Advances in Resid Hydrotreating Catalyst Technology

Kaidong Chen
Director of R&D, ART
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About ART

- **Who we are**
  - Grace and Chevron joint venture
  - Combine Chevron’s extensive operating experience, catalyst technology R&D leadership with Grace’s material science, manufacturing and sales strength

- **What we have**
  - A complete portfolio of hydroprocessing catalysts
  - Substantial resources dedicated to customer support and product development

- **What we do**
  - Improve the operation and profitability of our customers in the petroleum refining industry

- **How we do it**
  - Exceptional design of catalyst systems
  - Fully integrated technical support teams

- **Why we do it**
  - To help customers succeed and provide a single point of contact for refiners hydrosprocessing catalyst needs

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Global Presence

- Local sales offices in Dubai and Kuwait
- Sales offices throughout US, Europe, Asia
- Manufacturing locations in US, Asia, Kuwait
- Research and development centers in US
RDS Hydrotreating

- Operating catalyst temp: 355-410°C
- System pressure: 130-200 atm
- \( \text{H}_2 \) pressure: 110-170 atm
- \( \text{H}_2 \) consumption: 100-205 Nm\(^3\)/m\(^3\)

### Reaction Conversion

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Conversion</th>
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<tbody>
<tr>
<td>HDS</td>
<td>85-95%</td>
</tr>
<tr>
<td>HDM</td>
<td>70-98%</td>
</tr>
<tr>
<td>HDMCR</td>
<td>30-65%</td>
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Low Sulfur Fuel Oil
Resid FCC Feed
Coker Feed
RDS Catalyst Technology

Optimal Catalyst System

- Superior Catalyst
- Catalyst System Design
- Feed Reactivity
- Process Variable Effect
RDS Catalyst System Design

<table>
<thead>
<tr>
<th>Layers</th>
<th>Function</th>
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<tbody>
<tr>
<td>Grading</td>
<td>Trapping particulate to manage pressure drop</td>
</tr>
<tr>
<td>Demet</td>
<td>Provide metal capacity required to reach run length; low HDS activity</td>
</tr>
<tr>
<td>Transition</td>
<td>Continue metal removal; medium HDS activity</td>
</tr>
<tr>
<td>Conversion</td>
<td>Backbone for HDS/HDMCR/HDN; metals tolerant</td>
</tr>
<tr>
<td>Deep</td>
<td>Convert least reactive S/MCR to meet product target</td>
</tr>
</tbody>
</table>

- Allow flexibility to tailor catalyst systems for specific customer feed and product objectives
Design Activity For Each Layer
Metal Capacity Fit for Purpose

- HDV activity higher towards reactor inlet to remove the metals in feed and protect subsequent layers
- HDS activity higher towards reactor outlet to tackle more difficult sulfur species in feed
- Metal capacity for each layer is designed to be sufficient for the run length
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<tbody>
<tr>
<td>Demet</td>
<td>122</td>
<td>132</td>
<td>161</td>
<td>187</td>
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<tr>
<td>Transition</td>
<td>121</td>
<td>137</td>
<td>167</td>
<td></td>
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<tr>
<td>Conversion</td>
<td>105</td>
<td>131</td>
<td>170</td>
<td>196</td>
</tr>
<tr>
<td>Deep Conversion</td>
<td>135</td>
<td>153</td>
<td>173</td>
<td>192</td>
</tr>
</tbody>
</table>
ICR 192 Benefit in Client Unit

- ICR 192 introduced in run 14 and increased percentage in run 15
- Enhanced HDS activity as the final finishing layer of catalyst system
- Similar improvement in HDMCR activity
RDS Catalyst Technology

- Take on the challenge to develop superior catalyst and design enhanced catalyst system
- Extensive database accumulated over several decades of intensive R&D efforts
Balancing: Key for Optimized RDS Catalyst System

- **Catalyst Activity**
  - Meet All Product Targets

- **Catalyst Life**
  - Desired Run Length

- **Sulfur Removal**
- **Metals Removal**

- **Product Yields and Quality**

- Superior catalyst and optimized system design will help achieve multiple objectives
Full System Tests

- Designed new catalyst system to take advantage of newly developed catalysts
- Side by side comparison with identical process conditions
### WLP Properties Comparison

#### Process ME AR under typical RDS conditions

<table>
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<tr>
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<th>Base Case</th>
<th>New System</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur (wt%)</td>
<td>0.40</td>
<td>0.35</td>
<td>12% lower</td>
</tr>
<tr>
<td>MCR (wt%)</td>
<td>3.72</td>
<td>3.50</td>
<td>6% lower</td>
</tr>
<tr>
<td>Ni+V (ppm)</td>
<td>9.3</td>
<td>8.4</td>
<td>10% lower</td>
</tr>
</tbody>
</table>

- New system produced better quality product
- New system will allow more buffer in meeting bunker fuel oil sulfur spec
- RFCC application would benefit from lower MCR and metals in RFCC feed
Advanced Refining Technologies (ART) has been continuously innovating high performance RDS catalysts for several decades.

Customizing catalyst system to balance various product targets and operation objective.

Optimized catalyst systems design builds upon decades of commercial operation know-how benefits both RFCC and LSFO applications by improving overall product quality.

Thank you!