Focus on Slurry Hydrocracking Uniflex Process

*Upgrade Bottom-of-the-Barrel to Improve Margins*

Phil Hunt
UOP LLC, A Honeywell Company

Russia & CIS BBTC 2015
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Agenda

1. Market Opportunity, Russian Export Duties, Demand
2. UOP Residue Upgrading Technology Portfolio
3. UOP Uniflex Technology Update
4. Mendeleev Group Deep Processing Project
5. Summary
Global Refined Product Demand has Followed a Consistent Trend...

...with Distillate demand increasing and Fuel Oil demand declining

- Global HFO demand equaled each of Light and Middle Distillates in 1970
- Distillates have now passed 70% of total demand globally
- Globally HFO has declined to 10% of total product demand
- In Asia, the Light Distillate demand is driven by Petrochem Feedstock end-uses

Global Oil Product Demand
*(Fuel Oil and Distillates)*

Million barrels Per Day

Source: BP Statistical Review of World Energy 2013

...with Distillate demand increasing and Fuel Oil demand declining
There are 3 Parts to the European Fuel Oil Market

(Units presented are MTPA)

Bunkers

<table>
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<tr>
<th>Units</th>
<th>MTPA</th>
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<tbody>
<tr>
<td>HFO</td>
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Production

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Imports

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Exports

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1. European Fuel Oil demand is split between Marine Bunkers and HFO
2. Production currently aligns with demand
3. However, Europe also imports and then exports 65 million MTPA

Europe is very long in HFO (particularly HSFO)
Why do we also need to understand developments in Russia – and their impact on European HFO?

• Russia has ...
  – Third highest installed refining capacity (after U.S. and China)
  – The largest production of Vacuum Residue that is not upgraded, the majority of which is exported to Europe

• Russia recently introduced ...
  – New export duties on crude oil and products (so-named “60-66”)
  – These provide significant incentive to upgrade HFO into Distillate products

Most of Russia’s Fuel oil exports go to Europe

Russian refiners plan to invest $50 billion to minimize HFO exports
Marine Bunker Fuels: EU and IMO Developments

**Sulphur content allowable in bunker fuel (pc by weight)**

- **ECAs**: Sulphur reduces from 1.0% to 0.1% *(January 2015)*
- **EU**: Sulphur reduces from 3.5% to 0.5% *(January 2020)*
- **Rest of the World**: Sulphur reduces from 3.5% to 0.5% *(January 2020/2025)*

**IMO (MARPOL) Regulations**
Let’s Start with the Fundamentals...

**What is residue and why convert it?**

**Characteristics:** Heavy, dirty, low value, limited uses

**Properties:** High MW, stable and carbon rich, **hydrogen deficient**

**Composition:** Saturates, Aromatics, Resins, Asphaltenes

**Impurities:** Sulfur, nitrogen, heavy metals

Feedstock characterisation is a key parameter in residue processing – with composition, properties and molecular structure all important factors
UOP Solutions for Residue Conversion
(Low to Moderate Conversion Options)

UOP RCD Unionfining™ Process
- Limited conversion and feed flexibility
- LS fuel oil production
- or RFCC feed prep
- Emerging role again

UOP/FWUSA Visbreaking
- Up to 30% conversion
- Achieves reduction in cutter stock for fuel
- Can be a partial fix, not a full solution
- Fuel oil outlet needed

FWUSA SYDEC™ Delayed Coking Process
- Higher conversion - up to 75%
- Require further upgrading to meet final product specs
- Need an outlet for the pet coke
De-Asphalted Oil (DAO) feed to:
- FCC
- HCU

Not a conversion process, but a solvent / gravity separation process

Separation also driven by the molecular type - paraffins vs aromatics

Vacuum Residue (VR)

SDA Pitch feed to:
- Bitumen
- Boiler / Power
- DCU
- Uniflex Unit

DAO yield ("lift") is typically 40 - 60+%,
limited by DAO quality and at high lifts by pitch quality
The UOP Uniflex Technology Offering is......

- Once through Catalyst
- Products require further upgrading
- Offered either as a “stand-alone-unit” or with integrated DHT

UNIFLEX UNIT (Wt-%)

- H₂S, NH₃ Gas, LPG Naphtha
- Diesel
- VGO
- Pitch
- HDT
- MHC & FCC or HCU

- 90-95% Conversion
- Maximum Diesel
- Minimum VGO
Uniflex Process

Thermal Cracking of Asphaltenes

The process benefits from combination of:

1. **Thermal cracking** to shorter chain lengths

2. Inhibiting formation of coke through:
   - **Hydrogenation of free radicals** from thermal cracking
   - Catalyst **physically hinders mesophase coalescence**

Archipelago Model of Asphaltenes, Carbon # = 313, MW = 4705
Source: M. Gray, Univ of Alberta
Uniflex Process Reactor
Achieves High Conversion

• Optimal design for high conversion
  – Upflow
  – Near Isothermal
  – Efficient utilization of reactor volume

• Effective Asphaltene management
  – Inhibit formation of coke pre-cursors by hydrogen pressure, optimum temperature and catalyst

Simple Commercially proven Reactor design for highly effective performance
Catalyst (Additive) & Pitch

Catalyst (Additive)

• UOP global supply
• Multiple manufacturing locations
• Simple logistics and storage

Pitch

• Cement:
  – Often the most attractive outlet option

• Boiler/Power:
  – Conventional power plants
  – CFB or Rotary Kiln Furnace

• Gasification

• Solidification:
  – Proven technology (Pellets or Big Bags)
  – Facilitates transportation and storage
Uniflex Process Attributes Summary

- Converting VR into Diesel Needs
  - Thermal Cracking
  - Hydrogenation

- Uniflex Complex Achieves this
  - In a single slurry bed reactor
  - With Post treatment to meet finished product specifications

\( H_2 \) addition maximises margin
<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Capacity, MMTA</th>
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• Oil Gas Trade (OGT) was established in 2002

• Key Business is fuels (jet, diesel, gasoline) and lubricants supply

• Acquired Yaroslavl Mendeleev Refinery in 2012

**New Mendeleev Group Project / Complex**

• Construction of a new 3 MMTA “Deep Processing Complex” (DPC)

• Robust economics with Russian export duty regime

• Zero residue production (via Uniflex & Unicracking)

• Maximum diesel production

• Captive Power, Steam & H₂ production

100+ year old existing refinery, open to new innovation, planning new “Deep Processing Complex”
It is Essential to assess a Major Project’s “Rate-of-Return” Relative to “Risk”

• The early years of a Project’s performance are always the most visible

• Lifetime performance covers a 20+ year period

Consequences of Pushing the Risk Envelope too Far

• Reliability
• Availability
• Throughput

It is important to evaluate and mitigate any major project risks – technical, operational or other – otherwise forecast financial returns can be undermined through under-performance
Global Fuel Oil is now Entering the Final Stages of Decline, Trending to Zero...

It is realistic to assume further reduction via further switching to natural gas and tighter IMO MARPOL regulations for Bunker Fuels

Source: BP Statistical Review of World Energy 2012
Price spreads and project economics are the main driver of any major residue upgrading project:

The Diesel minus HSFO Price Spread is the Key Economic Driver

- Europe Pre 2012
- Europe 2013/15
- Russia 2014/15

$250/t
$350/t
$450/t

EXCELLENT
GOOD
MARGINAL

UOP Uniflex™ Process

Better Economics
- 2X Margin Lift
- Significant CapEx Savings

Simple Flow Scheme

Plug and Play
- Integrated Hydrotreater Makes Euro V Diesel
- Makes More Naphtha and Diesel

MAXIMIZE CONVERSION
from every barrel

UOP 7081-19

Russian pricing offers attractive economic returns
Demand for transportation fuels vs. fuel oil has driven a “seven times” increase in the “gasoline + diesel” yield enabling alignment of production with demand.
Q&A