Commercially proven Prenflo and High Temperature Winkler Gasification
By Bruce Bassett
Johannesburg, 6th November 2012
Presentation Outline

- ThyssenKrupp and Uhde
- Uhde’s experience and expertise in gasification
- PRENFLO (PSG / PDQ)
- High Temperature Winkler (HTW)
- Updates on Projects and Alliances
Fiscal Year 2010/2011: Sales € 49.1 billion  Employees 180,000

Materials

Steel Europe  Steel Americas  Stainless Global  Materials Services

Technologies

Elevator Technology  Plant Technology  Components Technology  Marine Systems

ThyssenKrupp Uhde
**BA PT builds plants – focus on markets - Fiscal Year 2010/2011**

A strong segment with 13,500 employees and an annual sales of 4.6 bn €

**Business Area Plant Technology**

Order intake: 4.6 bn EUR

Employees: ~13.500

Companies within the Business Area Plant Technology

- Engineer and build small to large-scale plants
- Use in-house or third-party technology
- Provide single work packages as well as turnkey (EPC) plants
- Deliver worldwide

A homogeneous business model reflected in 8 market segments

- TK Födertechnik
- TK Polysius
- TK Uhde
- TK System Eng.

Markets:
- Mining
- Minerals
- Cement
- Fertilizers
- Base Chemicals
- Polymers
- Contracting Services
- Automotive Plants
ThyssenKrupp Uhde Global Network

The global engineering network combines local knowledge with global expertise and provides 7.2 million engineering hours per year.
Overview of our Product divisions

- Ammonia & Urea
- Hydrogen & Nitrates
- Electrolysis
- Refining Technologies
- Org. Chemicals/Polymers
- Polyester
- Coke Plant Technologies

Gas Technologies
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What is Gasification?

- **Combustion** is full oxidation:
  \[
  2 \text{ (CH}_2\text{) + 3 O}_2 \rightarrow 2 \text{ CO}_2 + 2 \text{ H}_2\text{O}
  \]

- **Gasification** is partial oxidation:
  \[
  2 \text{ (CH}_2\text{) + O}_2 \rightarrow 2 \text{ CO} + 2 \text{ H}_2
  \]
Synthesis Gas as a Central Part of Uhde’s Process Chain
Gasification: Feedstock - Process - Product

Feedstock | Gasification | Syngas | Further processing | Product
--- | --- | --- | --- | ---
Gas, Naphtha | Steam Reformer/ATR | Methanol | MTO | Diesel
Oil/Residues | Oil Gasification | Ammonia | MTG | Petrol + LPG
Petroleum Coke | PRENFLO Gasification | Fischer Tropsch Synthesis | Urea | Fertilizer
Hard Coal | HTW Gasification | CO-Conversion | Diesel, Naphtha | Lubricants
Biomass | Biomass | Methanation | Hydrogen | Synthetic Natural Gas
Biomass | Brown Coal | Power Plant (IGCC) | Synthetic Natural Gas | Electricity
Waste | Waste |
Various Materials require various Gasification Technologies

Uhde's Gasification Portfolio

PRENFLO
PSG, PDQ
entained-flow gasification

HTW (High Temperature Winkler)
fluidized-bed gasification
Gasification Technologies

Fixed Bed
550 °C

Fluidised Bed
800 – 1100 °C

Entrained Flow
1350 – 1600 °C

Feedstock: 3 - 30 mm

Syngas

Feedstock: 1-5 mm

Syngas

Feedstock: 0.1 mm

Syngas

Oxidising Agents

Ash / Slag

Oxidising Agents

Ash

Oxidising Agents

Slag
Uhde’s Gasifiers

<table>
<thead>
<tr>
<th>PSG</th>
<th>PDQ</th>
<th>HTW</th>
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<tbody>
<tr>
<td>Entrained-flow gasification</td>
<td>Fluidized bed gasification</td>
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</tbody>
</table>
Classification of Feedstock

PRENFO

- Anthrazite
- Semi Anthrazite
- Low Volatile Bituminous Coal
- Medium Volatile Bituminous Coal
- High Volatile Bituminous Coal
- Subbituminous Coal
- Lignite
- Brown Coal
- Peat
- Wood, Biomasses

Fuels Processed in Prentfo Gasification Unit

Remark: Additional Co-Feeding of Biomasses (30%) is tested.

HTW

- Anthrazite
- Semi Anthrazite
- Low Volatile Bituminous Coal
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Fuels Processed in HTW Gasification Units
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- Summary
Developments
From Koppers-Totzek to PRENFLO

- **PRENFLO burner test rig**
  - Start Up: 1978
  - 6 t/d (450 m³n/h syngas)

- **PRENFLO Fürstenhausen**
  - Start Up: 1984
  - 48 t/d (3,500 m³n/h syngas)
  - Scale Up Factor: 8

- **PRENFLO Puertollano**
  - Start Up: 1998
  - 2,400 t/d (180,000 m³n/h syngas)
  - Scale Up Factor: 50

- **Shell-Koppers pilot plant Hamburg**
  - Start Up: 1978
  - 150 t/d coal

- **Koppers-Totzek**
  - Start of development 1941

57 years
Features

• dry coal/petcoke powder feed
• 4 horizontal co-annular burners
• membrane wall
• waste heat boiler (PSG)

PRENFLO with Steam Generation (PSG)
1000 MWth, 40 bar
PRENFLO Membrane Wall protected by the slag layer

- Molten slag
- Solidified slag
- > 1500 °C
- Gasification Reactor
- Molten slag flows downwards
- Water Tube (membrane wall)
- BFW, 40-70 bar
ELCOGAS IGCC plant: Gasification Island, Spain
Dry-fed, single train IGCC with CCS Pilot Plant at Elcogas, Spain
300 MW net based on pet coke / coal feedstock
PRENFLO Layout Comparison
PSG vs. PDQ

PRENFLO (PSG)
(Waste Heat Boiler)

PRENFLO (PDQ)
(Direct Quench)
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The HTW Process

HTW Laboratory Plant
RWTH-Aachen
12 t/d Coal, Atm.

Atmospheric Winkler generators
1956 – 1964  260 t/d Lignite

HTW- Pilot Plant
Rheinbraun Wachtberg
40 t/d Lignite, 10 bar
Start Up: 1978

HTW-Pilot Plant (WVW)
Rheinbraun Wesseling
185 t/d Lignite, 25 bar
Start Up: 1986

HTW-Pilot Plant (WVW)
Rheinbraun Berrenrath
720 t/d Lignite, 10 bar
Start Up: 1989

HTW- Demonstration Plant
Rheinbraun Berrenrath
720 t/d Lignite, 10 bar
Start Up: 1988

HTW-Peat Gasification, Kemira
Start Up: 1988

KoBra IGCC
RWE, Hürth
3700 t/d Lignite 27 bar
Engineering: 1994

Start Up Factor: 5

Scale Up Factor: 18

>20 Years

6 th November 2012 – Johannesburg – Page 24 Copyright TK Uhde 2012
HTW High Temperature Winkler - Gasifier
HTW Commercial Scale Demo Plant
Berrenrath/Germany

25 t/h dried lignite – 140 MWth
34,000 m³/h of syngas
≈ 300 t/d Methanol
67,000 total operating hours
84 % availability (last 10 years)
1986 - 1997
HTW-Precon-Gasification
Niihama / Japan
48 t/d Municipal Waste
1999 - 2002

Sumitomo Heavy Industries Ltd.
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Uhde/EMRE provide full range service for synfuel projects

- Uhde provides feasibility study for the entire process of clean gasoline production from coal. The study includes coal gasification, gas treatment, methanol synthesis, and MTG.
- Uhde provides licenses of different gasification technologies to meet customer's specific need.
- Uhde provides also methanol synthesis technology.
- Uhde is a full range EPC contractor.

EMRE:
- EMRE provides technology license for Methanol to Gasoline Technology.
- EMRE provides basic engineering design package for licensees to perform detailed engineering design and construction.
- EMRE provides catalysts for the MTG process.
- EMRE provides assistance for start-up and troubleshooting.
ICM’s 18,000 bbl/d CTL Plant in Mongolia
Coal-to-Gasoline (CTG) plant *

Applying
TK Uhde’s PRENFLO Gasification Technology

#1 coal preparation
#2 coal gasification
#3 CO-shift reactor
#4 acid gas removal
#5 methanol synthesis
#6 methanol-to-gasoline
#7 gasoline storage

*) Photo Courtesy TransgasDevelopment
**BioTfueL – integrated process chain**

**PRENFLO with FT based on solid and liquid feedstock**

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Pretreatment</th>
<th>Gasification</th>
<th>Gas Treatment</th>
<th>Synthesis</th>
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<tr>
<td>Wood</td>
<td>Torrefaction</td>
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<tr>
<td>Straw etc.</td>
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<tr>
<td>Coal</td>
<td>Milling</td>
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<td>Petcoke</td>
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<tr>
<td>Liquid Residues</td>
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Life-cycle analysis for optimum equilibrium between technical-economical performance and environmental demands.
SGCE – 9,500 bpd CTL, Mozambique
PRENFLO PDQ for high-ash coal

Applying TK Uhde’s PRENFL0 Gasification Technology
C.GEN – 450 MWe IGCC with CCS, Killingholme, UK
PRENFLO PDQ selected

- Optional hydrogen production
- Carbon capture & storage
- Synergies due to maximum integration into existing industrial network
- High level of standardization – beneficial for future plants
- Feedstock: hard coal, petcoke and biomass

Applying TK Uhde’s PRENFLO Gasification Technology
Gasification Summary

- Gasification is a **proven technology**, a vast number of gasifiers are operating since decades successfully on commercial basis.
- Gasification allows **flexibility** in feedstock and polygeneration of products.
- Gasification is **environmental friendly**.
- Uhde has more than 70 years of experience in gasification based on 8 different gasification technologies.
- ... received more than 100 contract awards for gasifiers.
- ... has proven **single sourcing** capability.
- ... is a process oriented EPC contractor and **not only licensor**.
- ... has built the **world’s largest** solid fuel based, single train IGCC.
- ... has built more than 2,000 plants worldwide.
Thank you for your attention