Innovative Solutions for Optimizing Refining & Petrochemicals Synergies

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Agenda

- Refining & Petrochemical (R&P) synergies: Flow exchanges

- R&P synergies for olefins production
  - Propylene (& Ethylene) production
  - Olefins upgrading and alpha-olefins production

- R&P synergies for aromatics
• Refining & Petrochemical (R&P) synergies: Flow exchanges

• R&P synergies for olefins production
  • Propylene (& Ethylene) production
  • Olefins upgrading and alpha-olefins production

• R&P synergies for aromatics
Propylene Production Forecast by Source

2010 Production
~ 75 Million tons (Mt)

- 12% From Refineries (DCC/RFCC/FCC)
- 36% From Steam crackers
- 52% On purpose production
  - Metathesis
  - Olefins cracking
  - MeOH to propylene
  - C₃ dehydrogenation

Additional Propylene Production by Process Technology

- Global Additional Demand 2010-2015: ~ 20 Mt
  Average annual growth rate: ~ 4.5%

- Additional propylene production from refineries > 4 Mt

Source: Axens (2011)
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Propylene Production from Refinery

- **Steam Cracker Complex**
  - LPG
  - Naphtha

- **Coker**
  - Resid

- **FCC**
  - VGO
  - High Propylene FCC
  - HS-FCC
  - Resid to Propylene

- **C_4-C_5 cut**

- **C_3** = 8 to 20 wt%

- **C_3** = unit

- **Alternative Fuel units**

- **Fischer-Tropsch**

- **Olicrack™**
  - >8 wt% C_2=
  - >30 wt% C_3=

- **FlexEne™**
  - C_3 =
  - Gasoline/Distillate

- **Olefins cracking**

- Unique integration With FCC for flexibility

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High Propylene FCC Technology

Location: Al Jubail, Saudi Arabia

- HP FCC Technology
  - 33,000 bpsd – Start-up in 2013
  - >10%wt Propylene production
  - LCN recycle before feed injection
  - Feed: Deeply hydrotreated VGO
  - 3 other recent similar units in Middle East

Source: Google Earth
HP FCC Technology

Regenerator

Bathtub catalyst distributor

Riser separator RS²

Stripper / Packing

Feed

LCN recycle

540-560°C
C/O = 10
ZSM-5 content
10-20% (40% crystal)
High Severity Fluidized Catalytic Cracking
HS-FCC

A worldwide cooperation
Saudi Aramco (Saudi Arabia)
JX (Japan)
Shaw (United States)
Axens (France)

HS-FCC Yields, wt.%
Ethylene = 4%
Propylene = 20%
Resid to Propylene FCC Technology

- Ruwais refinery, Abu Dhabi

- Resid to Propylene Technology (R2P)
  - 127,000 bpsd
  - R2R technology, >12 wt% Propylene
  - PetroRiser recycling LCN
  - Atm. Residue, API=21, CCR=4 to 6, S = 1.7 wt%
Resid to Propylene Process Scheme & Technology

FEED

R2R Risers & Regenerators

LCN Recycle

Fractionator & Gas Recovery

C3 C4 LPG Treatment & Separation

C3 Splitter

Naphtha Splitter

Fuel Gas

Propylene PG

Propane

Raw C4

HCN

LCO

Slurry/CLO

R2R Unit

Main Riser Resid

PetroRiser LCN

720-740°C

590°C C/O 12

660°C

550°C C/O 8
Propylene Production from Refinery

- **Steam Cracker Complex**
  - LPG Naphtha
  - C₄-C₅ cut

- **Coker**
  - Resid
  - C₄-C₅ cut

- **FCC**
  - VGO Resid
  - High Propylene FCC
  - HS-FCC
  - Resid to Propylene
  - C₃ = 8 to 20 wt%
  - C₄-C₅ cut

- **C₄-C₅ Olefins Recovery**
  - Olicrack™
    - >8wt% C₂=
    - >30wt% C₃=
    - On-purpose C₃= unit

- **Alternative Fuel units**
  - Fischer-Tropsch
  - C₄-C₅ cut

- **FlexEne™**
  - C₃=
  - Gasoline /Distillate
  - Unique integration With FCC for flexibility

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Recycle Oligomers from Polynaphtha to FCC riser to maximize $C_3^-$

Or

Valorize Polynaphtha Gasoline or Distillate to Motor Fuel to adjust Gasoline/Diesel ratio
FlexEne & Polynaphtha

- **FlexEne enables:**
  - The addition of 3-6% wt. of propylene yield, over and above the effect of ZSM-5
  - The increase of the desired Motor Fuels by flexible recycle selection

- **Polynaphtha:**
  - is an Oligomerization unit
  - Using a solid acidic catalyst
Petron Bataan Refinery

Location: Petron, Philippines

- **High Propylene FCC (HP FCC)**
  - 34,000 bpsd
  - 250 kt/y of Propylene
  - FlexEne™, Gasoline & Propylene mode
  - Feed: VGO + Hydrotreated Coker Gasoil
Propylene Production from Refinery

- **Steam Cracker Complex**
  - LPG
  - Naphtha
  - C₄-C₅ cut

- **Coker**
  - Resid
  - C₄-C₅ cut

- **FCC**
  - High Propylene FCC
  - HS-FCC
  - Resid to Propylene
  - VGO
  - C₃ = 8 to 20 wt%
  - C₄-C₅ cut

- **C₄-C₅ Olefins Recovery**
  - Olicrack™
    - >8 wt% C₂=
    - >30 wt% C₃=
    - On-purpose C₃ = unit
    - C₃ / C₂ = ratio > 3 - 4

- **Alternative Fuel units**
  - Fischer-Tropsch
  - FlexEne™
    - C₃=
    - Gasoline /Distillate

**Unique integration with FCC for flexibility**
Operability

Continuous Catalyst Regeneration is based on Axens CCR experience

> 100 Octanizing & Aromizing references

Iso-5 Process

Flexible and easy to operate regenerator
• Refining & Petrochemical (R&P) synergies: Flow exchanges

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• R&P synergies for aromatics
**AlphaHexol Key Features**

- **Selective ethylene trimerization mechanism (Cr catalyst)**

- **Recently born process, similar to AlphaButol, strongly backed up by extensive industrial experience in homogeneous catalysis**

- **Polymer grade 1-hexene suitable for LLDPE & HPDE**

- **Efficient ethylene feed use**

- **Process simplicity and ease of operation**

- **High flexibility**

- **Mild operating temperature and pressure**

- **Liquid phase Carbon steel equipment**

M = Metal  
Lₙ = Ligand

\[ LₙM + 3 C₂H₄ \rightarrow LₙM \rightarrow 1\text{-Hexene} \]
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Aromatic Complex Blocks Functions
ParamaX Suite

- CCR Reforming: Naphtha to BT/X/A9+
- Transalkylation: Tol+A9+ to BZ/C8A
- BT Extraction & Fractionation
- NHdI & Fractionation
- FRN
- BT
- A9+
- A8
- BZ
- PX
- Xylenes Loop: C8A to PX/BZ
Refinery with HCK, HP FCC + ParamaX

Aromatic Complex
ParamaX

Benzene
Paraxylene

Toluene rich cut, A8+
A9+, raffinate, light naphtha

Gasoline
Pool

Kero

Diesel

Propylene

Coke

CDU
SR Naphtha
Naphtha
H2

VDU
VGO
Naphtha

HCK

HCGO
LPG

HP FCC

Bleed
Gasoline

Refinery production
400,000 bbl/d

Aromatics production
Paraxylene: 700 kt/y (2.5% of 2009 PX world production)
Benzene: 140 kt/y

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Existing Refinery with Steam Cracker + ParamaX

Existing Refinery production
- Light Naphtha
- Heavy Naphtha
- Benzene: 650 kt/y
- Paraxylene: 1,400 kt/y (5% of 2009 PX world production)

Aromatics production
- Benzene
- Paraxylene
- Propylene
- Ethylene
- C2, LPG, raffinate

Existing refinery

Gasoline
Kero
Diesel
Residue

H2 export
Refining & Petrochemicals integration is achievable through:

- Full range of innovative technologies from residue conversion to olefins / aromatics maximization
- Full range of associated services: consulting (configuration studies), tech service....
- Full range of products: catalysts & adsorbents
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