Selection of Column Internals - Coker Unit
Coker Main Fractionator

Feed: Bottom of Barrel

- COKE DRUMS
- FEED
- Quench
- GAS
- LPG
- GASOLINE
- LCGO
- HCGO
Objectives

- Safety.
- Reduce coke and coking problems.
- Increase conversion.
- Debottleneck equipment limitations:
  - Cycle time.
  - Compressor.
  - Furnace.
  - Fractionator.
- Avoid salt deposits in fractionator overhead.
- Increase fractionation efficiency.
- Increase capacity.
Coking Problems

- Unit processes all the heavy residues from the various refinery process units, mainly Vacuum Residue.
- Coke forms at undesirable locations in the equipment.
- Coke is generally formed in the wash zone and at times in the HCGO section.
Wash Zone Objectives

- Quench the drum vapors
- De-entrain coke fines
- Improve HCGO quality and yield
Wash Zone Design

- HCGO quality
- Recycle ratio
- Feed quality
- Unit reliability
- Yields
- Capacity
- Fractionator internals
Wash Zone Design Requirements

- Test run for proper data collection and establish the design basis
- HTSD characterization curves for heavier products
- Antifouling internals
- Vapor and liquid distribution is very critical
- Uplift requirement to resist upset conditions
Conventional Coker MF Wash Zone Configurations
Use of Trays in Wash Section

**Advantages**

- High fouling resistance
- Can operate with fouling or plugging for some time
- Easy to inspect

**Disadvantages**

- Low mass transfer efficiency
- Requires high wash rates for contact efficiency
Use of Sulzer Grid Packing in Wash Section

**Advantages**
- Resistant to fouling or plugging due to open structure
- More efficient than spray chamber or sheds
- Can operate with less wash oil than trays
- Can be designed to resist upset conditions
- Higher capacity
- Better de-entrainment

**Disadvantages**
- More difficult to inspect
- Higher capital cost
CFR: Combined Feed Ratio

\[ \text{CFR} = \frac{\text{Fresh Feed Rate} + \text{Recycle Rate}}{\text{Fresh Feed Rate}} \]

Recycle: Direct condensation of distillate tail in O/H vapors which is a result of:

- Injection of quench in O/H line
- Heat losses in O/H line
- Fractionator internal reflux or wash oil fed to reduce entrainment
- Typical value is 1.05 to 1.1
CFR: Combined Feed Ratio

CFR affects:

- Type of coke produced: petroleum coke has lower CFR as compared to needle coke
- End point of HCGO
- Capacity
- Leads to more coke
- Furnace coking, fuel consumption
- Capital and operating costs

Use of any Internal:

- Reduces the requirement of wash oil
- Reduces the CFR and increases the capacity
- Reduces capital and operating costs
Major Equipment Limitations

- Furnace
- Compressor
- Coke drums - Cycle time
- Fractionator
Main Fractionator

- Typically has about 24 trays

- 3 types of sections:
  - Wash
  - Pumparound
  - Fractionation

- Pressure drop through 24 trays ~ 5 to 7 psi

- Pressure drop with packing ~ 1 psi

- Reduced pressure drop can significantly increase the product and/or increase the capacity.

- 5 psi pressure drop reduction will significantly decrease the coke yield and increases the liquid yield.
Lower DP debottlenecks all the major equipment

- **Furnace:** Lower firing, lower fuel and less coking
- **Compressor:** Higher pressure at the suction reduces the gas volume
- **Cycle time:** Less coke reduces cleaning frequency
- **Fractionator:** Better separation and hydraulic capacity
Feed: Vacuum Residue

- TBP Cut point: 1050 F+
- API: 2.6
- Sulphur: 3.5% wt
- Ni+V: 943 ppm wt
- TAN: 0.5

Products: Gas: C1 & C2
- LPG: C3 & C4
- Gasoline: C5 to C14
- LCGO: C15 to C22
- HCGO: C23 to C40
- Coke: C70+

Feed: 20,000 BPSD

<table>
<thead>
<tr>
<th>Coke Drum Pressure- Psig</th>
<th>Coke Make - t/d</th>
<th>Fuel Gas- MM BTU/HR</th>
<th>Liquid Yields (C5+) BPSD</th>
<th>% Increase</th>
<th>Incremental Product Value- US $/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>1,037</td>
<td>259.6</td>
<td>14,465</td>
<td>Base</td>
<td>Base</td>
</tr>
<tr>
<td>13</td>
<td>1,029</td>
<td>255.8</td>
<td>14,538</td>
<td>0.5</td>
<td>326,370</td>
</tr>
<tr>
<td>10</td>
<td>1,017</td>
<td>249.3</td>
<td>14,651</td>
<td>1.3</td>
<td>844,470</td>
</tr>
<tr>
<td>7</td>
<td>1,004</td>
<td>242.3</td>
<td>14,780</td>
<td>2.2</td>
<td>1,430,220</td>
</tr>
</tbody>
</table>
MELLAGRID

Special features:

• Resists coking and fouling due to its smooth surface
• Geometric structure efficiently dissipates temperature and concentration gradients
• Much better de-entrainment and separation efficiency than conventional grids
• The low element height and its smooth surface structure allow for easy cleaning
• Mechanically robust structure

Application examples:

• Atmospheric or Vacuum Tower
  - Wash section
  - Pumparound section with high liquid and gas loadings
• FCC Main Fractionator
  - Slurry pumparound section
• Coker or Visbreaker Fractionator
  - Wash section
Salt Deposition and Corrosion in Main Fractionator Overhead

**Circumstances:**
- Low Sulfur Naphtha production requirement.
- Processing deep cut vacuum residue.
- Undercutting heavy high sulfur naphtha via side d/o.

**Constraints:**
- Vacuum residue contains Chloride salts.
- Low operating temperature in top of main fractionator.

**Problems:**
- Deposition of Ammonia Chloride salts in upper sections of Coker MF and overhead condensation system
- Loss in capacity and efficiency in top of main fractionator
Areas prone to salt fouling

Salt Deposition and Corrosion in Main Fractionator Overhead

Methods employed to remove the salts:

- Maintaining the fractionator top temperature high enough to ensure the sublimation of all the salts.
- Water washing of column.
- Minimizing chlorides contaminants in coker feed. (Desalting).
- Use of chemical additives (salt dispersants).
Tray Deck Fully Plugged by Asphaltenes

Outlet Weir

Bubbling Area Equipped with 0.5” Sieve Holes !!!

Feed Inlet

Inlet Weir !!!
What Does Promote Fouling on Fractionation Trays?

Outlet Weirs, Round Valves, Long Flow Path Cause:

- Excessive liquid gradient along the tray deck;
- Vapor mal-distribution underneath the active area;
- Stagnant zones at the corners of the tray deck;
- Excessive residence time at the stagnant zones;
- Polymerization, fouling accumulation, reduced capacity.
What Promotes Fouling on Fractionator Trays?

- Inlet Weirs
- Recessed Downcomer Inlet Areas
- Conventional Outlet Weirs
- Seal Pans at Bottom of Tower
- Moving Valves, in Particular the Round Ones
- Excessive Flow Path Length
Sulzer VGAF™ Tray Features

- Larger Size V-Grid Valves (MVG, SVG, LVG)
- Highly Sloped Downcomers
- Pushing Valves
- Modified Outlet Weir
VG AF trays equipped with Stepped Outlet Weir

Push Valves at DC inlet area

Push Valves at middle of the Flow Path, if needed

Highly Sloped DC
VG AF trays equipped with Stepped Outlet Weir

- Push Valves at DC inlet area
- Push Valves at middle of the Flow Path, if needed
- Highly Sloped DC Truss
Features Inhibiting Fouling on Fractionator Trays

- Push Valves: At the downcomer inlet area.
  At the stagnant zone.
  At the middle of the flow path.

- Enhanced Outlet Weir design.

- V-Grid fixed valves.
VGAF Trays Equipped with Sloped Outlet Weir

Push Valves in Front of Sloped Outlet Weir

Sloped Outlet Weir at Side Downcomer
VGAF Trays Equipped with Sloped Outlet Weir
Froth Velocity Diagram Over the Active Area

Conventional Trays

VGAF Trays
Residence Time Diagram Over the Active Area

Conventional Trays

VG AF Trays
Options Available to Increase Capacity

- Revamp HCGO Pumparound.
- Revamp with Sulzer High Capacity MVG™ and VGPlus™ Trays.
- Revamp with Sulzer Mellapak, Mellagrid and Nutter Grid Packing.
Improving the Gas Oil/Naphtha Quality

- Tray efficiency ~ 50 to 60%
- Packing efficiency can be about 500 mm/stage
- Improve the fractionation efficiency by changing to Sulzer Mellapak™ and MellapakPlus™.

<table>
<thead>
<tr>
<th>Type</th>
<th>NTSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>M125.Y</td>
<td>1.2</td>
</tr>
<tr>
<td>M2.Y</td>
<td>2.0</td>
</tr>
<tr>
<td>M250.Y</td>
<td>2.5</td>
</tr>
<tr>
<td>M202.Y</td>
<td>2.0</td>
</tr>
<tr>
<td>M252.Y</td>
<td>2.5</td>
</tr>
</tbody>
</table>
The Largest Coker Main Fractionator
Equipped with VG AF (V-Grid Anti-Fouling) Trays

New 6 Pass Baffle Trays
ID 8840 mm
From Round Valve to VG AF trays
ID 6710 mm

- Nominal Capacity: 122 kbdpd
- Maximum Capacity before Revamp: 140 kbdpd
- Capacity after Revamp: 160 kbdpd
- Revamp Capacity: 122 kbdpd
2 Pass VG AF Trays ID: 8840 mm

- PV at the deck periphery
- PV at the CDC inlet area
- PV at the middle of the flow path
- PV in front of sloped outlet weir

Liquid Flow
## REFERENCES

<table>
<thead>
<tr>
<th>Year</th>
<th>Customer</th>
<th>Diameter</th>
<th>Supplied Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Marathon, USA</td>
<td>168” / 4267 mm</td>
<td>BDH Trays</td>
</tr>
<tr>
<td>2000</td>
<td>Seadrift Coke, USA</td>
<td>126” / 3200 mm</td>
<td>Mellagrid</td>
</tr>
<tr>
<td>2000</td>
<td>Equilon Enterprises, USA</td>
<td>120” / 3048 mm</td>
<td>MVG Trays / Mellapak / Mellagrid</td>
</tr>
<tr>
<td>2002</td>
<td>Husky Oil, CAN</td>
<td>114” / 2896 mm</td>
<td>BDH / SVG Trays / Mellapak</td>
</tr>
<tr>
<td>2002</td>
<td>ConocoPhillips, USA</td>
<td>168” / 4267 mm</td>
<td>SVG Trays</td>
</tr>
<tr>
<td>2003</td>
<td>PETROBRAS-REGAP, BR</td>
<td>122” / 3100 mm</td>
<td>MVG Trays / Mellapak</td>
</tr>
<tr>
<td>2004</td>
<td>ESSO, AR</td>
<td>134” / 3400 mm</td>
<td>SIV Trays / Mellagrid</td>
</tr>
<tr>
<td>2004</td>
<td>Premcor, USA</td>
<td>216-264” / 5486-6706 mm</td>
<td>MVG Trays</td>
</tr>
<tr>
<td>2004</td>
<td>ConocoPhillips, USA</td>
<td>96” / 2438 mm</td>
<td>MVG Trays</td>
</tr>
<tr>
<td>2005</td>
<td>ConocoPhillips, USA</td>
<td>150” / 3810 mm</td>
<td>SVG Trays</td>
</tr>
<tr>
<td>2005</td>
<td>Valero, Aruba</td>
<td>156” / 3962 mm</td>
<td>MVG / SVG Trays</td>
</tr>
<tr>
<td>2005</td>
<td>PetroCanada, CAN</td>
<td>120”-144” / 3048-3658 mm</td>
<td>BDH / SVG Trays / Nutter Grid</td>
</tr>
<tr>
<td>2005</td>
<td>Husky Oil, CAN</td>
<td>114” / 2896 mm</td>
<td>BDH / SVG Trays / Mellapak</td>
</tr>
<tr>
<td>2006</td>
<td>Shell, USA</td>
<td>216” / 5486 mm</td>
<td>MVG Trays</td>
</tr>
<tr>
<td>2006</td>
<td>Coffeyville, USA</td>
<td>132” / 3353 mm</td>
<td>Mellagrid</td>
</tr>
</tbody>
</table>
Obrigada!