SHELL COAL GASIFICATION

Delivering performance in Chinese operations today, Developing technology and deployment solutions for tomorrow

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TOPICS

- Performance in Operations
- Technical Solutions
- Enhancing Technology
1.0 PERFORMANCE IN OPERATIONS
INCREASING CAPACITIES

- Shell started its oil gasification technology in 1956
- 106 oil/gas gasification units in operation
- Shell Coal Gasification Process started in 1976

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>Pilot Unit, Amsterdam, The Netherlands</td>
<td>6 t/d</td>
</tr>
<tr>
<td>1978</td>
<td>Demo Unit, Harburg, Germany</td>
<td>150 t/d</td>
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<tr>
<td>1987</td>
<td>SCGP-1, Houston</td>
<td>250 t/d</td>
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<tr>
<td>1993</td>
<td>NUON IGCC 250MW, Buggenum, The Netherlands</td>
<td>2000 t/d</td>
</tr>
</tbody>
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- Australia project (4000 ton/day)
- YTH, Datang (2700 ton/day)
- Yueyang JV (2000 ton/day)
- Hubei Shuanghau (900 ton/day)

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SUCCESSFUL PERFORMANCE TEST RUNS IN CHINA

- 3 performance test runs successfully completed
- 4 sites accepted the plant performance without formal test run (either test done for similar design or plant operation satisfied owner)
- 1 underway, 3 in preparation
NEW AUTHORIZED VENDORS IN CHINA

- 3 for **gasifier and SGC** (Dongfang Boiler (Group) Co. Ltd., Suzhou Hailu Heavy Industry Co., Ltd, Wuxi Huaguang Boiler Co., Ltd)
- 2 for **aeration device** (Xi’an Baode and Beijing A&M)
- 1 for **coal flow diverter valve** (Hefei General), ongoing work to authorize a second
- 1 for **local coal burner repair** (YueyangFCC)
- 1 for **coal burner manufacturing** (Shanghai 711)
- 3 for **sluicing valves** (SHK, Hongsheng and Antiware)

Apart from two critical equipment items (velocity and density meter), all other SCGP critical equipment can now be sourced in China.
RELIABILITY IN CHINA: OVERVIEW SECOND WAVE

Reliability trend second-wave Chinese clients for past twelve months

Average availability for the month [%]

Month
2.0 PROVIDING TECHNICAL SOLUTIONS
Filter candles that had been in operation until 2008.

Life time of HPHT filters > 30 months
Steam make control can lower the gasification temperature fluctuation significantly, smoothing operation conditions.

Operating on O2/C control mode at 100% oxygen load:
- Compared to Gasifier steam make control, amplitude of fluctuations in gasification temperature is more than factor 2.

Operating on Gasifier steam make control mode at 100% oxygen load:
- Mean amplitude of fluctuations around average value of gasification temperature is ± 25 °C.
Frequent coal switches and changes in quality can be handled.

Coal and ash analysis are key to determine and manage the operating window.

Stable operating window.

Difficult to operate.
3.0
ENHANCING TECHNOLOGY
**COMPARISON: SYNGAS COOLER LINE UP**

- **Filter cake recycle**
- **Dry solids removal (U-1500)**
- **Coal milling & drying (U-1100)**
- **Wet scrubbing (U-1600)**
- **Coal Pressurisation & feeding (U-1200)**
- **Dry solids removal (U-1500)**
- **Flare gas (*)**
- **Gasification Battery Limit**
- **Film cake**
- **Stack gas**
- **Vent gas (CO2/N2)**
- **Flux**
- **Moderator steam (**)**
- **Air**
- **Coal**
- **Flux**
- **Oxygen**
- **Fuelgas**
- **LP N2**
- **Utilities (U-3100 – U-3600)**
- **Co2/N2 system (U-3000)**
- **N2/CO2 system (U-3000)**
- **Slag removal (U-1400)**
- **Dry solids removal (U-1500)**
- **Wet scrubbing (U-1600)**
- **Primary water treatment (U-1700)**
- **Slag**
- **BFW**
- **Fly ash**
- **Effluent water**
- **Blowdown(***) condensate**
- **Process water (*)**
- **Stripper off-gas**
- **Acid (*)**
- **Flare gas (*)**
- **VHP N2**
- **LP N2**
- **LP steam (**)**
- **HP/VHP N2/CO2**
- **VHP N2**

**Note:** (*) stream entering/leaving via utilities  (**) internal stream, interfacing with utilities
COMPARISON: (TOP) WATER QUENCH

Filter cake recycle
Coal milling & drying (U-1100)
Wet scrubbing (U-1600)
Coal
Slag
Oxygen
Raw Syngas
Gasification
Vent gas (N2/CO2)
Slagfines recycle
Coal milling & drying (U-1200)
Pressurisation & feeding
Slag removal (U-1400)
Primary water treatment (U-1700)
Wet scrubbing (U-1600)
N2/CO2 system (U-3000)
Utilities (U-3100 – U-3600)
Stack gas
Moderator steam (**)
Oxygen
Air
Coal
Flux
LP N2
Utilities
MP Saturated Steam
Process water (*)
Caustic (*)
Acid (*)
Stripper off-gas
LP steam (**)
LP N2/CO2 system
(N2/CO2)
Water quench
Gasification
Blowdown (**)
BFW
Effluent water
Flyash cake
Note: (*) stream entering/leaving via utilities  (**) internal stream, interfacing with utilities
IGCC + 90% CCS – USING TODAY’S TECHNOLOGY

LHV Efficiency Drop < 7 % points; 40% barrier can be broken!
OPERATING MODE OF THE LIANXIN LOW-STEAM SHIFT CATALYST

- Technology proven in operation in China in syngas application for 3 years+ (still on first catalyst fill), over 20 plants in operation in total
- The shift reaction is slightly exothermic. In standard sour shift catalysts, the heat generated is cooled away by excess steam.
- The Lianxin QDB-04 catalyst is operated under low-steam conditions, thus limiting the exotherm generated. The catalysts has special promoters which suppress coking.
- The highly exothermic methanation reaction is suppressed by applying a high space velocity
DIRECT THIOPAQ™ COMPARED TO INDIRECT THIOPAQ™

Today’s technology: Indirect THIOPAQ™ syngas treating

- Raw Syngas → SOUR SHIFT → H₂S removal → CO₂ removal → H₂ → GT → Power
- Sour Water → Acid Gas
- Sulphur

Today’s +1 technology: Direct THIOPAQ™ syngas treating

- Raw Syngas → SOUR SHIFT → THIOPAQ™ → CO₂ removal → CO₂ → H₂ → GT → Power
- Sour Water → Sulphur
Cost reductions potential:
- 5-6 % on total capex
- 25-30 % on treating line up capex
- Significant opex savings – case dependent
- Increase in IGCC plant efficiency of 0.5 – 1.5%
- The optimal application for THIOPAQ™:
  Sulphur capacity range of 0 – 50 t/sd, to be extended to 150 t/sd in the future

Demonstration in syngas line up planned for 2011, prior to final market roll-out.