“Automation of Separation for More Bottom of the Barrel return”

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Abstract

- The Search for better “bottom of the barrel”
- Particle Sensor Introduction
- FCC/RFCC
- Slurry Oil products
- Solid Removals option
- Slurry Yields and Properties
- Mechanical vs. Electrostatic Separation
- Economics
- Conclusions
Maximize Your Return from Every Barrel

- **Heavier Crudes**
  - Residual upgrading
  - Increased catalyst use

- **Catalyst Concerns**
  - Refiners are seeking to add value to Residual Fuel Oil
    - Have to remove catalyst
  - Downstream Catalyst in fuel oil and feedstock increases maintenance and fouling
    - Heavy Oil Processing
  - Higher concentrations of catalyst in clarified oil presents only a narrow range of applications
  - Build up of sludge in downstream refinery processes
  - Loss of catalyst in deteriorating FCC units
    - Catalyst contains Rare Earth Metals and ZSM5
Dark Oil Particle Sensor and Analyzer
FCC/RFCC

- Heavier crudes increase FCC catalyst consumption.
- FCC vital in the growing demand for propylene
- Increased economic demands require more residual to be sent to the FCC/RFCC
- Degrading FCC reactor side cyclone efficiency increases Catalyst lost, Recovery is key
- FCC/RFCC units approx. 20-25 tons of catalyst per day turnover with petrochemical driver.
- Catalyst removal from Fractionator bottoms:
  - Upgrade in (CSO) quality/value
  - Hazardous waste reduction
  - Decrease in downstream maintenance, downtime
  - Reduction in landfill and catalyst loss
The Real Deal – What is it Worth?

- FCCU 80,000 B/D – SLURRY AVERAGE 6%
- Removal of fines <5 microns at 3000ppm to <100ppm
- 5 tons/ day of fines removed from settling tanks
- Separation of fines upgrades CSO value
- Assuming $4.0 per barrel product increase
- Waste Savings $1.8 Million/year
- 4800 BPD*365*$4.0/ BPD =$7.0 Million/ year
- Think Millions!
CSO Value – More Valuable End Products

- Average FBO/CSO Differential: $4.00 - $6.00 USD Per Barrel
- Related Annual Increased Revenue: $4.7M USD Per Year
- CSO Payout from Increased Revenues: 7.7 Months

<table>
<thead>
<tr>
<th>CSO Market</th>
<th>Clarified Slurry Oil (CSO) Clarity (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Black Feedstock</td>
<td>100 – 500</td>
</tr>
<tr>
<td>Refinery Fuel</td>
<td>50 - 150</td>
</tr>
<tr>
<td>Marine Fuel</td>
<td>50 - 100</td>
</tr>
<tr>
<td>Pitch Feedstock</td>
<td>25 - 100</td>
</tr>
<tr>
<td>Needle Coke Feedstock</td>
<td>25 - 100</td>
</tr>
<tr>
<td>Hydrotreater Feedstock</td>
<td>10 - 50</td>
</tr>
<tr>
<td>Carbon Fiber Feedstock</td>
<td>5 - 10</td>
</tr>
</tbody>
</table>
Solids Removal Options

• **Decant Oil – Settling Tanks**
  - Time vs. cost
  - Settling agents
  - Hazardous waste

• **Mechanical Filtration/ Centrifuge**
  - Limited filtration size.
    - ≥ 100ppm
  - Susceptible to plugging with Asphaltenes, waxes
  - Deterioration of liners Q2yrs = increased cost
  - Membrane filters

• **Electrostatic Separation**
  - Effective on particle sizes <5μ
  - Not susceptible to blockage
  - Increased throughput
Table 2 Typical Particle Size Distribution in Slurry oils

<table>
<thead>
<tr>
<th>Particle Diameter, microns</th>
<th>% in Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>30-60</td>
</tr>
<tr>
<td>5-15</td>
<td>30-55</td>
</tr>
<tr>
<td>15-25</td>
<td>2-12</td>
</tr>
<tr>
<td>25+</td>
<td>1-5</td>
</tr>
</tbody>
</table>
Dark Oil Particle Sensor Automation Results

**Analysis Date:** 03/28/2013 13:22:6

**Run time (sec):** 50

**Sample name:** Dirty Oil

**Instrument Details**
- Sample run by: JH
- Configuration: flow cell offline
- Spatial Calibration: 100 micron grid
- Sample delivery: Pump

**Image**
- Field width: 340.199982 microns
- Pixel size: 0.210000 microns

**User Data**
- User Data1
- User Data2
- User Data3
- User Data4

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**JH CANYT PARTICLE ANALYSIS**

**Size (minor axis):**

<table>
<thead>
<tr>
<th>Particle Frequency (% diff. by vol)</th>
<th>Particle Size (minor axis) microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>50</td>
<td>6</td>
</tr>
<tr>
<td>70</td>
<td>9</td>
</tr>
<tr>
<td>90</td>
<td>12</td>
</tr>
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</table>

**Concentration (ppm):**

<table>
<thead>
<tr>
<th>Particle Frequency (ppm, moving average)</th>
<th>Sample Number</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>200</td>
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<tr>
<td>200</td>
<td>300</td>
</tr>
<tr>
<td>300</td>
<td>400</td>
</tr>
</tbody>
</table>

**Population Stats (N):**

<table>
<thead>
<tr>
<th>Value (N)</th>
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<tbody>
<tr>
<td>96,104</td>
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<tr>
<td>999</td>
</tr>
<tr>
<td>90</td>
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<td>2240.14</td>
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<td>2.09450</td>
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<tr>
<td>2.94004</td>
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<tr>
<td>5.25881</td>
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</table>
Electrostatic Separation Results with Particle Sensor Automation
Throughput: Mechanical Filtration vs. Electrostatic

**Mechanical Filtration**

- Hours of Operation: filter will progressively cake
- Pressure Drop: progressively increases
- Throughput: progressively decreases

= Operational Disruption

**Gulftronic®**

**Gulftronic® Skid**

- Skid – Multiple Modules
- Automated Back Flush/1 Module at a Time
- Pressure Drop: remains constant (< 4 Barg)
- Throughput: remains constant
- Impervious to “plugging” by Asphaltenes and Coke

= Continuous Operation
Electronic Separators – Increased Value

FCC/RFCC Reactor

Fractionator

Light Gases

Gasoline

Light Cycle Oil

Heavy Cycle Oil

Slurry Oil

Clarified Slurry Oil

Gulftronic® Separator

FCC/RFCC Feed Return Loop

FCC/RFCC Feed for Backflush

Catalyst Regenerator

Catalyst

Air

FCC/RFCC Feed

Slurry Hydrocracker/ H-Oil unit

Inventory Tank

Settling Tank

Backflush

Gulftronic® Separator

FCC/RFCC Feed for Backflush

FCC/RFCC Feed Return Loop
Refinery Benefits

- CSO increased value
- Increased Middle distillate production
- No decrease in FCC production
- Loss catalyst recovery and recycle
- Settling Tank waste reduction
- Lower Temperatures equates greater Safety
- Catalyst Concentration Equilibrium
- Relief from fouled exchangers and line plugging.
Conclusions

• Drive to more resid FCC favor solution to recover catalyst without coking and Asphaltenes.
• Heavier Crude slates has inevitably effected every FCC/RFCC operation and increase in Catalyst fines during processing
• Increased profit is lost without proper catalyst recovery.
• Mechanical Filtration is questionable with new refinery demands in safety and processing.
• Electrostatic Separation; Safe, Reliable and Effective.