A 100 year Search for the “Ideal” Mass Transfer Device

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Ancient Times: Simple Distillation

- **Essential Oils**
  - 1st century (Alexandria)

- **Ethanol**
  - 15th century (Europe)

- **Sulfur**
  - 16th century

**Main Challenges:**
- Temperature control
  - No instruments to measure
  - Adjusted through changes in the fuel source
- Condensation
  - Air
  - Water
  - Starting in 15th century
- Glass manufacturing techniques define apparatus size limitation
Middle Ages: First Rectification

- **First multi-stage distillation**
  - Achieved in a series of evaporation and condensation steps.

- **Introduction of spiral heat exchangers**
  - Improved the condensation.
  - Raising designs lead to the first true rectification column.

- **First vacuum distillation**
  - 18th century (England)
The rectification column takes shape

- The rectification of Ethanol influenced development in the 19th century.
  - In France, Adams arranged a horizontal rectification column.
  - With the introduction of the bubble cap tray by Cellier-Blumenthal in 1815 and the two column apparatus with sieve tray by Coffey in 1832, columns were finally built in the vertical.
Koch-Glitsch contributed with major developments in the 20th and 21st century

- **Fritz W. Glitsch**
  - Founded in 1913 as a fabrication and machine shop.
  - 1930s specialized in columns and Mass Transfer equipment.
  - Soon started to develop its own technology.

- **Koch Engineering**
  - Founded in 1945
  - Had its own tray design
  - Acquired Glitsch in 1997 to form Koch-Glitsch, a leader in Mass Transfer technology.
Crossflow Trays

- Most widely used Mass Transfer devices.
- Improved orifices and downcomer designs
  - Enlarged bubbling area and MINIVALVE™ technology lead to increased capacity
  - Longer flow path and uniform residence time result in enhanced separation efficiency.
- A wide variety of models and styles make it the most versatile device available today.
Multiple Downcomer Trays

- Increased weir lengths lead to superior liquid handling capacity.
- Short flow path length affects the tray efficiency.
  - Multi downcomer trays achieve the high capacity at the cost of relatively low tray efficiency. The low tray spacing, allows a higher tray count in a given column height.
  - MD and ECMD tray
  - Hi-Fi tray
Counter and Concurrent Flow Trays

Counter flow Trays
- Vapor and liquid counter flow at low velocity.
- Fouling resistant design

Centrifugal Trays
- Vapor and liquid concurrent flow at high velocity.
- Liquid separated by centrifugal force.
  - Mitsui MH tray – 1993
  - Consep tray - 1995
  - Gesip tray – 1999

Shed deck
Disc and Donut tray
Ripple Tray™
ULTRA-FRAC™ tray - 1992
Early Random Packing in Spherical Shapes

- Simple early development
  - Filled void space in the column
  - Increased the liquid/vapor contact area

- Pumice Stones – 1850s
- Glass balls – 1820s
- Ceramic Balls – 1880s
- Metal Balls – 1900s
- Berl Saddle – 1880s
Cylindrical Rings

- An effort to
  - Reduce pressure drop and
  - Increase mass transfer contact area

- Wide variety of styles
  - Louvers with different shapes and sizes
  - Aspect ratio changes

Raschig Rings - 1914

Pall Rings - 1944

HY-PAK™ random packing - 1966

CASCADE MINI-RINGS™ random packing - 1971
Metallic offspring of ceramic Berl saddle and INTALOX™ saddle brought further improvements to capacity and efficiency.
Structured Packing

- Lowest $\Delta p$ per theoretical stage.
- Industrial breakthrough with introduction of sheet metal packing.

- Kloss-type packing spiral wound mesh - 1960
- Wire gauze packing - 1964
- FLEXIPAC® HC™ structured packing - 1997
- FLEXIPAC® and METALPAK® and structured packing - 1977
Fouling Resistant Packing

- No horizontal surfaces; open structure
  - Do not allow solids to settle
  - Reduce the formation of coke on the packing surface

GLITSCH GRID™ severe service grid - 1982

FLEXIGRID™ severe service grid - 1982

PROFLUX™ severe service grid - 2009
Conclusions

- There is no single ideal mass transfer device for all applications.

- There is, however, an ideal device for every application.

- Positive past experience often leads to selection of proven design and equipment over the latest and greatest technology.
## Equipment Selection Criteria

<table>
<thead>
<tr>
<th></th>
<th>Trays</th>
<th>Grid Packing</th>
<th>Random Packing</th>
<th>Structured Packing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pressure drop</strong></td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Operating range</strong></td>
<td>High Liquid</td>
<td>Low Liquid</td>
<td>Low Liquid</td>
<td>Low Liquid High Vapor</td>
</tr>
<tr>
<td></td>
<td>Low Vapor*</td>
<td>High Vapor</td>
<td>High Vapor</td>
<td></td>
</tr>
<tr>
<td><strong>Liquid residence time</strong></td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Liquid load</strong></td>
<td>Low* to High</td>
<td>Low to High</td>
<td>Low to High</td>
<td>Low to Moderate</td>
</tr>
<tr>
<td><strong>Foaming</strong></td>
<td>No</td>
<td>Yes</td>
<td>Moderate</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Fouling resistance</strong></td>
<td>Yes*</td>
<td>Yes</td>
<td>Moderate</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Upset resistance</strong></td>
<td>Yes*</td>
<td>Yes</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Corrosion resistance</strong></td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Multiple feed locations</strong></td>
<td>Easy to install</td>
<td>Expensive; requires column height</td>
<td>Expensive; requires column height</td>
<td>Expensive; requires column height</td>
</tr>
</tbody>
</table>

* Requires special features
21st Century: Moonshinners

- Still today, there are people applying simple distillation technology to separate Ethanol from Water *

*DO NOT TRY THIS AT HOME

* This presentation is for informational purposes only, Koch-Glitsch LP does not recommend or endorse the distillation of alcohol. Consult with an attorney and safety personnel prior to any related activity.
Thank you.

Questions?

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