Haldor Topsøe

Optimising diesel yield and product properties in hydrocracking

Bettina Sander-Thomsen, New Delhi, April 2012
Outline

- Topsøe in hydrocracking
- Importance of pretreatment
  - Changes in feedstock properties
  - Changes in unit requirements
- Red or blue series Topsøe hydrocracking catalysts
  - Arctic diesel
  - Lube oil production
  - $H_2$ utilisation
- 3 different hydrocrackers
  - Objectives
  - Evaluation
  - Solution
  - Conclusion
Topsøe in hydrocracking

- Supplier of complete catalyst portfolio for middle distillate hydrocracking since the 90’ies
- Hydrocracking technology supplier since the 90’ies
- More than 40 charges of hydrocracking catalyst installed
- Large R&D group focusing on development of hydrocracking catalysts and technology
Pretreatment catalysts

- Driving force to develop new PTR catalysts?
  - Continuously increasing severity of feeds
  - Continuously increasing requirements for barrels processed
  - Continuously increasing product requirements
  - Most hydrocrackers are limited in PTR activity

- Newest development TK-607 BRIM™
  - Successor of TK-565 and TK-605 BRIM™
  - Based on the BRIM™ technology
  - High stability and high HDN activity
Features of Red and Blue series TK catalysts

- **Red series**
  - Improve hydrogenation
  - Make UCO for lube oil production of ethylene crackers

- **Blue series**
  - Improve cold flow properties
  - Improve quality of jet fuel
  - Reduce H₂ consumption
### 3 Case stories

<table>
<thead>
<tr>
<th>Unit</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td>Pressure, bar</td>
<td>150</td>
<td>160</td>
<td>140</td>
</tr>
<tr>
<td>Conversion, %</td>
<td>50-60</td>
<td>&gt;80</td>
<td>60-70</td>
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<tr>
<td>Feed type</td>
<td>VGO</td>
<td>VGO</td>
<td>HVGO + VBGO</td>
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<tr>
<td>N, wt ppm</td>
<td>1500</td>
<td>1475</td>
<td>955</td>
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<tr>
<td>SG</td>
<td>0.92</td>
<td>0.93</td>
<td>0.914</td>
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<tr>
<td>FBP, C</td>
<td>590</td>
<td>570</td>
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</table>
Hydrocracker 1

- Objectives
  - Cold flow properties of diesel
  - Low density of kerosene
  - High density of UCO to meet heat balance in FCC

- Red series vs. Blue series
  - Testing
    - Yields
    - Cold flow properties
    - Kerosene properties
    - UCO properties
  - Conclusion: Best result = Blue Series

- Commercial results
Hydrocracker 1

- Test results

<table>
<thead>
<tr>
<th>Catalyst system</th>
<th>Red</th>
<th>Blue</th>
<th>Stacked</th>
<th>Target</th>
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<tbody>
<tr>
<td>Middle distillate yield</td>
<td>Base</td>
<td>Base + 1%</td>
<td></td>
<td>Maximise</td>
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<tr>
<td>H₂ consumption</td>
<td>Base</td>
<td>Base</td>
<td></td>
<td>Minimise</td>
</tr>
<tr>
<td>Diesel cloud point, °C</td>
<td>-10</td>
<td>-15</td>
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<td>Minimise</td>
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<tr>
<td>UCO density</td>
<td>0.86</td>
<td>0.87</td>
<td>&gt;0.870</td>
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<tr>
<td>Diesel Cl</td>
<td>55</td>
<td>55</td>
<td></td>
<td>Maximise</td>
</tr>
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</table>
Commercial performance (#1)

- Diesel cloud point
  - 3 to -15°C
  - Lower conversion UCO in diesel
  - Stopped using additives to improve cold flow properties

- UCO density > 0.870
- Diesel CI = 55-59
- H₂ cons. as expected
- Good activity
- Good stability
Hydrocracker 2

- Objectives:
  - Low BMCI and high VI of UCO
- Red series vs. Blue series
  - Test results
  - Conclusion: Best result = Red series
- Commercial results
Hydrocracker 2

- Test results

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Middle distillate yield</td>
<td>Base</td>
<td>Base+1%</td>
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<td>Maximise</td>
</tr>
<tr>
<td>H₂ consumption</td>
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<td>Base-3%</td>
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<td>Diesel pour point, C</td>
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<td>UCO VI</td>
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<td>80</td>
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<td>&gt;135</td>
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<td>UCO BMCI</td>
<td>7</td>
<td>25</td>
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<td>&lt;12</td>
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Commercial performance (#2)

- BMCI and VI fulfilled throughout entire cycle
- Stable and good middle distillate yields
- \( \text{H}_2 \) consumption in line with expectations
- Client recently installed a new charge of Topsøe hydrocracking catalyst for this unit
Hydrocracker 3

- Objectives:
  - Diesel + Jet yield and properties
- Red series vs. Blue series
  - Test results
  - Conclusion: Best result = stacked bed
- Commercial results
Hydrocracker 3

- Test results

<table>
<thead>
<tr>
<th></th>
<th>Catalyst system</th>
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<th></th>
<th>Target</th>
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<tbody>
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<td>Blue</td>
<td>Stacked</td>
<td>Base</td>
<td>Maximise</td>
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<tr>
<td><strong>H₂ consumption</strong></td>
<td>Base</td>
<td>Base-10%</td>
<td>Base-5%</td>
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<td><strong>Diesel cloud point, C</strong></td>
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<td><strong>Diesel pour point, C</strong></td>
<td>-28</td>
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<td><strong>Diesel CI</strong></td>
<td>64</td>
<td>53</td>
<td>57</td>
<td>&gt;52</td>
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<td><strong>Diesel SG</strong></td>
<td>0.84</td>
<td>0.88</td>
<td>0.85</td>
<td>&lt;0.85</td>
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Commercial performance (#3)

- Low cloud point?
  - Diesel contains 15-20% UCO

- Exceeding CI and density requirement
  - CI = 55-65
  - Density = 820-840 kg/m³

- Diesel yield exceeded predicted values
  - Due to changes in cut points the diesel yield exceeded the test diesel yield by >15%

- H₂ consumption as expected

- Good activity
Perspectives for stacked bed loadings

- Use temperature control to move conversion to different beds to adjust the product quality
  - Example: Increase temperature in beds with Blue series catalysts in the winter to improve cold flow properties
  - Example: Lower severity on blue series catalyst when producing lubes
Conclusion

- Topsoe improved pretreatment catalysts enable refiners to process higher severity feeds
- It is possible to obtain the required product properties by tailoring the catalyst loading
- The performance of Topsoe catalysts for hydrocrackers has been demonstrated by commercial operation
Questions