Lecture 9.
Absorption and Stripping (1)
[Ch. 6]

- Absorption *vs.* Stripping
- Coupling of Absorber and Stripper
- Equipments
- Equilibrium Curve and Operating Line
  - Absorber
  - Stripper
- Number of Equilibrium Stages

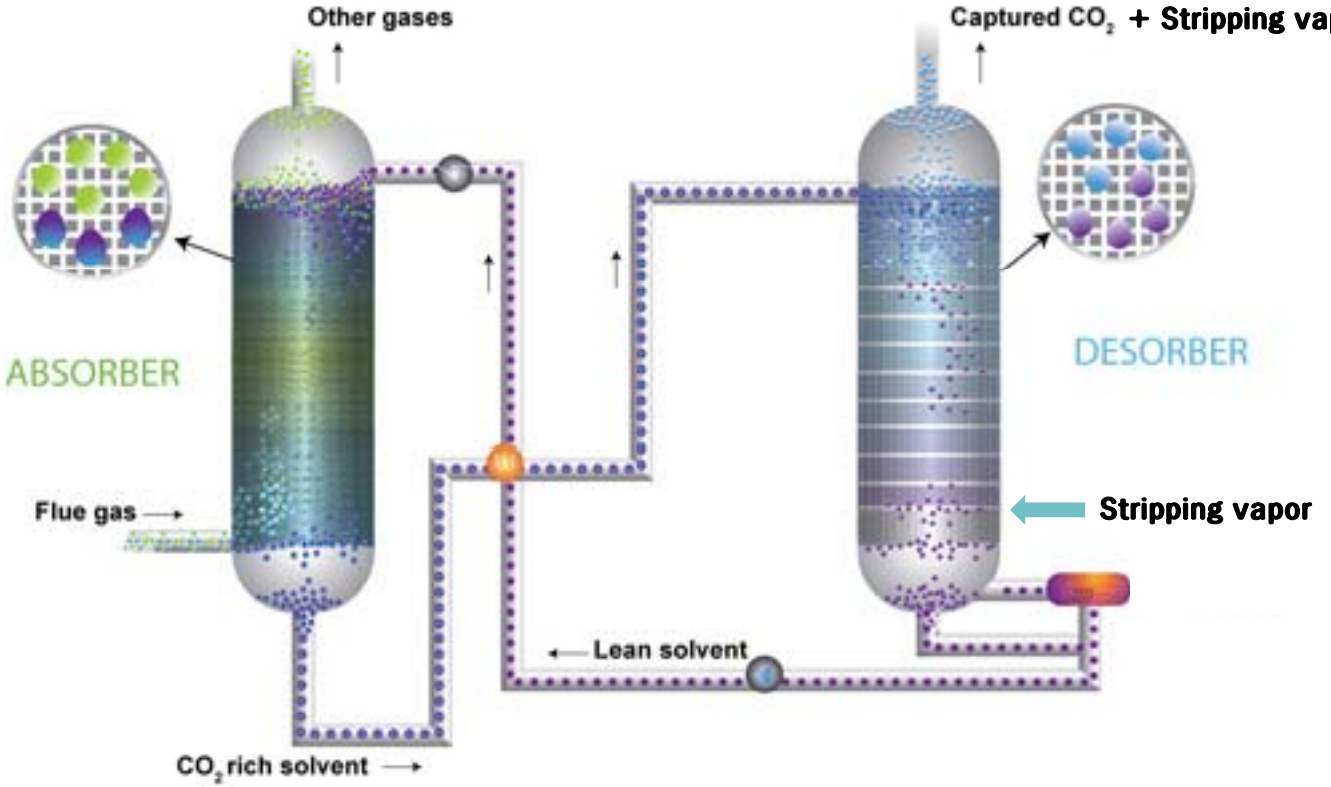
Absorption *vs.* Stripping

- Absorption (gas absorption, gas scrubbing, gas washing)
  - A gas mixture is contacted with a liquid (absorbent or solvent) to selectively dissolve one or more components (solutes or absorbate) by mass transfer from the gas to the liquid
  - Used to separate gas mixtures; remove impurities, contaminants, pollutants, or catalyst poisons from a gas; or recover valuable chemicals
  - Example: removal of H_2S and CO_2 from natural gas using MEA (monoethanolamine)

- Stripping (desorption)
  - A liquid mixture is contacted with a gas to selectively remove components by mass transfer from the to the
  - Example: removal of H_2S from sour crude oil

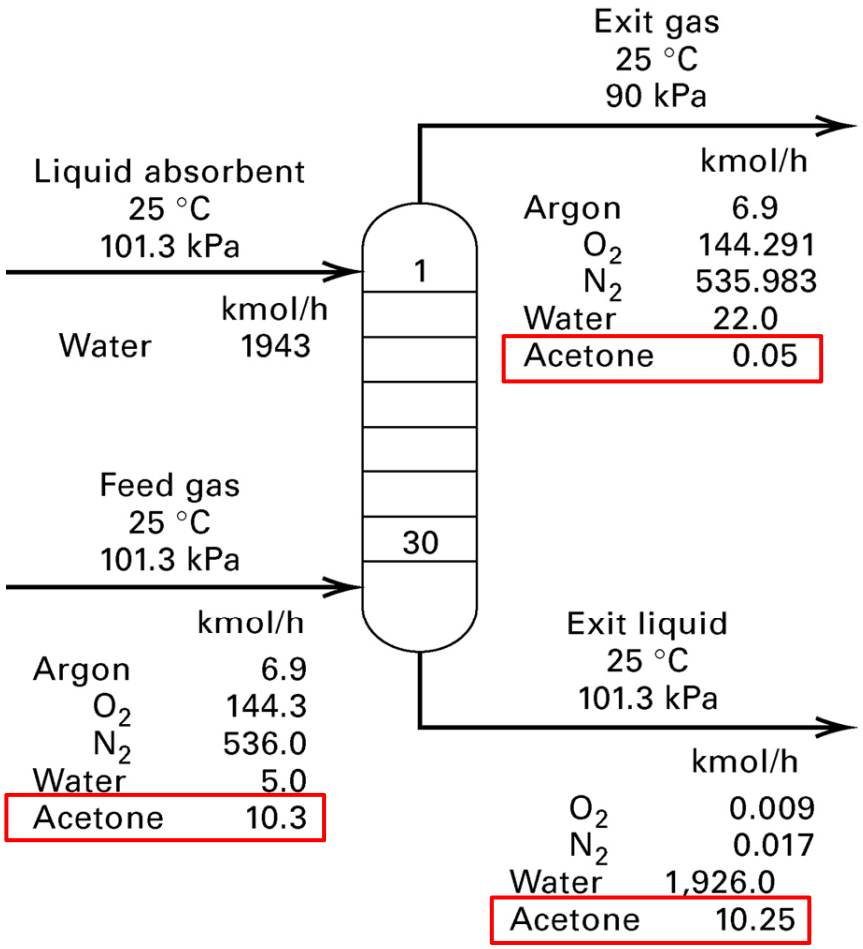
Coupling of Absorber and Stripper

- Absorbers are frequently coupled with strippers to permit regeneration (or recovery) and recycling of the absorbent



- Because stripping is not perfect, recycled absorbent contains solutes (absorbates)

Absorption Factor & Stripping Factor



- Absorption factor, A = L/(KV)

Component	A	K-value
Water	89.2	0.031
Acetone	1.38	2.0
Oxygen	0.00006	45,000
Nitrogen	0.00003	90,000
Argon	0.00008	35,000

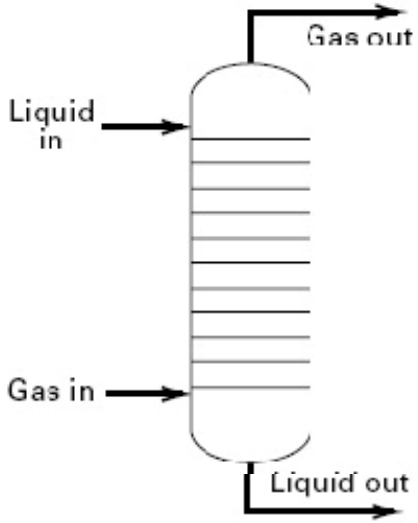
The larger the value of A, the fewer the number of stages required for absorption

The required absorbent flow rate ↓
⇐ the K-value of solute ↓
⇐ temperature ↓ and/or pressure ↑

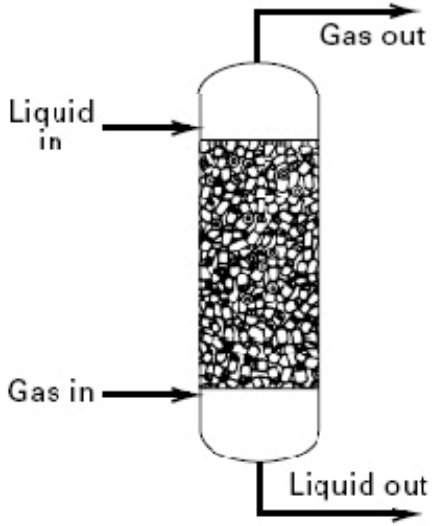
- Stripping factor, S = 1/A = KV/L

Equipment for Absorption and Stripping

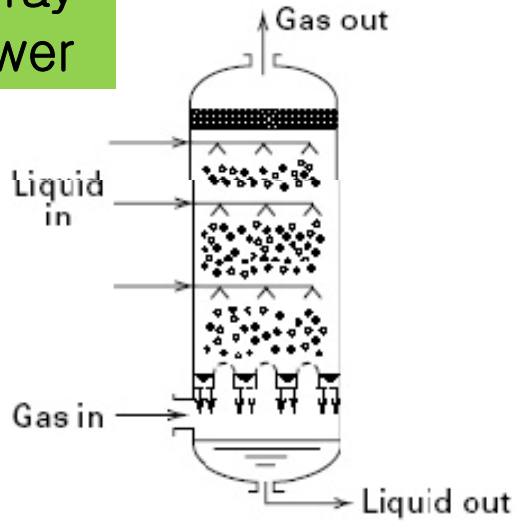
Trayed tower



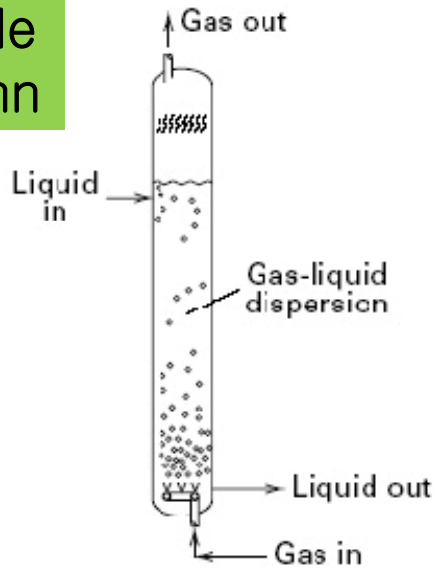
Packed column



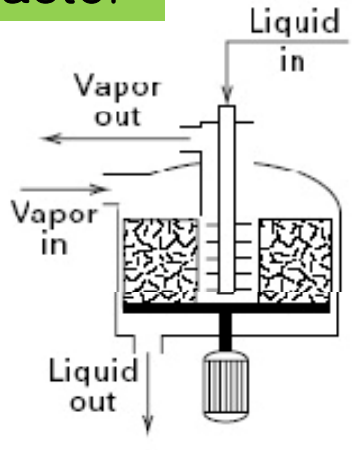
Spray tower



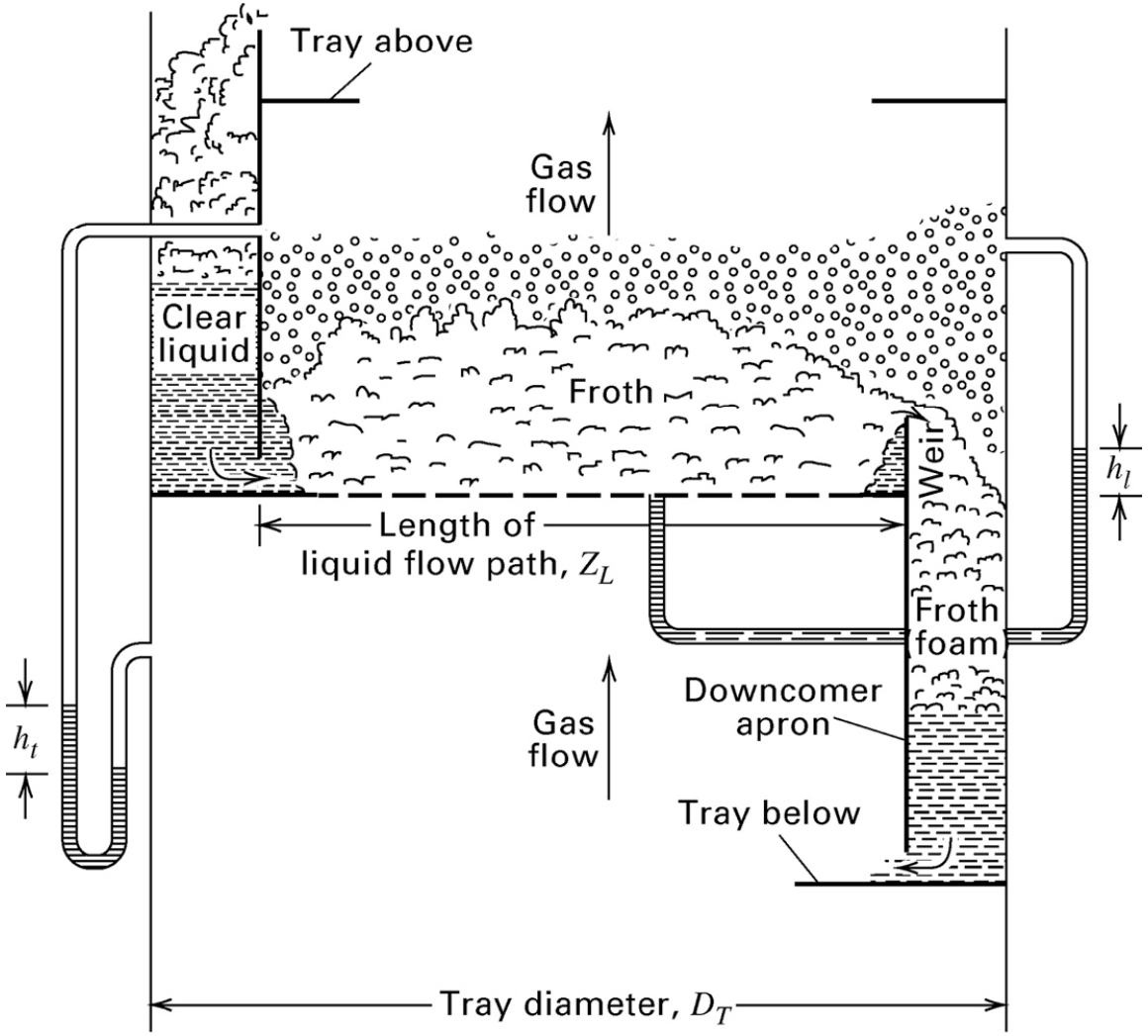
Bubble column



Centrifugal contactor



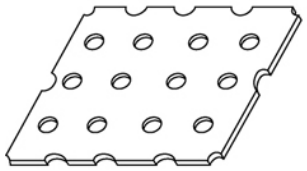
Contacting Tray in a Trayed Tower

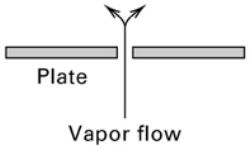


- Ideal operation
: phase equilibrium at each tray between the vapor and liquid streams leaving the tray
→ Each tray is treated as an equilibrium stage

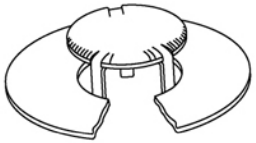
Tray Openings for Vapor Passage

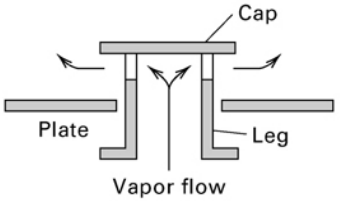
Perforation

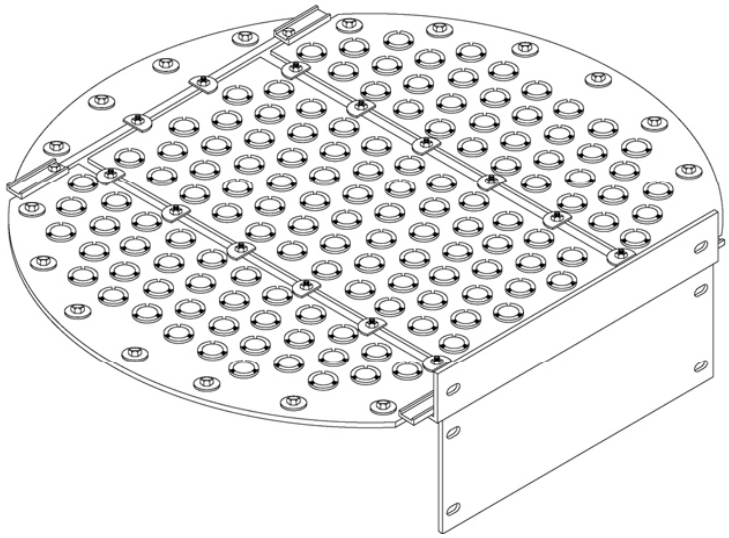




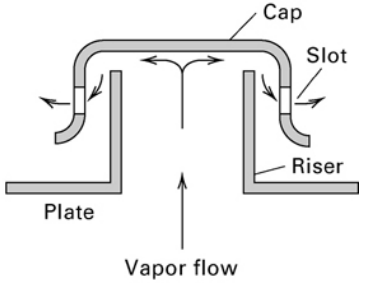
Valve cap





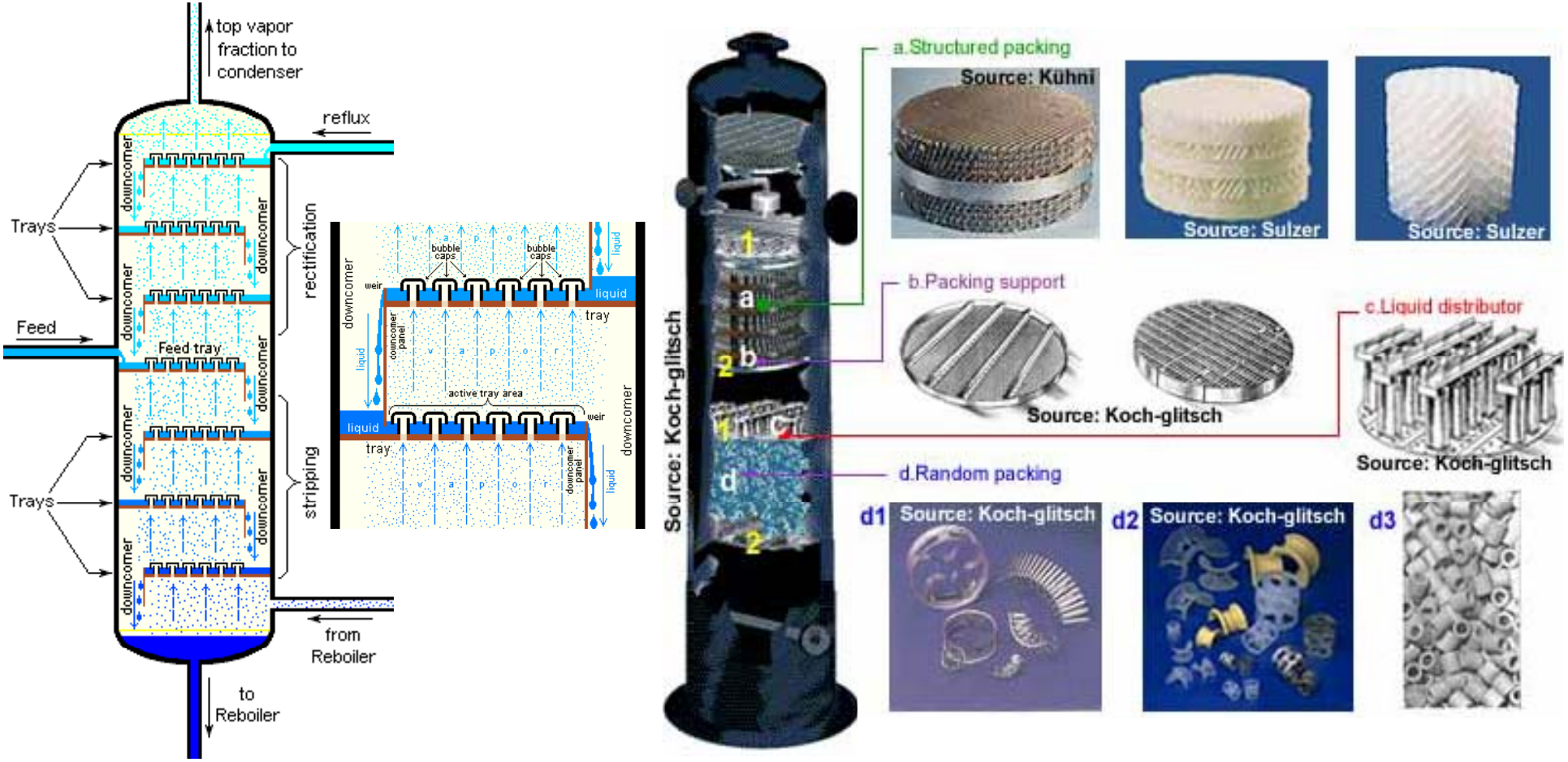


Bubble cap



Tray with valve caps

Trayed Tower & Packed Column



- Additional separation capacity can be achieved by replacing all or some of the trays with sections of random or structured packing

Equilibrium Curve and Operating Line for Absorber

- For trayed tower,

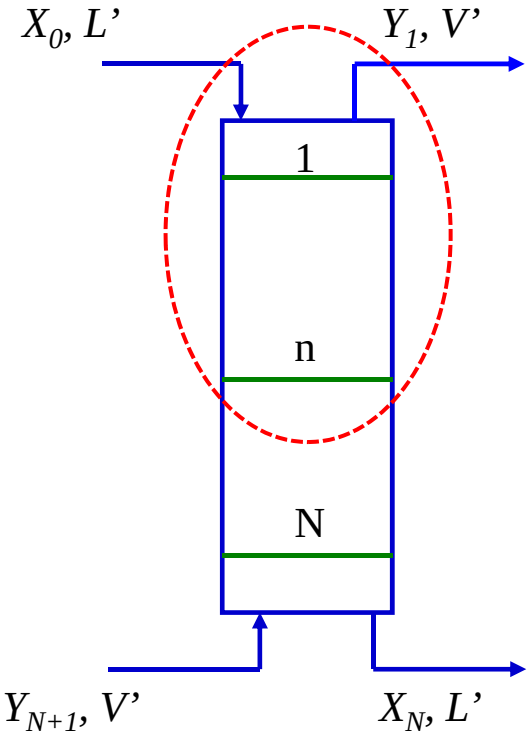
Mass balance

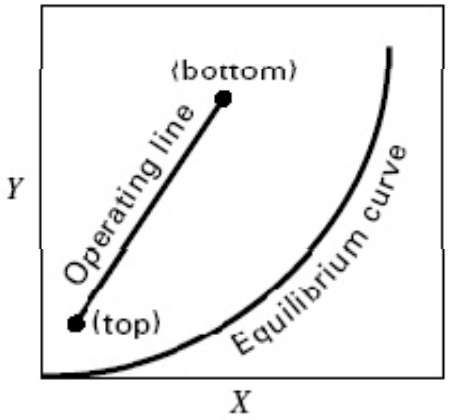
$$X_0 L' + Y_{n+1} V' = X_n L' + Y_1 V'$$

$$Y_{n+1} = X_n (L'/V') + Y_1 - X_0 (L'/V')$$

Equilibrium relation

$$K_n = \frac{y_n}{x_n} = \frac{Y_n/(1+Y_n)}{X_n/(1+X_n)}$$





The operating line is above the equilibrium line because, for a given solute concentration in the liquid, the solute concentration in the gas is always greater than the equilibrium value

Equilibrium Curve and Operating Line for Stripper

- For trayed tower,

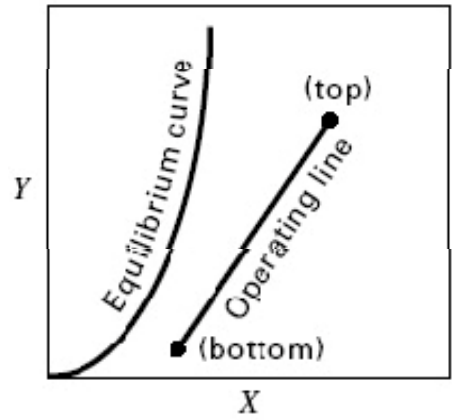
Mass balance

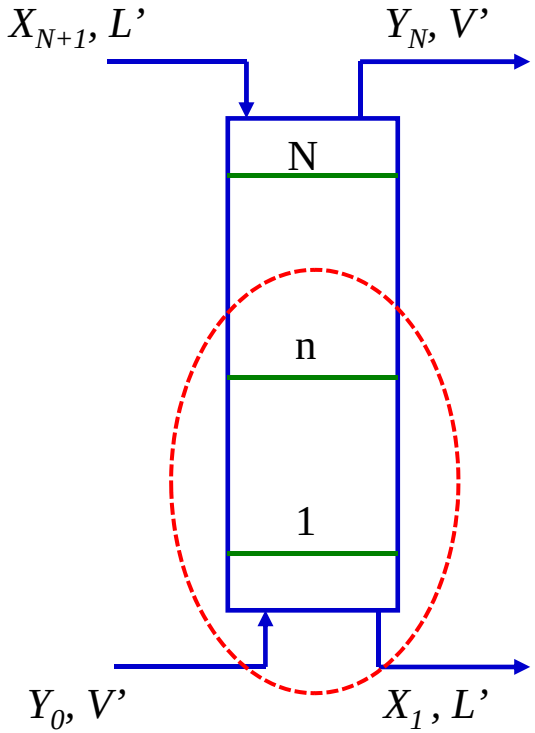
$$X_{n+1}L' + Y_0V' = X_1L' + Y_nV'$$

$$Y_n = X_{n+1}(L'/V') + Y_0 - X_1(L'/V')$$

Equilibrium relation

$$K_n = \frac{y_n}{x_n} = \frac{Y_n/(1+Y_n)}{X_n/(1+X_n)}$$

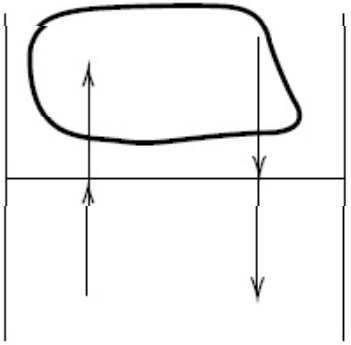




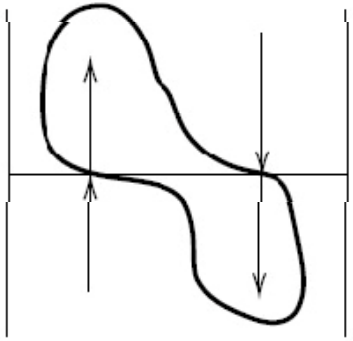
The operating line lies below the equilibrium line

Number of Equilibrium Stages

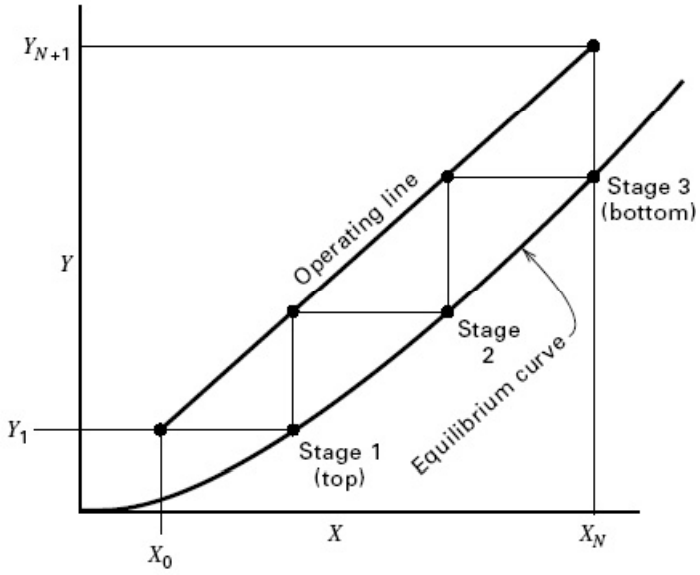
Operating line



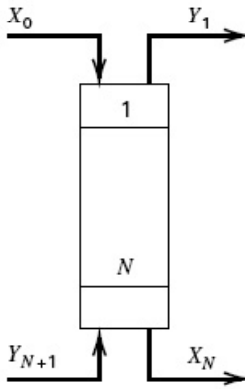
Equilibrium curve

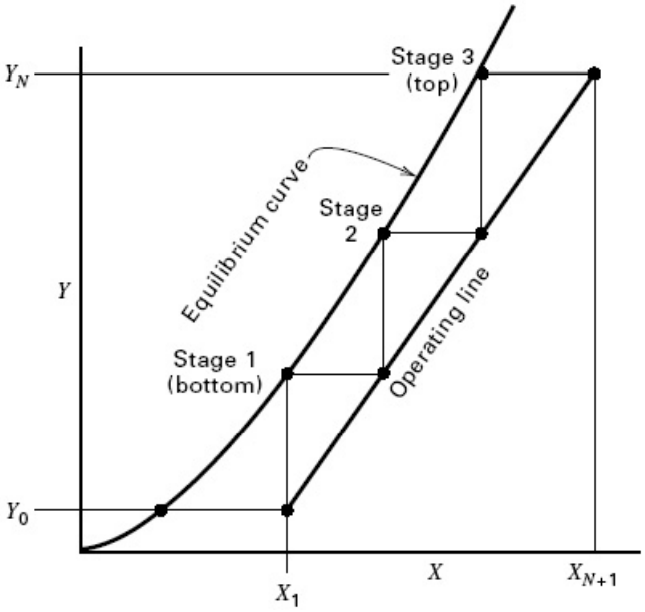


- The operating line relates the solute concentration in the vapor passing upward between two stages to the solute concentration in the liquid passing downward between the same two stages
- The equilibrium curve relates the solute concentration in the vapor leaving an equilibrium stage to the solute concentration in the liquid leaving the same stage



Absorber





Stripper