DESIGN, SIMULATION AND PRACTICAL EXPERIENCE OF THE LARGEST SYNGAS COOLER IN OPERATION FOR COAL GASIFICATION

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THE THREE DIVISIONS OF ARVOS GROUP

RAYMOND BARTLETT SNOW

SCHMIDTSCHE SCHACK

LJUNGSTRÖM

Heat Transfer Solutions for

- Olefins (Ethylene)
- Ammonia, Methanol, Hydrogen
- Gasification, Methanation
- Carbon Black
- DRI Metallurgy
- Nitric Acid
FROM KASSEL WORLDWIDE SUCCESSFUL

ARVOS GMBH | SCHMIDTSCHE SCHACK
350 employees, order intake more than 150 Mio.€/a

Own fabrication in Kassel, Germany
12 representative supporting the sales team
OUTLINE

Overview about process and site

Syngas cooler concept, design, fabrication

Simulation of transient operation

Operational results
E-GAS BY CB&I
PROCESS OVERVIEW

SCHMIDTSCHE SCHACK scope of supply

• HTHR Cooler (Steam generator)
• Steam Drum
• Piping

POSCO GWANGYANG SNG PLANT

POSCO is the 4th largest steel company in the world and also has a strong presence in Power Generation

Plant capacity: 500 kto/year SNG, three lines

Coal: 1.8 Million to/year

Licensor Gasification: CB&I

Satellite map of Gwanyang, Korea
DESIGN CONCEPT OF SYNGAS COOLER

Application of proven transfer line exchanger design to gasification process

General challenges:

- Performance scale-up by a factor 20
- Particle loaded gas → erosion
- Sulfur in gas → corrosion

But good reputation for syngas applications

- Smaller units in operation since decades

Typical transfer line exchanger
Established since 50 years in more than 7000 units in the Ethylene industry

Gas side:
- Gas inlet temperature approx. 900°C
- Low pressure drop

Water / Steam side:
- Low temperature amplitudes due to small steam bubbles
- Low thermal / mechanical stresses protect the iron magnetite layer (corrosion protection)
- Low water volume for faster response to load variations
# SYNGAS COOLER CHARACTERISTICS

<table>
<thead>
<tr>
<th>General Key Data</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Exchanged Heat</td>
<td>~ 85MW</td>
</tr>
<tr>
<td>Water/ Steam pressure</td>
<td>~ 80 bar</td>
</tr>
<tr>
<td>Steam production</td>
<td>~ 200 to/h</td>
</tr>
<tr>
<td>Syngas inlet temperature</td>
<td>~ 900°C</td>
</tr>
<tr>
<td>Dust particles</td>
<td>~ 2%</td>
</tr>
<tr>
<td>Apparatus length</td>
<td>~ 34m</td>
</tr>
<tr>
<td>Apparatus weight</td>
<td>~ 300 to</td>
</tr>
<tr>
<td>Water / Steam Cycle</td>
<td>Natural circulation</td>
</tr>
</tbody>
</table>
APPLICATION OF DOUBLE TUBE TO SYNGAS COOLER

Ensure reliability by trumped shaped gas flow inlet (patented)

Smooth velocity profile without recirculation zones and low turbulence to ensure

- wall temperatures at low level
- avoidance of erosion due to dust particles
DESIGN OF GAS INLET CHAMBER

Homogenous inlet flow profile to heat exchanging area for all load cases

Load case 10% mass flow (start-up):
Max. deviation ±0.3% mass flow / tube
SULFUR IN SYNGAS
MITIGATION OF H₂S CORROSION

Ensure reliability by compound tubes:
base material with inner layer from Alloy as corrosion protection

Challenge:
• Available tubes are shorter than required for syngas cooler
• Weld imperfection acts as hurdle for the flow (same effect as for Ferules at tube inlet)
• Flow separation, recirculation area increase erosion dramatically

• SCHMIDTSCHE SCHACK patented method for circumferential tube welding with no reinforcement
• Strength of weld was confirmed by cyclic load test
MANUFACTURING, SHIPPING AND ERECTION OF SYNGAS COOLER
SIMULATION OF TRANSIENT LOAD POINTS

Syngas cooler operational behavior strongly depends on gasifier

Necessity of common alignment between licensor CB&I and SCHMIDTSCHE SCHACK
OpenModelica applied to get deeper insight into Syngas cooler package
COMPARISON OF SIMULATION METHODS

Start-up Sequence

Quasi-stationary approach provides sufficient results compared to dynamic simulation

Dynamic model provides further information for mechanical structure

Oscillation during pressure ramp due to simple controller modelling

Operation pressure / Temperature achieved

Switch to slurry

Steam Production

Time

Operation pressure / Temperature achieved

Temperature

Time

Switch to slurry

OpenModelica

Quasi-stationary

Bearing system temperature

Downcomer water temperature
Start-up Sequence before slurry operation

- Ignition of burner
- First steam production
- Increase of gas temperature / mass flow

Operation pressure

- Measurement
- Simulation

Heat drum pressure

- Time

Temperature

- Gas Temp Inlet
- Fluid Temp in Drum
- Gas Temp Outlet

- Further BFW filling
- Heating surface active

Time
SIMULATION AND OPERATION

Switch to slurry operation – Steam Production

Operational data show good agreement in absolute steam production at higher gradient
SUMMARY

- Syngas cooler for coal gasification process is not only a heat exchanger but a key component
- SCHMIDT’SCHÉ® double system was successfully applied to the current largest syngas cooler in operation
- Special design solutions were implemented to ensure reliability of the apparatus and the process
- Start-up procedure requires close cooperation with gasification licensor to achieve optimum system behavior
- Operational data confirm dynamic and quasi steady simulation
THANK YOU FOR YOUR ATTENTION!
ANY QUESTIONS?

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