Calculation of Tower Height

The physical absorption process can be carried out in countercurrent flow process, which may be carried out in packed or tray column:

Packed Tower **Z =**

HOG * NOG

Where:

HOG: is the height of transfer unit (HTU) based on gas phase, and it can be calculated from the equation below:

$$\mathbf{HOG} = \frac{\bar{\mathbf{G}}_{\mathbf{s}}}{\mathbf{KoG.a}} \quad , \text{in (meter)}$$

NOG: is the number of transfer unit (NTU) based on gas phase, and it can be calculated based on equilibrium data:

- If the equilibrium data are ***linear***, then **NOG** will be calculated using a suitable equation.
- If the equilibrium data are ***non-linear***, then **NOG** will be calculated graphical method.

Tray Tower

Z = H * N

Where:

H : is the distance between two trays, and it is given (0.3 - 0.7 m)

N : is the number of trays, and it can be calculated based on equilibrium data:

- If the equilibrium data are ***linear***, then **N** will be calculated using a suitable equation.
- If the equilibrium data are ***non-linear***, then **N** will be calculated graphical method.

1. Packed tower:

Absorption and stripping are frequently conducted in packed columns, particularly when:

(1) the required column diameter is less than 0.6 m.

(2) the pressure drop must be low, as for a vacuum service.

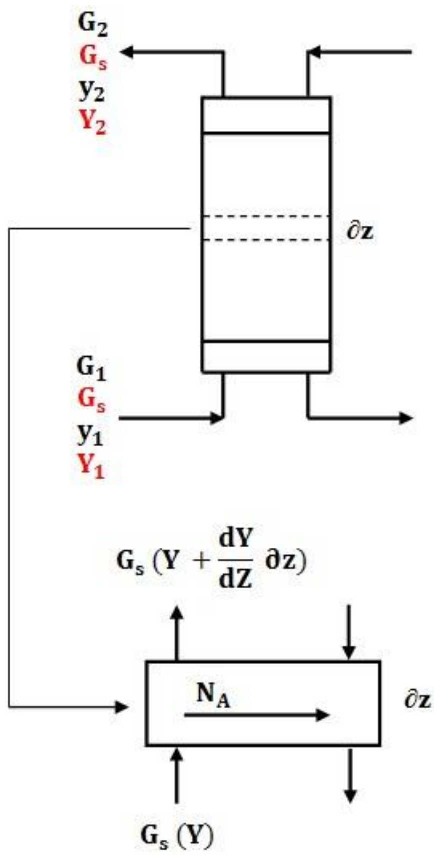
(3) corrosion consideration favor the use of ceramic or polymeric material.

(4) low liquid holdup is desirable.

The gas liquid contact in a packed bed column is continuous, not stage-wise, as in a plate column. The liquid flows down the column over the packing surface and the gas or vapour, counter-currently, up the column. In some gas-absorption columns co-current flow is used. The performance of a packed column is very dependent on the maintenance of good liquid and gas distribution throughout the packed bed, and this is an important consideration in packed-column design.

Calculations of the packing height based on gas phase:

Overall material balance on the solute (A) over an element (∂z) based on gas phase:



$$\mathbf{G_S\, dY = L_S\, dX = N_A .\ A}$$

$$\mathbf{N_A = G_s\, Y - G_s \left(Y + \frac{dY}{dZ}\, \partial z\right) = (KoG)(a\ S\ \partial z)(Y - Y^*)}$$

Where:

$$\textbf{The interficial area for transfer} = \mathbf{a\ dV = a\ \ S\ \partial z}$$

S: is the cross-sectional area of column (m^2).

a: is the surface area of interface per unit volume of column (m^2/m^3).

$$\mathbf{-G_s \left(\frac{dY}{dZ}\, \partial z\right) = (KoG.\,a)(S\,.\,\partial z)(Y - Y^*)}$$

$$\mathbf{G_s \frac{dY}{dZ} = -(KoG.\,a)(S\,.\,\partial z)(Y - Y^*)}$$

$$\int_{0}^{Z} dZ = \frac{-G_s}{(KoG.a).S} \int_{Y_1}^{Y_2} \frac{dY}{(Y - Y^*)}$$

$$Z = \frac{(G_s/S)}{KoG.a} \int_{Y_2}^{Y_1} \frac{dY}{(Y - Y^*)}$$

$$\boxed{Z = \frac{G_s}{KoG.a} \int_{Y_2}^{Y_1} \frac{dY}{(Y - Y^*)}}$$

Z = HOG * NOG = HTU * NTU

Where:

$$HOG = \frac{\bar{G}_s}{KoG.a}$$: heiht of transfer unit (HTU) based on gas phase, with the units of (m).

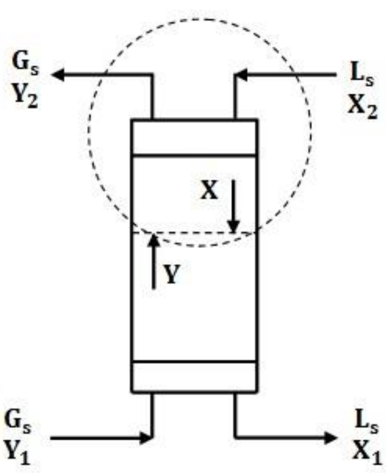
$$NOG = \int_{Y_2}^{Y_1} \frac{dY}{(Y - Y^*)}$$: number of transfer unit (NTU) based on gas phase, without units.

Equation of the operating line:

Solute material balance between one end of the column and any point will give:

$$G_s\,(Y - Y_2) = L_s\,(X - X_2)$$

$$\boxed{Y = \frac{L_s}{G_s}\ X - X_2\ + Y_2}$$



* The equation of operating line is a relation between mole ratio of solute in gas phase (Y) and the mole ratio of solute in liquid phase (X).

* The operating line can be draw from two points **(X_1, Y_1)** and **(X_2, Y_2)**, or from its slope ($\frac{L_s}{G_s}$)
and one of the two points.