Converting Visbreakers to Delayed Cokers
- An Opportunity for European Refiners

European Coking.com Conference

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Lummus Technology
a CB&I company
Overview

- Introduction
- Delayed Coking
- Delayed Coking vs. Visbreaking
- Case Study
- Conclusions
Fuel Oil Market

- General trend: reduction of sulfur content in fuel oil
  - Typically 1.0-1.5 wt% S
- International Maritime Organization introduced \( \text{SO}_x \) Emission Control Areas:
  - Sulfur content of fuel oil on board ships < 1.5 wt%
  - 1st SECA: Baltic Sea (effective 2006)
  - North Sea end of 2007
  - More to follow
- Similar trend in other fuel oil application areas
- End of bunker fuel oil as sulfur sink?
European Fuels Market

- Increased demand for ULS diesel
- Gradually decreasing fuel oil market
- Price gap between low sulfur crudes and opportunity crudes

- Re-evaluation of bottom-of-the-barrel strategy
  - maximize diesel and minimize/eliminate fuel oil production

- What are the options?
<table>
<thead>
<tr>
<th>Non Catalytic</th>
<th>Catalytic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delayed coking</td>
<td>Atm. / vac. resid hydrotreating</td>
</tr>
<tr>
<td>Fluid / flexicoking</td>
<td>Ebullated bed hydrocracking</td>
</tr>
<tr>
<td>Gasification</td>
<td>Resid FCC</td>
</tr>
</tbody>
</table>
Lummus Capabilities for Bottom-of-the-Barrel

Lummus Technology – Houston
♦ Delayed coking
♦ Resid FCC

Chevron Lummus Global JV – Bloomfield
♦ Atmospheric/vacuum residue hydrotreating
♦ LC-FINING ebullated bed hydrocracking

Lummus Technology – Bloomfield / The Hague
♦ Refinery planning studies (e.g., grassroots, revamps, processing of opportunity crudes)

Extensive experience in heavy crude upgrade scenarios
Overview

✨ Introduction
✨ **Delayed Coking**
✨ Delayed Coking vs. Visbreaking
✨ Case Study
✨ Conclusions
Renewed interest in delayed coking:
- Attractive distillates yield \( \Rightarrow C_5^+ \) liquid yield 55-65wt% 
- Eliminates fuel oil production 
- Relative low investment 
- Flexibility towards feed quality \( \Rightarrow \) opportunity crudes

What about coke?
- Fuel grade \( \Rightarrow \) Coal fired power plants / cement kilns 
- Anode grade \( \Rightarrow \) Anodes for aluminum industry 
- Needle coke \( \Rightarrow \) Electrodes for steel industry

Europe is net importer of petroleum coke
- 14 million tons in 2004 
- Directly sold to users or via intermediary parties
## Product Destinations

<table>
<thead>
<tr>
<th>Product</th>
<th>Boiling Range</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sour Gas</td>
<td>C&lt;sub&gt;1&lt;/sub&gt;-C&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Fuel gas system after H&lt;sub&gt;2&lt;/sub&gt;S removal</td>
</tr>
<tr>
<td>LPG</td>
<td>C&lt;sub&gt;3&lt;/sub&gt;-C&lt;sub&gt;4&lt;/sub&gt;</td>
<td>LPG blending after H&lt;sub&gt;2&lt;/sub&gt;S/mercaptans removal</td>
</tr>
<tr>
<td>Coker Naphtha</td>
<td>C&lt;sub&gt;5&lt;/sub&gt; - 180 °C</td>
<td>Hydrotreated and split, with Light Naphtha to Isomerization or product and Heavy Naphtha to Catalytic Reforming or product</td>
</tr>
<tr>
<td>Light Coker Gasoil</td>
<td>180 - 365 °C</td>
<td>Diesel pool after Hydrotreating</td>
</tr>
<tr>
<td>Heavy Coker Gasoil</td>
<td>365 °C +</td>
<td>Hydrocracker or FCC</td>
</tr>
</tbody>
</table>
| Coke             | Solid         | Fuel Grade: Power Plants / Cements Kilns  
|                  |               |     Anode Grade: Aluminum production  
|                  |               |     Needle Coke: Electrodes for metal industry                              |
Lummus Delayed Coking technology

- 60 years experience in design and EPC process for 60+ designs based on a wide variety of feedstocks
- 16 licenses in the last three years
- Process design as per latest requirements
  - Lowest coke drum pressure for highest distillate yield
  - Lowest recycle rate, with HCGO quality in accordance with requirements of downstream hydrocracker or FCC
  - Safety aspects (e.g. unheading devices, interlock systems)
- Largest grassroots delayed coker: 26,000 MT/SD (156,000 BPSD) of Athabasca bitumen from oil sands; currently under construction with anticipated start-up end of 2008
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Converting Visbreakers to Cokers

♦ Now:
  - Europe oriented towards visbreaking
  - 50% of European refineries have a visbreaker

♦ Future:
  - Delayed coking recognized as opportunity to maximize distillates production and eliminate fuel oil production

Why not convert existing visbreakers into delayed cokers?
Converting Visbreakers to Cokers

Or, convert:

into:
Different objectives

♦ Visbreaking
  ▪ Viscosity reduction through mild thermal cracking
  ▪ Producing stable fuel oil product after cutterstock blending
  ▪ Economic benefit: reduction of cutterstock to meet fuel oil viscosity specification

♦ Delayed coking
  ▪ Severe thermal cracking
  ▪ Economic benefit: maximize distillates production
  ▪ Elimination of fuel oil production
YIELD COMPARISON BASED ON TYPICAL RUSSIAN EXPORT BLEND

- Coke
- Residue
- HCGO
- LCGO / VBU Gasoil
- Naphtha
- LPG
- Fuel gas

Typ. 55-65 wt% liquid yield on feed for Delayed Coker products
Introduction

Delayed Coking

Delayed Coking vs. Visbreaking

Case Study

Conclusions
A simple case study was defined to investigate feasibility of converting an existing visbreaker to a delayed coker.

- Capacity basis 4,000 MT/SD (~ 24,500 BPD)
- Visbreaker configuration
  - Soaker visbreaker
  - No naphtha stabilizer section
  - No vacuum flasher section

Represents ‘worst case’ in terms of number of equipment services that can be re-used.
Two drum 4,000 MT/SD delayed coker

Products
- Offgas
- Coker naphtha
- LCGO
- HCGO
- Fuel grade coke

No LPG recovery
- For smaller coker capacities may not always be feasible
- Refiners with FCC: coker offgas to FCC wet gas section
Feed surge drum

Pre-heat train
- Installed heat exchange surface area for visbreaker is larger than required for coker service
- Modifications may be required

Heater charge pumps

Heater
- Soaker visbreaker heater provides 60% of coker duty at same capacity
- Additional booster heater required
Main fractionator
- Serves as top section of coker fractionator
- Additional bottom section tower required

Overhead condenser
- Additional capacity to be added

Gas oil stripper
- As LCGO stripper

Re-use of about 50% of existing visbreaker equipment
Re-use of Main Equipment Visbreaker

Re-used equipment indicated in yellow
New Main Equipment

In ‘visbreaker’ area
- Booster heater
- Bottom tower section fractionator

Specific for delayed coker
- Coke drum area
  - Coke drums, including automatic unheading devices
  - Coke drop out pit/pad
  - Coke cutting system, including water re-use system
New Main Equipment

Specific for delayed coker

♦ Blowdown system
  ▪ Blowdown tower
  ▪ Overhead drum
  ▪ Overhead cooler

♦ Gas section
  ▪ Wet gas compressor
  ▪ Sponge absorber
  ▪ Naphtha stabilizer
  ▪ Fuel gas scrubber
Total Installed Cost estimates were generated for grassroots delayed coker and converted visbreaker

- ISBL only
- Revamp factor included for converted visbreaker

- Base case: 4,000 MT/SD grassroots delayed coker
  TIC = 109 MM Euro
- Converted visbreaker:
  $\Delta$TIC = 16 MM Euro (15%)
## Gross Margin

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Euro/ton</th>
<th>MTA</th>
<th>MM Euro/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum Residue</td>
<td>100</td>
<td>1,400,000</td>
<td>139.5</td>
</tr>
<tr>
<td><strong>Products</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel Gas</td>
<td>120</td>
<td>103,180</td>
<td>12.4</td>
</tr>
<tr>
<td>Coker Naphtha</td>
<td>328</td>
<td>186,480</td>
<td>61.1</td>
</tr>
<tr>
<td>LCGO</td>
<td>330</td>
<td>362,180</td>
<td>119.6</td>
</tr>
<tr>
<td>HCGO</td>
<td>126</td>
<td>349,440</td>
<td>44.1</td>
</tr>
<tr>
<td>Coke</td>
<td>22</td>
<td>389,060</td>
<td>8.5</td>
</tr>
<tr>
<td><strong>GROSS MARGIN</strong></td>
<td></td>
<td></td>
<td><strong>106.2</strong></td>
</tr>
<tr>
<td></td>
<td>MM Euro/year</td>
<td></td>
<td></td>
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<tr>
<td>----------------------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Utility costs</td>
<td>20.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating labor</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>4.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemicals</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPEX</td>
<td>25.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Margin</td>
<td>106.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NET MARGIN</strong></td>
<td><strong>80.6</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Simple Pay-out**
- Grassroots Delayed Coker: 16 months
- Converted Visbreaker: 14 months
Further reductions in TIC:

- Coil visbreaker
  - Additional heater will not be required
- Naphtha stabilizing section
  - Several equipment services can be re-used
- Vacuum flasher
  - Vacuum column can be re-used as bottom section of coker fractionator
- Utility systems
  - Existing utility systems cater for delayed coker implementation
Depending on visbreaker configuration, a reduction as high as 30% of TIC can be realized.

- For a 4,000 MT/SD converted visbreaker:
  \[ \Delta TIC = 33 \text{ MM Euro (30\%)} \]
- Payout 11 months compared to 16 months for grassroots unit
Interesting concept. How realistic is it?

♦ US client, mid 1990s
  - Existing coil visbreaker converted to 4-drum, 8,400 MT/SD delayed coker
  - Lummus provided license, basic design, and part of the detailed design
  - Currently running at 11,500 MT/SD with original visbreaker heaters

♦ Studies performed for other clients
Existing visbreaker equipment and buildings are shown dotted
Introduction

Delayed Coking

Delayed Coking vs. Visbreaking

Case Study

Conclusions
Conclusion

♦ Increased distillates production and elimination of fuel oil production are drivers for current interest in delayed coking in Europe

♦ Conversion of existing visbreakers to delayed cokers provides an opportunity for European refineries

♦ Capitalize on existing equipment and infrastructure

♦ Success depends on site-specific conditions

♦ Savings as high as 30% on Total Installed Cost compared to a grassroots delayed coker
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