Efficiency Benefits of High Performance Structured Packings

Kevin Bennett, Sulzer Chemtech
Mark Pilling, Sulzer Chemtech

Prepared for Presentation at
Department of Energy
Texas Technology Showcase 2003
Separation & Distillation Technology Session
Structured Packing is the Internal of Choice for Low Pressure and Low Liquid Rate Systems

- High Capacity
- High Efficiency
- Low Pressure Drop
- Proper Distribution is Critical
Mechanical Construction

- Thin Sheet Metal
- Angled Corrugation
- Textured & Perforated
- Layers are Segmented & Rotated
• Sheet Metal Typically 0.004” - 0.008”
  – Larger Crimp Packings May Require More Thickness
  – Essentially No Corrosion Allowance
    • Material Selection is Critical

• Gauze Packings Made From Woven Metal Cloth
  – Usually for Very High Efficiency Applications
• Typically Textured & Perforated
  – Texturing Promotes Spreading of Liquid on Surface
  – Perforation Allows Equalization of Flows and Pressures Between Sheets
  – Lack of Texture and/or Perforation Reduces Efficiency
Most Commonly 45° (Sulzer Y Designation)
- Usually the Optimum Angle for Efficiency, Capacity & Cost

Second Most Commonly 60° (Sulzer X Designation)
- More Often Used in Absorption & Heat Transfer Applications Where Surface Area is More Important
• Typically Expressed in Units of m\(^2/m^3\)
  – Normal Range (40 - 900 m\(^2/m^3\))
  – Benchmark M250.Y
  – Lower Surface Area Packing (40 - 90 m\(^2/m^3\))
    Often Grid Type
  • Heat Transfer & Scrubbing
  – High Surface Area > 500 m\(^2/m^3\)
  • Air Separation & Fine Chemicals
When To Use Structured Packing

- System Pressure & Liquid Rates
- Vessel Diameter
- Number of Stages
- Presence of Two Liquid Phases
- Thermal Degradation
Structured Packing Works Has its Greatest Advantage with Low Liquid Rates and High Vapor Velocities

- In Distillation Systems, Low Pressure Means Low Liquid Rates and High Vapor Velocities. Ideal for Structured Packing

- High Pressure Absorption with Low Liquid Rates are also Good Structured Packing Applications
Number of Stages Required

- Structured Packing’s High Efficiency Makes it Ideal for Applications Requiring Many Stages
  - Exception: Superfractionators with High Pressures and High Liquid Rates
• Mainly a Function of:
  – Packing Geometry
    • Surface Area
    • Crimp Angle
  – Distribution Quality
  – Process System Properties
• Packing Geometry

  – Surface Area: Efficiency Increases With Surface Area

  – Crimp Angle: Efficiency Increases with Decreasing Crimp Angle
Things Requiring Special Consideration:

- High Liquid Rates
  - Rates Above 20-25 gpm/ft\textsuperscript{2} May Have Lower Efficiencies
- High Relative Volatility ($\alpha > 3$)
- High Liquid Viscosity & High Stripping Factors
- Absorption & Stripping Applications
- High Surface Tension

All These Systems Have Been Packed with Structured Packing. Special Design Considerations are Needed
Performance Characteristics - Hydraulic

- Beyond the Loading Point, Liquid Holdup in Conventional Structured Packing Begins at the Interface Between Layers
1. MellapakPlus: Background, Performances & Potential

Development steps

- Concept: modify transition between the packing layers
- CFD Analysis
- Mechanical issues
Product

Mellapak®

MellapakPlus®
Close Up Mellapak 252.Y
Sulzer Chemtech Testing

- **Facility:** Winterthur, Switzerland
- **Column Diameter:** 3.3 ft (1 m)
- **Bed Depth:** 9.9 ft (3.03 m)
- **Distributor Type:** Sulzer Chemtech VKG
- **Test System:** Chloro/Ethyl Benzene at 75mm Hg (100 mbar)
FRI Testing

- F.R.I. 2000 Category 1 Packing Test
- Industrial Scale Test Facility
- Measure efficiency, capacity, pressure drop, holdup
FRI Testing

- Facility: Stillwater, OK
- Column Diameter: 4 ft (1.2 m)
- Bed Depth: 12 ft (3.7 m)
- Distributor Type: Sulzer Chemtech VKG
- Test Systems:
  - Ortho/Para-Xylene at 100mm Hg (133 mbar)
  - C₆/C₇ at 5 & 24 psia (345 & 1650 mbar)
FRACTIONATION RESEARCH, INC.
Low Pressure Column
12 feet (3.7m) Bed of Sulzer Mellapak 252.Y Structured Packing

- Distributor Bubbler

- Temperature
- Pressure Top
- Composition

Sulzer Chemtech
4.3mm Orifice VKG Dist.

17 Layers of Sulzer Chemtech Mellapak 252.Y

Top

Overall

Bottom

East 5"

Vane Collector

2 Half-Layers of Sulzer Chemtech Mellapak 250.X

Packing Height: 8.3"

- Distributor
- 143"
- 113"
- 83"
- West 71"
- East 65"
- 59"
- 35"
- Below Bed Cross
- Vane Collector

EAST

WEST
Figure 3. Mellapak Plus 252.Y Efficiency
o/p Xylene System, 100 mm Hg (FRI)
& Chloro/Ethyl Benzene, 77 mm Hg (Sulzer CT)
Capacity Factor $C_s$, m/s

HETP, inches

M252Y (FRI) M250Y (FRI) Optiflow (FRI) M250Y (WT) M252Y (WT)
Figure 4. Mellapak Plus 252.Y Efficiency
12 foot (3.67 m) Bed Depth
C₆/C₇ System, 5 psia (0.34 bar)

Capacity Factor $C_v$, m/s

HETP, inches

- △ M252.Y VKG 5.3 mm (Midbed 16-38%C6)
- - M252.Y VKG 5.3 mm (Midbed 45-52%C6)
- - M252.Y VKG 5.3 mm (Midbed 83-91%C6)
- - M250.Y 1988 TDP (midbed 40-66%C6)
- - M250.Y 1988 TDP (midbed 90-96%C6)
Figure 5. Mellapak Plus 252.Y Efficiency
12 foot (3.67 m) Bed Depth
C_6/C_7 System, 24 psia (1.65 bar)

Capacity Factor $C_s$, m/s

HETP, inches

- **M252.Y VKG 6.7 mm (Midbed 34-58%C6)**
- **M250.Y 1988 TDP (midbed 44-53%C6)**
- **M250.Y 1988 TDP (midbed 61-79%C6)**
- **M250.Y 1988 TDP (dc-reflux)**
Figure 6. Mellapak Plus 252.Y Efficiency

Effect of Pressure on HETP

Capacity Factor $C_s$, m/s

HETP, inches

- 100 mm Hg xylene
- 5 psia (0.34 bar) C6/C7
- 24 psia (1.65 bar) C6/C7
- 75 mm Hg CB/EB

Capacity Factor $C_s$, ft/s

HETP, m

0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18

0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18

0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80

10 12 14 16 18 20 22 24 26 28 30 32
Efficiency Conclusions

- M252.Y HETP 14 -16 inches (0.35-0.4 m) as good or better than M250.Y & Optiflow
- Maximum useful capacity 100 mm Hg: 40% above M250.Y, 15% above Optiflow
- Maximum useful capacity 5 psia (0.34 bar): 25% above M250.Y
- Maximum useful capacity 24 psia (1.65 bar): 18% above M250.Y
Figure 7. Mellapak Plus 252.Y Pressure Drop
12 foot (3.67 m) Bed Depth
o/p Xylene System, 100 mm Hg
Total Reflux

Pressure Drop, in H₂O/ft x 8.167 = mbar/m
Figure 8. Mellapak Plus 252.Y Pressure Drop
12 foot (3.67 m) Bed Depth
C_6/C_7 System, 24 psia (1.65 bar)
Total Reflux

in H_2/O/ft x 8.167 = mbar/m
Figure 9. Mellapak Plus 252.Y Pressure Drop/Stage
12 foot (3.67 m) Bed Depth
o/p Xylene System, 100 mm Hg
Total Reflux

M252.Y
M250.Y 1988 TDP
Optiflow VEP

In H₂O/stage x 2.5 = mbar/stage
ft/s x 0.3048 = m/s
Pressure Drop Conclusions

- M252.Y pressure drop less than M250.Y
- Good agreement with Sulpak predictions
- Lowest pressure drop per stage measured in 100 mm Hg xylene at F.R.I.
Other MellapakPlus Data

**Separation Efficiency**

- **HETP (m)** vs. gas load F-factor \([\text{Pa}^{0.5}]\)
- **Pressure Drop** \([\text{mbar/m}]\)

**Pressure Drop**

- **\(\Delta p\) [mbar/m]** vs. gas load F-factor \([\text{Pa}^{0.5}]\)

**100 mbar**

- MellapakPlus 752.Y
- Mellapak 750.Y
- Mellapak 500.Y

**960 mbar**

- MellapakPlus 752.Y
- Mellapak 750.Y
- Mellapak 500.Y