Absorption of Gases

((Gas – Liquid Separation))

In absorption (also called gas absorption, gas scrubbing, and gas washing), a gas mixture is contacted with a liquid (the absorbent or solvent) to selectively dissolve one or more components by mass transfer from the gas to the liquid. The components transferred to the liquid are referred to as solute or absorbate.

Absorption is used to separate gas mixture; remove impurities, contaminants, pollutants, or catalyst poisons from gas; or recovery valuable chemicals. Thus, the species of interest in the gas mixture may be all components, only the component(s) not transferred, or only the component(s) transferred. The opposite of absorption is ***stripping*** (also called ***desorption***), wherein a liquid mixture is contacted with gas to selectively remove components by mass transfer from the liquid to the gas phase.

There are two types of absorption processes:

1. Physical process (e.g. absorption of acetone from acetone – air mixture by water).
2. Chemical process, sometimes called chemi-sorption (e.g. absorption of nitrogen oxides by water to produce nitric acid.

Equipment:

Absorption and stripping are conducted in tray towers (plate column), packed column, spray tower, bubble column, and centrifugal contactors. The first two types of these equipment will be considered in our course for this year.

1. Tray tower:

A tray tower is a vertical, cylindrical pressure vessel in which gas and liquid, which flow counter currently, are contacted on a series of metal trays or plates. Liquid flows across any tray over an outlet weir, and into a down comer, which takes the liquid by gravity to the tray below. The gas flows upward through opening in each tray,

bubbling through the liquid on the other tray. A schematic diagram for the flow patterns inside the tray column is shown below.

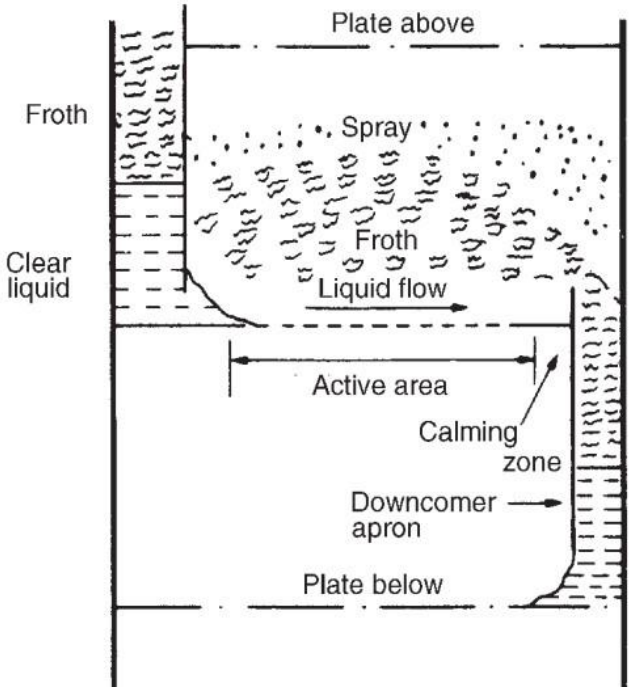

Figure : Typical cross-flow plate (sieve)

2. Packed tower:

The packed column is a vertical, cylindrical pressure vessel containing one or more section of packing material over who's the liquid flows down wards by gravity as a film or as droplets between packing elements. Gas flows upwards through the wetted packing contacting the liquid. The sections of packing are contained between a lower gas – injection support plate, which holds the packing, and an upper grid or mish hold – down plate, which prevent packing movement. A liquid distributor, placed above the hold – down plate, ensures uniform distribution of liquid as it enters the packing section.

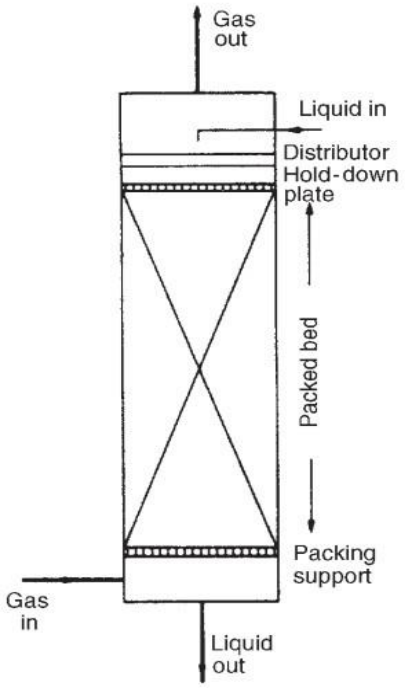

Figure: Packing absorber column.

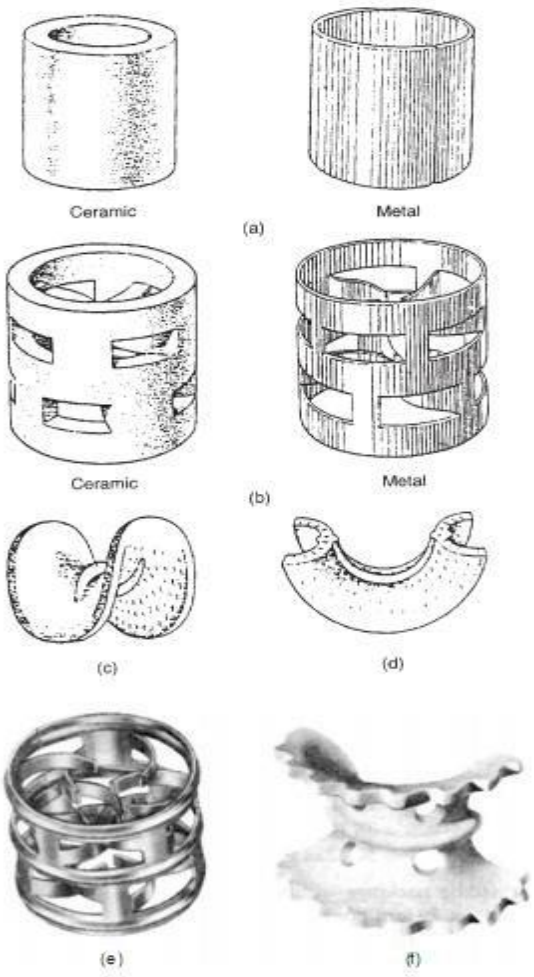

Figure: Types of packing (a) Raschig rings (b) Pall rings (c) Berl saddle ceramic (d) Intalox saddle ceramic (e) Metal Hypac (f) Ceramic, super Intalox.

General Design Consideration:

Design or analysis of an absorber (or stripper) requires consideration of a number of factors, including:

1. Entering gas (liquid) flow rate, composition, temperature, and pressure.
2. Design degree of recovery (R) of one or more solutes.
3. Choice absorbent (solvent) agent.
4. Operating pressure and temperature and allowable pressure drop.
5. Minimum absorbent (solvent) agent flow rate and actual solvent flow rate as a multiple of the minimum rate needed to make the separation.
6. Number of equilibrium stages.
7. Heat effects and need for cooling (heating).
8. Type of absorber (stripper) equipment.
9. Height of absorber (stripper) column.
10. Diameter of absorber (stripper) column.

The ideal absorbent (solvent) should have:

a. High solubility for the solute(s) to minimize the need for absorbent (solvent).
b. A low volatility to reduce the loss of absorbent (solvent) and facilitate separation of absorbent (solvent) from solute(s).
c. Be stable to maximize absorbent (solvent) life and reduce absorbent makeup requirement.
d. Be non – corrosive to permit use of common material of construction.
e. Have a low viscosity to provide low pressure drop and high mass and heat transfer rates.
f. Be non – foaming when contacted with gas so as to make it unnecessary.
g. Be non – toxic and non – flammable to facilitate its safe use.
h. Be available, if possible.

The most widely absorbent (solvent) used are water, hydrocarbon oils, and aqueous solutions of acids and bases. While the most common stripping agents used are water vapor, air, inert gases, and hydrocarbon gases.