Saudi Aramco TOTAL Refining & Petrochemical Company (SATORP)

Saudi Arabia’s First Delayed Coker Unit

Maximizing DCU Liquid Yields from Arabian Heavy Feedstock

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Operation Engineer, SATORP
2 Nations
Complex Deep Conversion Refinery with high level of Automation.

- Refined High Value Product Complying with most Stringent International Specifications.
- 400 kbd of Arabian Heavy.
- Full Conversion; Integrated with Petrochemical.
- Solomon Benchmark Ranking #7 in complexity index among more than 300 Refineries worldwide.

### Equipments of a Complex & Sophisticated Refinery

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps</td>
<td>1,260</td>
</tr>
<tr>
<td>Vessels</td>
<td>866</td>
</tr>
<tr>
<td>Analyzers</td>
<td>600</td>
</tr>
<tr>
<td>Columns</td>
<td>121</td>
</tr>
<tr>
<td>Compressors</td>
<td>80</td>
</tr>
<tr>
<td>Reactors</td>
<td>68</td>
</tr>
<tr>
<td>Boiler &amp; Furnaces</td>
<td>43</td>
</tr>
<tr>
<td>Loops</td>
<td>120,000</td>
</tr>
</tbody>
</table>
SATORP Complex

- 103,000 BPD CAPACITY FW COKER DESIGN
- 36 HR CYCLE TIME/18 HR COKING TIME
- 3 PAIRS OF DRUMS
- DUAL FIRED FURNACE WITH 6 PASSES EACH
- SLOP & SLUDGE PROCESSING FACILITY
- 26 KM BELT CONVEYOR UP TO PORT.
Coking Section

VacRes BOD

API/Sp.Gr. 2.8/1.054
5% Distillation 547
ConCarbon 27.2
Asphaltenen:CCR Ratio 0.625
# Basis of Design

<table>
<thead>
<tr>
<th>Design Operating Conditions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil Outlet Temperature</td>
<td>496 °C</td>
</tr>
<tr>
<td>Drum Pressure</td>
<td>1.03 Bar</td>
</tr>
<tr>
<td>Recycle Ratio - Normal /Flexibility</td>
<td>17% (5% - 20%)</td>
</tr>
<tr>
<td>Quenched Vapor Temperature</td>
<td>425 - 433 °C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Liquids &amp; Coke Yields</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquids (C5+)</td>
<td>56 – 58 wt%</td>
</tr>
<tr>
<td>Coke</td>
<td>32.9 – 34.6 wt%</td>
</tr>
</tbody>
</table>
Key Parameters to Improve Liquid Yield

- Improving liquid yield by 1% results in 8% additional margin per ton of VR processed.
- Below are the parameters that we have manipulated to increase the liquid yield:

**Temperature:**
- Drum Inlet
- Vapor Outlet
- COT

**Pressure:**
- Coke Drum Pressure

**Recycle Ratio:**
- Wash Oil
- Vapor Line Quench
- Wash Zone Design

**Additives:**
- Additives to Boost Liquid Yield
<table>
<thead>
<tr>
<th>Temperature</th>
<th>Current Position</th>
<th>Forseen</th>
</tr>
</thead>
<tbody>
<tr>
<td>COT</td>
<td>Increased to 506 °C (10 °C higher than design)</td>
<td>Further 2 – 4 °C</td>
</tr>
</tbody>
</table>
| Drum Inlet Temperature | Increase by 5 – 6 °C (current 486 °C) | Up to 490 °C  
- Further COT.  
- Ongoing Insulation improving project. |
Temperature vs. Liquid Yield

- Predicted Yield based on CCR.
- COT increase.
- Temperature drop across the transfer line.
- Foreseen inlet temperature.
- Stopping Hydrocarbon to flash zone (BD, CCD).
- Routing fractionator bottom fine removal pump to heater charge pump.
- Optimizing Heavy service seal oil (plan-32).
- Recovery of liquid yield is higher after overhead line cleaning.
- Vapor line cleaning frequency.
- Upstream unit VGO slippage recovery.
Further Improvement

- Chemical Additives.
- Reducing partial pressure of hydrocarbon by increasing condensate rate (velocity medium).
- Improvement of flash zone.
Conclusion

Although we have improved yields, and are operating in what is outside of accepted rule of thumb and even design conditions, we will continue to push further for the maximum DCU liquid yield.
THANK YOU.

Q & A