Development and Engineering of a Synthetic Gas Cooler Concept Integrated in a Siemens Gasifier Design

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“A technical invention obtains importance and significance, if the technology itself is advanced so far that the invention has become feasible and a general need”

Werner von Siemens 1892
Agenda

- Siemens Strategy and Place of Gasification
- Main Project Landscape SFGT
- Application Fields and Business Model
- TEIMAB Project Overview
- Conclusion and Future Opportunities
Siemens AG – Strategy
Reorganization in order to better serve our customers

The planned structure as of October 1, 2011

Industry
- Industry Automation
- Drive Technologies
- Service

Infrastructure & Cities
- Power Distribution/Smart Grid Applications
- Building Technologies
- Mobility

Energy
- Fossil Power Generation
  Siemens Fuel Gasification
- Renewable Energy
- Power Transmission
- Oil & Gas
- Energy Service

Healthcare
- Imaging & Therapy
- Clinical Products
- Diagnostics
- Customer Solutions

Industry Solutions
- Osram
- Building Technologies
- Mobility

Power Distribution

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Energy Sector

Siemens Energy Sector – Newly focused on the markets of tomorrow

Energy products and solutions – in 6 Divisions

- Oil & Gas
- Fossil Power Generation
- Wind Power
- Solar & Hydro
- Energy Service
- Power Transmission

Siemens Energy Sector

Energy products and solutions – in 6 Divisions

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Energy Sector
9 SFG-500 gasifiers shipped / installed for 3 projects
8 SFG-500 gasifier under manufacturing and additional 22 SFG-500 (CtL) under contract
China NCPP Project
Site Impression

Gasifier building
Slag formation on cooling screen
Entire gasification unit with gasifier building CO shift and black water treatment plant
Siemens Fuel Gasification Technology: Application Fields - Cooling screen reactor

**SFG Gasifier**

- **Fuel**
- **Oxygen, steam**
- **Burner**
- **Pressur. water outlet**
- **Cooling screen**
- **Pressur. water inlet**
- **Quench water**
- **Cooling jacket**
- **Gas outlet**
- **Water outlet**
- **Granulated slag**

**Highlights**

**Multi-fuel gasifier (standard 500 MW_th)**

- accepts a wide variety of fuels with ash content of > 3%
- compact size compared to other gasifiers
- Ability to supply syngas at higher pressures
- No ash to handle (only solid slag as saleable by-product)

**Dry feeding (entrained flow)**

- high efficiency
- high carbon conversion rate (> 98%)

**Cooling screen**

- short start-up / shut-down
- low maintenance (lifetime > 10 years)
- high availability

**Full quench**

- simple and reliable
- ideal for CO sour shift
- High syngas quality (free of tar)
- Minimal efforts in gas cleaning

**Market Request for Improvement of Effectiveness with High Reliability**
New Application Fields and Business Model with HRSG

Fuel
- Coal
- Lignite
- Petcoke
- Refinery residues
- Biomass

Gas Island
- Fuel preparation
- Air Separation Unit
- Gasifier Island
- Gasifier
- CO Shift (optional)
- Sulfur Removal
- CO₂ Removal (optional)
- Steam Drum and Steam Circuit incl. Pumps

Applications
- Combined Cycle
  - Gas turbine
  - Steam turbine
  - Generator
- Power Island
  - Power
- FT Synthesis
- Methanol Synthesis
- Ammonia Production
- SNG Production

Chemical and Synfuel Production
- Transportation fuels
- Methanol
- Ammonia / Fertilizer
- SNG
- Hydrogen

Siemens Basic Engineering & Design
Siemens Supply of Key Equipment
Siemens EPC
Third Party Scope for FEED and EPC
HRSG - Heat Recovery Steam Generator

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Page 9
21. May 2012, Freiberg
TEIMAB Project Organization Chart

Germany Government (BMWI / PTJ) funded R&D Project COORETEC

TEIMAB-Project

Siemens AG (Coordinator)

TP1

Development of Concepts
reactor with HRSG

Siemens AG / SFGT

Subcontr. SE

TP2

Specif. Measurem. and Analysis Technol.

IVT

TP3

CFD-Calculations

LUAT (IVT)

TP4

Thermodynamic modelling of ash and slag performance

IEC (GTT)

TP5

Testing of pilot HRSG/gasification tests in 5 MWth pilot plant

Siemens AG / SFGT

Abkürzungen:

HRSG = Heat recovery steam generator
LUAT = Lehrstuhl f. Umweltverfahrenstechnik u. Anlagentechnik / Uni Duisburg-Essen
IVT = Institut f. Verbrennungstechnik, Stuttgart / Deutsches Zentrum für Luft- u. Raumfahrt
IEC = Institut für Energieverfahrenstechnik u. Chemieingenieurwesen, TU Freiberg
SE = Steinmüller Engineering GmbH
Step 1: Variation of Main Tech. Sys. Gasification Island

Comparison of Process Models:

Variant A:

Variant B:

Page 12

21. May 2012, Freiberg
Step 2 Thermodynamic Investigation

Results:
• generation of HP steam it’s a large efficiency advantage in relation to IP steam generation
• efficiency improvement between 1.4 and max. 1.9 % points for the variants
• comparing the two cooler types, the radiant cooler shows a slight efficiency advantage

Therefore, the thermodynamic results did not lead to a clear decision criterion for concept selection.
Step 3 Comparison of Design Concepts

Technical conceptual design of main HRSG concepts
Based on Steinmueller Engineering

Investigation:
• Process integration
• Additional CAPEX and OPEX

Risctor plugging + limited cleaning efficiency 3D Detail studies
Development criteria technical evaluation:

- New Equipment necessary?
- Availability of new equipment?
- Range of load control?
- Risk of fouling and scaling?
- Cleaning possibilities of new equipment?

SFGT Gasifier extended by a Radiant Cooler promises

- lowest complexity
- use proven design with full quench and wet gas cleaning
- offers a high efficiency for future IGCC plants (> 1.5 %)
SFGT Gasifier with Heat Recovery

Design features

- Radiant Cooler followed by full quench of raw gas
- Efficient use of the high temperature heat in the steam generator for HP steam generation
- High raw gas water content benefits CO-shift
- Proven reactor and quench design extended by Radiant Cooler

Efficiency improvement potential:

- IGCC w/o CO₂ capture
  **Plant net efficiency** ca. + > 3,5 %
  (depends upon coal type, water/steam condition, gas turbine)

- IGCC with CO₂ capture
  **Plant net efficiency** ca. + > 1.5 %
  (depends upon process conditions of CO-shift, coal type, water/steam condition)
University Partner Scope LUAT CFD Modelling

Verification and Validation of Submodels

- Ensure the process parameter
- Selection of suitable material for the walls depending on heat load
- Sensitive study of suitable nozzle geometries
- Find an appropriate cleaning system for the walls depending on particle load

- Selection of suitable material for the walls depending on heat load
- Find an appropriate cleaning system for the walls depending on particle load

Related heat flux to the inner wall:

- 1.00
- 0.40
- 0.01

Related heat flux to the outer wall:

- [-]
- < 0.01
Conclusion And Siemens SFGT Future Opportunities

→ Risk and cost reduction of mega coal to chemical plants
→ Where: support of China pioneers mega CTL and CTO technologies
→ Have a possibility to integrate a HRSG in Siemens SFGT Gasifier if profitable
→ Maximum product flexibility: chemicals/liquid fuels ↔ electricity
→ Long term issues: attractive for peak load and energy storage
→ Energy storage by importing renewable power to balance auxiliary power consumption

Current and future application for coal gasification with polygeneration concepts worldwide with the option to implement a radiant cooler
Thank you for your attention!

“A Winner Is A Dreamer Who Never Gives Up “
Nelson Mandela

NCPP  |  Large Coal to Chemical Plant in China
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