Lurgi´s FBDB Gasification – recent developments and project up-dates

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Agenda

- Lurgi in the Air Liquide Group
- FBDB gasification technology
- References
- Ongoing projects
- Summary
Lurgi – member of the Air Liquide Group

**AL** founded in 1902, (Lurgi 1897)

Present in 75 countries,

More than 43,000 employees,

8 R&D centers:
Each year 200 new patents registered,

1 million customers across various industries and healthcare activities

€13,100 million in sales (2008)

**Lurgi** joined the group in 2007
Lurgi is a **leading technology company** operating worldwide in the fields of process engineering and plant contracting.

The strength of Lurgi lies in **innovative technologies of the future** focussing on customized solutions for growth markets.

The **technological leadership** is based on proprietary technologies and exclusively licensed technologies in the areas

- gas-to-petrochemical products and synthetic fuels,
- gas generation and treatment,
- refining,
- petrochemical intermediates and end products,
- polymers,
- biofuels,
- food and oleochemicals.

From **project development** to the **turn-key construction** of plants through to full plant operation Lurgi globally engineers, builds and commissions plant complexes **from a single source** and under **its overall responsibility**.
Lurgi Product Portfolio

Traditional
(from crude oil)

Alternative
(from gas & coal)

Renewable
(from biomass)

Chemicals, Fuels & Energy

- Sel. Refinery Technologies
- Hydrocracker
- FCC
- HDS
- Petchems
- Aromatics
- Polymers
- Syngas
- Hydrogen
- Methanol
- MTP
- DME
- FT
- MPG
- Coal Gasification
- Biodiesel
- Ethylester
- Fatty Acid
- Fatty Alcohol
- Bioethanol
- BioCrude
70 years ago: Saxony gave birth to Lurgi’s Continuous Pressure Gasification

Hirschfelde, Saxony

Böhlen, Saxony
Lurgi Fixed Bed Dry Bottom Gasification Process

Drying
Devolatilisation
Gasification
Combustion
The Lurgi FBDB Gasifier
(FBDB = Fixed Bed Dry Bottom = dry ashing)

Typical FBDB Gas Composition

<table>
<thead>
<tr>
<th>Gas</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂</td>
<td>38%</td>
</tr>
<tr>
<td>CO</td>
<td>22%</td>
</tr>
<tr>
<td>CO₂</td>
<td>28%</td>
</tr>
<tr>
<td>CH₄</td>
<td>12%</td>
</tr>
</tbody>
</table>
Characteristics of Lurgi FBDB Gasification Technology

- Developed by Lurgi in the 1930’s
- High cold gas efficiency due to low gas off take- and ash temperatures
- Low specific oxygen consumption due to counter current gasification and dry ash removal
- Optimum operation for lignite and reactive fuels / coals, high thermal efficiency
- Unique for low rank coals with high ash & moisture
- Gasifiers built for 20 to 100 bar gasification pressure
- Typical crude gas production proven at 30 bar: up to 65,000 Nm³/h Mk IV, 100,000 Nm³/h Mk V (based on known coal)
- The majority of all worldwide gasified coal is still converted to gas by the Lurgi process principle
- Unmatched plant availability & mechanical reliability
- Stable Gasifier performance & robust operation by using simple control systems
Characteristics of Lurgi FBDB Gasification Technology (2)

- **Direct use of coarse coal by screening & crushing or washing, no drying & milling required**
- **Fine coal used for steam raising**
- **Surplus of fine coal can be agglomerated and fed to the FBDB gasifiers**
- **Co-products add considerable value to the plant economics**
- **E.g. the Sasol CtL plant improves its profit by selling gasification co-products like NH_3, phenols, char for electrodes, higher hydrocarbons, etc.**
- **The H_2:CO ratio 1.7 – 2.0 of the FBDB derived gas is a very good match for the Fischer-Tropsch Synthesis, no CO-Shift required**
- **Fuel additives being produced from tar and oil fractions**
- **High methane yield, which is an advantage for SNG production**
- **Methane in the gas requires reforming to CO and H_2 for Methanol- & Ammonia synthesis**
Lurgi FBDB Gasification Worldwide Deployments – Current Update

Current worldwide operation of 101 Sasol-Lurgi FBDB Gasifiers

- South Africa 80
- USA 14
- China 7

Successful Deployment and Operation of well over 101 Lurgi FBDB Gasifiers in the last 50 years, >20 million gasifier operating hours and well over 1 billion tonnes coal consumption at Sasol alone

41% of Total Global Gasification Capacity
75% of Global Coal Gasification Capacity
Source: GTC 2005
Sasol Coal to Synfuels Plant

80 x Mk IV Units, 30 years in Operation: 1979 – 2009
Coal: Low Rank, Sub-Bituminous
Products: Syngas to Fischer Tropsch Fuels, Ammonia, Phenols, Anode Coke, Sulphur

Sasol Synfuels, Secunda, South Africa
14 x Mk IV Units, 24 years in Operation: 1985 – 2009
Coal: Low Rank, Lignite
Products: Substitute Natural Gas (SNG), Ammonium Sulphate, Phenols, CO₂ for EOR
First commercial coal-based CCS plant

Dakota Gasification Company – Beulah, North Dakota USA
Shanxi Coal to Ammonia Plant

5 x Mk IV Units, 22 years in Operation: 1987 – 2009
Coal: Semi-Anthracite
Products: Ammonia

Shanxi – Tianji Coal Chemical Company, Shanxi Province, PRC
Yima Coal to Methanol Plant

2 x Mk IV Units, 9 years in Operation: 2000 – 2009
Coal: Low Rank, Sub-Bituminous
Products: Methanol

Yima Coal Gasification, Henan Province, PRC
<table>
<thead>
<tr>
<th>Units</th>
<th>Plant</th>
<th>Location</th>
<th>Start Up</th>
<th>Plant Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Sasol Chemical Industries <em>(decommissioned now)</em></td>
<td>Sasolburg, South-Africa</td>
<td>1955</td>
<td>13 MK III FBDB Gasifiers 3 MK IV FBDB Gasifiers 1 MK V FBDB Gasifiers 11 x 10^6 nm^3/day syngas for liquid fuels and chemicals <em>(today operated on natural gas, as all coal fields are depleted)</em></td>
</tr>
<tr>
<td>80</td>
<td>Sasol Synfuels</td>
<td>Secunda, South Africa</td>
<td>1979</td>
<td>80 MK IV FBDB Gasifiers 80 x 10^6 nm^3/day syngas for liquid fuels and chemicals</td>
</tr>
<tr>
<td>14</td>
<td>Dakota Gasification Company</td>
<td>North Dakota, USA</td>
<td>1985</td>
<td>14 MK IV FBDB Gasifiers 1.45 x 10^6 nm^3/day SNG (Substitute Natural Gas)</td>
</tr>
<tr>
<td>5</td>
<td>Shanxi-Tianji Coal Chemical Company</td>
<td>People’s Republic of China Lucheng – Shanxi Province</td>
<td>1987</td>
<td>5 MK IV FBDB Gasifiers Ammonia: 300 ktpa (kilo tons per annum) (\text{HNO}_3): 540 ktpa Nitro Phosphate: 900 ktpa Ammonium Nitrate (explosive grade): 200 ktpa</td>
</tr>
<tr>
<td>2</td>
<td>Yima</td>
<td>People’s Republic of China Yima City – Henan Province</td>
<td>2000</td>
<td>2 MK IV FBDB Gasifiers 80,000 ton per annum methanol</td>
</tr>
</tbody>
</table>
Multi-train Operation e.g. applied at Sasol Synfuels, Secunda, South Africa

- 80 Mk IV gasifiers in operation - 4 sections each 20 units
- Gasifier availability ~ 93% yearly average, single Gasifier > 91%
  - No spare units
  - 24 hour operation – 330 days per year
  - Cumulative time of operation well over 20 Million hours gasifying sub-bituminous coals with high ash
  - Turn down ratio 2.7
- Continuous Feeding of Coal
- Continuous ash removal & increase of ash handling capacity
- Ongoing development of process control & algorithms
- Enhancement of Feed Stock Flexibility
- Redeployment of an advanced coal distributor-stirrer design for caking coals
- Fines Agglomeration
- Reduction of steam consumption by manipulating ash fusion properties
- Biomass co-gasification, increase of biomass proportion
- Complementary gasification of co-products in an MPG for SynGas production
- Improvement on environmental aspects
- Fundamental research & plant orientated development

Gasifier Unit Size & Development Topics

<table>
<thead>
<tr>
<th>Mark II &amp; III</th>
<th>Mark IV</th>
<th>Mark V</th>
<th>Mark VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID 2,6m &amp; 3,6m</td>
<td>ID 3,9m</td>
<td>ID 4,7m</td>
<td>Quo Vadis?</td>
</tr>
<tr>
<td>34 000</td>
<td>65 000</td>
<td>100 000</td>
<td></td>
</tr>
</tbody>
</table>

$m^3/h$ per Gasifier

Number of Units built for Sasol

raw coal t/h

dry gas throughput per unit
Lurgi FBDB Gasification
Feedstock Suitability

- Ash fusion temperatures at oxidizing conditions > ~1200°C
- \( \sum \) Total Moisture + Ash ~50 % w
- Minimum Ash Content ~ 4 % w
- Caking behavior of coal
  - Caking propensity will be balanced by blending of coals
  - A coal distributor & stirrer will be used for caking coals
- Thermal fragmentation < ~55% (Proprietary laboratory method)
- Mechanical fragmentation < ~55% (Proprietary laboratory method)
- Biomass: 10% blend of biomass pellets with coal feed successfully demonstrated on commercial scale
Lurgi FBDB Gasification Market & Landscape

Unique FBDB Market Position for High Ash Coals with High Melting Temperatures
Client:  
**Jindal Steel & Power Limited, New Delhi, India**

Location of Facility  
**Angul, Orissa, India**

Application:  
- *Syngas for Direct Reduction of Iron*

Coal Properties:  
- Ash content ~ 37 to 42%

Scope of Supply:  
- Basic & Detail Engineering  
- Proprietary Equipment Supply  
- Process Performance Guarantees  
- Plant Commissioning Assistance  
- Detail Engineering  
- Purchasing assistance

Planned Start-up  
**Q IV 2010**

Features:  
- World first integration of DRI & Coal Gasification  
- Seven (7) MKIV Lurgi Gasifiers  
- Syngas Island to produce pure ammonia, crude phenol and elemental sulphur  
- Ready for CCS (high-pure CO₂)
Typical FBDB Crude Gas Island (JINDAL 1)
New Lurgi FBDB references: Raigarh 1

- **Client:**
  - *Jindal Steel & Power Limited, New Delhi, India*

- **Location of Facility**
  - *Raigarh, Orissa, India*

- **Application:**
  - *Syngas for Direct Reduction of Iron*

- **Coal Properties:**
  - *Ash content ~ 37 to 42%*

- **Scope of Supply:**
  - *Basic & Detail Engineering*
  - *Proprietary Equipment Supply*
  - *Process Performance Guarantees*
  - *Plant Commissioning Assistance*
  - *Detail Engineering*
  - *Purchasing assistance*

- **Status:**
  - *Contract awarded December 2008*

- **Planned Start-up**
  - *2012*

- **Features**
  - *World second integration of DRI & Coal Gasification (Jindal 1 copy)*
  - *Seven (7) MKIV Lurgi Gasifiers*
  - *Syngas Island to produce pure ammonia, crude phenol and elemental sulphur*
  - *Ready for CCS (high-pure CO2)*
New Lurgi FBDB project: Jindal CtL

Client:
- **Jindal Steel & Power Limited**, New Delhi, India

Location of Facility
- **Kishore Nagar, Ramchandi, Orissa, India**

Status:
- Coal field allotted to Jindal: February 2009
- MoU signed between Lurgi and Jindal on project development

Application:
- **CtL 80 000 bbd FT fuels**

Features:
- **Lurgi’s indirect coal liquefaction technology (FBDB & GTL.F1)**
Lurgi’s Gasification offer: Summary

- Ideal for countries with no oil & gas resources but low rank coals
- Securing the future because low rank coal reserves exist in abundance
- Provides a secure energy source utilizing high ash coals at mine mouth
- High melting ash is an advantage to the process
- Flexible in the variety of products
- High availability by multi unit scheme, modular concept
- Robust process and easy to operate
- Advanced proprietary design requiring low grade steel only
- Well proven large scale operation with well over 50 years record
- Many coals tested
- Will also gasify high rank coals at high cold gas efficiency
Thank you for your kind attention!

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Lurgi’s FBDB coal gasification technology

Back-up slides
Commercial Application of Lurgi FBDB Gasification

**Lurgi FBDB Gasification**

- **Electricity Generation**
  - Integrated Gasification Combined Cycle (IGCC)
  - Compete with NGCC, Coal-fired power boilers; Nuclear; Wind; Hydro

- **Chemicals/Fuels Production**
  - Chemical Complex e.g. Ammonia; methanol; liquid fuels, waxes etc.
  - Political Incentive Strategic drive

- **Steel Industry**
  - Coal Based Syngas to DRI Modules
  - Competes with reformed Natural Gas

- **Substitute Natural Gas**
  - Low availability of Natural gas / oil
  - Competes with imported LNG or Pipeline gas

*Gasification is unique – “...creates a primary energy carrier...”*
Process routes from Gasification

- Fischer Tropsch Synthesis
- Megammonia®
- Megamethanol®
- Lurgi proprietary process

Upgrading
- Fuel Gas
- LPG
- Naphtha
- Diesel
- Waxes
- Ammonia
- Fuel Cells
- Chemicals (MTBE, Acetic Acid, Formaldehyde, ...)
- Diesel, transport. fuels
- Propylene/Polypropylene
- Acrylic Acid/Acrylates
- Ethylene/Propylene
- Power/Fuel/DME(Diesel)
- Hydrogen