CHOREN
entrained flow gasification
– update of technology and projects

9th International Freiberg Conference
June 2018 · Berlin
Content

- CHOREN History
- CCG® Technology
- Reference Plants & Current Projects
- Key Development Activities
1970 → 1979: DBI / GSP
Gasification lab research started, pilot plant 3 MW_{th}

1984 → 1990s: Industrial plant 200 MW (720 TPD),
CHOREN (as UET) founded by former staff of DBI

2007: Kaiyang Project = First CCG® in China
500 kTPA NH₃, 2x 1500 TPD gasifiers
2013: Start of commercial operation

2012: CHOREN reorganization (Dresden/Beijing)

2016: HBHY Project
350 kTPA NH₃, 1x 1500 TPD gasifier
2017/18: Eq. manufacturing

1990s → 2000s
Carbo-V dev. & demonstration
R&D on coal gasification CCG®

2013: Connell Project
300 kTPA EG, 2x 1200 TPD gasifiers
2015: CCG® Gasifiers delivered

2014: QHMC Project
600 kTPA Olefins, 6x 2000 TPD gasifiers
2015-17: BDEP finished / DE Phase,
Environmental Assessment passed
CCG® Process Flow

CCG®:
CHOREN
Coal
Gasification

Coal

Crusher

Pulverized Coal Bin

Coal Lock Hopper

Coal Lock Hopper

Pulverized Coal Dosing Vessel

CCG® Gasifier

Process Steam

Oxygen

Venturi Scrubber

Syngas

Process Condensate

Grey Water Recycle

Syngas Scrubber

Black Water Treatment

Waste Water

Filter Cake

Vent Gas to Claus Plant

Purification & Water Treatment

Coal Feeding

CMD

Coal Feeding

Gasification

Drag Conveyor

Slag Lock

Slag

CCG®: CHOREN Coal Gasification
Fuel flexibility
- lignite, bituminous- and sub-bituminous coals, hard coal, anthracite, pet coke, …
- FT: ≤1500°C or >1500°C+flux
- slagging operation: 7%≤ ash% ≤35%

Dry feeding
- high cold gas efficiency (> 80%)
- carbon conversion rate up to > 99%

Multi-burner concept
- optimized reactor size for high C-conversion, good mixing
- high lifetime of burner tip (up to 2 years, 1 inspection/y)

Cooling screen
- start-up/shut-down time < 2h
- high availability (lifetime min. 20 y)

Full water quench with dip-/draft-tube
- robust, simple and reliable
- raw gas saturation with steam for CO-shift

Typical syngas composition for Lignite
- CO - 59 Vol. %
- H₂ - 34 Vol. %
- CH₄ - < 0.1 Vol. %
- CO₂ - < 7 Vol. % 

* incl. N₂, NH₄, COS, H₂S, other impurities
### Kaiyang 500 kTPA Ammonia Plant

#### Table: Key Performance Indicators

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design capacity</strong></td>
<td>Nm³/h</td>
<td>140,000</td>
</tr>
<tr>
<td><strong>Max. load</strong></td>
<td>Nm³/h</td>
<td>165,000</td>
</tr>
<tr>
<td><strong>Specific coal consumption</strong></td>
<td>kg/kNm³</td>
<td>600 - 635</td>
</tr>
<tr>
<td><strong>Specific oxygen consumption</strong></td>
<td>Nm³/kNm³</td>
<td>320 - 350</td>
</tr>
<tr>
<td><strong>Syngas pressure</strong></td>
<td>MPa</td>
<td>3.65 - 3.75</td>
</tr>
<tr>
<td><strong>Syngas temperature</strong></td>
<td>°C</td>
<td>205 - 210</td>
</tr>
<tr>
<td><strong>Effective gas (CO+H2)</strong></td>
<td>%</td>
<td>86 - 91</td>
</tr>
<tr>
<td><strong>Dust content</strong></td>
<td>mg/Nm³</td>
<td>&lt; 1</td>
</tr>
<tr>
<td><strong>Cold gas eff.</strong></td>
<td>%</td>
<td>78 - 80</td>
</tr>
<tr>
<td><strong>Slag/ash ratio</strong></td>
<td></td>
<td>6:4 - 7:3</td>
</tr>
<tr>
<td><strong>Carbon conversion</strong></td>
<td>%</td>
<td>96-98</td>
</tr>
</tbody>
</table>

#### Graph: Gasification Reliability
- Gasification Reliability:
- Avrg. Single Gasifier Reliability

- **2013:** Start of commercial operation
- **2016:** Plant operation availability raised to 92%
- **2018:** Currently both gasifiers cont. on line for ~4 months

**Steady improvement**

**Gasifier:** 2 x 400 MW<sub>th</sub> (1500 TPD)

**Coal:** 100% Anthracite, >20% ash / FT ≤1450°C
### Connell 300 kTPA Ethylene Glycol Plant

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design capacity</td>
<td>Nm³/h CO+H₂</td>
<td>110,000</td>
</tr>
<tr>
<td>Max. load</td>
<td>Nm³/h CO+H₂</td>
<td>121,000</td>
</tr>
<tr>
<td>Specific coal consumption</td>
<td>kg/kNm³</td>
<td>~ 770</td>
</tr>
<tr>
<td>Specific oxygen consumption</td>
<td>Nm³/kNm³</td>
<td>~ 335</td>
</tr>
<tr>
<td>Syngas pressure</td>
<td>MPa</td>
<td>3.9</td>
</tr>
<tr>
<td>Syngas temperature</td>
<td>℃</td>
<td>~ 215</td>
</tr>
<tr>
<td>Effective gas (CO+H₂)</td>
<td>%</td>
<td>~ 87</td>
</tr>
<tr>
<td>Dust content</td>
<td>mg/Nm³</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Cold gas eff.</td>
<td>%</td>
<td>~ 77</td>
</tr>
<tr>
<td>Slag/ash ratio</td>
<td></td>
<td>~ 7:3</td>
</tr>
<tr>
<td>Carbon conversion</td>
<td>%</td>
<td>&gt;99</td>
</tr>
</tbody>
</table>

- **Gasifier:** 2 x 300 MW<sub>th</sub> (1200 TPD)
- **Coal:** Lignite

- 2013/14: PDP and Key Equipment Contracts
- 2015: plant under construction, 2x 300 MW CCG® Gasifiers and further Key Equipment delivered to site at Tongliao City / Inner Mongolia
- In 2016/17, commissioning had been scheduled; local lignite as feedstock for commercial ethylene glycol production
- Re-start of activities in 2018
### QHMC 600 kTPA Olefins Project

- **Design capacity**: 527,600 Nm³/h \(\text{CO}+\text{H}_2\)
- **Max. load**: 120% Single gasifier
- **Specific coal consumption**: ~ 650 kg/kNm³ \(\text{CO}+\text{H}_2\)
- **Specific oxygen consumption**: ~ 340 Nm³/kNm³
- **Syngas pressure**: 3.9 MPa
- **Syngas temperature**: ~ 210 °C
- **Effective gas (CO+H2)**: ~ 90%
- **Dust content**: < 1 mg/Nm³
- **Cold gas eff.**: ~ 80%
- **Slag/ash ratio**: ~ 6:4
- **Carbon conversion**: ~ 99%

- **2014/15**: PDP and BDEP completed
- **Site location**: Haixi City / Qinghai, local volatile coal as feedstock for commercial olefin production
- **In 2016/17**: PR China’s Environmental Assessment has been passed successfully
- **Re-start of project activities in 2018 → Manufacturing**

### Gasifier
- **6 x 600 MW\textsubscript{th} (2000 TPD)**

### Coal
- **Volatile hard coal**
### Hubei Yihua Renovation Projects

- **2016/17**: PDP Contracts about two renovation projects for the application of the entrained flow CCG® process:
  - **HBHY**: 350 kTPA Ammonia Project (1x 400 MW)
  - **2017/18**: manufacturing of the 400 MW CCG® Gasifier for site at Yingcheng City / Hubei
  - LuAn coal from Shanxi as feedstock for commercial ammonia production
- **Follow-up**: Guizhou Yihua Anthracite 2x 400 MW

### Performance Data

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design capacity</td>
<td>Nm³/h CO+H₂</td>
<td>86,000</td>
</tr>
<tr>
<td>Max. load</td>
<td>Nm³/h CO+H₂</td>
<td>94,600</td>
</tr>
<tr>
<td>Specific coal consumption</td>
<td>kg/kNm³</td>
<td>~ 540</td>
</tr>
<tr>
<td>Specific oxygen consumption</td>
<td>Nm³/kNm³</td>
<td>~ 310</td>
</tr>
<tr>
<td>Syngas pressure</td>
<td>MPa</td>
<td>3.6</td>
</tr>
<tr>
<td>Syngas temperature</td>
<td>°C</td>
<td>~ 205</td>
</tr>
<tr>
<td>Effective gas (CO+H₂)</td>
<td>%</td>
<td>~ 89</td>
</tr>
<tr>
<td>Dust content</td>
<td>mg/Nm³</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Cold gas eff.</td>
<td>%</td>
<td>~ 80-82</td>
</tr>
<tr>
<td>Slag/ash ratio</td>
<td></td>
<td>~ 4:6</td>
</tr>
<tr>
<td>Carbon conversion</td>
<td>%</td>
<td>~ 99</td>
</tr>
</tbody>
</table>

- **Gasifier**: 1 x 400 MW<sub>th</sub> (1500 TPD)
- **Coal**: HBHY → Bituminous & sub-bituminous coal
CCG Projects Overview

**CCG® plants**

- **Connell**
  - 2x 1200 TPD
  - 300 kTPA Ethylene Glycol

- **QHMC**
  - 6x 2000 TPD
  - 600 kTPA Olefins

- **HBHY**
  - 1x 1500 TPD
  - 350 kTPA Ammonia

- **Kaiyang**
  - 2x 1500 TPD
  - 500 kTPA Ammonia

**Further activities outside of China, e.g.**

- Australia
- Malaysia
- Cambodia
- South Korea
- India
- Turkey
- Indonesia
- Vietnam
Key Development Activities

- Large capacity gasifier with **3000 TPD** coal input
  
  Multi-burner concept with central combined burner

- Partial **heat recovery from syngas** for additional HP steam production
  
  Radiant cooler, optimization for target S/G ratio at B.L. (for CO Shift)

- Utilization of alternative feedstocks like char and **petcoke**
  
  Consideration of relevant properties like PSD, reactivity, ash content

- Utilization of alternative process elements, e.g. **slurry feed**
  
  Keeping multi-burner & membrane wall design, pressure ~65 bar

- **DWT process** for low rank coal drying
  
  Based on former GDR process (e.g. Borna (Germany), Loy Yang (Australia)), process development for fine grain to eliminate additional CMD unit
3000 TPD Gasifier Dimensions

600 MW ≈ 2000 TPD

900 MW ≈ 3000 TPD

Suitable for transport from manufacturer’s workshop to the plant
CCG Gasifier Typical Energy Flow

- **Coal**: 100%

- **LHV syngas**: 80%
- **Partial heat recovery**: 3%
- **Sensible heat**: 12%
- **Loss**: 5%

**Sensible heat utilization alternatives:**

- **Water quench**: Steam saturation of syngas
  - Required for shift reaction

- **Syngas cooler**: HP steam production
  - External utilization, e.g. IGCC

**Possible change by low steam CO-Shift:**

**Partial** syngas cooler (only moderate invest) + water quench to maximize benefits
### Integration of Syngas Cooler

#### Graph
- **Gasifier Outlet**
- **Steam Demand of Shift Unit**
- **Quench Inlet Temperature °C**

<table>
<thead>
<tr>
<th>topic</th>
<th>challenge</th>
<th>measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>heat transfer</td>
<td>peak heat flux (&quot;clean&quot; surfaces, inlet)</td>
<td>design (flow pattern), material selection</td>
</tr>
<tr>
<td>heat transfer</td>
<td>fouling (liquid or pasty ash at high T)</td>
<td>excess surface, cleaning precautions</td>
</tr>
<tr>
<td>lifetime</td>
<td>H₂S corrosion</td>
<td>material selection</td>
</tr>
<tr>
<td>safety</td>
<td>MAWP_{H₂O} &gt;&gt; MAWP_{gas}</td>
<td>avoid headers, consider pipe rupture</td>
</tr>
</tbody>
</table>
DWT - Low Rank Coal Drying

- Reducing water content from 30-60% down to 5-15%
- Safe process conditions at slight overpressure in inert steam atmosphere (no O₂)
- Large unit capacity well suited for power / gasification plants
- Exergetic advantage: LP steam instead of hot flue gas
Thank you for your attention!

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