Siemens Gasification and IGCC Update

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Presented at
Gasification Technologies 2008
Washington, DC
October 7, 2008
**Agenda**

- Recent Highlights
- Gasification Update
- IGCC Update
- IGCC and Gasification O&M / Gasifier Services
- Conclusions

**Experience breeds confidence**
Recent Siemens IGCC and Gasification Highlights

- 2 SFG-500 gasifiers have arrived in China, two more will ship this month, and two will ship for Secure Energy at end of 2008

- New contracts:
  - EPCOR, Genesee IGCC Project (SFG-500 gasifier)
  - AEC, Latrobe Valley, UREA, Australia

- Technology selected for two IGCCs in the US and Europe

- Vresova refractory lined gasifier in commercial operation

- 4 FEEDs completed

- 10 feasibility studies completed
• Two SFG-500 Gasifiers shipped, 7 being manufactured
• Technology selected and in pre-selection in further projects
Siemens SFG Gasification Technology

SFG Gasifiers

Current Gasifier Products
- SFG-500 500 MW<sub>th</sub>
  • Cooling Screen Design
  • Refractory Lined Gasifier

Siemens Gasification Test Facility

Highlights

- **OEM Support**
  - Siemens manufactures the critical gasification equipment
  - Siemens invests in R&D to improve both gasifier and gasification island design
  - Siemens provides local sales and gasifier component/service support throughout life of project

- **Project Development Support**
  - Siemens can provide feasibility or pre-FEED information for initial project definition
  - Siemens can provide gasification island basic design and process design packages during FEED
  - Siemens comprehensive gasification test facility is available to confirm gasification characteristics

Siemens OEM support before, during and after construction
Gasification conditions depend on feedstock characteristics:

- Carbon, hydrogen content, heating value, moisture level
- Ash composition determines ash melting temperature
- Gasification temperature above AMT: 1,300 - 1,800 °C (2,370 - 3,270 F)

### Feedstock Type

<table>
<thead>
<tr>
<th>Solid</th>
<th>Liquid</th>
<th>&gt; 2 %</th>
<th>&lt; 2 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumatic dense flow feeding system</td>
<td>Feed pumping</td>
<td>Reactor wall with cooling screen</td>
<td>Reactor wall with refractory lining</td>
</tr>
<tr>
<td>Dust fuel burner</td>
<td>Liquid spray burner</td>
<td>Slag layer for thermal protection</td>
<td></td>
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## Typical Design Challenges for Gasification Applications

<table>
<thead>
<tr>
<th>Typical feedstock characteristics</th>
<th>Siemens design solution</th>
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<tbody>
<tr>
<td>Solids or liquids</td>
<td>Dry and liquid feeding systems available</td>
</tr>
<tr>
<td>Low ash content</td>
<td>Mixing with coal or addition of ash</td>
</tr>
<tr>
<td>High sulfur content</td>
<td>Tolerant to high sulfur levels</td>
</tr>
<tr>
<td>Heavy metals</td>
<td>Captured in slag</td>
</tr>
<tr>
<td>Alkali metals, chlorines</td>
<td>Condensed by full quench</td>
</tr>
</tbody>
</table>

### Typical feedstock characteristics:
- **Coal**
- **Slag**

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Siemens SFG-500 Gasification Island with Full Water Quench

Features

Feedstock flexibility
- Wide range of coals
- Petcoke
- Coal / Petcoke blends
- Liquid Feedstocks

Entrained flow gasifier
- No tars or oils produced
- Vitreous slag

Full Water Quench
- High water content in raw gas

Mechanical syngas cleaning system

Optimized for chemical syntheses and IGCC with CO₂ capture
Siemens Fuel Gasification Technology Highlights
SFG-500 Standard Design (Cooling Screen)

Dry feeding
- High efficiency
- High carbon conversion rate (> 98 %)

Cooling screen
- Short start-up / shut-down
- Low maintenance
- High availability

Full quench
- Simple and reliable
- Ideal for CO sour shift

Multi-fuel gasifier
- Accepts a wide variety of fuels (e.g., bituminous & sub-bituminous coal, lignite, biomass, liquid wastes)
- Tar free raw gas
Siemens Fuel Gasification Technology Highlights
Refractory Lined Gasifier Design

- **Liquid feeding**
  - High efficiency
  - High carbon conversion rate (> 98 %)

- **Refractory lined**
  - Accommodates low ash feedstocks

- **Full quench**
  - Simple and reliable
  - Ideal for CO sour shift

- **Multi-fuel gasifier**
  - Accepts a variety of low-ash fuels (e.g., tars, oils, and other liquid wastes)
  - Tar free raw gas
Siemens Gasification Test Facility

- Gasifier reactor with cooling screen, 3-5 MW, max. 30 bar
- Different fuel feeding systems (300 kg/h)
  - Pulverized fuel dosing & feeding system
  - Slurry feeding
- Full gas treatment
  - Desulphurization unit (Sulferox)
  - COS hydrolysis
  - HCN hydrolysis
- Waste water treatment

Over 60 feedstocks tested in over 100 tests provides valuable design data for better FEEDs
Siemens Gasification Test Facility
Gasification Test Results

Recent Feedstocks Tested:
- Bituminous Coal
- PRB
- Lignite
- Petcoke
- Biomass
- Pyrolysis oil

Information Generated:
- Syngas Compositions
- Carbon Conversion Rates
- Specific $O_2$ Consumption
- Optimized Gasification Temperatures
- Slag Composition
- Waste Water and Soot Compositions

Results used for:
- Research and development
- Project development support
  - Design input
  - Permitting support
Next Steps
R&D Focus Areas

- Gasifier Scale-up
- Partial quench with heat recovery for IGCC applications
- Biomass feedstocks
- Higher operating pressures with CO₂ carrier gas

Objective is to improve plant economics for a range of application
SGT6-5000F for IGCC Applications

Combustion System
New combustion system for IGCC based on existing Siemens Diffusion Flame technology

Casing
Use existing access port for air extraction / integration purposes

Auxiliary Systems
Fuel handling auxiliaries and engine control system modified for IGCC application

Testing with high $\text{H}_2$ syngas completed
Siemens – DOE Advanced H2 Turbine Program
Technology Development is Key to Meeting Program Goals

- IGCC Plant
  - Improved Efficiency
  - Fuel Flexibility
  - NG, Syngas, H2
  - Low Emissions
  - Reduction in Plant Cost $/KW
  - CO2 Sequestration Ready

- Engine
  - Firing Temperature
  - Exhaust Temperature
  - Pressure Ratio
  - Mass Flow
  - Fuel Dilution
  - ASU Integration

- Combustion
  - Modeling
  - Technologies
  - Rig Testing
  - Turbine
    - Aerodynamics
    - Cooling and Leakage
  - Compressor
    - Aerodynamics
    - Operational Flexibility

- Materials
  - TBC & Bondcoats
  - Alloys
  - Fabricated Airfoils

- Sensors
  - Emissions and Fuel Sensors
  - TBC Monitoring
  - Tip Clearance Monitoring

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Active involvement by OEM after the commercial operation date can help improve plant availability and reliability in the early years of operation.
Conclusions

Global demand for gasification is still strong
- Chemicals / SNG
- Transportation liquids
- IGCC + CCS

Better technology will provide more options and improved plant economics
- Today’s F class turbines are ready for high H₂ syngas
- Better gasification technologies being developed based on lessons learned allowing the use of lower rank coals
- H class gas turbine technology being developed for IGCC + CCS

OEM business model well accepted in market

Siemens is leveraging its 150 years of OEM and 45+ years of gasification know-how to develop gasification based solutions for tomorrow
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