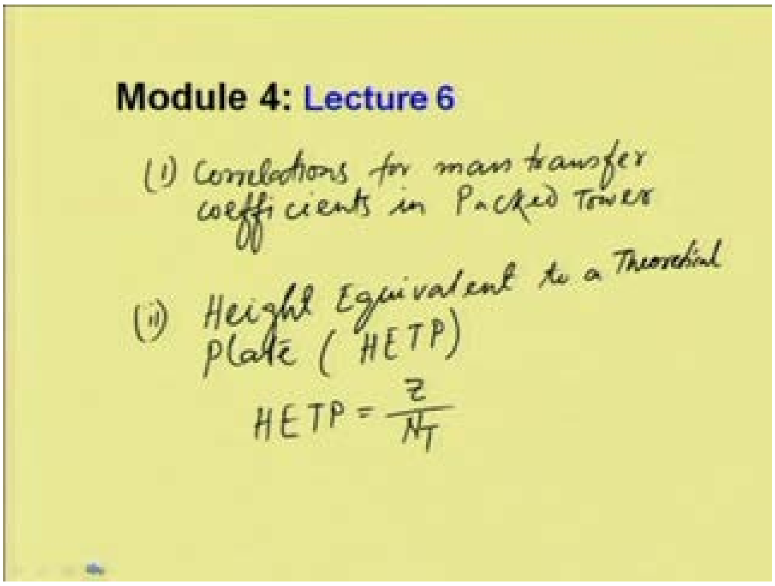

Module 4: Lecture 6

(i) Correlations for mass transfer coefficients in Packed Tower

(ii) Height Equivalent to a Theoretical plate (HETP)

$$HETP = \frac{z}{N_T}$$

Welcome to the sixth lecture of module four. The module four is on Absorption. In our previous lecture, we have discussed the different correlations for mass transfer coefficients in Packed Towers. And another topic we have discussed is the height equivalent to a theoretical Plate. So, that is we called HETP concept. HETP is basically the ratio of height of packing in a packed tower with the number of ideal plates required to do a given job. HETP is equal to z by NT. In this lecture, we will discuss the tray tower design, absorption in tray towers.

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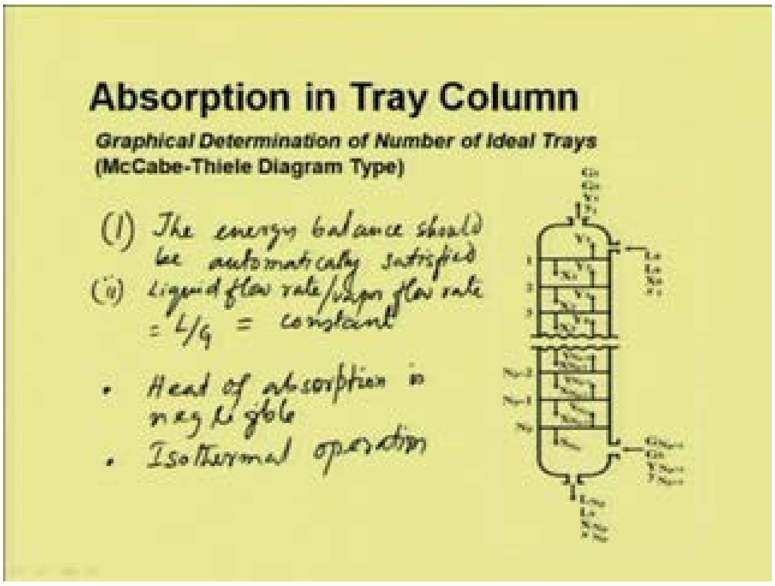

Absorption in Tray Column

Graphical Determination of Number of Ideal Trays

(McCabe-Thiele Diagram Type)

(I) The energy balance should be automatically satisfied

(ii) Liquid flow rate/vapor flow rate $= L/G =$ constant

- Heat of absorption is negligible
- Isothermal operation

We will discuss the McCabe-Thiele method of diagram where we can calculate graphically the number of ideal trays required to do a given job. This McCabe-Thiele method of operations is applicable only when the operating line for an observer is straight. This is a plate columns for an observer, where we have used N P number of trays and they inlet of gas and liquid is shown over here, it is counter current flow and the gas which is coming out at the top of the tower and the liquid which is coming out at the bottom of the tower is given. The trays are numbered from the top to bottom.

And for the McCabe-Thiele diagram we require that the operating line should be straight and this require two important assumptions: one is the energy balance should be automatically satisfied, and second assumption is that the liquid flow rate by vapor flow rate; that means, L by G should be constant. In order to satisfy the first assumption that is the energy balance should be automatically valid, it requires that the heat of the absorption is negligible and the operation is Isothermal, Isothermal operation. And this is usually valid when the gas and liquid streams are both purely dilute solutions; in that case these assumptions are valid.

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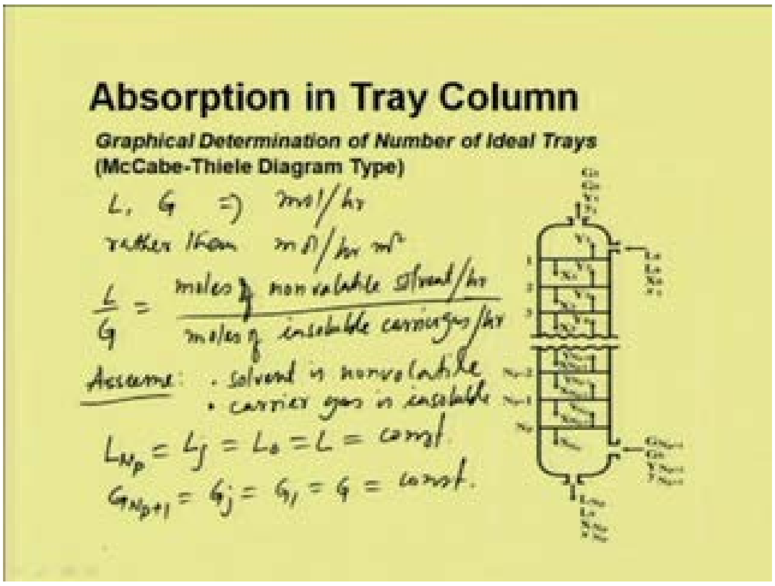

Absorption in Tray Column

Graphical Determination of Number of Ideal Trays (McCabe-Thiele Diagram Type)

L, G ⇒ mol/hr

rather than mol/hr m²

$$\frac{L}{G} = \frac{\text{moles of nonvolatile solvent/hr}}{\text{moles of insoluble carrier gas/hr}}$$

Assume:
- solvent is nonvolatile
- carrier gas is insoluble

$L_{N_p} = L_j = L_0 = L = \text{const}$

$G_{N_p+1} = G_j = G_1 = G = \text{const.}$

If you define the flow rates, for liquid is L and for gas is G, in terms of mol per hour this will be convenient rather than per unit cross sectional area, hour meter square. We also desire that the operating line should be straight and this will be true only when if you define L by G is equal to moles of nonvolatile solvent that is per hour divided by moles of insoluble carrier gas per hour. We have to assume solvent is nonvolatile and second carrier gas is insoluble. Based on this two assumptions we can write L N P liquid outlet, L N P from n plate would be equal to L j j at any plate liquid flow rate will be equal to L G row which will be equal to L and equal to constant. Similarly if you do the mass balance for career gas then G N P plus 1 would be G j would be G 1 would be G is equal to constant.

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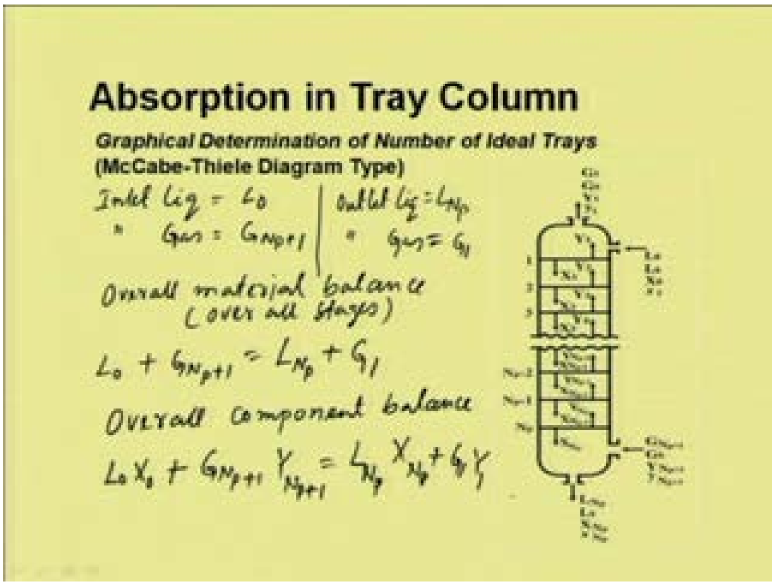

Absorption in Tray Column

Graphical Determination of Number of Ideal Trays
(McCabe-Thiele Diagram Type)

Inlet Liq = L_0 | Outlet Liq = L_{N_p}
" Gas = G_{N_p+1} | " Gas = G_1

Overall material balance
(over all stages)

$L_0 + G_{N_p+1} = L_{N_p} + G_1$

Overall component balance

$L_0 X_0 + G_{N_p+1} Y_{N_p+1} = L_{N_p} X_{N_p} + G_1 Y_1$

Now, we will derive the general equations for this general flow diagram. Inlet liquid is L 0, inlet gas is G N P plus 1. The outlet liquid is equal to L N P and outlet gas is G 1. So, making an overall material balance, over all stages, we can write L 0 plus G N P plus 1 is equal to L N P plus G 1. And overall component balance would be L 0 X naught plus G N P plus 1 Y N P plus 1 is equal to L N P X N P plus G 1 Y 1. Capital X and capital Y are the mole ratios.

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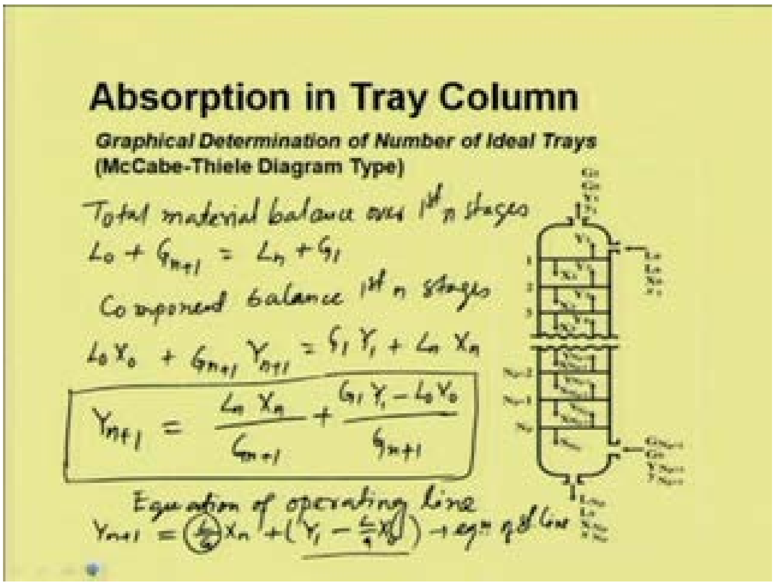

Absorption in Tray Column

Graphical Determination of Number of Ideal Trays
(McCabe-Thiele Diagram Type)

Total material balance over 1st n stages

$L_0 + G_{n+1} = L_n + G_1$

Component balance 1st n stages

$L_0 X_0 + G_{n+1} Y_{n+1} = G_1 Y_1 + L_n X_n$

$$\boxed{Y_{n+1} = \frac{L_n X_n}{G_{n+1}} + \frac{G_1 Y_1 - L_0 X_0}{G_{n+1}}}$$

Equation of operating line

$Y_{n+1} = \left(\frac{L_n}{G_{n+1}}\right) X_n + \underline{\left(Y_1 - \frac{L_0}{G_{n+1}} X_0\right)} \rightarrow$ eqn of line

If we do the total material balance over first n stages we can write L naught plus G n plus 1 is equal to L n plus G 1. And if we do a component balance over the first n stages it will give L naught X naught plus G n plus 1 capital Y n plus one is equal to G one Y one plus L n X m now if we solve for Y n plus 1 Y n plus 1 this would be L n X n divided by G n plus 1 plus G 1 Y 1 minus L naught X naught divided by G n plus 1. This is the very important material balance equations for a tray absorber and this is known as the equation of operating line.

Now, if we apply the earlier assumptions, the assumption is that constant molar over flow rate that is all L will be constant and G will be constant. If we apply that then we can write Y n plus 1 would be equal to L by G X n X n plus Y 1 minus L by G X naught, this is the equation of a straight line with a slope of L by G and intercept of Y 1 minus L by G X naught and if we plot Y verses X it will generate the McCabe-Thiele type of diagram.

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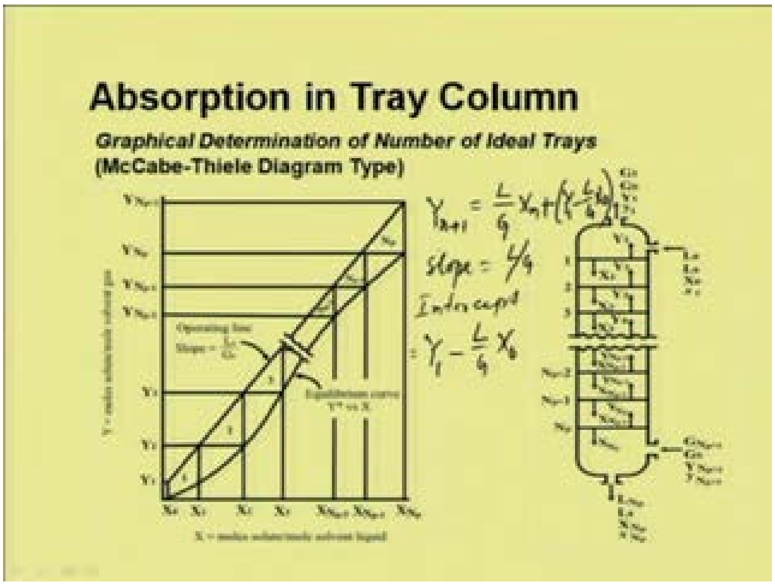

Absorption in Tray Column

Graphical Determination of Number of Ideal Trays

(McCabe-Thiele Diagram Type)

$Y_{n+1} = \frac{L}{G} X_n + \left(Y_1 - \frac{L}{G} X_0\right)$

$slope = L/G$

Intercept

$= Y_1 - \frac{L}{G} X_0$

This is the diagram. So, we have the equations Y n plus 1 is equal to L by G into X n plus Y 1 minus L by G X naught and slope is L by G or L S by G S, and intercept is Y 1 minus L by G X naught. This is the equations operating line and this is an equilibrium line. To solve McCabe-Thiele diagram for a particular system we should have the equilibrium data of the solutes in the gas and the liquid phases.

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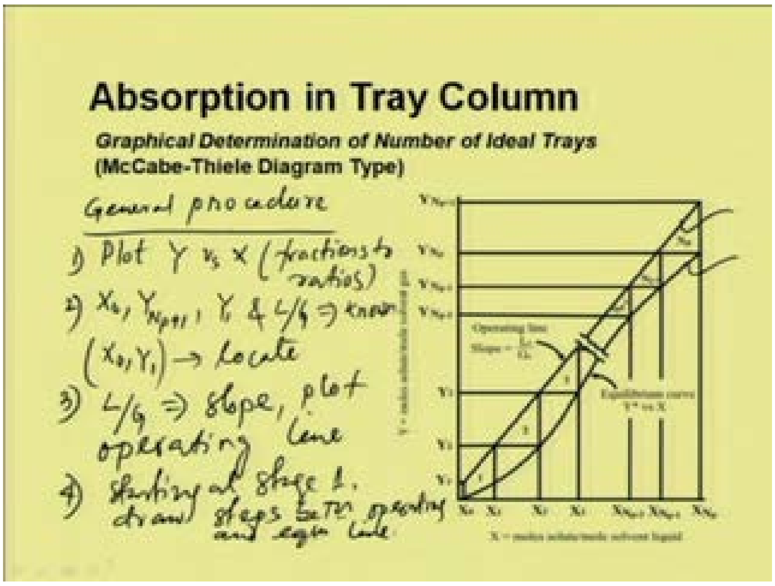

Absorption in Tray Column

Graphical Determination of Number of Ideal Trays
(McCabe-Thiele Diagram Type)

General procedure

1) Plot Y vs X (fractions to ratios)
2) X_0, Y_{Np+1}, Y_1 & L/G ⇒ known
(X_0, Y_1) → locate
3) L/G ⇒ slope, plot operating line
4) starting at stage 1. draw steps betn operating and eqm line

The general procedure to follow for the McCabe-Thiele diagram. General procedure: first we have to plot equilibrium line Y verses capital X and here we have to convert mol fraction to mol ratio, second we know the value of X naught Y N P plus 1 Y 1 and L by G these are known. So, first this equilibrium line is drawn and then we know this data. Then from point X naught Y1 we can get the point over here. Locate this L by G is the slope. So, plot operating line. This is the operating line. And then from stage draw one line; so then equilibrium, then operating, and then equilibrium. This will give a stage, number of stages required between operating and equilibrium line.

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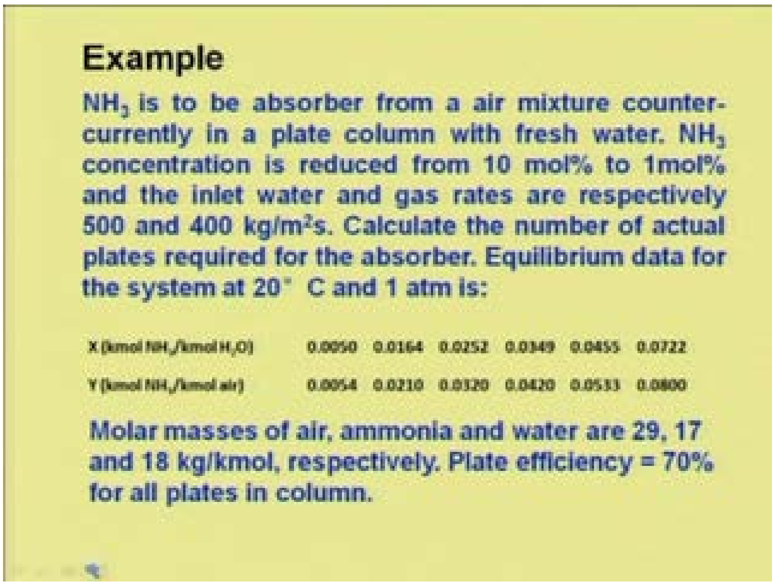

Example

NH_3 is to be absorber from a air mixture counter-currently in a plate column with fresh water. NH_3 concentration is reduced from 10 mol% to 1mol% and the inlet water and gas rates are respectively 500 and 400 kg/m²s. Calculate the number of actual plates required for the absorber. Equilibrium data for the system at 20° C and 1 atm is:

X (kmol NH_3/kmol H_2O)	0.0050	0.0164	0.0252	0.0349	0.0455	0.0722
Y (kmol NH_3/kmol air)	0.0054	0.0210	0.0320	0.0420	0.0533	0.0800

Molar masses of air, ammonia and water are 29, 17 and 18 kg/kmol, respectively. Plate efficiency = 70% for all plates in column.

Now, let us take an example how to solve using the McCabe-Thiele diagram. Here ammonia is to be observed from air mixture counter currently in a plate column, similar to the earlier example we have discussed in case of packed column. Ammonia concentration is to be reduced from 10 mol percent to 1 mol percent and the inlet water and gas rate are respectively 500 and 400 kg per meter square second. Calculate the number of actual plates required for the observer. Equilibrium data for the system at 20 degree centigrade and at one atmosphere pressure which is given. And molar masses of air, ammonium and water are 29, 17 and 18 kg per k mol. And then plate efficiency is given as 70 percent for all plates in plate columns. We have to calculate the number of actual plates required for the absorbers.

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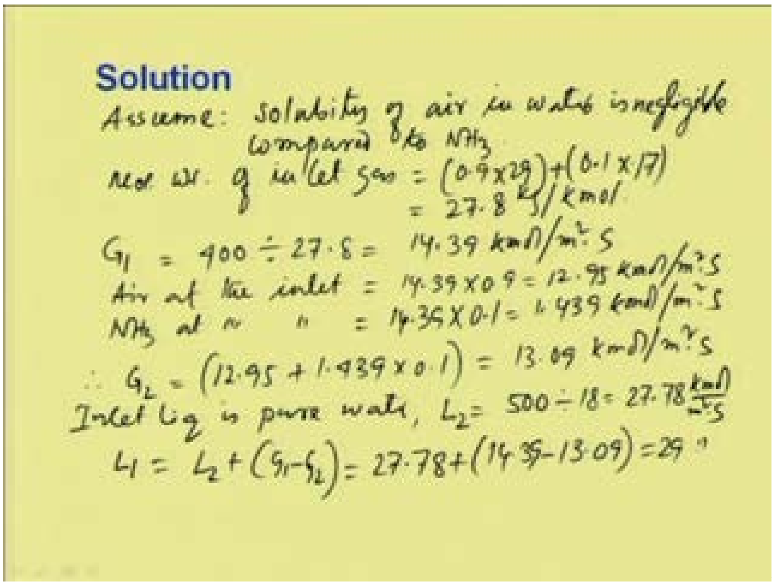

Solution

Assume: solubility of air in water is negligible compared to NH_3

Mol wt. of inlet gas $= (0.9 \times 29) + (0.1 \times 17)$
$= 27.8$ kg/kmol

$G_1 = 400 \div 27.8 = 14.39$ kmol/m^{2}s

Air at the inlet $= 14.39 \times 0.9 = 12.95$ kmol/m^{2}s

NH_3 at " " $= 14.39 \times 0.1 = 1.439$ kmol/m^{2}s

$\therefore G_2 = (12.95 + 1.439 \times 0.1) = 13.09$ kmol/m^{2}s

Inlet liq is pure water, $L_2 = 500 \div 18 = 27.78 \frac{\text{kmol}}{\text{m}^2\text{s}}$

$L_1 = L_2 + (G_1 - G_2) = 27.78 + (14.39 - 13.09) = 29$ "

Initially we have to calculate the number of ideal plates required. We assume that solubility of air in water is negligible, compared to ammonia. We can calculate the molecular weight of inlet gas, which is 90 percent air, 0.9 into 29 plus ten percent ammonia into 17 which is about 27.8 kg per k mol. Now, the gas flow rate G 1 would be 400 divided by the average molecular weight of the gas is 27.8 is equal to 14.39 k mol per meter square second. Now out of this 14.39, 90 percent is air. So the air at the inlet is equal to 14.39 into 0.9 is equal to 12.95 k mol per meter square second. Ammonia in the feet at the inlet is equal to 14.39 into 0.1 which is 1.439 k mol per meter square second, ammonia inlet rate. Then we can calculate G 2 which is air 12.95 plus 1.439 into 0.1. This is equal to 13.09 k mol per meter square second. The inlet liquid is pure water so L

2 would be 500 by 18 which is 27.78 k mol per meter square second. Therefore, L 1 would be L 2 plus G 1 minus G 2, which is equal to 27.78 plus 14.39 minus 13.09, which is equal to 29 k mol per meter square second.

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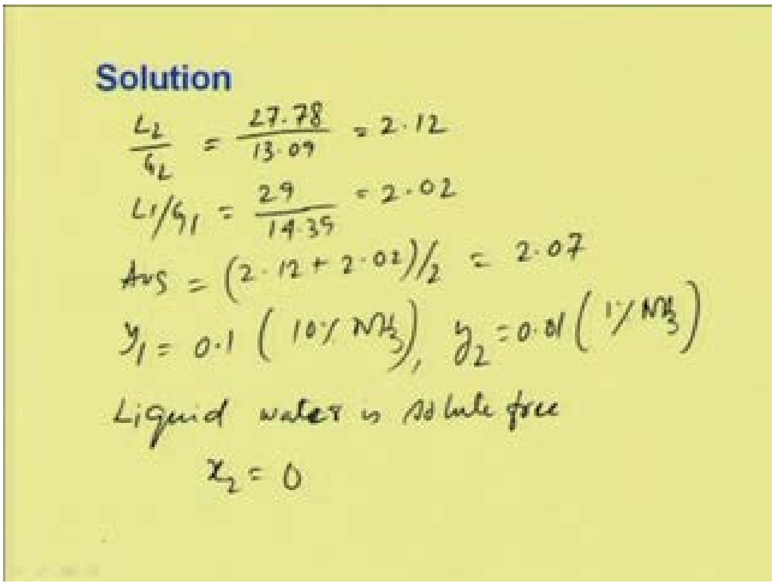

Solution

$\frac{L_2}{G_2} = \frac{27.78}{13.09} = 2.12$

$L_1/G_1 = \frac{29}{14.35} = 2.02$

$Avg = (2.12 + 2.02)/2 = 2.07$

$y_1 = 0.1$ (10% NH_3), $y_2 = 0.01$ (1% NH_3)

Liquid water is solute free

$x_2 = 0$

If we compare the liquid flow rate at the top and bottom of the tower, we can calculate L 2 by G 2 which would be 27.78 divided by 13.09 which is equal to 2.12, and L 1 by G 1 would be 29 divided by 14.39 would be equal to 2.02. The average would be 2.12 plus 2.02 divided by 2 which is around 2.07. With this ratio we can approximate that the average L by G would be 2.07, and we know that Y 1 is 0.1 which is ten percent ammonia and Y 2 is equal to 0.01 which is one percent ammonia and the liquid solvent is solute free, therefore x 2 would be 0.

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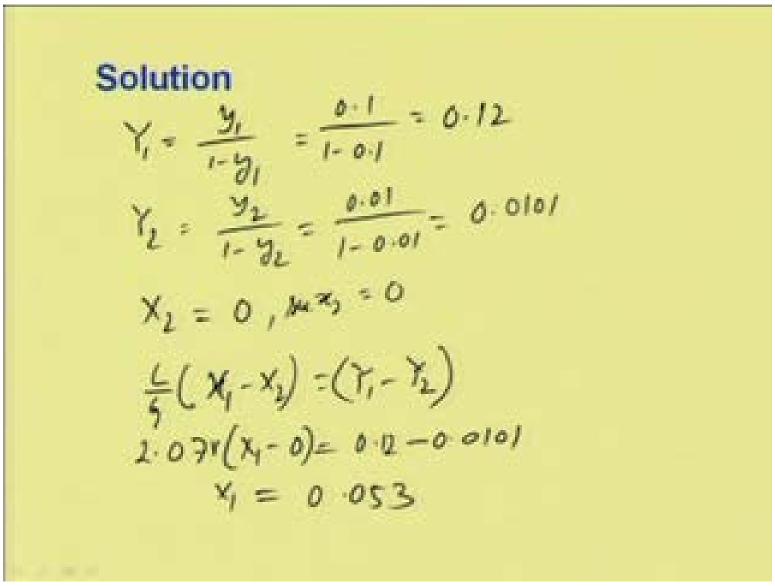

Solution

$Y_1 = \frac{y_1}{1-y_1} = \frac{0.1}{1-0.1} = 0.12$

$Y_2 = \frac{y_2}{1-y_2} = \frac{0.01}{1-0.01} = 0.0101$

$X_2 = 0$, as $x_2 = 0$

$\frac{L}{S}(X_1 - X_2) = (Y_1 - Y_2)$

$2.078(X_1 - 0) = 0.12 - 0.0101$

$X_1 = 0.053$

Now if we convert this two mol ratio we will have capital Y 1 would be y 1 by 1 minus y 1 which is equal to 0.1 divided by 1 minus 0.1 this is 0.12. And Y 2 would be y 2 divided by 1 minus y 2 would be 0.01 divided by 1 minus 0.01 which would be 0.0101. And capital X 2 would be 0, since x 2 is 0. If we do the overall material balance you can write the equation of the operating line L by G into X 1 minus X 2 would be Y 1 minus Y 2. From this we know this is 2.07 into X 1 minus 0 is equal to 0.12 minus 0.0101. So from this X 1 would be 0. 053.

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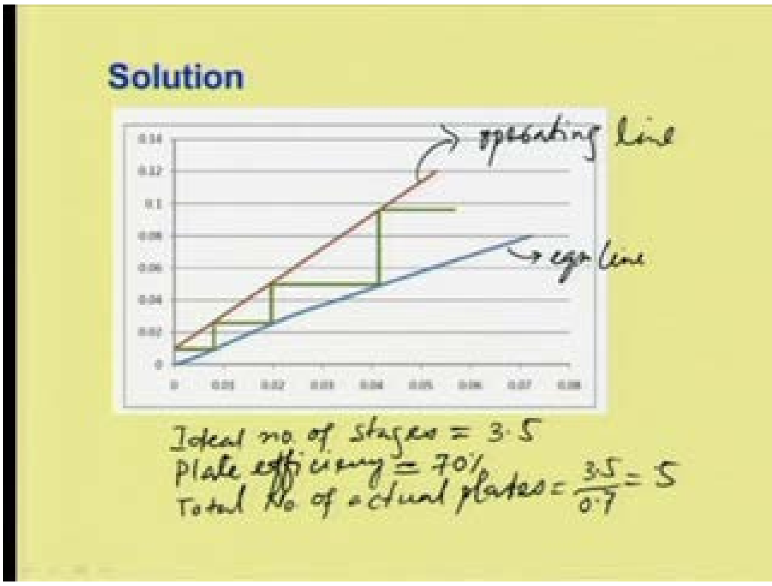

Solution

Ideal no. of stages = 3.5

Plate efficiency = 70%

Total No of actual plates = $\frac{3.5}{0.7} = 5$

Now, if we plot the graph between the operating line and equilibrium line, this is based on the equilibrium data which is given, this is equilibrium line and this is operating line. And if we draw line between equilibrium and operating line there will be ideal number of stages would be approximately equal to 3.5, and the plate efficiency is given which is equal to 70 percent. So total number of actual plates would be 3.5 divided by 0.7 which is 5. 5 numbers of stages are required.

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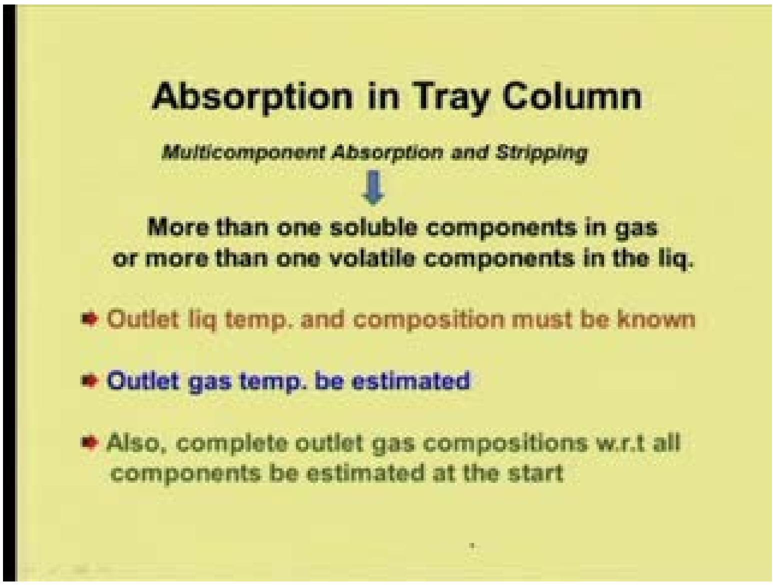

Absorption in Tray Column

Multicomponent Absorption and Stripping

⬇

More than one soluble components in gas or more than one volatile components in the liq.

- Outlet liq temp. and composition must be known
- Outlet gas temp. be estimated
- Also, complete outlet gas compositions w.r.t all components be estimated at the start

Now, we will discuss the absorption in tray columns where not single components, but multicomponents are involved. Multicomponent absorption stripping; when we see that there are more than one soluble components in gas or more than one volatile component in the liquid phase then this is multi component systems. And in this case for design the outlet liquid temperature as well as compositions must be known, outlet gas temperature should be estimated and complete outlet gas compositions with respect to all components be estimated at the beginning.

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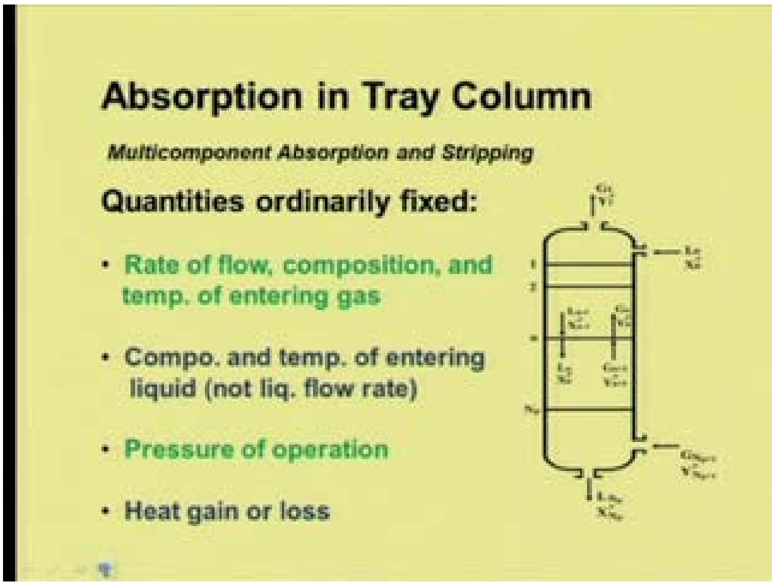

Absorption in Tray Column

Multicomponent Absorption and Stripping

Quantities ordinarily fixed:

- Rate of flow, composition, and temp. of entering gas
- Compo. and temp. of entering liquid (not liq. flow rate)
- Pressure of operation
- Heat gain or loss

The quantities which are generally fixed for any absorber design; first is the rate of flow compositions and temperature of the entering gas, then composition and temperature of an entering liquid, not the liquid flow rate. Then what pressure the column operates and third any heat loss or heat gain.

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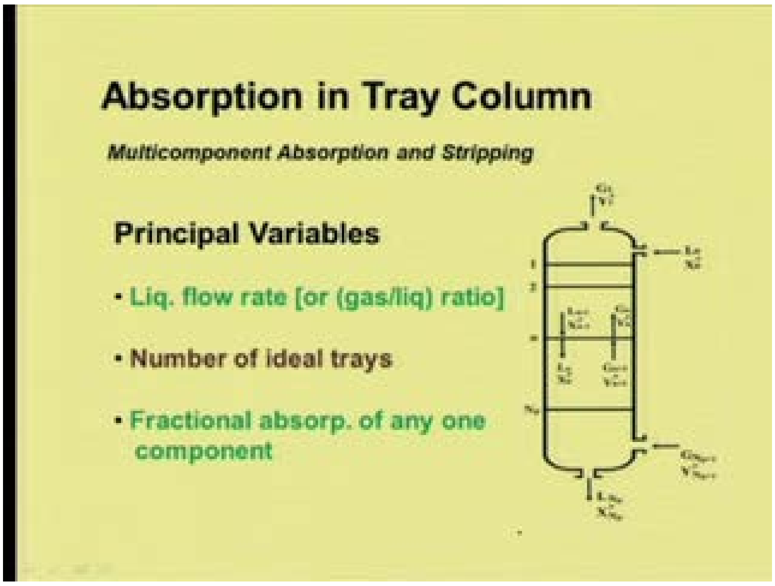

Absorption in Tray Column

Multicomponent Absorption and Stripping

Principal Variables

- Liq. flow rate [or (gas/liq) ratio]
- Number of ideal trays
- Fractional absorp. of any one component

So, the principle variables which are still remains are the liquid flow rate or the gas liquid ratio, the number of ideal trays and the fractional absorption of any one component. So, if we fix any of this two then the third will be automatically fixed.

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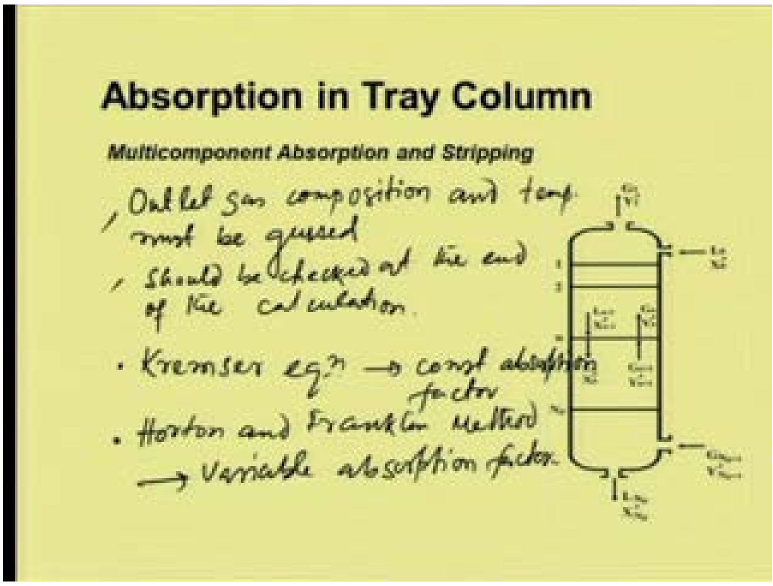

Absorption in Tray Column

Multicomponent Absorption and Stripping

- Outlet gas composition and temp. must be guessed
- Should be checked at the end of the calculation.
- Kremser eqn → const absorption factor
- Horton and Franklin method → variable absorption factor.

Now to do the design, the outlet gas compositions and temperature must be guessed. And this should be checked at the end of the calculation. This is not very simple procedure. So, until and unless we have some preliminary data or the basic guidelines to guess the compositions and the temperature, this is very difficult and very complicated procedure for doing the trial and error method. So, to get a basic idea and some approximate procedure are already discussed, like for constant absorption factor: one is the Kremser equations, this is for the constant absorption factor and second one is the Horton and Franklin method, this is for variable absorption factor.

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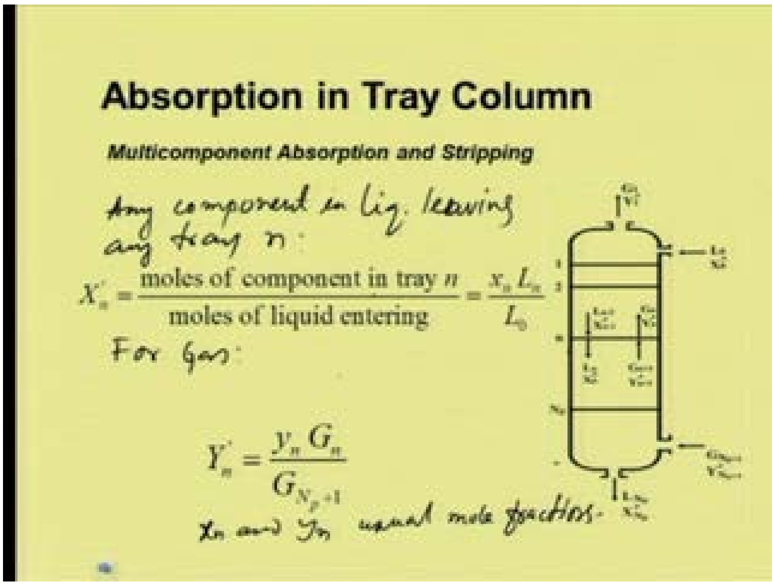

Absorption in Tray Column

Multicomponent Absorption and Stripping

Any component in liq. leaving any tray n:

$$X_n' = \frac{\text{moles of component in tray } n}{\text{moles of liquid entering}} = \frac{x_n L_n}{L_0}$$

For Gas:

$$Y_n' = \frac{y_n G_n}{G_{N_p+1}}$$

x_n and y_n usual mole fractions.

For multicomponent absorber there are many components which can transfer between gas and liquids. So, it is very difficult to get the inside gas and liquid fluorides based on the compositions inside the tower and in each tray. It is better to define them based on the inlet and outlet terms. For any component in liquid leaving any tray n, we can write X n dash would be moles of component in tray n divided by moles of liquid entering, which is equal to X n L n divided by L 0. And similarly for gas we can write Yn dash is equal to Y n G n by G N P plus 1, where X n and Y n are the usual mole fractions.

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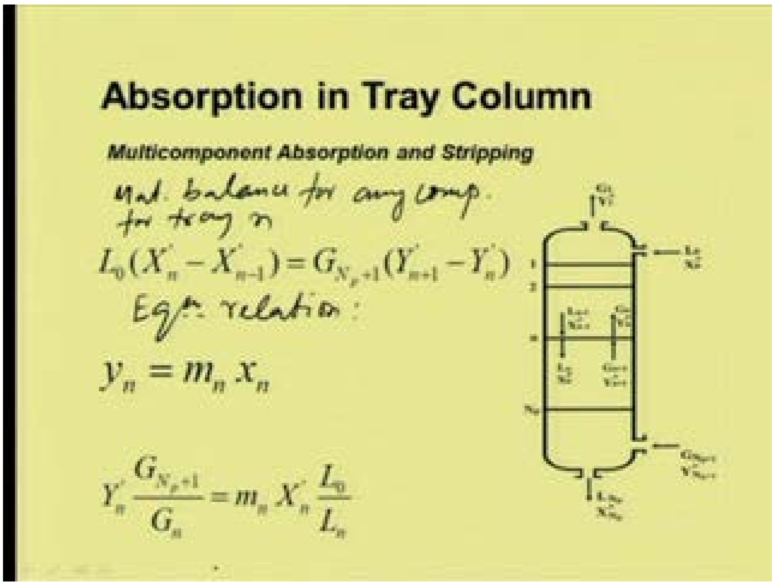

Absorption in Tray Column

Multicomponent Absorption and Stripping

Mat. balance for any comp. for tray n

$$L_0(X'_n - X'_{n-1}) = G_{N_p+1}(Y'_{n+1} - Y'_n)$$

Eqm. relation :

$$y_n = m_n x_n$$

$$Y'_n \frac{G_{N_p+1}}{G_n} = m_n X'_n \frac{L_0}{L_n}$$

For the tray absorber, if we do the material balance for any component for tray n, this is the material balance equation. Then equilibrium relation which is Y n is equal to m n x n and if we substitute the equilibrium relation, the earlier equations then we will get Y n G N P plus 1 by G n is equal to m n X n dash L naught by L n.

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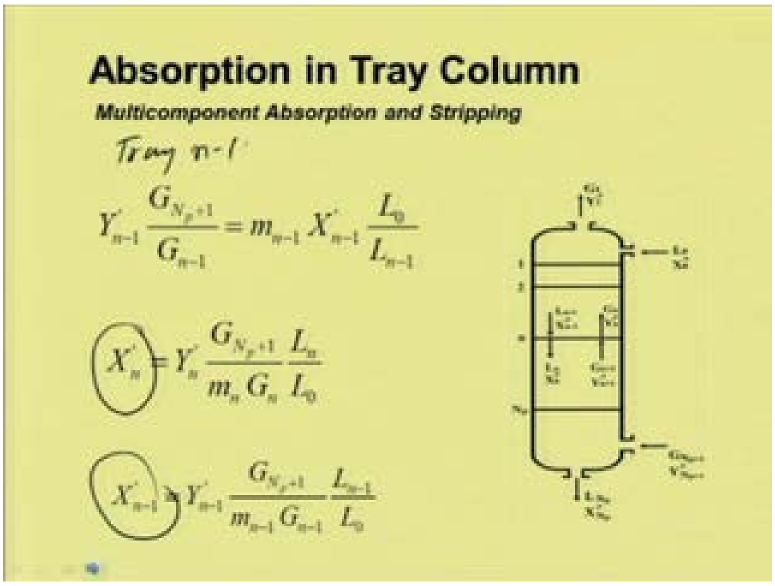

Absorption in Tray Column

Multicomponent Absorption and Stripping

Tray n-1

$$Y'_{n-1}\frac{G_{N_p+1}}{G_{n-1}} = m_{n-1}X'_{n-1}\frac{L_0}{L_{n-1}}$$

$$X'_n = Y'_n\frac{G_{N_p+1}}{m_n G_n}\frac{L_n}{L_0}$$

$$X'_{n-1} = Y'_{n-1}\frac{G_{N_p+1}}{m_{n-1}G_{n-1}}\frac{L_{n-1}}{L_0}$$

Similarly, for tray n minus 1, this is the equation and then we can obtain X n dash is this, and X n dash minus 1 is this.

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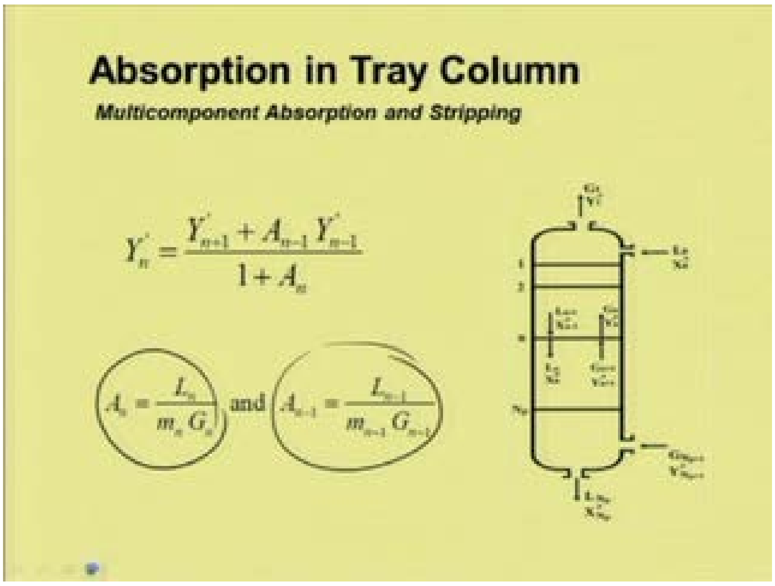

Absorption in Tray Column

Multicomponent Absorption and Stripping

$$Y'_n = \frac{Y'_{n+1} + A_{n-1}Y'_{n-1}}{1 + A_n}$$

$$A_n = \frac{L_n}{m_n G_n} \text{ and } A_{n-1} = \frac{L_{n-1}}{m_{n-1}G_{n-1}}$$

After substitute X n and X n minus 1 dash we can get Y n would be Y dash n plus 1 plus A n minus 1 Y n minus 1 dash by one plus A n, where A n is the absorption factor and A n minus 1 is the for tray n and this for tray n minus 1.

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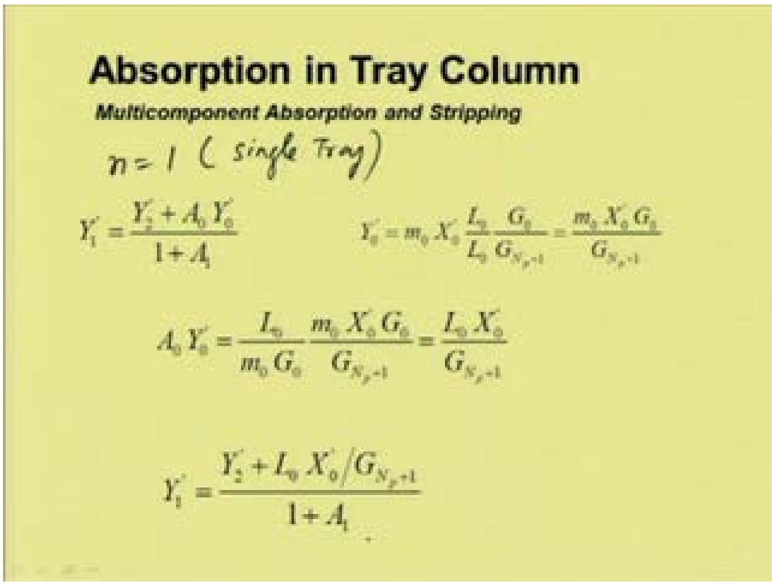

Absorption in Tray Column

Multicomponent Absorption and Stripping

n = 1 (single Tray)

$$Y_1' = \frac{Y_2' + A_0 Y_0'}{1+A_1}$$

$$Y_0' = m_0 X_0' \frac{L_0}{L_0}\frac{G_0}{G_{N_p+1}} = \frac{m_0 X_0' G_0}{G_{N_p+1}}$$

$$A_0 Y_0' = \frac{L_0}{m_0 G_0}\frac{m_0 X_0' G_0}{G_{N_p+1}} = \frac{L_0 X_0'}{G_{N_p+1}}$$

$$Y_1' = \frac{Y_2' + L_0 X_0'/G_{N_p+1}}{1+A_1}$$

So, if we considered n is equal to 1 then we can obtain Y 1 is equal to Y 2 dash plus A naught Y naught dash by 1 plus A1 for n is equal to 1, that is single tray. Similarly, we can obtain Y naught is equal to this, and A naught Y naught would be this. From this if you substitute this two over here A naught Y naught, then we can obtain Y 1 dash is equal to Y 2 dash plus L naught X naught dash by G N P plus 1 by 1 plus A 1.

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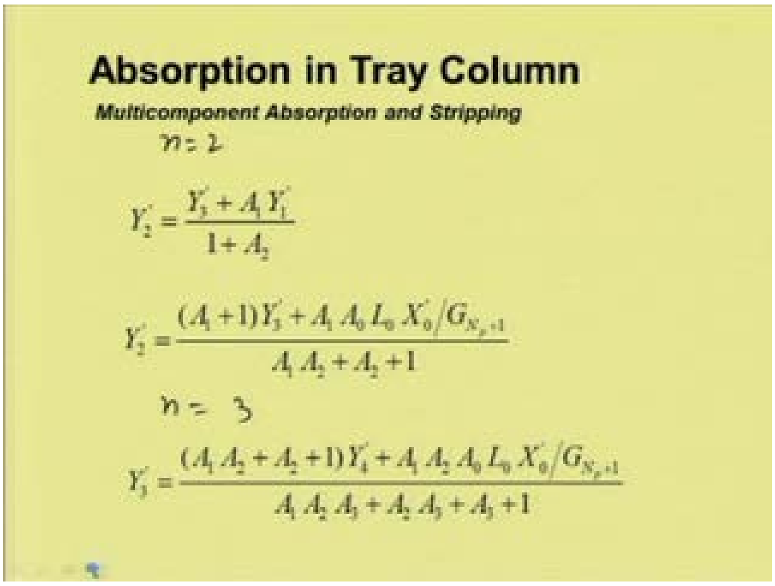

Absorption in Tray Column

Multicomponent Absorption and Stripping

n = 2

$$Y_2' = \frac{Y_3' + A_1 Y_1'}{1+A_2}$$

$$Y_2' = \frac{(A_1+1)Y_3' + A_1 A_0 L_0 X_0'/G_{N_p+1}}{A_1 A_2 + A_2 + 1}$$

n = 3

$$Y_3' = \frac{(A_1 A_2 + A_2 + 1)Y_4' + A_1 A_2 A_0 L_0 X_0'/G_{N_p+1}}{A_1 A_2 A_3 + A_2 A_3 + A_3 + 1}$$

If we take n is equal to two, that is two tray then Y 2 is like this. If you substitute the earlier equation Y 2 would be this and similarly for n is equal to 3, we can obtain Y 3 dash is this.

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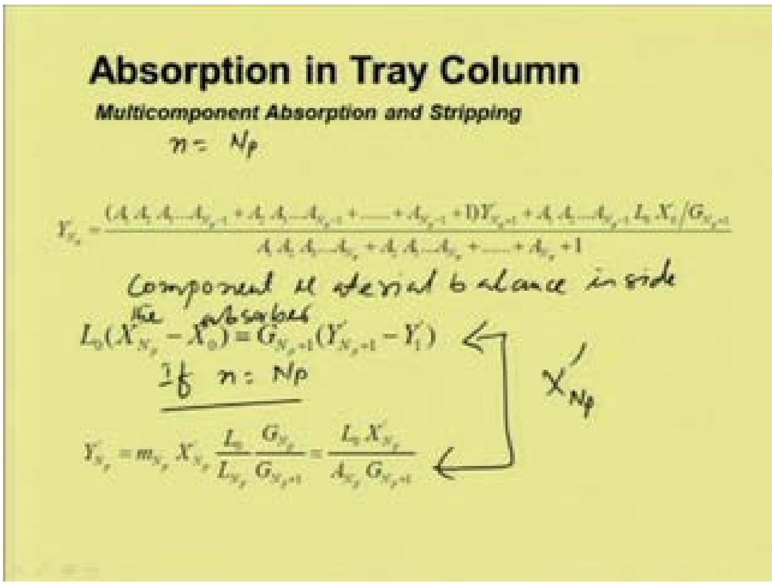

Absorption in Tray Column

Multicomponent Absorption and Stripping

$n = N_p$

$$Y'_{N_p} = \frac{(A_1A_2A_3\ldots A_{N_p-1} + A_2A_3\ldots A_{N_p-1} + \ldots\ldots + A_{N_p-1} + 1)Y'_{N_p+1} + A_1A_2\ldots A_{N_p-1}L_0X'_0/G_{N_p+1}}{A_1A_2A_3\ldots A_{N_p} + A_2A_3\ldots A_{N_p} + \ldots\ldots + A_{N_p} + 1}$$

Component material balance inside the absorber

$$L_0(X'_{N_p} - X'_0) = G_{N_p+1}(Y'_{N_p+1} - Y'_1)$$

If $n = N_p$

$$Y'_{N_p} = m_{N_p} X'_{N_p} \frac{L_0}{L_{N_p}} \frac{G_{N_p}}{G_{N_p+1}} = \frac{L_0 X'_{N_p}}{A_{N_p} G_{N_p+1}}$$

X'_{N_p}

For n is equal to N P, number of trays. Y N P similarly we can obtain is this. And in order to eliminate Y N P dash we can do the component material balance inside the absorber. So, we can get L naught is into X N P dash minus X naught would be equal to G N P plus 1into Y N P plus 1 dash minus Y 1 dash. If n is equal to N P then we can obtain Y N P dash is this. If we eliminate X N P dash from this two relations and then if we substitute the earlier Y N P dash equations we can obtain the equation for absorber.

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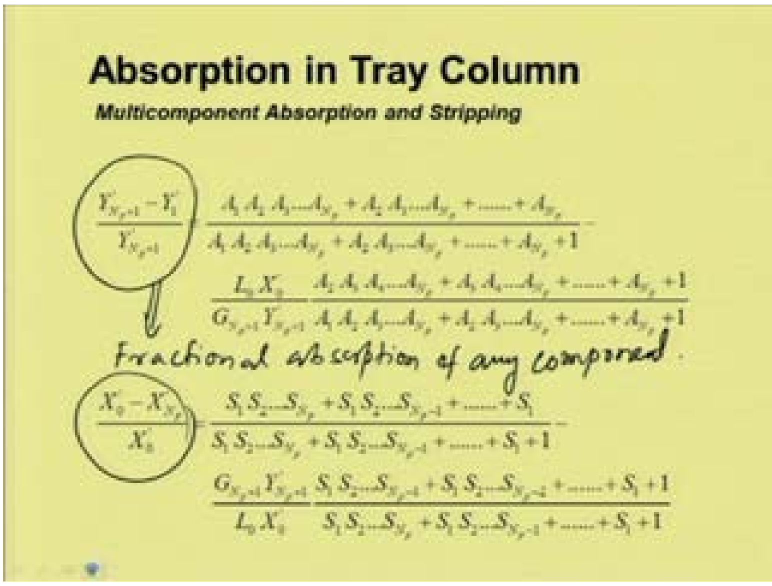

Absorption in Tray Column

Multicomponent Absorption and Stripping

$$\frac{Y'_{N_p+1}-Y'_1}{Y'_{N_p+1}} = \frac{A_1A_2A_3 \ldots A_{N_p} + A_2A_3 \ldots A_{N_p} + \ldots\ldots + A_{N_p}}{A_1A_2A_3 \ldots A_{N_p} + A_2A_3 \ldots A_{N_p} + \ldots\ldots + A_{N_p} + 1}$$

$$\frac{L_0X'_0}{G_{N_p+1}Y'_{N_p+1}} \frac{A_2A_3A_4 \ldots A_{N_p} + A_3A_4 \ldots A_{N_p} + \ldots\ldots + A_{N_p} + 1}{A_1A_2A_3 \ldots A_{N_p} + A_2A_3 \ldots A_{N_p} + \ldots\ldots + A_{N_p} + 1}$$

Fractional absorption of any component.

$$\frac{X'_0-X'_{N_p}}{X'_0} = \frac{S_1S_2 \ldots S_{N_p} + S_1S_2 \ldots S_{N_p-1} + \ldots\ldots + S_1}{S_1S_2 \ldots S_{N_p} + S_1S_2 \ldots S_{N_p-1} + \ldots\ldots + S_1 + 1}$$

$$\frac{G_{N_p+1}Y'_{N_p+1}}{L_0X'_0} \frac{S_1S_2 \ldots S_{N_p-1} + S_1S_2 \ldots S_{N_p-2} + \ldots\ldots + S_1 + 1}{S_1S_2 \ldots S_{N_p} + S_1S_2 \ldots S_{N_p-1} + \ldots\ldots + S_1 + 1}$$

This is the absorber equations. And this is called expression for fractional absorption of any component. Similarly for stripper also this is the fractional desorption a stripping for any component.

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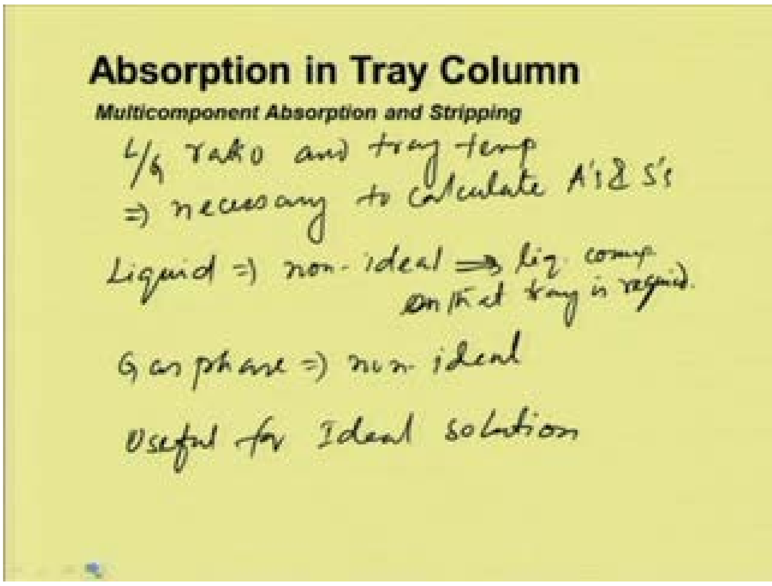

Absorption in Tray Column

Multicomponent Absorption and Stripping

L/G ratio and tray temp
⇒ necessary to calculate A's & S's

Liquid ⇒ non-ideal ⇒ liq comp on that tray is required.

Gas phase ⇒ non ideal

Useful for Ideal solution

This different L by G ratio and tray temperature is necessary to calculate A’s and S’s. If the liquid is non ideal then it requires the liquid compositions on that tray. Similarly, for gas phase, if the gas phase is non-ideal the similar thing is valid. Therefore, the equations we derived for variable absorption factor and stripping factor is valid or applicable or we can say useful for ideal solutions.

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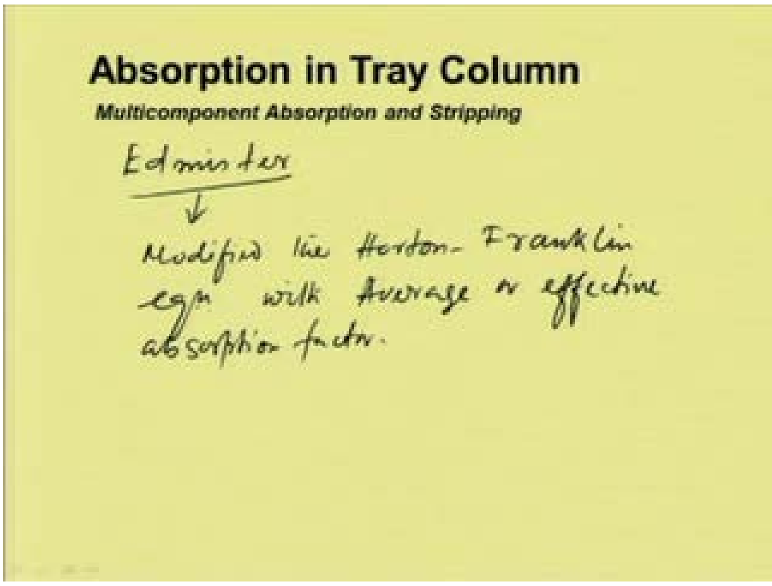

Absorption in Tray Column

Multicomponent Absorption and Stripping

Edminster
↓
Modified the Horton- Franklin eqn with Average or effective absorption factor.

So, there is a simplifications of this method. Instead of getting variable absorption factor, there is an average or effective absorption factor which is derived by Edmister. They modified the Horton Franklin equations with average or effective absorption factor.

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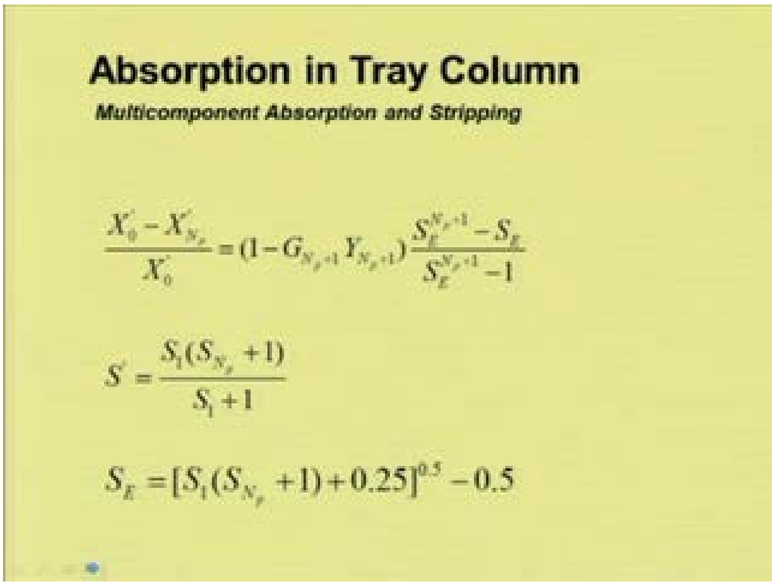

Absorption in Tray Column

Multicomponent Absorption and Stripping

$$\frac{X_0' - X_{N_p}'}{X_0'} = (1 - G_{N_p+1} Y_{N_p+1}) \frac{S_E^{N_p+1} - S_E}{S_E^{N_p+1} - 1}$$

$$S' = \frac{S_1(S_{N_p} + 1)}{S_1 + 1}$$

$$S_E = [S_1(S_{N_p} + 1) + 0.25]^{0.5} - 0.5$$

So far absorber their earlier equations will be Y N P plus 1 dash minus Y 1 dash by Y N P plus 1 would be equal to 1 minus L naught X naught dash divided by A dash G N P plus 1 Y N P dash plus 1 into A E N P plus 1 minus A E divided by A E N P plus 1 minus 1, where A dash is the A N P A 1 plus 1 divided by A N P plus 1. And A E the average absorption factor which is equal to A and P into 1 plus 1 plus 0.25 to the power 0.5 minus 0.5. The similar equations was derived for the stripping sections, so these equations can be used usually with the average absorption or stripping factor.