New results from the PCC pilot plant Niederaussem

Torsten Stoffregen (Linde-KCA-Dresden)
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Cooperation of RWE – Linde – BASF
joint development of a PCC technology

The interdisciplinary approach – key to success:

- BASF – “The Chemical Company”: development of new solvents and optimized process design
- Linde – “Engineering company”: engineering and construction of the pilot plant, system optimization, scale up
- RWE Power – “Power producer and utility”: plant integration, interface optimization, operation
1st phase of the new solvent testing is finished successfully

Solvent Development BASF
- Screening
- Miniplant performance tests

CO₂ Capture Pilot Plant
- Engineering, Procurement
- Construction
- Operation MEA
- Operation 2 new solvents

Working Group “PCC-Demo”
- Optimization of the PCC concept
- Scale up for a full-scale plant
- Designing of the demo plant
Pilot Plant Niederaussem
Process

Flue gas cooling and SO₂-pre scrubbing

CO₂-capture

CO₂-lean flue gas

Absorber

Prescrubber

Flue gas (after FGD)

Drain

Cooling water

Make up water

Booster fan

Condenser

CO₂

Drain

Cooling water

Make up water

Filter

Reboiler

Steam generator

NaOH solution tank

Solvent tank

Make-up water

Solvent

NaOH

NaOH

Make-up water

Solvent

CO₂-capture Flue gas cooling and SO₂-pre scrubbing

Solvent regeneration

Linde-KCA-Dresden GmbH
<table>
<thead>
<tr>
<th><strong>Type</strong></th>
<th>Pilot plant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>lignite</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Flue gas</strong></td>
<td>1552 Nm³/h</td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td>159 Nm³/h CO₂; 7.2 t/d CO₂</td>
</tr>
<tr>
<td><strong>Source</strong></td>
<td>lignite-fired power plant</td>
</tr>
<tr>
<td><strong>Start-up</strong></td>
<td>June 2009</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>6 Skids, 2 Container</td>
</tr>
<tr>
<td><strong>Skid 1</strong></td>
<td>4 x 4 x 41 m; weight: 80 t</td>
</tr>
<tr>
<td><strong>Instrumentation</strong></td>
<td>240</td>
</tr>
<tr>
<td><strong>MOC</strong></td>
<td>tests at 15 different locations</td>
</tr>
</tbody>
</table>
Operation key figures within 1.5 years of operation:
- 10000 hours operation
- 2500 t CO₂ captured
Specific energy consumption for the 3 tested solvents

Comparison of MEA with the 2 tested new solvents
- Gustav and Ludwig have a 20% lower specific energy consumption
- Gustav and Ludwig have a significant lower solvent circulation rate
Impact of interstage cooling
Example: Gustav 200

Specific energy consumption [MJ/tCO₂]

Solvent circulation rate

Impact of Interstage Cooling
- no cooling leads to higher specific energy requirement for regeneration
- Implementation of interstage cooler is economically
Impact of CO2 recovery rate
MEA and Gustav 200

- solvent circulation rate can be reduced
- impact on minimum achievable specific energy consumption is minor
Degradation: heat stable salts (HSS)

Comparison of MEA with Gustav200

- building of HSS for Gustav200 is significantly lower
- no reclaiming required for Gustav200 after 4000 operating hours
Material testing
Location and type of Samples

A1, A3 – A6:
Flanges, tubes, gaskets

A2:
Concrete module

B1 – B7:
Coupons

Pre-scrubber

Absorber

Desorber

Flue gas

CO₂-lean flue gas

Make-up water

CO₂ from regeneration

Drain

Caustic soda

Solvent

Drain

A1

B1

B2

B3

B4

B5

B6

B7

B8

A2

A3

A4

A5

A6
## Material tests for MEA

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
<th>Type</th>
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<tr>
<td>Steel</td>
<td>1.4541</td>
<td>coupon + flange-tube-flange</td>
</tr>
<tr>
<td></td>
<td>1.4571</td>
<td>coupon</td>
</tr>
<tr>
<td></td>
<td>1.4462</td>
<td>coupon</td>
</tr>
<tr>
<td></td>
<td>2.4548</td>
<td>coupon</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>PP-H</td>
<td>coupon</td>
</tr>
<tr>
<td>FRP</td>
<td>Vinyl ester</td>
<td>flange-tube-flange</td>
</tr>
<tr>
<td></td>
<td>Epoxy ester</td>
<td>flange-tube-flange</td>
</tr>
<tr>
<td>Gasket</td>
<td>EPDM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NBR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PTFE</td>
<td></td>
</tr>
<tr>
<td>Concrete module</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>with PP-H inliner</td>
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- **Tensile test specimens of PP-H**
- **Metal coupons with welding seam**
- **Cut concrete module with PP-H inliner**
Material Tests for MEA
Examination + Results for steel

Examination
— based on DIN 50905 and ASTM G31-72
— Determination of linear corrosion rate
— Visual inspection of local corrosion (pitting, crevice corrosion, stress corrosion cracking)

Results
— Corrosion rate < 0.001 mm/year for all type of tested steel grades
— No local corrosion attack

Conclusion
— All tested steel types are resistant to corrosion.
Demo Plant as Intermediate Step from Pilot Plant to Commercial Application

**Pilot Plant**
- Niederaußem
- app. 0.5 MW\textsubscript{el, equiv.}
- \( \approx 2,500 \text{ t/a CO}_2 \)

**Demo Plant**
- 1 train
- app. 250 MW\textsubscript{el, equiv.}
- \( \approx 1.3 \text{ million t/a CO}_2 \)

**Commercial PCC Plant**
- 2 trains for a 1,100 MW power plant
- app. 550 MW\textsubscript{el, equiv.} per train
- \( \approx 3 \text{ million t/a CO}_2 \) per train

<table>
<thead>
<tr>
<th>Operation</th>
<th>Design, Construction, Commissioning</th>
<th>Design, Construction, Commissioning</th>
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<tbody>
<tr>
<td>Today</td>
<td>2011 *</td>
<td>2016 *</td>
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</tbody>
</table>

**Scale-up factor**
- 500
- 2

**No CO\textsubscript{2} Storage**

**CO\textsubscript{2} Transportation and Storage** - Design, Construction, Commissioning

*Timeline depends on development progress and especially project boundary conditions (e.g. permitting).
Outlook

Second phase of Niederaussem test program - Cooperation will proceed until 2013

New tests scheduled
— 2 long term tests (with conventional FGD and with high performance FGD)
— long term test of materials, degradation and emission

Modification of pilot plant
— installation of high-performance column internals
— improved emission control system at top of Absorber
— additional online gas analysis equipment
Your Questions?

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