De-Butanizer Revamp at PreemRaff, Lysekil, Sweden

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* Speaker
Outlook

1) Background
2) Scope of the Revamping
3) Tower modifications
4) Test run data
5) Analysis of the plant data
6) Conclusions
Background, page 1 of 2


2) The feed quality to the FCC improved significantly.

3) The conversion of the FCC plant was increased towards the production of Gasoline and LPG by higher dosage of ZSM-5 catalyst, as well as improved feed-stock.

4) The feed rate to the De-Butanizer increased, as well as its LPG content.
Fluid Catalytic Cracking
Reactor, Main Fractionator, Absorbers & Stripper
5) The De-Butanizer was originally equipped with 30 Conventional 2 pass trays, and put on stream in 1985.

6) Ten years later, it was retrofitted with 30 High Performance Chordal Downcomer trays to boost the capacity by 15%.

7) The column achieved the target of the first revamping, and was running at its maximum useful capacity, in particular the Stripping section was not able to produce more than 80 m³/h of Stabilized Naphtha with 75 m³/h of LPG from the Rectifying section.

8) The tray efficiency at the maximum achievable throughput was not more than 65%
Scope of the Revamp

1) Increase the capacity by approx 15 % over the maximum achievable throughput after the first revamp:
   - case 1: feed 175 m3/h; LPG 79.3 m3/h; LCN 95.7 m3/h
   - case 2: feed 175 m3/h; LPG 90.3 m3/h; LCN 84.7 m3/h

2) Operating range: 1 to 2.5, to comply with the two different cases: Normal and Rich LPG.

3) Maximize the Mass Transfer Efficiency.

4) C5\textsubscript{s} content on the top Stream less than 0.6 % Vol.

5) RVP of the bottom LCN <=85 KPa

6) Minimize the investment cost
Scope of the Supply

Based on a process study developed by an Engineering company and cross-checked by the Refinery, the following goods were supplied:

1) 15 HiFi Plus™ trays in the rectifying section, designed by Sulzer and cross-checked by Shell Global Solutions.

2) 15 ConSep™ Trays in the Stripping sections designed by Shell Global Solutions.

3) Top reflux distributor designed by Sulzer.

4) Mixed Phase feed inlet distributor designed by Sulzer.

5) Expansion Rings and other tower internal supports designed by Sulzer.
Modifications in the Rectifying Section

- Top Reflux
- Chordal DC HPT
- Feed
- HiFi Plus™ Trays
Modifications in the Stripping Section

Feed

Chordal DC HPT

ConSep™ Trays

To Reboiler
HiFi Plus™ trays in the Rectifying Section
ConSep™ Trays in the stripping section

Swirl Tube

HiFi™ downcomer
PreemRaff

ConSep™ Trays in the stripping section

HiFi™ downcomer

Swirl Tube

Secondary downcomer
ConSep™: The Ultra System Limit Mass Transfer Component tested at FRI
Combination

Large Bubbling Area and Liquid Handling Capacity of HiFi™ Tray

Liquid De-Entrainment Device of Swirl Tube Tray

Clear Vapor

Liquid

Liquid entrainment

Liquid
Efficiency Comparison with high capacity trays at FRI
(iC4/nC4 at 11.4 bar)

- Shell ConSep™ tray
- Sulzer VGPlus™ tray
Swirl Tubes underneath the active area
Top Reflux Distributor
Mixed Phase Feed Inlet Distributor
Test Run 16-19 January 2007
Test #1: 16Jan, 0 am 11 pm, 24 hours

- **Top Reflux**: Flow Rate (m³/h)
  - Time (Hours): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
  - Values: 82, 83, 84, 85, 86, 87, 88

- **C5s Bottom T1512**: C5s content (% Vol.)
  - Maximum acceptable
  - Time (Hours): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
  - Values: 0.3, 0.5, 0.7, 0.9, 1.1, 1.3, 1.5

- **Tower Pressure Drop**: Pressure Drop (mBar)
  - Time (Hours): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
  - Values: 250, 300, 350, 400

- **Reboiler Duty**: Reboiler Duty (MMKcal/h)
  - Time (Hours): 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
  - Values: 6.5, 6.6, 6.7, 6.8
Test #1: 16Jan, 0 am 11 pm, 24 hours
Test #1: 16Jan, 0 am 11 pm, 24 hours
Test #1: 16Jan, 0 am 11 pm: measured plant data

<table>
<thead>
<tr>
<th></th>
<th>Feed</th>
<th>LCN</th>
<th>C4s+</th>
<th>C3s-</th>
</tr>
</thead>
<tbody>
<tr>
<td>m3/h</td>
<td>180.9</td>
<td>100.4</td>
<td>50.6</td>
<td>34.9</td>
</tr>
</tbody>
</table>

Material Balance: \[
\frac{\text{Out} - \text{In}}{\text{Out}} = \frac{185.9 - 180.9}{185.9} = 2.69 \%
\]

Top Reflux: 86 m3/h
Reboiler Duty: 6.64 MMKcal/h

Simulation results of Test #1, Feed = 185.9 m3/h

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<table>
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<tbody>
<tr>
<td>Tray Efficiency (%)</td>
<td>93.3</td>
<td>100</td>
</tr>
<tr>
<td>Top Reflux (m3/h)</td>
<td>86.1</td>
<td>85.3</td>
</tr>
<tr>
<td>Reboiler Duty (MMKcal/h)</td>
<td>7.01</td>
<td>6.96</td>
</tr>
</tbody>
</table>

Reb. Duty deviation: \[
\frac{\text{Sim.} - \text{Plant}}{\text{Sim.}} = \frac{7.00 - 6.64}{7.00} = 5.14 \%
\]
Test #2: 17Jan, 2-9 pm, Maximum Useful Capacity at 7.15 pm
Test #2: 17Jan, 2-9 pm, Maximum Useful Capacity at 7.15 pm

- **Top Pilot Tray #5**
  - Temperature (°C)
  - MUC

- **Bottom Pilot Tray #29**
  - Temperature (°C)

- **Flow Rate (m³/h)**
  - Top
  - Bottom
  - Feed

- **Percent (%)**
  - Top Receiver Level
  - Btm Tower Level

- **Time (Hours)**
Test #2: 2-9 pm, 17Jan; Maximum Useful Capacity at 7.15 pm
Test #2: 17Jan, 2-9 pm, MUC at 7.15 pm: measured plant data

Material Balance:  \[
\text{Out} - \text{In} = \frac{186.9 - 180.7}{186.9} = 3.32\%.
\]

Top Reflux: 105.2 m³/h

Reboiler Duty: 7.52 MMKcal/h

Simulation results of Test #2, Feed = 186.9 m³/h

Tray Efficiency (%): 66.7 73 69.4

Top Reflux (m³/h): 108.2 101.3 105.2

Reboiler Duty (MMKcal/h): 8.35 8.02 8.21

Reb. Duty deviation:  \[
\frac{\text{Sim.} - \text{Plant}}{\text{Sim.}} = \frac{8.21 - 7.52}{8.21} = 8.40\%.
\]
Test #3: 10 pm 17Jan / 09 am 18Jan, 12 hours

- **Top Reflux**

- **C5s Bottom T1512**
  - Maximum acceptable

- **Tower Pressure Drop**

- **Reboiler Duty**

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De-C4 Revamp / Gas Plant FCC / PreemRaff / AIChE April 2007
Test #3: 10 pm 17Jan / 09 am 18Jan, 12 hours

Flow Rate (m³/h) vs. Time (hours):

- Bottom
- Top
- Feed

Percent (%) vs. Time (hours):

- Top Receiver Level
- Btm Tower Level

Temperature (°C) vs. Time (Hours):

- Top Pilot Tray #5
- Bottom Pilot Tray #29
Test #3: 10 pm 17Jan / 09 am 18Jan, 12 hours
Test #3: 10 pm 17Jan / 09 am 18Jan: measured plant data

<table>
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<th>C3&lt;sub&gt;s&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>m3/h</td>
<td>176.2</td>
<td>95.4</td>
<td>52.2</td>
<td>33.8</td>
</tr>
</tbody>
</table>

Material Balance: \[
\frac{\text{Out} - \text{In}}{\text{Out}} = \frac{181.4 - 176.2}{181.4} = 2.87\%
\]

Top Reflux: 100 m3/h
Reboiler Duty: 7.38 MMKcal/h

Simulation results of Test #3, Feed = 181.4 m3/h

Tray Efficiency (%): 80\% 86.7
Top Reflux (m3/h): 105.5 100
Reboiler Duty (MMKcal/h): 8.09 7.82

Reb. Duty deviation: \[
\frac{\text{Sim.} - \text{Plant}}{\text{Sim.}} = \frac{7.82 - 7.38}{7.82} = 5.96\%
\]
Conclusions

1) The Unit was re-started 8 months ago.

2) The Column has a proven capacity higher than revamp design for the normal case: 185 VS 175 m³/h, with lower C5s content in the top and lower RVP in the LCN as well.

3) The overall tray efficiency (HiFi Plus™ & ConSep™) has exceeded any optimistic expectation: > 86%.

4) The column can operate steadily even at an average tray pressure drop of 14 mBar.

5) The Maximum Useful Capacity has been detected at an average tray pressure drop of 15.6 mBar, at which the trays can still provide an efficiency of 69%.
De-C4 in the FCC Gas Plant
PreemRaff, Lysekil, Sweden

Thank You