Maximizing Profitability with High Residue Conversion

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Current Marine Bunker Demand by Region

- Marine bunkers represents a high proportion of residual fuel demand
- Marine Bunkers is major outlet for RFO in key segments of Asia Pacific (45%), Middle East (24%), Latin America (24%) and Europe (60%)
- Over Abundance of Residual Fuel Oil in CIS and EUR: Calls for conversion

Source: IHS
MARPOL Annex will have **Worldwide** Effects on High Sulphur Fuel Oil (HSFO) Demand and Price

- Significantly reduced HSFO use for bunkering as a result of new regulations
- Surplus residue expected after residue conversion and power generation usage
- Will significantly impact product price differentials in 2020
- HSFO expected to be priced at significant discount after 2020 compared with 2016 (~40% lower)

**Source:** IHS
Refinery Decision Dilemma

How long should I wait?
• Ship owners strategy?
• Wait for others to move and join the herd?

What should I do?
• Sell Bunker into HS fuel oil market
• Convert HS Bunkers to distillates / gasoline
• Convert HS fuel to LS Bunkers (0.5% S)
Refinery Options to Upgrade HS Fuel

Conversion Options

• Slurry bed process such as Uniflex™ process  
  – Good payback
• Ebullated bed process  
  – Limited conversion
• Delayed coking process  
  – Similar capex. Lower payback.

Treating Options

• Desulphurise HS bunkers with process such as RCD Unionfining™ process  
  – Limited product value uplift
• Process VR in new SDA and desulphurise DAO  
  – Lowest capex, but still makes some HSFO

Uniflex Units Give Highest NPV Based On Our Analysis
Uniflex Performance with Integrated Distillate Unionfining™ Unit

- **95% conversion**: Higher conversion comparable to other residue conversion processes
- **Euro V Diesel**: Highest yield of diesel compared to other slurry processes
- **Minimum VGO**: Can be accommodated in existing conversion units
- **Naphtha**: < 1 wppm S and N
- **Pitch**: Cement Plant, Gasification Unit, Boiler/Kiln, or solidified into pellets
Integrated Hydrotreater Significantly Minimizes the Number of Pieces of Equipment, therefore Capex is Reduced. External Diesel Streams could be Hydrotreated to Euro 5
## UOP Uniflex Process Licensed Units Update

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Capacity, MMTA</th>
<th>Feeds</th>
<th>Start-up</th>
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<tbody>
<tr>
<td>Petro-Canada, Montreal</td>
<td>Canada</td>
<td>0.3</td>
<td>Venezuelan, Mexican, North Sea, Cold Lake, Visbroken VR</td>
<td>1985 S/D 2003</td>
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<tr>
<td>NRL, Pakistan</td>
<td>Pakistan</td>
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<td>Light Arabian, Pakistani</td>
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<td>Shandong Longgang</td>
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<td>Med Arab, Merey, Russian Export</td>
<td>2019</td>
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<td>Oil Gas Trade CJSC</td>
<td>Russia</td>
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<td>SDA Pitch</td>
<td>Cancelled</td>
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<td>Undisclosed</td>
<td>China</td>
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<td>Merey, Russian Export, Shengli</td>
<td>Delayed</td>
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<td>China</td>
<td>0.9</td>
<td>Arab Light, Russian Export</td>
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<tr>
<td>Undisclosed</td>
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<td>Arab Light, Russian Export</td>
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</tr>
</tbody>
</table>
Uniflex Process - Continuous Improvement
Based on Voice of the Customer

- High conversion to valued products
- Process design for sustained operability and reliability
- Economically efficient catalyst systems, and manufacturing capability
- Economically advantaged disposition for all products
- Robust feed and product characterization

New catalyst innovations
Process enhancements

Continuous Improvement

Comprehensive development program
Responding to customer and market needs
Molybdenum-based MicroCat™ Catalyst
Key Enabling Technology

- Moly on a carbonaceous base
- High-activity catalyst allows for smaller reactors
- No proprietary catalyst purchases
  - Produced at the refinery from raw materials readily available on the open market
- Low injection rate required
Two Reactors in Series: Enhanced Reliability and Performance

- Higher single-train capacity
- Staged conversion
  - No incompatibility issues
- Pitch (Vacuum Tower Bottoms) recycle
  - Lower light ends yield
  - Lower hydrogen consumption
  - Heavier product slate
External Reactor Circulation: Low Conversion per Pass, Improved Yields

- Low recycle gas rates
- Low liquid feed heater duty
- Operates in low-foaming regime
- Carries solids out of reactor

Also contributes to improved yield slate
Solids Removal Enables Conversion up to 98%

- Removes metals, mesophase, beta resins from unconverted pitch
- Individual process steps well proven
- Dried solids to metals recovery
- Attractive option if environmental regulations prohibit burning the pitch
Next Generation Uniflex MC

- **Feed**
- **Microcat Catalyst Preparation Section**
  - VR Matrix
- **Catalyst Made by refiner on site**
- **HVGO**
- **2 Reactors w Interstage Sep**
- **Pump-Around**
- **No Quench or Anti-foam**
- **Recycle H₂**
- **C₄⁻**
- **Flash Gas**
- **Naphtha**
- **Diesel**
- **LVGO**
- **VTB & Slop Wax Recycle**
- **No Heater**
- **Solids Recovery**
- **no net HVGO**
Uniflex MC Process – Enhancement Benefits

- **Reduced catalyst addition rate**
  - Injection rate in ppm of fresh feed
  - Highly efficient molybdenum based catalyst
  - On-site catalyst manufacturing capability

- **Reduced CAPEX and OPEX**
  - Smaller reactors
  - Lower recycle gas rates
  - Lower fired heater duty

- **Improved VTB (Vacuum Tower Bottoms) quality**
  - Low solids content, low sulfur level, and no iron
  - Fungible product (e.g. fuel, low sulfur petcoke or asphalt production)

- **Solids recovery from VTB**
  - Recovered oil product quality upgraded, or
  - Recycle operation in unit for higher conversion and yields
  - Recovered solids to metals recovery

- **Enables 95 to 98 Wt-% conversion (525°C+ material)**
  - 95% base conversion, 98% conversion with solids recovery option
UOP Heavy Oil Development Center

• Expanded capabilities to support Bottom of Barrel Technology Development

• New facility for pilot plant expansion at UOP
  – High throughput Feed Preparation / Fractionation:
    • 3 BPD capacity multi-column fractionation unit
  – Uniflex pilot plant:
    • High capacity operation with multiple reactors capable of staged operation
  – Solvent De-asphalting (SDA) pilot plant:
    • Multi solvent capability: Propane, Butane, Pentane
  – Flexible Heavy Oil Hydroprocessing pilot plant:
    • Heavy Oil Technologies fully integrated with UOP Unicracking™ and RCD and Distillate Unionfining™ pilot plants
    • Capable of high pressure (5000 psi) operation with reactor configurable in all Hydrocracking and Hydrotreating modes
Conclusions

- HS bunkers, restricted in ships after 1st Jan 2020, will have negative effect on high sulphur fuel oil (HSFO) pricing
- Refineries with significant HSFO production will require profitable residue conversion projects
- For zero HSFO, the Uniflex MC Process provides for conversion at an excellent payback
- Huge R&D effort by UOP with Uniflex MC Process results in a high-conversion design with low catalyst consumption and better pitch quality