THE MERITS OF HEAVY RESIDUE GASIFICATION IN TODAY’S WORLD

IChemE Conference 2010

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PRESENTATION OVERVIEW

- The Global Energy Challenge
- Gasification Technology
- Gasification in Refining
- Gasification in Oil Sands
- Gasification in Gas-to-Liquids
- Gasification for Power and EOR
- Conclusion
9 billion people

2.5 billion more than today

4-5 times richer

with most extra wealth coming from developing countries

Double the energy

using twice as much energy as now

Twice as efficient

using half the energy as now to produce each dollar of wealth

6-10 times more energy

from renewable sources
Rising and shifting demands
Cleaner fuels
Biofuels

Energy efficiency
Lower emissions
CO₂ reduction

More unconventional crude/feedstocks

Market is changing
Refining will need to invest
Upstream is changing
# SHELL GASIFICATION TECHNOLOGIES

<table>
<thead>
<tr>
<th>SGP</th>
<th>SCGP</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Gasifier Diagram" /></td>
<td><img src="image2.png" alt="Gasifier Diagram" /></td>
</tr>
</tbody>
</table>

**Non-slagging condition**
- Refractory lined gasifier
- Liquid feed system
- Fire tube boiler
- Soot water handling

**Slagging condition**
- Membrane wall gasifier
- Dry feed system
- Water tube boiler
- Solid slag handling

**Liquid refinery residues**

**Coal and coke**
VERSATILITY OF SHELL GASIFICATION TECHNOLOGIES

Legend
SGP – Shell Gasification Process
SCGP – Shell Coal Gasification Process
DRI – Direct Reduced Iron
FT – Fischer-Tropsch

Coal/Lignite → SGP or SCGP → Syngas → Hydrogen → Shift → Carbon dioxide

Petcoke → SGP or SCGP
Biomass → SGP or SCGP
Heavy Oil → SGP or SCGP
Heavy residue → SGP or SCGP

Syngas → Power & water → DRI → EOR
Syngas → Power & water → Steam/heat → EOR
Syngas → Methanol → Petrochemicals
Syngas → Synthetic NG → Town gas
Syngas → Ammonia → Urea
Syngas → FT liquid fuels
Syngas → Fuel cells
Syngas → Oil refineries

Carbon dioxide → Scenario: Saline Aquifers Depleted Hydrocarbon Reservoirs

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CONVERTING “BOTTOM OF THE BARREL” INTO VALUABLE PRODUCTS

- Proven track record in gasification since 1950’s
  - Residue/gas: >150 reactors built, >80 reactors in operation
  - Gas: major equity investment in GTL Qatar (18 reactors)
  - Coal: 24 units sold globally, 13 plants currently in operations
- Proven track record on heavy, high sulphur, viscous residues, s/a Thermal Cracker residue, Solvent Deasphalter residue
- High syngas yield (typically >2,600 Nm3 CO+H2 per ton feed), low oxygen consumption and low soot formation, and high thermal efficiency through syngas cooler
CONVERTING “BOTTOM OF THE BARREL” INTO VALUABLE PRODUCTS

- Safe and Reliable operation: automated and fully safeguarded heat-up, start-up, shutdown sequences
- Long burner run length and long refractory lifetime
- Extensive experience in start-up, operation and maintenance of own units and licensed units.

- Shell Pernis 1997
  Cracked Residue
  3x550 t/d

- ENI Sannazzaro 2006
  Residue/Asphalt
  2x600 t/d

- Nexen (Opti) 2008
  Asphalt
  4x1033 t/d

- Fujian 2009
  Asphalt
  3x1200 t/d
GASIFICATION IN OIL SANDS

- JV between Nexen and OPTI Canada, operated by Nexen
- Produces 72,000 bbl/day of bitumen
- Heavy asphaltene by-product is gasified in a SGP unit, which generates all hydrogen for the hydrocracking unit and high-quality steam for use throughout the plant.
- Excess syngas is used for power and steam generation.
- Therefore unlocking the value of oil sands, without using natural gas
- Shell delivered four oil gasification installations to Nexen, with a total capacity of 3,600 t/d, the largest in the world.
- The start-up of the units progressed well and the gasification units have successfully demonstrated their intended performance.
- TSA signed in 2010
GASIFICATION IN OIL SANDS
LONG LAKE PROJECT, CANADA
GASIFICATION IN GAS-TO-LIQUIDS
PEARL GTL PROJECT, QATAR

- World’s largest GTL plant
- 120,000 boe/d of natural gas liquids and ethane and 140,000 b/d of liquid hydrocarbon products
- Major construction completed end 2010, production ramp up in 2011
- Entered the testing phase
PEARL – A WORLD CLASS INTEGRATED GTL PROJECT

Offshore production
Qatar North Field
1.6 bcf/d

GTL plant
140 kbbl/d

Products (indicative)

LPG

Ethane

Condensate

GTL Gasoil

Kerosene

Synthetic Base Oil

Base Oil

Gasoil

Naphtha

Other

>1 mtpa

>2 mtpa

>1 mtpa

Development & Production Sharing Agreement

Upstream

Downstream

Marketing
Shift of syngas with steam leads to pure streams of CO2 and H2.
N2 is used to dilute H2 before its combustion in gas turbines.
Power price is competitive when CO2 is sold as a valuable product.
RELATIVE COSTS OF CO$_2$ AS A BY-PRODUCT OF POWER PRODUCTION

Based on an internal Shell study
CONCLUSION

- Global demand for energy will continue to increase, while CO$_2$ emissions will have to be reduced
- More stringent industrial and environmental requirements in the oil and gas business are imminent
- Gasification technology applications can provide solutions
- Upstream operations will present new areas of application – in regions with EOR potential residue gasification-to-power could well be a key enabler
- Shell is strongly positioned to meet the energy challenge
# RECENT SGP PROJECTS

<table>
<thead>
<tr>
<th>Owner</th>
<th>Location</th>
<th>Feedstock</th>
<th>Input, t/d</th>
<th>Syngas, $10^6$Nm$^3$/d</th>
<th>End product</th>
<th>Startup date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell Nederland Raffinaderij</td>
<td>Rotterdam, Netherlands</td>
<td>Cracked residue</td>
<td>1650</td>
<td>4.7</td>
<td>Hydrogen/power/steam</td>
<td>1997</td>
</tr>
<tr>
<td>Lanzhou Chemical</td>
<td>Lanzhou, China</td>
<td>Vacuum residue</td>
<td>700</td>
<td>2.1</td>
<td>Chemicals</td>
<td>1998</td>
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<tr>
<td>Chemopetrol revamp</td>
<td>Litvinov, Czech Republic</td>
<td>Cracked residue</td>
<td>1250</td>
<td>3.6</td>
<td>Chemicals/hydrogen</td>
<td>2001</td>
</tr>
<tr>
<td>Lucky Goldstar</td>
<td>Naju, Korea</td>
<td>Vacuum residue</td>
<td>225</td>
<td>0.7</td>
<td>Chemicals</td>
<td>2001</td>
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<tr>
<td>Eni SpA</td>
<td>Sannazzaro, Italy</td>
<td>Cracked residue</td>
<td>1200</td>
<td>3.4</td>
<td>Hydrogen/power</td>
<td>2006</td>
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<tr>
<td>Opti/Nexen</td>
<td>Alberta, Canada</td>
<td>Asphalt</td>
<td>3790</td>
<td>9.7</td>
<td>Steam/hydrogen</td>
<td>2008</td>
</tr>
<tr>
<td>Fujian ethylene project</td>
<td>Fujian, China</td>
<td>Asphalt</td>
<td>2180</td>
<td>5.7</td>
<td>Hydrogen/power</td>
<td>2009</td>
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