Shell Coal Gasification Process for Power and CO\(_2\) capture

Gasification Conference Freiberg, June 2005

Rik van der Ploeg
Rob van den Berg
Ico van den Born

Shell Coal Gasification Process for Power and CO\(_2\) capture

- Introduction, Progress
- Features, Benefits
- European Case Study 400 MW\(_\text{e net}\)
  - German Brown Coal
  - Results With/Without Capture
- Conclusions
Shell Gasification Optional Products

Shell Gasification Projects

New SGP projects:
- Agip Sannazzaro Refinery
- Opti, Canada
- Rafineria Gdanska, Poland
- Fujian, China

New SCGP projects:
- 12 projects in China
- 1 project USA (WMPI)
### Shell Coal Gasification Projects in China

<table>
<thead>
<tr>
<th>Owner</th>
<th>Place</th>
<th>Feed t/d</th>
<th>H₂+CO 10⁶ Nm³/d</th>
<th>Products</th>
<th>Startup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinopec/Shell</td>
<td>Yueyang</td>
<td>2000</td>
<td>3.4</td>
<td>Ammonia</td>
<td>2006</td>
</tr>
<tr>
<td>Shuanghuan</td>
<td>Yingcheng</td>
<td>900</td>
<td>1.4</td>
<td>Ammonia</td>
<td>2005</td>
</tr>
<tr>
<td>Liuzhou</td>
<td>Liuzhou</td>
<td>1200</td>
<td>1.7</td>
<td>Ammonia</td>
<td>2005</td>
</tr>
<tr>
<td>Sinopec</td>
<td>Zhijiang</td>
<td>2000</td>
<td>3.4</td>
<td>Ammonia</td>
<td>2006</td>
</tr>
<tr>
<td>Sinopec</td>
<td>Anqing</td>
<td>2000</td>
<td>3.4</td>
<td>Ammonia</td>
<td>2006</td>
</tr>
<tr>
<td>Yuntianhua</td>
<td>Anning</td>
<td>2700</td>
<td>3.4</td>
<td>Ammonia</td>
<td>2006</td>
</tr>
<tr>
<td>Yuzhanhua</td>
<td>Huashan</td>
<td>2700</td>
<td>3.4</td>
<td>Ammonia</td>
<td>2006</td>
</tr>
<tr>
<td>Dahua</td>
<td>Dalian</td>
<td>1100</td>
<td>1.7</td>
<td>Methanol</td>
<td>2006</td>
</tr>
<tr>
<td>Shenhua</td>
<td>Majiata</td>
<td>2 x 2200</td>
<td>2 x 3.7</td>
<td>H₂</td>
<td>2007</td>
</tr>
<tr>
<td>Yongcheng</td>
<td>Yongcheng</td>
<td>2100</td>
<td>3.2</td>
<td>Methanol</td>
<td>2007</td>
</tr>
<tr>
<td>Zhongyuan</td>
<td>Puyang</td>
<td>2100</td>
<td>3.2</td>
<td>Methanol</td>
<td>2007</td>
</tr>
<tr>
<td>Kaixiang</td>
<td>Yima, Henan</td>
<td>1100</td>
<td>1.7</td>
<td>Methanol</td>
<td>2008</td>
</tr>
</tbody>
</table>

### SCGP Process Flow Diagram

- **Coal/Petcoke** → **Milling/Drying** → **Fly Ash Recirc** → **Coal Feeding**
- **Gasifier** at 1600 °C
- **Dry Solids Removal**
- **Wet Scrubbing**
- **Gas Treatment**
- **Fly Ash to Milling and Drying**
- **Quench Gas**
- **Water Treatment**
- **Sulphur**
- **Clean Syngas**
- **Fresh Steam Condensate**
- **LP Steam**
- **STM Condensate**
- **Or MP Steam only**
**SCGP Reactor & Cooler Assembly**

**Features/Benefits**

- Reactor Membrane wall life-time expected > 25 yrs
- Burner life-times > 20,000 hrs
- Reactor-Syngas Cooler train feasible up to 5000 tpd
- Reactor-Syngas Cooler ~40% cheaper
  - Steam system simplified (MP only, piping, materials)
  - Wider procurement options equipment, standardization
- \( \text{N}_2 \) or \( \text{CO}_2 \) as carrier gas
- Availability 90% (scheduled maintenance project specific)
  - Water-cooled skirt
  - Slag crusher
  - Improved ASU interface (ASU itself separate issue)

---

**Shell Treating in Synthesis Gas Service**

**ADIP/Sulfinol (worldwide > 700 licenses)**

13 Oil gasification  
(2 in combination with SGP)

16 Synthesis gas from steam reforming

2 Coal gasification

SCOT, SulFerox, HCN/COS hydrolysis, Shell-Paques
Gas Treating Building Blocks

Amine + Acid Gas Processing

SulFerox

Shell SulFerox Process

-\( \text{H}_2\text{S} \) removal by liquid redox

\[ \text{H}_2\text{S} + 2 \text{Fe}^{3+} \rightarrow 2 \text{H}^+ + \text{S} + 2 \text{Fe}^{2+} \]

-Applications
  - Low-S AGR (up to 15 t/d S)
  - Absolute selectivity for \( \text{H}_2\text{S} \)
  - Applied in several waste gasification units
SCGP IGCC Brown Coal Study – Main Premises

- Project location Germany (ISO conditions)
- Project life 25 years, 85% full load IGCC
- Project cost basis 2005, US Gulf Coast budget type
- EPC contractor soft costs typical, no Owners Cost’s/Risks
- Single string 400 MW_e net power, V94.3 based
- Low-S, high moisture (>50%) Brown Coal, steam dried
- CO₂ @80 bara dried, 85% capture included (Cases 2,3)
- Electricity price (year 0) 50 $/MWh (higher than now)
- Fuel price (year 0) 1 $/GJ (assumed)
SCGP IGCC Brown Coal Case Study – Cases 2, 3

Brown Coal IGCC with CO₂ Capture

SCGP IGCC Brown Coal Study – Econ Results (1)

Relative investment increase 24-31% due to capture

Capex [$/kWₑ]

0 200 400 600 800 1000 1200 1400 1600 1800 2000

Ref - SGC130 Case 1 CO₂ - SGC130 Case 2 CO₂ - SGC50 Case 3

CC Power Plant Gasification ASU AGR-SRU-Shift-CO₂ IGCC general
Conclusions SCGP based IGCC for Carbon Capture

**Non-Captured IGCC400 Reference (HP steam system SCGP)**
- LHV efficiency 44-45% including steam drying
- IGCC costs can be as low 1350 $/kW_e

**Captured IGCC400 Plants Options (HP and/or MP steam system)**
- LHV efficiency 35.7-37.7% including steam drying
- IGCC costs can be as low as 1680-1760 $/kW_e
- Relative investment increase 24-31%
- Relative Cost Of Electricity increase ~20% (excluding pipe, wells)

And more improvements / synergy options in the pipeline…