Value Addition through Coke Gasification: Case Study

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Abstract

Value Addition through Coke Gasification: Case Study
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Given the spiraling prices of LNG in international market and receding production of natural gas from KG basin in India, almost all the gas connected industries in India have come under pressure, the major being Fertilizer and Power. It has become almost inevitable to look for sustainable alternate feedstock.

In the context of the same, a comprehensive study has been conducted at our end, wherein, economics has been established via 3 different case studies for an existing refinery coming up with Coker Unit. Two standalone refinery case studies where the syn-gas from coke gasification unit were used for generating Power & Steam and H2 respectively, thereby providing substantial value-addition. In the third case study, the refinery has been integrated to an existing fertilizer complex, currently being fed by naphtha. The syngas integration leads to substantial saving in OPEX of fertilizer complex as with syngas availability, the naphtha storage, feed treatment, primary and secondary reformer is not required. The acid gases are also directly converted to Sulphuric acid, which shall be consumed in the existing fertilizer complex as well. High CAPEX involved in gasification unit has been rationalised by adopting suitable strategies. The naphtha (C5-160) displaced from the fertilizer complex is further used to envisage a new Aromatic complex (Paraxylene maximization). Further, the existing refinery streams were optimized, and LNG was also integrated strategically to refinery for enhancing the aromatic production from proposed complex. By virtue of PX production the returns from the project are extremely attractive and provides tremendous value-add to the refiner.
Welcome

- Challenges & Ways to Increase Margins
- Gasification: The Way to Go
- Petcoke Gasification Drivers & Challenges
- Case Study
- Overview of Engineers India Limited ("EIL")
Challenges For An Owner

- Fluctuating Crude price: Low Refinery Margin
- Existing old inefficient refineries
- Environmental Concerns/ stringent product quality
- Minimization/ Elimination of Fuel oil
- Increasing Fuel & utility cost
- Feed-mix selection & cyclical margins in petchem
- Bunker Fuel quality
Ways to Increase Margins

- Limiting Existing metallurgy & heavier fraction/processing

- Carbon Rejection Process (DCU, SDA)
- Hydrogen Addition Process (Ebullated Bed, Slurry HYK)

- Refinery Petrochem Integration
  - Gasification of Coke/Pitch, CFBC
  - Modifications within existing set up.

- Processing Dirty sour Crudes

- Replacing old lower efficiency units & Integration

- Innovative methods to reduce Feedstock/Fuel & Utility Cost

- Refinery Petrochem Integration

- For refineries having clustered units, phase wise capacity build up.
Gasification: The Way to Go

A commercially proven **partial oxidation process** that converts Hydrocarbons, such as heavy oils, petcoke, and coal into H2 and CO (Syn gas)

\[
\begin{align*}
4 \text{CH} & \quad + \quad 2 \text{H}_2\text{O} & \quad + \quad \text{O}_2 \\
\text{(Fuel)} & \quad \text{(Water)} & \quad \text{(Oxygen)} \\
\hline
4 \text{H}_2 & \quad \quad \quad + \\
\text{(Hydrogen)} & \quad \text{4 CO} \\
\text{(Carbon Monoxide)} & \\
\end{align*}
\]

**MOVING BED**
- Dry ash : Lurgi
- Slagging : BGL

**FLUIDIZED BED**
- Bubbling : Winkler-Uhde, GPE
- Circulating : FW, U-gas
- Transport gasifier: TRIG- KBR

**ENTRAINED BED**
- Slurry feed type: GE(Texaco), CB&I (E-Gas)
- Dry feed type: Shell, Uhde-Prenflow, Noell.
### Gasification: Proven Technologies Available

<table>
<thead>
<tr>
<th>Technology</th>
<th>No. of Stages</th>
<th>Oxidant</th>
<th>Feed Type</th>
<th>Reactor Wall</th>
<th>Syngas Cooling</th>
<th>Flow Regime</th>
</tr>
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<tbody>
<tr>
<td>Lurgi</td>
<td>1</td>
<td>Oxygen</td>
<td>Dry</td>
<td>Double Walled w/ Water Jacket</td>
<td>Quench &amp; Convective</td>
<td>Fixed or moving (Bed Non-slagging)</td>
</tr>
<tr>
<td>Uhde HTW</td>
<td>1</td>
<td>Air/Oxygen</td>
<td>Dry</td>
<td>Refractory</td>
<td>Convective</td>
<td>Fluidized Bed (Non-slagging)</td>
</tr>
<tr>
<td>SES</td>
<td>1</td>
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<td>Dry</td>
<td>Refractory</td>
<td>Convective</td>
<td></td>
</tr>
<tr>
<td>GE(Texaco)</td>
<td>1</td>
<td>Oxygen</td>
<td>Slurry</td>
<td>Refractory</td>
<td>Quench or Radiant</td>
<td></td>
</tr>
<tr>
<td>CB&amp;I (E-Gas)</td>
<td>2</td>
<td>Oxygen</td>
<td>Slurry</td>
<td>Refractory</td>
<td>Convective</td>
<td></td>
</tr>
<tr>
<td>Shell</td>
<td>1</td>
<td>Oxygen</td>
<td>Dry</td>
<td>Membrane Wall</td>
<td>Convective</td>
<td></td>
</tr>
<tr>
<td>Uhde Prenflo</td>
<td>1</td>
<td>Oxygen</td>
<td>Dry</td>
<td>Membrane Wall or Refractory</td>
<td>Convective or Quench</td>
<td></td>
</tr>
<tr>
<td>MHI</td>
<td>2</td>
<td>Air/Oxygen</td>
<td>Dry</td>
<td>Membrane Wall</td>
<td>Convective</td>
<td></td>
</tr>
<tr>
<td>Siemens</td>
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<td>Oxygen</td>
<td>Dry</td>
<td>Cooling Screen</td>
<td>Quench</td>
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<tr>
<td>TPRI</td>
<td>2</td>
<td>Air/Oxygen</td>
<td>Dry</td>
<td>Membrane Wall</td>
<td>Convective</td>
<td></td>
</tr>
<tr>
<td>KBR</td>
<td>1</td>
<td>Air/Oxygen</td>
<td>Dry</td>
<td>Refractory</td>
<td>Convective</td>
<td>TRIG (Non-slagging)</td>
</tr>
<tr>
<td>Solena</td>
<td>1</td>
<td>Air/Oxygen</td>
<td>Dry</td>
<td>Refractory</td>
<td>Quench</td>
<td>Plasma</td>
</tr>
</tbody>
</table>
Gasification: Feed & Product Flexibility

Potential Feeds:
- Natural gas
- Residual oils
- Orimulsion
- Petroleum coke
- Coal
- Waste Oils
- Biomass
- Black liquor
- Municipal Waste

Gasification Plant

Combined Cycle

Chemical Production

Fischer-Tropsch Synthesis

Slag/Ash

Potential Products:
- Oxygen
- Nitrogen
- Argon
- Carbon Dioxide
- Sulfur/Sulfuric Acid
- Steam
- Electric Power
- Hydrogen
- Carbon Monoxide
- Ammonia, Urea
- Methanol-to-Gasoline
- SNG
- Industrial Chemicals
- Methanol/Higher Alcohols
- Acetic Acid
- Naphtha
- Diesel
- Jet Fuel
- Wax
Gasification: Typical Configuration

Typical Gasification Island

- **O2 FROM ASU**
- **PETCOKE SLURRY**
- **PETCOKE HANDLING AND SLURRY PREP**
- **COARSE SLAG**
- **BLACK WATER HANDLING, COARSE SLAG HANDLING**
- **GREY WATER HANDLING & FINES FILTRATION**
- **GREYWATER BLOWDOWN**
- **FINE SLAG**
- **RAW SYNGAS**
- **CONDENSATE**

- **DME**
- **Olefins**
- **Acetic Acid**
- **Ethanol**
- **SNG**
- **H2, Power, Steam**
- **DRI**
- **NH3/ Urea**
Various Syngas processing:

- Reducing syngas temperature:
  - Extract valuable energy

- Removal of chemical species that:
  - Foul, corrode, or erode system components
  - Poison or deactivate chemical processing agents

- Target Syngas purity
  - H2S / CO2 concentration

- Adjustment of H2/CO ratio: H2/CO adjustment via water Shift Gas:
  - Hydrogen production
  - SNG production (H2/CO ~ 3)
  - Ammonia production
  - Methanol production (H2/CO ~ 2)
Petcoke Gasification: Drivers/ Opportunity

- Value-add opportunity for Coke. Global DCU capacity build up ~ 125 MMTPA. ~13 MMTPA of coke by 2015-16 in India from 40 MMTPA DCU capacity.

- Shortage of domestic gas & Increasing LNG price across Europe & Asia: Opportunity for both refiners & Fertilizer industry ➔ Subsidy Relief for govt.

Source: world LNG report-2013, Bloomberg, EIL internal

**past 5 months
Crude oil fallen by 45% & Spot LNG available at 9 $/mmbtu

Widening Delta LNG-petcoke to be exploited
Petcoke Gasification: Drivers/ Opportunity

- Proven Technology to process different refinery residues.
- Alternate economical route for the production of Fuel/ chemicals / power(Naptha ~22 $/mmbtu)
- Value addition to the bottom of barrel, thereby increase in GRM.
- Provides energy security to nations having large coal reserves & high petcoke availability
Petcoke Gasification: Challenges

- Energy price fluctuation wrt Crude oil & Natural Gas

- A capital Intensive complex project (Gasification/ASU/AGR etc) & Large Land requirement

- High R&M cost, and additional due to for reliability.

- Economics favorable for large scale gasification - Coal to supplement

- Government’s support for CCS development to maximize profit from “Green technology”
Case Study: Options to Value-add

- Case Study 1: Value-add from Standalone Refinery Options
- Case Study 2: Maximizing value-add by exploring all Integration options

- Fertilizer Complex (1050 Ammonia & 1450 Urea)
- Refinery (11.2 MMTPA)
- LNG Terminal (5 MMTPA)

Coastal Region

Existing

Proposed (by 2016)
### Existing Opportunities/ Drivers for Gasification

<table>
<thead>
<tr>
<th>Current Opportunity/Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke availability of around 2000 TPD in future</td>
</tr>
<tr>
<td>Naptha (C5-160) being used as Fertilizer feedstock for 1050 TPD Ammonia unit</td>
</tr>
<tr>
<td>Higher fuel &amp; Utility Cost for Refiner. Naptha being used for 3 Nos. Hydrogen Generation Units (110,500 Nm3/hr H2) &amp; 3 Nos. GT- HRSGs in refinery</td>
</tr>
<tr>
<td>BTX potential exists in the refinery CCR Reformate and FCC Gasoline.</td>
</tr>
<tr>
<td>Sulphuric acid required for future anticipated SSP production in Fertilizer Complex</td>
</tr>
<tr>
<td>Decreasing the burgeoning subsidy burden on GOI in Fertilizer sector.</td>
</tr>
<tr>
<td>Substantial Land availability with Fertilizer complex owner</td>
</tr>
</tbody>
</table>
Case Study 1: Standalone Refinery (Power Case)

Naptha displaced from GT-HRSG ~250 KTPA

Gasification & Scrubbing

Syn Gas

Acid Gas Removal

Sour flash/ Acid Gas

Sulphur

~ 130 TPD

Power Recovery Option

63 MW power & ~225 TPH HP steam

GTs & HRSG

2000 TPD

24% absorbed in Gasoline pool with minor modifications in existing ISOM and CCR unit & Balance in Naptha pool

GRM Increment by ~1.4 $/bbl

2200 TPD

~ 1350 TPD

CO2 recovery potential

250 KTPA

200 TPD

~130 TPD

Low Temp. Heat Recovery

Pet Coke

Naptha

HP Oxygen

Syn gas to ASU/ FG Header ~ 125 MMKcal/hr Energy potential

Argon

Nitrogen

HP Steam

ASU (BOO/New)

Sour flash/ Acid Gas

Post GDM ~ 225 TPH HP Steam

~63 MW power
Case Study 1A: Standalone Refinery (H2 Case)

Naptha displaced from HGUs - 275 KTPA

Gasification & Scrubbing

20% absorbed in Gasoline pool with minor modifications in existing ISOM and CCR unit & Balance in Naptha pool

Pet Coke
2000 Tpd

HP Oxygen
2200 Tpd

ASU (New)

HP Steam

Deficit fuel for GTs

Nitrogen

Argon

Sour flash/ Acid Gas

HP Steam

Condensate

Balance Syn gas to ASU/ FG Header

Sulphur

~ 130 TPD

CO2 recovery potential ~ 3900 TPD

Sulphur

PSA off Gas

H2
78 KTPA
110 Nm3/hr

PSA

FG header

GRM Increment by ~1. 8 $/ bbl

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Case Study 2: Refinery Integration with Fertilizer complex

- **Pet Coke** (2000 TPD) through Gasification & Scrubbing to Syn Gas
- **Syn Gas** to Sour Shift
- **Sour Shift** outputs HP Steam and Acid/Sour Gas
- **WSA** generates Sulphuric Acid (~ 300 TPD)
- **Syn Gas** to ASU/FG Header
- **ASU** (BOO) generates Nitrogen
- **HP Oxygen** (2200 TPD) to Syn Gas
- **Balance Syn Gas to ASU/FG Header**
- **HP Steam** to WSA
- **Carbon Dioxide Equivalent for 1450 TPD Urea**
- **PSA** off Gas to FG header
- **H2** to NH3 syn. Loop
- **NH3 syn. Loop** to Urea

Nitrogen

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Air Separation Unit

Coke Grinding slurry Preparation in Refinery

Main Gasifier in Fertilizer Complex

Syngas Scrubbing

CO Shift/Gas Cooling

Acid Gas Removal (Selexol/Rectisol)

Sulfur Recovery

Pressure Swing Absorption (PSA)

Ammonia Synthesis

NH₃

Ammonia Product

UREA

CO₂ Purification

CO₂ Vent

CO₂

H₂S

N₂

O₂

H₂

H₂CO₂

For Sulfuric acid Production

Legend:

- Spare
Case Study 2: Envisaged Aromatic Complex

Existing Refinery

Displaced C5-130 Naptha from HGUs & GT-HRSG

New Gasification Island (2000 TPD coke)

Syn Gas

C5-160 Displaced Naptha

Sulphuric Acid 300 TPD

Existing Fertilizer Complex

Para-Xylene 625 KTPA

Benzene 175 KTPA

H2/ LPG to refinery 18/ 34 KTPA

C5-70 Naptha to Ref Gasoline pool 213 KTPA

Parafinic Raffinate/ C10+ aromatic Naptha Gasoline pool

New Aromatic Complex

BTX extracted from Reformate & FCC Gasoline

LNG 0.825 MMSCMD

Existing Refinery

LNG 1.9 MMSCMD

coke slurry

New Gasification Island (2000 TPD coke)
New Aromatic Complex

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Case Economic Comparison

- Refinery Power Case (ASU:BOO): $0.7 B US$
- Refinery Power Case: $1 B US$
- Refinery H2 Case: $1.05 B US$
- Refinery Integration Case (ASU:BOO): $1.7 B US$

IRR, %

CAPEX, Billion US$ (India)
Success Mantra for Gasification

- The returns from Gasification depend on:
  - Differential between displaced fuel & the Syngas cost
  - Exploiting the displaced fuel’s potential for further value-add

- Until technologies & market for CCS matures, integration with Fertilizer complex offers perfect synergy for CO2 disposal. Other being downstream Acetic acid/ Ethanol units.

- CAPEX can be checked by opting ASU on BOO basis.

- SNG from gasification is another attractive option provided large quantity of refinery off gases & NG are available to displace
Lines of Business: Total Solution Consultancy & Leading EPC

- **Oil & Gas**
  - Oil and Gas Processing
  - Offshore & Onshore
  - Refinery
  - Strategic Storage, Terminals and Pipelines

- **Chemicals & Metallurgy**
  - Petrochemicals
  - Fertilizer
  - Mining and Metallurgy

- **Infrastructure**
  - City Gas
  - Urban Development
  - Water and Waste Management

- **Power**
  - Solar
  - Thermal
  - Nuclear
## Concept to Commissioning

### Process Design
- Technology and Licensor selection
- Conceptual design & feasibility
- Process design
- Residual Engineering

### Engineering
- Detailed Engineering
- Specialized services
  - Heat and mass transfer
  - Environment engineering
  - Maintenance services

### Procurement
- Supplier and Contractor management,
- Exediting, inspection
- Vendor Development

### Commissioning
- Pre-commissioning and commissioning assistance
- Safety audit,
- Hazard and operability studies,
- Risk analysis

### Construction Management
- Materials and warehouse
- QA/QC and HSE
- Progress monitoring/ scheduling
- Mechanical Completion
- Site Closure

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## Experience Credentials

<table>
<thead>
<tr>
<th>INDIA</th>
<th>INTERNATIONAL</th>
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<tr>
<td>209 Offshore Platforms</td>
<td>🇮🇳 GSPC 🇮🇳</td>
</tr>
<tr>
<td>37 Oil &amp; Gas Processing Projects</td>
<td>🇮🇳 Cairn 🇮🇳 GSPC 🇮🇳</td>
</tr>
<tr>
<td>59 Major Refinery projects including 10 green-field projects</td>
<td>🇮🇳 Essar 🇮🇳 BRP 🇮🇳 NFL 🇮🇳 BPCL 🇮🇳 HMEL 🇮🇳</td>
</tr>
<tr>
<td>9 Petrochemical Complexes</td>
<td>🇮🇳 IPCL 🇮🇳 BCPL 🇮🇳 HMEL 🇮🇳</td>
</tr>
<tr>
<td>13 Ports &amp; Storage Terminals</td>
<td>🇮🇳 ISPL 🇮🇳 BHARAT OMNIA REFINERIES LIMITED 🇮🇳 HMEL 🇮🇳 OIL INDIA LIMITED 🇮🇳</td>
</tr>
<tr>
<td>42 Pipeline Projects</td>
<td>🇮🇳 BPCL 🇮🇳</td>
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<tr>
<td>8 Fertiliser Projects</td>
<td>🇮🇳 IFFCO 🇮🇳</td>
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<tr>
<td>Infrastructure Projects</td>
<td>🇮🇳 JANHAR AGRO INDUSTRIES LTD 🇮🇳 Bombay 🇮🇳</td>
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<td>Power / Captive Power Projects</td>
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<td>29 Mining &amp; Metal Projects</td>
<td>🇮🇳 NALCO 🇮🇳 INDAL 🇮🇳</td>
</tr>
<tr>
<td>17 EPC Projects</td>
<td>🇮🇳 GSPC 🇮🇳 🇮🇳 GSPC 🇮🇳 🇮🇳</td>
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</tbody>
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Operating Margin Maximization: Options for Client

- Distillate yield improvement & Product quality improvement
- Operating margin improvement through stream routing optimisation / cut point optimisation / product profile optimisation
- Energy efficiency improvement / heat integration
- Replacement of old / inefficient process units / hardware by energy efficient units based on cost benefit analysis
- On-stream factor improvement
- Process loss minimisation (minimise quality give-away, Flare loss mitigation, slop processing, HC losses from storage tanks)
This information is confidential and shared only for Knowledge sharing Programme-2015 at Takreer Research Centre. Information upon which this presentation is based comes from our own experience, knowledge and databases, supplemented by reference to primary sources and published industry data.
Typical Gasification Block
Global Coke Scenario

- Global production 125 MMTPA. Around 30% is calcined coke.
- Coke to increase by 25% by 2018.