THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

Mass Transfer-I

Mass Transfer Equipment (Continue…)

DEPARTMENT OF CHEMICAL ENGINEERING
Thapar Institute of Engineering & Technology
Patiala (Punjab), INDIA-147004

Dr. Avinash Chandra
(Ph.D., IIT Kanpur)
Associate Professor

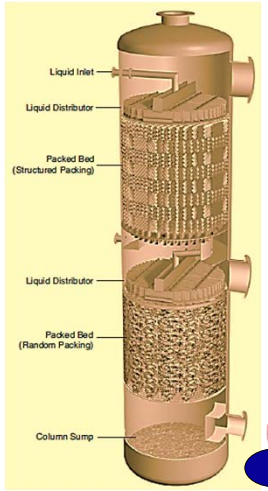
Web: http://www.thapar.edu/faculties/view/Dr.-Avinash-Chandra/ODU=/Mg==

Mass Transfer Equipment (Continue…)

Liquid disperse equipment

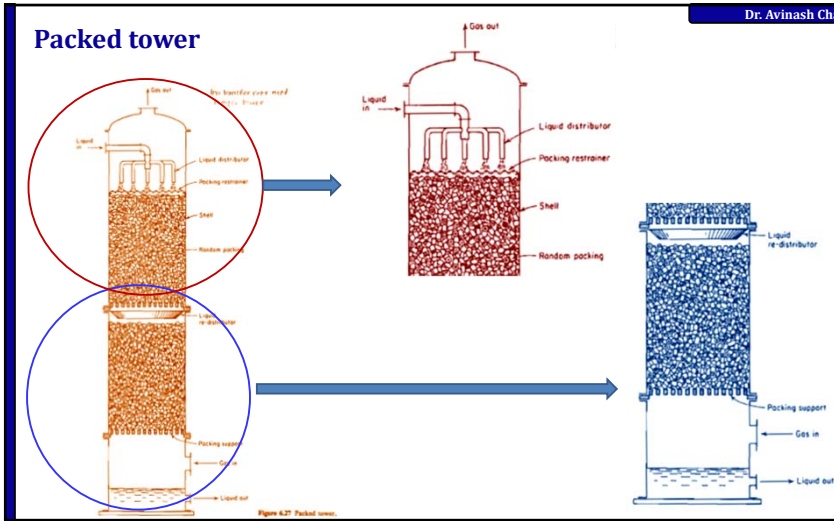
Packed tower

- A packed bed is a hollow tube, pipe, or other vessel filled with a packing material.
- The packing can be randomly filled with small objects like Raschig rings or else it can be a specifically designed structured packing.
- Packed beds may also contain catalyst particles or adsorbents such as zeolite pellets, granular activated carbon, etc.
- The purpose of a packed bed is typically to improve contact between two phases in a chemical or similar process.
- Packed bed scan be used in a chemical reactor, a distillation process, or a scrubber, etc.

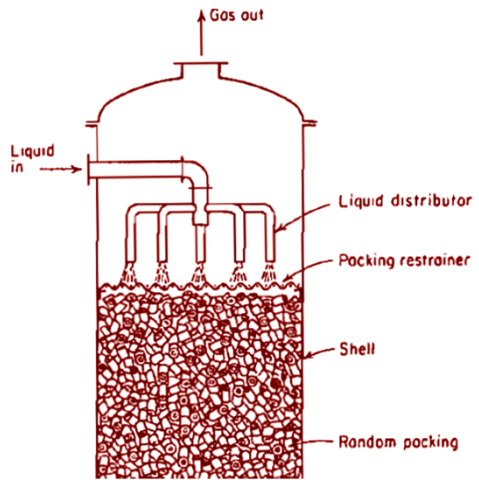


Sources: A. Mersmann, M. Kind, J. Stichlmair: Thermal Separation Technology, Springer 2011;
D.W. Green (ed.): Perry's Chemical Engineers' Handbook, McGraw-Hill 2008
Prof. Dr. M. Reppich | Conceptual Design of Distillation, Absorption and Stripping Systems

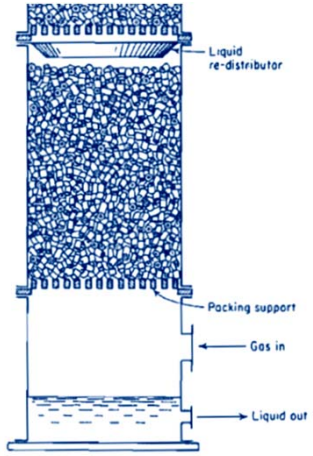
Packed tower



Cont…



Cont…



Packing

- Chemically inert to the fluids
- Strong and light weight
- Contain adequate passages (void volume) for both streams without excessive liquid old-up or pressure drop
- Provide good contact between the liquid and the gas.
- Reasonable in cost.

Types of packing

- **Random Packing**
- **Structured Packing**
- **Grid packing**

Common random packing particles made of metal, plastic, ceramic

Cont…

Random packing

Random packings are simply dumped into the tower during installation and allowed to fall at random.

1. Raschig rings

- Made of chemical stoneware or porcelain (Not used for alkali & acids), carbon (Except strongly oxidizing atmospheres), metals or specific plastics
- Diameter ranges from 6 to 100 mm.
- Simple shapes with closed surfaces,
- Robust and stable design
- Cost-effective production

2. Lessing ring

- Lessing and others with internal classifications are less frequently used (partition along the ring of the axis).
- Partition increase the surface area, but advantages is rather the small in practice.

1) Cross partition ring: consists of two partition

2) Spiral ring: (internal helix)enhance the rate of mass transfer

Cont...

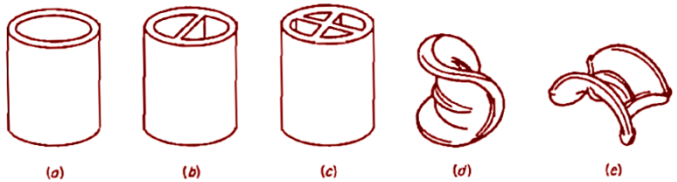
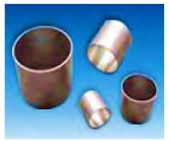


Figure 6.28 Some random tower packings: (*a*) Raschig rings, (*b*) Lessing ring, (*c*) partition ring, (*d*) Berl saddle *(courtesy of Maurice A. Knight)*, (*e*) Intalox saddle *(Chemical Processing Products Division, Norton Co.)*, (*f*) Tellerette *(Ceilcote Company, Inc.)*, and (*g*) pall ring *(Chemical Processing Products Division, Norton Co.)*.

Cont...

3. Berl Saddle

- Modern packing of 6 to 75 mm diameter.
- Has large specific surface are and smaller voidage than racshing ring
- Pressure drop is less because of it's "aerodynamic shape".
- Material is chemical stoneware or plastics
- Simple shapes with closed surfaces,
- Robust and stable design
- Cost-effective production



Raschig Ring, Berl Saddle

4. Intalox saddle

- 6 to 75 mm diameter
- It is improved version of erl seddle, which offers less form-friction to gas flow.
- Material is chemical stoneware or plastics

Cont...

5. Tellerette

- Plastics & metals
- The smooth edges of Intalox seddle are scalloped and holes inserted too make super intalox.

6. Pall ring

- The Pall ring has increased number of edges (surfaces with cutted windows and bent tongues) to disrupt flow and reduced volume taken up by the ring packing.
- The Pall ring resembles an open basket structure of thin bars.
- These form both a tube and also a radial structure of cross bars.
- Improved area distribution with lowering pressure drop and enhancing capacity
- Pall rings may be injection moulded of plastics, moulded of ceramics or press-formed from metal sheet.

Pall Ring, Intalox Saddle

Cont...

Regular or Structured Packing

- Woven wire screen rolled as a fabric into cylinders provide a large interfacial surface for contacted liquid and gas, and very low pressure drop.
- Wood grids or hurdles are inexpensive and frequently used where large void volume is required.
- Stacked Raschig rings are economically practical in very large size only.
- Advantage of low pressure drop for gas side flow and greater fluid flow but on the other side requires more cost for installation.

Structured packings Mellapak™ made of metal and plastic

Fitting structured packing elements Flexipac™ to a large-diameter tower

Structured packing of corrugated metal sheets

Sources: Sulzer Chemtech AG; Koch-Glitsch, Inc.

Dr. Avinash Chandra

Cont…

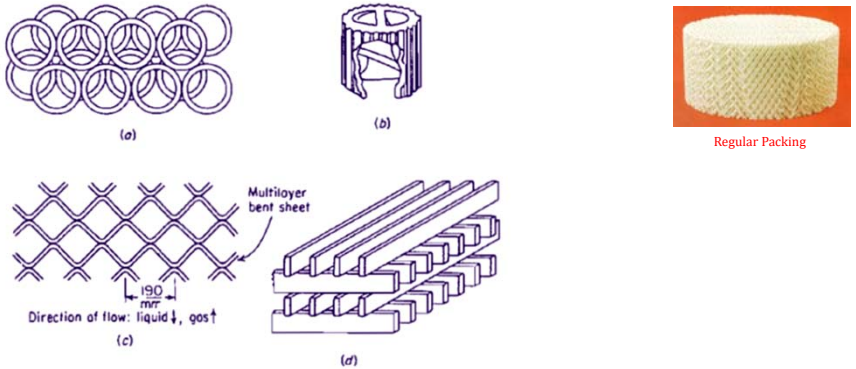


Figure 6.29 Regular, or stacked, packings: (*a*) Raschig rings, stacked staggered (top view), (*b*) double spiral ring *(Chemical Processing Products Division, Norton Co.)*, (*c*) section through expanded-metal-lath packing, (*d*) wood grids.

Dr. Avinash Chandra

Tray column vs Packed column

Tray column	Packed column
Can handle a wider range of liquid and gas flow-rates	Applicable for limited and specific applications
Large holdup on the tray	The liquid hold-up is appreciably lower
For corrosive liquid tray towers are less preffered or avoided	For corrosive liquids a packed tower will usually be cheaper than the equivalent tray tower
The efficiency calculations are acurate	The equivalent term HETPorHTU are used to predict the efficency
Cross flow of the two phases on the trays	Counter current flow of the two phases
Always used in columns of large diameters and towers that have more than 20 to 30 equilibrium stages,	Packings are generally more expensive than plates, less expensive than tray columns for small column diameter (D<0.6 m),
in applications with liquid rates of 30 $m^3/(m^2h)$ and above, when liquid flowrate is high relative to vapor flowrate	used in lower liquid-rate-applications (i.e. less than 50 $m^3/(m^2 h)$

Dr. Avinash Chandra

Tray column vs Packed column

Tray column	Packed column
Various metallic materials (D=500–10000 mm)	More choices in materials of construction especially in corrosive service (e.g. plastic, ceramic, metal alloys, carbon), random (D=50–800 mm) or structured packings (D=20–11000 mm)
Pressure drop is high, typically 7 mbar per equilibrium stage (not well suited for vacuum services)	Lower pressure drop, typically 0,1 to 0,5 mbar per equilibrium stage (important in vacuum distillation)
Cleaning is easy	Cleaning is difficult/ complicated and expensive
Stable and robust operation of the separation process	Foaming liquids can be handled more readily (less agitation of liquid by the vapour)
More flexible to variations in operating conditions	Due to novel developments of packing elements the industrial use of packed columns is steadily increasing
High liquid residence time	Less liquid entrainment, low liquid holdup, especially suitable for thermally sensitive material

Dr. Avinash Chandra

References

- Lecture notes/ppt of Dr. Yahya Banat (ybanat@qu.edu.qa)