Transient Behavior of Post Combustion 
$\text{CO}_2$ Capture Process

2nd IEA Post Combustion Capture Conference
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Background

- Increased capacity of intermittent energy sources in the electricity mix
  - Demand for load flexibility in base load power plants increases
- Effects on downstream CO₂ capture systems
  - Dynamic analysis is needed
Aim

• Evaluate transient behavior of the capture system with respect to a typical load-change ramp rate in modern coal power plants
  – Discuss connections for the steam cycle and CO$_2$ transportation network

• Evaluate steady state effects on power plant performance at different load conditions
The model

- 30 wt% MEA-based absorption model constructed in Dymola (Åkesson et al. 2012)
- Rate-based model
- Chemical equilibrium assumed in model parts
Evaluation of absorption model

- Experimental results from step response tests conducted at DONG Energy coal fired power station in Denmark
- Experimental data from two operating points
  - Both steady-state and dynamic operation

Source: Åkesson et al., 2012
The model applied I

- Capture system dynamics
  - Dynamic sensitivity analysis
  - Effects of different control strategies

<table>
<thead>
<tr>
<th>Control strategy</th>
<th>Controlled variable</th>
<th>Varied variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>No control</td>
<td>Lean solvent loading</td>
<td>Steam flow to reboiler</td>
</tr>
<tr>
<td>Capture efficiency</td>
<td>Capture efficiency + Lean solvent loading</td>
<td>Solvent flow rate + Steam flow to reboiler</td>
</tr>
<tr>
<td>L/G</td>
<td>L/G ratio + Lean solvent loading</td>
<td>Solvent flow rate + Steam flow to reboiler</td>
</tr>
</tbody>
</table>
The model applied II

- Power plant application
  - Steady state evaluation of power plant performance during full load and part load
  - Effects of controllers on power plant performance
Capture system dynamics
Dynamic sensitivity analysis

- A mount of liquid in the system varied without varying flow rates or properties of the packed volumes
- Increased liquid mass → slower system dynamics
Effects of process control

- Power plant load is ramped down from full load to 60%
Interaction with connected systems

- Capture system acts like a buffer

Results

Steam flow from power cycle

CO₂ flow to pipeline system
Power plant application
Power plant application

- Evaluation of power plant performance based on steady-state modeling of Nordjyllandsvaerket in Denmark
  - Steam for capture system extracted between two intermediate pressure turbines
  - Full load and part load operation
Effects on power plant

Results

CO₂ compression work and other mechanical work is not included in the power plant efficiency values.
Conclusions

• The simulations show that the CO$_2$ capture process responds to load changes within few minutes
• Implementation of active control strategies improves capture system performance with respect to heat requirement
  − The response time of the system is generally lower in these cases
• Integration with the power plant results in an efficiency decrease in the range of 8-12 percentage points
Thank you for your attention!
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