PRENFLO: PSG and PDQ

Latest Developments based on

10 years Operating Experience at Elcogas IGCC, Puertollano, Spain

Uhde

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Uhde’s Gasification Highlights – SUMMARY:

Invention of Entrained-Flow Gasification:

- **Koppers-Totzek**: dry-fed, membrane wall, multiple burners (1941)

Development, Design and Construction of

- first Koppers-Totzek Coal Gasification Plant
- first Texaco Coal Gasification Plant
- first HTW Coal Gasification Plant
- first Shell-Koppers Coal Gasification Plant
- first PRENFLO Coal Gasification Plant

Over 100 Gasifiers designed, built and put into successful operation by Uhde
Uhde’s proprietary Koppers-Totzek Gasification Process
First Entrained-Flow Gasification Technology

Koppers-Totzek gasification plant
Ramagundam, India
900 t/d of ammonia

Koppers-Totzek gasification plant
Modderfontein, South Africa
1,000 t/d of ammonia
PRENFL O
with Steam Generation

PSG
Pressurised Entrained Flow Demonstration plants

Shell-Koppers plant in Hamburg / Germany

PRENFLO plant in Fürstenhausen / Germany
World's largest IGCC: Elcogas, Puertollano, Spain (300 MWe)
based on petcoke / coal feedstock

- PRENFLO Gasifier
- Coal Preparation
- ASU
- Gas Treatment
- Combined Cycle
- New CO₂ capture Pilot Plant under implementation
PRENFLO gasifier and waste heat boiler (PSG)

- dry coal/petcoke powder feed
- 4 horizontal co-annular burners
- membrane wall
- waste heat boiler (PSG)
PREFLO Membrane Wall protected by the slag layer

- Gasification Reactor
  - molten slag flows downwards
  - Water Tube (membrane wall)
- BFW, 40-70 bar
- molten slag
- solidified slag

> 1500 °C
PRENFLO Gasifier Membrane Wall

View of gasifier membrane wall before 1st operation (PRENFLO burner)

View of gasifier membrane wall after operation (PRENFLO burner)

Perfect slag layer protecting membrane wall
PRENFLO Gasifier - erection of internals (Puertollano)
Lifting of PRENFLO Gasifier / HP-Boiler (Puertollano)
Puertollano IGCC: Operating Experience

General

- Gasification is **flexible** with broad range of **solid fuels**
  - high-ash hard coal and petroleum coke
  - addition of biomass successfully demonstrated
- Flexible **load change** behaviour
- Nearly **constant** gas **heating value** irrespective of fuel
- **No formation** of **higher hydrocarbons**, methane < 0.1 vol. %
- **Non-leachable slag** production
- **Fly ash** sold to cement industry
- Elcogas statistics show that the vast majority of down-times was caused by **non-gasifier** related issues
Puertollano IGCC: **Lessons Learned**  
**Major Problems and Solutions**  
Source: Elcogas, 2008

<table>
<thead>
<tr>
<th>System</th>
<th>Problem</th>
<th>Solution</th>
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</thead>
<tbody>
<tr>
<td>Overall plant</td>
<td>100% ASU integration restricts plant operation</td>
<td>start-up compressor required (future plants)</td>
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<tr>
<td>Gas turbine</td>
<td>Burner &amp; combustor overheating</td>
<td>Various modifications</td>
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<tr>
<td>Coal preparation</td>
<td>Frequent problems at mixing unit (plugging, ...)</td>
<td>Utilize mill as mixing device (future plants)</td>
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<tr>
<td>Gasifier</td>
<td>Membrane wall water leakages</td>
<td>Improve water chemistry (pH&gt;9.5), Design change at distributor</td>
</tr>
<tr>
<td>Slag</td>
<td>Slow slag transfer from accumulator to sluice vessel</td>
<td>Install sluice support pump (forced slag flow towards sluice vessel)</td>
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<tr>
<td>Waste heat boiler</td>
<td>Erosion at vessel outlets</td>
<td>Install replaceable erosion protection, preventive maintenance</td>
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<tr>
<td>Fly ash</td>
<td>Fouling, short useful lifetime</td>
<td>Change operation strategy (less cleaning pulses)</td>
</tr>
<tr>
<td>Overall plant</td>
<td>Low level of preventive maintenance</td>
<td>Integrate trained operators and maintenance services</td>
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**AVAILABILITY 2007**

![Availability Chart](image)
### Puertollano IGCC: Lessons Learned

**Operating Data: IGCC is least cost power generation**

<table>
<thead>
<tr>
<th>Fuel mode</th>
<th>Fuel</th>
<th>Heat rate ($kJ_{HHV}/kWh)$</th>
<th>Fuel cost ($€/GJ_{HHV}$)</th>
<th>Partial cost ($€/MWh$)</th>
<th>Total cost ($€/MWh$)</th>
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<tbody>
<tr>
<td><strong>GT</strong></td>
<td>Natural gas</td>
<td>18504</td>
<td>7,20</td>
<td>133,25</td>
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<td>Natural gas</td>
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<td><strong>NGCC + ASU</strong></td>
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<td>78,49</td>
<td>78,49</td>
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<tr>
<td><strong>NGCC + ASU + Gasifier by flare</strong></td>
<td>Natural gas</td>
<td>10280</td>
<td>7,20</td>
<td>74,03</td>
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<td>Coal</td>
<td>2232</td>
<td>2,46</td>
<td>5,50</td>
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<tr>
<td></td>
<td>Petcoke</td>
<td>5999</td>
<td>1,89</td>
<td>11,32</td>
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<td><strong>IGCC</strong></td>
<td>NG auxiliar consumption</td>
<td>389</td>
<td>7,20</td>
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<td></td>
<td>Petcoke</td>
<td>6941</td>
<td>1,89</td>
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</tbody>
</table>

**Note:** Data for the year 2007

PRENFLO
with Direct Quench

PDQ
The PRENFLO process with Direct Quench (PDQ)

**Targets**

- Integrate *Lessons Learned* from 10 years operation of Puertollano IGCC
- Optimize PRENFLO technology for *chemical* and *hydrogen* applications
- Identify areas of *significant Capital Cost Reduction*
- **Water Quench** instead of Gas Quench and Waste Heat Boiler
- Keep *commercially proven elements* of PRENFLO technology
- Design of a *robust system*
The PRENFLO process with Direct Quench (PDQ)

**Process characteristics**

- Pressurized entrained-flow gasification
- Dry coal dust feeding
- Multiple co-annular burners (horizontal, tangential arrangement)
- Membrane Wall, no refractory
- Operation pressure flexible to requirements
  - approx. 25 - 40 bar
- Raw gas temperature outlet of quench
  - approx. 200 - 250 °C
- Slag lock-hopper system
PRENFLO Gasification
Direct Quench Pilot Tests Germany
PREFLO gasifier with Steam Generation (PSG) and with Direct Quench (PDQ). The processes involve feeding oxygen, producing raw gas (including fly ash), and generating slag. Both systems share the same gasifier design.
PDQ – Design Aspects

- **Slag Drip Edge** is Required (Proven Design)
- Install Slag Drip Edge at **Dry/Hot Location** ("No Water Contact!")
- All Downstream Surfaces **Permanently Wetted** (Protective Water Film)
- Defined Minimum Residence Time to Ensure **Proper Cooling**

Quench water:

- perfect distribution

Temperature zones:

- optimal dry/hot vs. wet separation
PRENFLO with Direct Quench

1000 MWth, 40 bar

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PRENFLO PSG vs. PRENFLO PDQ
Impact on Cost: Process Configuration (e.g. H₂ plant)

**PSG:**
- PSG Gasifier
  - Gas Quench
  - Waste H. Boiler
  - FA Filter
  - Scrubber
  - CO-Shift
  - Saturator
  - Raw Gas S/G=1.3

**PDQ:**
- PDQ Gasifier
  - Direct Quench
  - Scrubber
  - CO-Shift
  - H₂ Gas
  - Steam

substituted by Direct Quench
PRENFLO PSG vs. PRENFLO PDQ
Impact on Cost: Plant Layout

EPC cost savings: ~30 %
In the targeted applications, PDQ is -1.0 to -1.8 %-points lower than PSG. This low impact does not justify the higher capital cost of a waste heat boiler design.
Lessons Learned from 10 years operation of the Puertollano plant and decades of experience in coal gasification and all related down-stream processes are fully integrated in PRENFLO.

As a technology-driven engineering company, Uhde can act as integrated Licensor, E, EP or EPCM contractor – PRENFLO is a commercial product.

PRENFLO is available with conventional steam generation (PSG) or direct quench mode (PDQ) with significant cost savings.

PDQ Gasification was launched in February 2008. By October 2008, PDQ has been selected around the world for approx. 15,000 MWth new plant capacity.
Thank you for your attention.