OPPORTUNITY CRUDES:
TO PROCESS OR NOT TO PROCESS?

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Oct. 27, 2011
COQA Meeting
Doubletree by Hilton Hotel
Tulsa, Oklahoma
OUTLINE

Part 1
- Definition of opportunity crudes
- Drivers
- Concerns

Part 2
- Technology solutions
- Refinery approaches
- Future outlooks
WHAT ARE OPPORTUNITY CRUDES?

- **Heavy, sour** (<26° API, >1 wt.% sulfur)
  - e.g., Bachaquero (Venezuela), Maya (Mexico)

- **Extra-heavy** (<15° API)
  - e.g., Athabasca bitumen (Canada), Orinoco (Venezuela)

- **High-TAN** (>0.5mg KOH/g oil)
  - e.g., Alba (North Sea), Duri (Indonesia)
OPPORTUNITY CRUDES 2011 SURVEY

- **Timeframe**: End of 2010 to early 2011

- **Participants**:
  - Refineries with capacities >25K b/d
  - Including refineries in North America, South America, Europe, Asia, the Middle East, and Africa
SURVEY RESULTS: TYPES OF OPCRUDES PROCESSED

Type of opportunity crude

Percentage of responses, %

- Heavy, sour
- High-TAN
- Brazilian
- DilBit
- SCO
- SynDilBit
- SynBit
- Orinoco
- Other
SURVEY RESULTS: AMOUNT OF OPCRUDES PROCESSED

- 5-20% of crude slate (34%)
- 21-35% of crude slate (13%)
- 36-50% of crude slate (24%)
- >50% of crude slate (8%)
- <5% of crude slate (13%)
- Do not know (8%)
SURVEY RESULTS: DRIVERS FOR PROCESSING OPCRUDES

<table>
<thead>
<tr>
<th>Reasons to process more opportunity crudes</th>
<th>Percentage of responses, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price discount</td>
<td>70</td>
</tr>
<tr>
<td>Crude access and security</td>
<td>45</td>
</tr>
<tr>
<td>Demand shift</td>
<td>25</td>
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<tr>
<td>Recession</td>
<td>15</td>
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<tr>
<td>Carbon legislation</td>
<td>10</td>
</tr>
<tr>
<td>Increase in renewable fuel</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>10</td>
</tr>
</tbody>
</table>
DRIVERS FOR PROCESSING OPCRUDES

Survey Results
- Lower crude costs
- Accessibility and stability of supply

Additional Drivers
- Higher diesel yield
- Increased propylene production
- Increased coking vs. cracking margins
SURVEY RESULTS: BARRIERS TO PROCESSING OPCRUES

Percentage of responses, %

0 10 20 30 40 50 60 70 80 90 100

Primary issue/barrier to processing more opportunity crude:

- Corrosion
- Fouling
- Compatibility
- Access
- Crude quality variation
- Hydromade
- Coke make
- Product yield
- Energy demand
BARRIERS TO PROCESSING OPCRUDES

Survey Results

- Increased fouling and corrosion
- Crude compatibility
- Accessibility of opportunity crudes

Additional Barriers

- Production of more high sulfur fuel oil
- Increased CO$_2$ emissions
TO SUCCESSFULLY PROCESS OPPORTUNITY CRUDES:

- Minimize fouling
- Minimize corrosion
- Convert additional resid material
- Make the products that are in demand
  - Reduce production of high sulfur fuel oil
  - Increase diesel production
  - Consider increasing propylene yield
SOLUTIONS FOR FOULING

- Maintain flowrates above 5 ft/s in heat exchangers
- Antifoulant chemicals
- Tube inserts
- Install welded plate heat exchangers
- Utilize programs to monitor stability and optimize cleaning schedules
SOLUTIONS FOR CORROSION

- Monitor desalter operations closely

- Additives
  - Phosphorous vs. phosphorous-free additives

- Upgrade metallurgy
  - Particularly useful in high velocity, turbulent areas
  - Higher Mo content increases resistance to naphthenic acid corrosion
  - Higher Cr content increases resistance to sulfidic corrosion
TECHNOLOGIES FOR UPGRADING RESID

Hydrogen addition

- Ebullated-bed RHC
- Fixed-bed RHC
- Slurry-phase RHC
- Resid HT
- Hydrovisbreaking

Conversion

0% 50% 100%

Carbon rejection

- Visbreaking
- Delayed coking
- Fluid/Flexi coking
- SDA*
- Resid FCC

*Deasphalting provides physical separation rather than conversion
OPTIONS FOR HANDLING RESID (1)

- Fluid catalytic cracker
  - Adjust catalyst composition ($)
  - Add a catalyst cooler ($$)
  - Add a resid HT unit to pretreat the feed ($$$)

- Hydrocracker
  - Increase hydrogen partial pressure ($)
  - Adjust catalyst composition ($$)
  - Add an additional HC stage ($$$)
OPTIONS FOR HANDLING RESID (2)

- Coker
  - Reduce pressure/optimize temperature ($)
  - Minimize recycle ratio ($$$)
  - Install larger or additional coke drums ($$$$)
  - Consider an SDA or visbreaker to reduce feed to coker ($$$$)
SURVEY RESULTS: APPROACH TO PROCESSING OPPORTUNITY CRUDES

Has your refinery performed a major revamp to process opportunity crudes?

- Yes: 71%
- No: 21%
- Do not know: 8%
TO PROCESS OR NOT TO PROCESS?

**Pros**
- Lower crude costs
- Coking margins > cracking margins
- Dieselization trend
- Rising propylene demand
- Growing supplies of unconventional crudes
- Higher worldwide crude demand

**Cons**
- Lower demand for HSFO
- Higher processing costs
- Climate change legislation
- Increasing use of biofuels
- Higher vehicle fuel efficiency
- Increasing supplies of shale oil and NG condensates
FUTURE OUTLOOK

Opportunity crudes will be an important part of refinery crude slates going forward.

Keys to success include:

- Proactive measures to reduce fouling and corrosion
- Maximize diesel production
- Minimize HSFO yield
- Increase propylene
- Monitoring CO$_2$ emissions
ACKNOWLEDGEMENTS

Much of the information in this presentation is from HPC’s recent report titled "Opportunity Crudes II: Technologies & Strategies for Meeting Evolving Market & Environmental Challenges".

Special thanks to the following HPC staff:

- Pat Christensen
- Thomas Garrett
- Brett Goldhammer
- Thomas Yeung
Opportunity Crudes II: Technologies & Strategies for Meeting Evolving Market & Environmental Challenges


Report analyzes:

- Market and legislative conditions affecting opportunity crudes
- Technologies to minimize corrosion, fouling, CO₂ emissions & HSFO and to maximize diesel & propylene
- Three investment levels:
  - Low cost – primarily operational adjustments
  - Medium cost – revamps and modifications to existing equipment
  - High cost – addition of new process units
- Direct survey results and literature study to identify company strategies
- Specific strategies based on refinery configuration or location
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Hydrocarbon Publishing Co., Frazer, PA
www.hydrocarbonpublishing.com
www.OpportunityCrudes.com
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