Siemens IGCC and Gasification Technology – Today’s Solution and Developments

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Siemens Power Generation
Market drivers and challenges for clean coal

- Coal price stability and availability
- High natural gas price
- Security of supply

- Continuation of coal use
- Multi-pollutant emissions legislation
- CO₂ mitigation efforts

- Competitive terms & economics
- Compliance with tightening environmental standards

- Material enhancements
- Experience from IGCC demonstration plants
- Gas turbine development
- Single source IGCC product
- Carbon capture and storage technologies (CCS)

Energy Sources - Fuels
Customer Requirements
Clean Coal
Government Influence
Innovation
Siemens acquired Sustec Holding with subsidiaries

FUTURE ENERGY GmbH (Freiberg, Saxony), entrained-flow gasifier technology company (~ 60 employees)

Sustec GSP China Corp. Ltd., 50% of the Joint Venture (Beijing) (~ 20 employees)
Gasifier –
Current SFG Design with Full Water Quench

Current design
Cooling of the raw gas to about 200°C by direct water quench and subsequent mechanical cleaning (water wash) for downstream gas treatment and synthesis

Attributes
😊 Flexible feedstock
😊 World class gasification test facility
😊 Cooling screen for high availability
😊 Dry feed for high efficiency
😊 Quench technology for simplicity & improved reliability
😊 High water content in rawgas
  ⇒ partial CO shift
  ⇒ benefit for chemical syntheses and IGCC with CO₂ capture
Gasifier – NCPP: Largest Coal to Chemical Plant in China

Recent Success: 5 x 500 MW$_{th}$ (Ningxia Coal Based Polypropylene Project)
Contract signed Q1/2007; Start commissioning Q1/2009

NCPP Project:
- Province Ningxia
- Distance to federal capital appr. 40 km

Customer:
- SNCG - Shenhua Ningxia Coal Industry Group Co., Ltd.
- IPMT - Integrated Project Management Team consisting of SNCG and AMEC

SFGT Scope:
- Engineering Contract (PDP)
- Engineering Supply Contract (Training, TFA ..)
- Equipment Supply Contract (Reactor, Burner ..)
Gasifier – Determination of Parameters / First Project Phase

Costumer Inquiry

- yes Coal known
- no

Ultimate / Proximate Analysis
Determination of Ash Fusion Temperature

- yes Coal and Ash properties known
- no

Slag Viscosity and Deeper Coal Analysis (e.g. Petrological)

Determination of Moisture Level and Particle Size Distribution

Fluidisation Tests

Gasification Tests for high Ash Containing Coals or critical Fusion Temperature

Basic Engineering Package and Project Execution
Objective:
- Measurements of slag melting behaviour up to 1800°C under reducing atmosphere and with 2 different viscometers
  - Rotational viscometer
  - Falling body viscometer

Target:
- Optimization of gasification temperature
- Systematic analysis of different slag compositions produced under both oxidised and reduced conditions
  - Correlation in melting behaviour
  - Set up of database
Objective

- Test of coal dust flow measurement and monitoring devices
  - Comparison of different velocity measurements (capacity, frictional electricity, ...)
- Test of alternative coal flow measurement technologies
- Investigation of CO2 and other feeding gases for pressurisation, fluidisation and coal feeding
- Optimisation of lock hopper cycle and de-pressurisation with different throttling devices (silencer plates or ceramic valves)
- Long term test of different dust flow valves
- Investigation of fluidisation behaviour under elevated pressure condition
Own gasification technology allows to optimize the complete system and offer competitive IGCC solutions.

Gas Island
- **Coal Preparation**
- **Air Separation Unit**
- **Gasifier**

Power Island
- **Air Separation Unit**
- **Oxygen**
- **CO₂ Removal**
- **Sulfur Removal**
- **Gas Island**
- **Gas Island**
- **Air**
- **N₂**
- **H₂ rich Syngas**
- **CCPP (Combined Cycle Power Plant)**
- **Electricity**

Co-Production of Chemicals
- **Synthesis**
  - **Transportation fuels**
    - Methanol
    - Ammonia
    - Hydrogen

**Siemens PG scope of delivery**
Gasifier –
Partial Quench with Heat Recovery as Future Option

Future design for IGCC
Combination of
- Water quench of raw gas and slag down to 700 to 900°C (below ash melting point)
- Efficient use of the high temperature heat in the steam generator for HP steam generation (optional: IP steam)
- Optimization of the reactor similar to current design
  ⇒ Reliability
- Optimization and design of the partial quench system by investigation of mass and heat transfer (supported by CFD)
- Development of a waste heat recovery steam generator
- Constructional aspects
- Experimental testing on pilot plant

Mid-term R&D project together with partners
⇒ SFG optimized for IGCC applications.
Objective:
Optimized IGCC concept consisting of one gasifier and single shaft power train configuration

Advanced F Class SGCC Design with CO₂ Capture
Plant Design -
Gas Conditioning as a Parameter for Optimization

- Dilution with nitrogen
- Humidification
- Mitigation of combustion conditions (reactivity, NO\textsubscript{x} formation)
- Enhancement of overall plant performance (increase mass flow, use of low temperature heat)

Integration of Air Separation Unit
air- and nitrogen-side

Evaluation of integration concepts needs to look at the complete IGCC plant performance.
Plant Design – Integration of Air Separation Unit

Air-side partial or non-integrated systems

😊 Operational behavior

😊 ASU as separate plant unit for independent gas supply ("over the fence") in case of non-integration

Nitrogen-side partial or non-integrated systems

😊 Advanced premix combustion systems do not need high dilution (and H₂O more effective)

😊 Lower N₂ compressor mass flow

Thermodynamic study of effect of ASU on power output and efficiency – Typical trends
Plant Design – Integration of Air Separation Unit

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ASU concepts differ regarding

➢ air inlet pressure

➢ waste N₂ product pressure

⇒ power demand

![Diagram showing IGCC net power output and IGCC net efficiency](image)

- **IGCC net power output**:
  - 11 bar air inlet
  - 3 bar N₂
  - 2 columns
  - 6 bar air inlet
  - 1 bar N₂
  - 2 columns

- **IGCC net efficiency**:
  - 16.5 bar air inlet
  - 5 bar N₂
  - 3 columns

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Restriction by syngas burner (combustibility, geometry of gas passages, etc.)

Integration defined by burner & turbine, plant layout, operational & economical aspects. For optimal performance optimum ASU configuration is needed.
Conclusion / Summary

- Coal based ZEIGCC application are ready for demonstration and subsequent commercialisation
- Siemens offers both IGCC key components and provides integrated and cost effective IGCC solutions
- Siemens Gasification Combined Cycle (SGCC) Technology is optimised for concepts with CO₂ capture
- Siemens gasification technology is well accepted and several gasification projects are under consideration
- High R&D investment into Freiberg facility ensures further technology development
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