Integration and Onsite System Aspects of Industrial Post-Combustion CCS

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Process flowsheet

To stack

Flue gas in

A2

CO₂ to storage

Wash

S1

S2

A3
System Aspects on Desorber Heating

Heating in the desorber the most expensive part of the whole CCS plant, including distribution and storage

Main aims of this presentation
• To discuss opportunities for integration with the industrial energy excess heat system
• To compare excess heat usage with other measures for desorber heating

Examples from two industry types:
Oil refinery
Pulp and paper
Main Questions

• Can industrial excess heat be used for reducing this cost?

• What importance does the excess heat temperature level have?

• Can industrial excess heat compete with other measures for desorber heating?

• What levels of avoidance costs can be achieved?
Oil refinery

- 1.8 Mtonne CO₂/year
- 11.4 Mtonne crude oil/year
- 4 main chimneys
- Electricity
- Oil products
- District heat
Excess heat recovery

Optimal heat exchanger network

Actual cooling taking place at refinery
Excess heat recovery

- Energy efficiency to be implemented before CCS
- 20% of identified possible measures implemented
- Energy efficiency to take place at 130 – 170 °C
- Decrease in heat and CO₂ emissions
Excess heat recovery

$T_{\text{reb.}} = 120 \, ^\circ\text{C} \rightarrow 55 \, \text{MW excess heat}$

$T_{\text{reb.}} = 105 \, ^\circ\text{C} \rightarrow 90 \, \text{MW excess heat}$

$T_{\text{reb.}} = 90 \, ^\circ\text{C} \rightarrow 125 \, \text{MW excess heat}$
Heat Integration of MEA Process

- Excess Heat Refinery
- MEA Process

\[ Q_{\text{rec.}} = 153 \text{ MW} \]
\[ T_{\text{reb.}} = 90 \, ^\circ\text{C} \]

\[ Q_{\text{rec.}} = 69 \text{ MW} \]
\[ T_{\text{reb.}} = 120 \, ^\circ\text{C} \]
Heat pump

Excess heat at specified temperature

Temperature lift

Available excess heat (MW)
Three main consequences of the temperature level

A lower temperature means:

• More excess heat available

• Higher need for desorber heat

• Lower temperature lift for a heat pump
Specific heat demand and temperature correlation
Heat demands at 85% capture

Current situation:
- 1.8 Mt\textsubscript{CO\textsubscript{2}}/y emitted
- 1.5 Mt\textsubscript{CO\textsubscript{2}}/y captured

Future situation:
- 1.7 Mt\textsubscript{CO\textsubscript{2}}/y emitted
- 1.4 Mt\textsubscript{CO\textsubscript{2}}/y captured
Heat collecting system

<table>
<thead>
<tr>
<th>Stream type</th>
<th>ΔT contribution (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>7.5</td>
</tr>
<tr>
<td>Liquid</td>
<td>5</td>
</tr>
<tr>
<td>Evap./Cond.</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Future developments

\[ T_{\text{Reb.}} = 80 \, ^\circ\text{C} \rightarrow 160 \, \text{MW excess heat} \]

\[ T_{\text{Reb.}} = 60 \, ^\circ\text{C} \rightarrow 235 \, \text{MW excess heat} \]
Pulp and paper mill

Flue gases
1 065 600 tonne CO$_2$/year

Black liquor 340 MW
Biofuel 80 MW

Steam
Electricity

Swedish total emissions of fossil CO$_2$: 55 Mtonne / year
Swedish total emissions of biomass CO$_2$: 34 Mtonne / year
Swedish total emissions of CO$_2$: 89 Mtonne / year
CO$_2$ emissions from pulp and paper mills: 14 Mtonne / year (16 %)
Excess heat

Integrated pulp and paper mill

Temperature, °C

Heat flow, GJ/ADMT

Excess heat
Possible Heat Sources

- Biofuel boiler
  (+ Thermal process integration)
- NGCC – CHP
  (+ Thermal process integration)
- Heat pump

CO₂ lean flue gases

CO₂ to storage

Absorption unit (MEA)
Biofuel boiler

- Fuel: Biofuel
- Fuel demand: 209 MW
- Change in electricity surplus: + 14 MW

Boiler + Process integration

- Fuel: Biofuel
- Fuel demand: 142 MW
- Change in electricity surplus: + 4 MW
NGCC

• Fuel: Natural gas
• Fuel demand: 260 MW
  (- 80 MW biofuel)
• Change in electricity surplus: + 99 MW

NGCC + Process integration

• Fuel: Natural gas
• Fuel demand: 123 MW
  (- 80 MW biofuel)
• Change in electricity surplus: + 47 MW
Heat pump

- Electrically driven closed cycle
- Three stage turbo compressor
- COP: 4.4
- Electricity consumption: 38 MW
Process integration - the example of CO$_2$ capture

Oil refinery

Excess heat refinery

Heat integration of CO$_2$ capture plant

Post-combustion CO$_2$ capture plant
What is the **most-cost effective and robust heat supply alternative** for a post-combustion CO$_2$ capture plant?

![Diagram showing CO$_2$ capture avoidance costs](image-url)
Conclusions

• Excess heat amounts at usable temperature levels are in many cases available in process industries
• At least parts of the desorber heat can be covered by direct use of excess heat
• Reasonable costs for collection of excess heat possible to achieve, according to case studies
• Use of excess heat can reduce the cost for desorber heating compared with other measures

• New absorption fluids, working at lower temperatures (60-80 C), could increase the usable excess heat amounts considerably