Efficient Technologies for Down Stream Gasification Process and Integration with IGCC Power Production

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GTC Conference, 14-17 October 2007, San Francisco, US
Efficient technologies

One definition of Sustainable technologies: Meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

- For synthesis gas utilisation downstream gasification
  - Low environmental impact – locally and globally
  - Products useable today and tomorrow
  - High efficiency in production (low energy waste)
  - Ability to use long term solutions for feed supply – and renewable
Topics to be covered

- Topsøe’s list of technologies
  - Overall process steps
  - Synthesis gas conditioning & adjustment
  - Sulphur management
  - Synthesis

- Examples
  - Conversion of coal to ammonia
  - TIGAS and polygeneration

- Conclusion
Overview of building blocks

Air separation unit

Gasifier

Sour shift

Acid gas removal

Synthesis

Air

O₂

Steam

Coal, petcoke, or biomass

Steam

Sulphuric acid

WSA™

CO₂/H₂S

CO₂

Steam
Topsøe technologies

- Synthesis gas conditioning and adjustment
  - CO and COS conversion
- Sulphur management
- Synthesis
  - Methanol
  - DME
  - Ammonia
  - Gasoline
  - SNG
  - Hydrogen
Synthesis gas conditioning Water Gas Shift (WGS) and COS hydrolysis (CKA)

Coal gas: H₂/CO < 1

- SSK
  - High activity in sulphur-containing gas 50ppm – 5% H₂S
  - Active catalyst in low concentrations of CO (0.1-5%)
  - Converts COS to H₂S
  - Converts HCN
  - Active between 200°C and 500°C

CKA → WGS

Acid wash: H₂S, CO₂ removal

Pure syngas

H₂/CO = 3 (SNG)
H₂/CO = 2 (MeOH/FT)
H₂/CO = 1 (TIGAS/DME)
H₂/CO = ∞ (H₂, NH₃)
Sulphur management

- **Wet Sulphuric Acid (WSA):** A process for purification of sulphur containing off-gases by production of concentrated sulphuric acid.

- **SNOX™:** Combination of WSA with SCR DeNOx for flue gas cleaning.

**Features**
- Few components
- Simple and energy effective process
- No secondary effluents
- High steam production
- Low cooling water consumption
- Commercial quality product
- 56 industrial references
Wet gas Sulphuric Acid (WSA) for H$_2$S gas

Chemical reactions:

\[
\begin{align*}
    \text{H}_2\text{S} + \frac{1}{2} \text{O}_2 &= \text{SO}_2 + \text{H}_2\text{O} \\
    \text{SO}_2 + \frac{1}{2} \text{O}_2 &= \text{SO}_3 \\
    \text{SO}_3 + \text{H}_2\text{O} &= \text{H}_2\text{SO}_4 \ (g) \\
    \text{H}_2\text{SO}_4 \ (g) + 0.17 \text{H}_2\text{O} \ (g) &= \text{H}_2\text{SO}_4 \ (l)
\end{align*}
\]
Methanol synthesis

- Make-up gas from gasifier
- Sulphur guard
- Methanol reactor
- H₂ recovery unit
- Purge gas scrubber
- LP separator
- HP separator
- LP steam
- DMW
- Off-gas to fuel
- Off-gas to fuel
- Raw MeOH for purification or further processing

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Methanol technology matters

Topsøe methanol projects ordered in 2006

- **Rashtriya Chemicals and Fertilizer Co, India (2008)**
  220 MTPD natural gas based plant (revamp)
- **SFCCL, Al Jubail, Saudi Arabia (2008)**
  700 MTPD natural gas based plant (SMR)
- **Eurochem, Lekki Peninsula, Nigeria (2010-11)**
  7500 MTPD natural gas based plant (Autothermal reforming - FEED)
- **Shaanxi Xianyang Chemical Industry Co, China (2008)**
  2000 MTPD based on coal gasification
- **Tianjin Soda Plant, China (2009)**
  1500 MTPD based on coal gasification
- **Guizhou Tianfu, China (2009)**
  750 MTPD based on coal gasification
- **Gujerat State Fertilizer Co, India (2009)**
  525 MTPD natural gas based plant (revamp)
Substitute natural gas TREMP™ technology

Feed (H₂-CO₂/(CO+CO₂) ratio = 3

Steam drum

Recycle compressor

Superheater

HP boiler

Natural gas product

BFW

Process condensate

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Typical consumption figures

- **Basis**
  - 180,000 Nm$^3$ SNG/h

- **Consumption**
  - 400 MT coal/h

- **Production**
  - 610 MT/h superheated steam

<table>
<thead>
<tr>
<th>Component</th>
<th>Mole – %</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH$_4$</td>
<td>94 – 96</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>0.5 – 1</td>
</tr>
<tr>
<td>H$_2$</td>
<td>0.5 – 1</td>
</tr>
<tr>
<td>CO</td>
<td>Nil</td>
</tr>
<tr>
<td>N$_2$ + Ar</td>
<td>2 – 3</td>
</tr>
</tbody>
</table>
Coal to ammonia; The overall process

1. **Air** → **ASU**
2. **Coal** → **Gasifier** → **Syngas**
3. **Steam** → **Gasifier**
4. **Steam** → **(Steam)** → **Sour shift**
5. **Syngas** → **Acid gas removal** → **N₂ wash**
6. **H₂S** → **N₂ wash**
7. **CO₂** → **Urea synthesis**
8. **NH₃** → **Urea product**
9. **WSA** → **Sulphuric acid**
10. **NH₃ product**
Relative catalyst volume

<table>
<thead>
<tr>
<th></th>
<th>Inert-free</th>
<th>With inerts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1630 MTPD (1797 STPD) NH₃</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Converter inlet pressure, bar g (psig)</td>
<td>187 (2712)</td>
<td>187 (2712)</td>
</tr>
<tr>
<td>Separator temperature, °C (°F)</td>
<td>0 (32)</td>
<td>0 (32)</td>
</tr>
<tr>
<td>Inert level, inlet converter (%)</td>
<td>2.1</td>
<td>8.0</td>
</tr>
<tr>
<td>NH₃ conc., inlet/outlet converter</td>
<td>2.6/22.3</td>
<td>4.0/22.3</td>
</tr>
</tbody>
</table>
IGCC and TIGAS operational flexibility

- **Power value, c/kWh**
  - **Equal product value**
  - **TIGAS favorable**
  - **Polygeneration favorable**
  - **IGCC favorable**

<table>
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<th>Table: Gasoline and Operational Flexibility</th>
</tr>
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<tbody>
<tr>
<td><strong>Power value</strong></td>
</tr>
<tr>
<td><strong>Fraction of time</strong></td>
</tr>
<tr>
<td><strong>Gasoline value</strong></td>
</tr>
<tr>
<td><strong>Max gasoline</strong></td>
</tr>
<tr>
<td><strong>Operational flex.</strong></td>
</tr>
</tbody>
</table>
Conclusion

- The market for gasification based production of numerous products already exists and the technology is well proven.
- Environmental technologies with high efficiency and features suitable for the gasification concept are ready to tackle the environmental challenge.
- Efficient synthesis technologies for numerous products tackle the energy challenge:
  - For an inert free ammonia synthesis loop, the catalyst volume and converter size can be reduced by 40%.
  - Methanol synthesis.
  - Production of substitute natural gas.
  - New fuels like DME.
  - Polygeneration schemes and multi-product approach are some of the answers.
- In short: Technologies are ready to tackle the production challenge in a sustainable and efficient manner.