KNPC FCC Revamp Project
Opportunities, Challenges and Lessons Learnt

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Agenda

• Overview
• Objectives and Opportunities
• Challenges and Lessons Learnt
• Results and Conclusion
KPC was established in 1980, fully owned by the State of Kuwait
8 specialized Subsidiaries operate in Kuwait and across the world
Position of KNPC in Value Chain of Kuwait

Feedstock supply

- Natural Gas & Condensate
  - Sour Gas
  - Gas Sweetening
  - Sweet Gas

- Crude Oil

Domestic Refining

- Gas processing: 2.3 BSCFD
- Gas for Power Generation
- Oil sector requirements (KNPC, KOC, PIC)

Fuel demand

- LNG imports
- Fuel Oil & Gas Oil for Power Generation
- Ministry of Electricity and Water (MEW)
- Transportation & industrial (domestic & international)
- Domestic: 300 - 400 M BPD
- Export: 500 - 600 M BPD
- Most of products exported to Asian Region

KNPC is responsible for Domestic Refining & Gas Processing to satisfy the local fuel demands for Power Generation, Transportation, Industries & supply products for International market.
Retired SHU refinery of 200 KBPD

New Refinery of 615 KBPD under construction
Overview

FCC Revamp - Part of CFP Strategy and Objectives

• Develop KNPC refineries into integrated merchant refining complexes to meet diversified market needs.

• Meet future market demand and specifications for local & international markets.

• Enhance the environmental & safety performance of KNPC refineries.

• Major upgrade of MAA and MAB refineries to convert high sulfur fuel oil to higher value products.

• Respond effectively to KPC / KNPC strategic directives for expanding the refining capacity in Kuwait.

• Provide new employment opportunities for Kuwaitis in the refining sector.
Overview

FCC Revamp - Part of CFP Strategy and Objectives

- KNPC Mina Al Ahmadi processes about 460000 BPD of crude oil
- First designed by UOP in 1984 and commissioned in 1986 as a 30000 BPSD High efficiency regenerator and riser with down turn arms.
- Revamped by UOP in 1997, increasing from its original nameplate capacity to 40000 BPSD (30000 BPSD VGO+10000 BPSD CGO).
- Current revamp (November 2015) feed capacity at 42500 BPSD processing a mix of CGO/UCO/TGO
KNPC Objectives for FCC Revamp

- Improve unit Reliability & On Stream Factor
- Processing difficult feed stocks & optimize conversion
  - Key to meet local Mogas and Propylene commitments
- Extended operation run length
- Sustained operation at higher capacity
- Improved Environmental Performance (Flare less during start up, SOx & control of Particulate emissions)
KNPC FCC Project Scope

• New Reactor incorporating the following:
  – VSS™ G2
  – Optimix™ feed distributors
  – AF™ Stripper

• Additional auxiliary air blower & New Orifice chamber

• Main Fractionator changes
  – Top four sections (LCN/HCN fractionation, HCN pump around, HCN/Distillate fractionation, Distillate pump around) replaced trays with random packing to save WGC modifications

• Gas Concentration columns
  – Replaced internals in different sections with high capacity trays
Performance of UOP’s Reactor Technologies

Impact of latest UOP’s Reactor Technologies included in KNPC’s new reactor design.

- Conversion
- Gasoline Selectivity
- Dry Gas, \( \Delta \text{Coke}, \text{Trg} \)
- Improved Reliability
- Improved Ops Flexibility

VSS™ Riser Termination

AF™ Stripper

Elevated Optimix™ Feed Distributor

- Conversion
- Gasoline Selectivity
- Dry Gas, \( \Delta \text{Coke}, \text{Trg} \)
- Improved Reliability
KNPC FCC Challenges & Solutions

- High Sulfur → from FCC Unit
- High Aromatics → from CCR units
- High Olefins → from FCC
- KNPC Mogas pool currently meets Bz spec as two existing CCR Units at MAA Refinery are designed to meet the Bz spec of < 1 Vol. %

Technology Solutions:
- FCC Light and Heavy Gasoline Selective desulfurization, Cap.: 26 KBPSD to meet future sulfur spec
- Isomerization unit of 30 KBPSD for reducing olefins/aromatics
- DIP unit of 42 KBPSD to produce iso-pentane as Mogas component to reduce Aromatics/Olefins
- Alkylation unit revamp for higher production to reduce Aromatics/Olefin
KNPC FCC Challenges & Lessons Learnt

- Scope Growth at FEED stage
- Split scope from CFP
- Avoid scope overlap between FCC and CFP contractor
- Raise DCN to include appropriate scope to FCC to avoid additional FCC shutdowns
- Coordination with Licensor to define specific requirements
- MAA alignment on the final scope
- Execution challenge due to interface during shutdown
- Pre-commissioning
- Commissioning and start up
KNPC FCC Challenges & Lessons Learnt

Scope Growth at FEED Stage:
Sour Water Treatment (SWT), Cooling Water System, Pipe rack and underground piping scope

- [Portion 1] Unit-86 FCC (Revamp)
- [Portion 2] Unit-195 SWT (New)
- [Portion 3] Unit-275 C/W System (New)
- [Portion 4] Unit-97 Piping Works: Demolition, New lines, Tie-ins (Revamp)
  - Unit-179 U/G Pipe line: FW, CW, OWS, SW (Revamp)
  - Unit-161 Pipe Rack Extension: Process, Utility (New)
KNPC FCC Challenges & Lessons Learnt

Coordination with Licensor:

- FEED completed in year 2008, but EPC awarded in 2013. Technology upgrades incorporated resulted in additional changes.
- FCC FEED was a basic engineering package, not full blown FEED package, required close coordination throughout EPC phase.
KNPC FCC Challenges & Lessons Learnt

Utility/tie-in Conditions Changes

• Actual utility conditions are different than BEDD.
• Wet slops tie-in conditions (cold tie-in to hot tie-in resulted in scope change.
• HSE changes
  – Move from Chlorine injection to sodium hypochlorite
KNPC FCC Challenges & Lessons Learnt

Refinery Coordination Challenges:

• Wet Gas compressor modification
• Regenerator cyclones
• Scaffolding and other works inside vessels
• Scope alignment
KNPC FCC Challenges & Lessons Learnt

Construction Stage:

- Lifting of heavy equipment
- Timely Handover of equipment
- Skilled EPC manpower/subcontractor

Focused teamwork only way for safe and timely completion of the project
KNPC FCC Challenges & Lessons Learnt

Pre-commissioning Stage:

- Punch listing and categorization.
- Instrument Loop Checking
- Effective Communication and Full Participation
- Maintain cleanliness at site to avoid accidents
- Plan in advance for utilities
- PSSR: Pre Safety Start up Review
KNPC FCC Challenges & Lessons Learnt

**Post-commissioning Stage:**

- Availability of design feed for PGT run of FCC
- EPC/Licensor/Vendor resources, Lab Resources
- Fractionator related issues (Heavy Gasoline EP Vs. Performance Guarantees)
- Hot spot on stand pipes
- Auxiliary Air Blower commissioning
KNPC Revamp Results Summary

• Rx- Regen Section – Success!
  – Flawless start-up
  – Excellent catalyst containment
  – Ease of operation
  – Selectivity to C$_3$= and Gasoline better than UOP prediction
  – Regen temp on lower side reflects on improved stripper efficiency

• Main Column and Gas Concentration Unit – Success with some challenges

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<thead>
<tr>
<th></th>
<th>Pre Revamp</th>
<th>Post Revamp</th>
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<tbody>
<tr>
<td>Feed density, API</td>
<td>Base</td>
<td>Base -3</td>
</tr>
<tr>
<td>Propylene, Wt-%</td>
<td>Base</td>
<td>Base + 8%</td>
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<tr>
<td>Gasoline, vol-%</td>
<td>Base</td>
<td>Base + 1.5%</td>
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Economics and Payback

- Processing of poorer feed (Heavier feed like TGO/CGO)
- Improvement in Gasoline yield
- Improvement in Propylene yield
- Improved OSF

*Total Estimated Financial Benefits* = $25-30 \text{ MMUS$/Annum}$

*Payback* of about … 6 years
Conclusions

• Reactor replacement met unit processing objectives
• Project maximized use of existing assets
• Improve refinery profitability
  – Improved product slate, especially Gasoline and Propylene yield
• Challenge of improved run length from 3 to 4 years and operational availability under assessment and can be addressed after completion of current operating cycle.