Maximize Vacuum Residue Conversion and Processing Flexibility with the UOP Uniflex™ Process

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Impact of Global Crude Oil and Natural Gas Prices

- Natural gas price has not risen as quickly as crude oil
- This favours upgrading because heavy fuel oil competes with gas, whereas transportation fuels are linked to crude oil price
- This offers an increased residue conversion margin uplift

- The widening differential favours “Hydrogen Addition”, rather than “Carbon Rejection”, due to:
  - Increased product values
  - Decreased H₂ manufacturing costs

Source: BP Statistical Review of World Energy 2011
1990 – 2010 History

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

Global Oil Product Demand
(Heavy Fuel Oil and Distillates)

Source: BP Statistical Review of World Energy 2011
Mexico’s Oil Market

- Pemex’s strategy is to reduce imports of gasoline and diesel by expanding capacity and increasing residue conversion capability

  Source: Business Plan of Petróleos Mexicanos and Subsidiary Entities June 1, 2010

- Dominant crude varieties in Mexico have high sulfur and high residue content

- Addition of residue conversion with Delayed Coking increase a refinery's yield of Naphtha + Diesel

- High yield of Pet Coke
UOP’s Heavy Oil Upgrading Processes

Crude Oil

- Distillation
  - Naphtha
- Distillation
  - Distillates
  - Vacuum Gas Oil
- Vacuum Residue

Residue Conversion

- FCC or Hydrocracking
- Naphtha Hydrotreating & Reforming

Transportation 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
Uniflex Process
Commercial Experience

- 25 years R&D
- 15 years commercial operation
- High conversion

Petro-Canada Montreal Unit

Many UOP improvements in the last 5 years
Uniflex Process
Commercial Experience

Commercial Operations:
• 5000 BPD unit operated for 15 years in Montreal
• Processed wide range of feedstocks
• Excellent design correlations allowing accurate scale-up
• Very high reliability / availability demonstrated (97+%)

UOP Enhancements:
• Completed UOP Schedule A design
• Petro-Canada Montreal Unit with improvements
  – Single train design: parallel reactors, common separation
  – More efficient heat integration
  – High conversion of HVGO
• Integrated pilot plant matches with commercial performance
• Analytical modeling supports optimization
Uniflex Process

Thermal Cracking of Asphaltenes

- Heavier, higher sulfur feeds have higher reactivity
- Wide boiling range containing olefins, aromatics, S, N
- Further hydroprocessing is required

Benefits from a combination of:
1. Thermal cracking to shorter chain lengths
2. Catalyst inhibits coke through:
   - Hydrogenation of free radicals formed in thermal cracking
   - Physically hinders growth of coke precursors.

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
  - Intense liquid backmixing
  - Near isothermal
- Asphaltene management
  - Nano-scale dispersed catalyst
  - Solubility control techniques
Uniflex Process with HVGO Recycle

Recycling Benefits:

- HVGO is difficult to process in HT, HC and FCC units
- Uniflex converts HVGO to valuable products
Simple Integration into Existing Refineries

Crude Oil → Crude & Vacuum Distillation → UOP Uniflex → Distillates

Vacuum Residue → Vacuum Hydrocracking, MHC or FCC → New Distillate Hydrotreating → Diesel Pool

Yield Comparison

Uniflex Integration Benefits

- >55% yield of diesel: 2x Delayed Coking
- Simple stand-alone hydrotreater produces reformer feed and Euro V diesel
- ½ VGO yield of Delayed Coking often allows VGO to be processed in existing units
Maximizing Naphtha and Diesel in an FCC Refinery

Basis: Maya Crude

Uniflex increases transportation fuel yields by 10 Wt-% when compared to the Coker case
So what else is new and different that makes the above even more compelling?
The answer is higher prevailing crude oil prices
The value-added margin is high – given low value feed and high value products.
Uniflex Process

Pitch Product

- Can be handled in:
  - Liquid form for nearby uses
  - Solidified for offsite markets

- End Uses include:
  - Cement Kilns
  - Fluidized Bed Boilers
  - Conventional Boilers
  - Gasification
  - Delayed Coking
Global Average Gross Refining Margins
3 – 8 $/bbl over the last 20 years

Indicative margin (GRM) after installation of a Uniflex complex

~10 – 16 $/bbl
• Low-quality and low-value feed (typically Vacuum Residue)
• High conversion to high quality products

Source of Historical Global Indicator Margin (GIM): BP

Uniflex complex DOUBLES your refinery margins
NRL in Pakistan to Construct 2nd Uniflex Unit

Increases margins by $150 million/year
Uniflex Benefits....

- The Time is Now:
  - Falling fuel oil demand
  - Rising clean distillates demand
  - High prevailing crude oil prices
  - Low cost of hydrogen production

Uniflex is a highly compelling technology, maximizing the use of existing facilities to minimize capital cost, while offering a new commercially proven industry benchmark in Residue Conversion.
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