Maximise Residue Conversion Economics with UOP Bottom-of-the-Barrel Technologies

Soumendra Banerjee (UOP India Pvt Ltd)  
Phil Hunt (UOP Ltd, UK)  
UOP LLC, A Honeywell Company

PetroFed  
International Conference on Refining Challenges & Way Forward  
April 16th -17th 2012, New Delhi, India

© 2012 UOP LLC. All rights reserved.
We Will Cover Five Related Topics

1. Why India and Why Now?
2. Outline of Process Offering
3. Integration Opportunities
4. Key Economics Drivers
5. Benefits & Opportunities
UOP Uniflex™ Process is Ideal for the Indian Market

- **State of the Indian Market**
  - Is the 4th largest oil consumer (after USA, China and Japan)
  - The rise in international crude oil prices in recent years has created major challenges for India, given the high reliance on imports, and has resulted in a need to maximize the utilization and conversion of crude oil processed in the country.
  - The increased use of heavy crudes, distillate demand, particularly diesel, continues to show strong growth, and Indian refiners are being challenged to provide cleaner fuels to address concerns of air pollution and climate change.
  - The cost advantage of heavy crudes over light crudes has incentivized many Indian refiners to process heavier crudes, therefore increasing the heavy residue produced at a time when fuel oil demand is declining.

*These is a strong need of residue upgrading technologies that maximize transportation fuels*
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

Vacuum residue is lower value than fuel oil due to the need to use cutter stocks
Natural gas price has not risen as quickly as crude oil. This favours upgrading because HFO competes with gas, whereas transportation fuels are linked to crude oil price.

The widening differential favours “Hydrogen Addition,” rather than “Carbon Rejection,” due to:

- Increased product values
- Decreased H₂ production costs

Source: BP Statistical Review of World Energy 2011
In 1970, 80, 90 – fuel oil was 50, 40, 30% of distillates demand

By 2010 – fuel oil had declined to only 15%

By 2020 – fuel oil is likely to be only 10% of distillates demand
UOP’s Heavy Oil Upgrading Processes

Crude Oil

Vacuum Residue

Distillation

Naphtha

Distillates

Vacuum Gas Oil

Residue Conversion

FCC or Hydrocracking

Naphtha Hydrotreating & Reforming

Transport Fuels:
Gasoline, Jet Fuel, Diesel

Residues:
Heavy Fuel Oil, Pitch, Coke

UOP Solutions for Residue Conversion

UOP RCD Unionfining™ Process

UOP/FWUSA Solvent Deasphalting

FWUSA SYDEC™ Delayed Coking Process

UOP/FWUSA Visbreaking

UOP Uniflex™ Process
The Uniflex Technology Offering is......

- Once through Catalyst
- Similar scheme to Unicracking
- Product streams require further upgrading

- 90% Conversion
- Maximum Diesel
- Minimum VGO
- VGO integration
UOP has nearly 100 Years of Technology Expertise

This experience has been utilized to bring to market a commercially proven residue slurry bed hydrocracking technology for licensing...

Excellent correlation across:
- CANMET commercial plant
- UOP pilot plants
- Scale-up models

Comprehensive feedstock and operating data:
- Yields
- Conversion
- Consumption (H₂, Catalyst)
- Product qualities

Wide range of:
- Feedstocks
- Operating conditions

Significant resources committed to construct and operate the CANMET plant for several years and for the subsequent UOP Uniflex Process enhancements
The Uniflex Process is very similar in scheme to VGO hydrocracking

**FEED HEATING, REACTOR, SEPARATION and FRACTIONATION**

Uniflex Process operates at a similar reactor pressure to VGO hydrocracking (140 barg) with make-up and recycle hydrogen.
Uniflex Process

**Commercial Experience**

**Commercial Operations:**
- 5,000 BPD unit operated for 15 years at Petro-Canada Montreal
- Developed excellent design correlations allowing accurate scale-up
- Very high reliability demonstrated
- Achieved 95% conversion

**UOP Enhancements:**
- Completed UOP Schedule A design
- Reflects experience of Petro-Canada Montreal Unit with improvements
  - Large single train designs – parallel reactors, common separation
  - More efficient heat integration
  - High conversion of HVGO
- Integrated pilot plant closely matches commercial performance
- Analytical, modeling development programs support optimization
Uniflex Process
Thermal Cracking of Asphaltenes

- Heavier, higher sulfur feeds have higher reactivity
- Wide boiling range of products containing olefins, S, N
- Further hydroprocessing of the distillate products is required

The process benefits from a combination of:
1. Thermal cracking to shorter chain lengths
2. Inhibiting formation of coke through:
   - Hydrogenation of free radicals formed in 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
  - High temperature and moderate pressure

- Efficient utilization of reactor volume
  - Low gas voidage
  - High product vaporization
  - Near Isothermal

- Asphaltene management
  - Inhibit formation of coke pre-cursors

Commercially proven Reactor design with minor scale-up.
**Catalyst & Pitch**

**Catalyst**
- UOP global supply of catalyst
- Multiple manufacturing locations
- Simple logistics and storage

**Pitch**
- **Cement:**
  - Often the most attractive outlet option
- **Boiler/Power:**
  - Conventional power plants
  - CFB
- **Solidification:**
  - Proven technology
  - Facilitates transportation and storage
Uniflex Process Key Success Factors

Commercially Proven
Low Value Feed
High Conversion
High Quality Products
Step Change Margin Increase

So what else makes the above even more compelling - the answer is high crude oil prices
Uniflex Complex Scope

Uniflex Process Integration Benefits
- >55% yield of diesel: 2x Delayed Coking
- Stand-alone hydrotreater produces reformer feed and Euro V diesel
- ½ VGO yield of Delayed Coking enables processing in existing units
An important cost parameter is the alternative value of feedstock.

**Indicative Annual Cash Revenues / Costs ($ Billion)**

The value-add margin is high – given low value feed and high value products.
Uniflex cases typically offer around a two times uplift in refinery margin, under typical pricing scenarios.
UOP LLC, a Honeywell company, recently announced that its new process technology designed to help refiners get more high-value product from each barrel of crude oil has been selected by an Asian refiner.

The facility, which is scheduled for start-up in 2016, will use Uniflex technology to upgrade its heavy residue into high-value distillate products. Of particular value to the refinery is the high yield of diesel from the Uniflex technology, which is nearly double that of competing residue conversion technologies.

The technology will be integrated with UOP Unionfining hydroprocessing solutions to process distillates into high-quality diesel fuel and naphtha into high-quality feedstock used for gasoline production.
Uniflex Process Attributes Recap

- Converting Vacuum Residue into Diesel requires:
  - Thermal Cracking
  - Hydrogenation
  - Inhibiting Coke formation

- Uniflex Process achieves all the above:
  - In a single slurry bed reactor
  - With post treatment to meet finished product quality specifications
Summary of the Uniflex Technology Offering

The key global market drivers for refiners are now aligned in support of residue upgrading – falling fuel oil demand, rising clean distillates demand and high prevailing crude oil prices

Uniflex Process is...

...a very flexible residue upgrading “Technology Solution”
...offering a step change (improvement) in refining margin

Uniflex Technology is a highly compelling process, that is commercially proven, offering maximum use of existing facilities, and a new industry benchmark in “zero fuel oil” refining