MEMBRANE AND MEMBRANE ASSISTED LIQUEFACTION PROCESSES FOR CO$_2$ CAPTURE FROM CEMENT PLANTS

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Background

- 6-7% of global anthropogenic CO₂ emissions from the cement industry

- CO₂ emissions an inherent part of the cement production process
Membranes processes and their applicability in cement plants

• Low environmental impact
• Ease of integration (no steam required in the process)
• Compact process
• Membrane separation processes favour high CO₂ partial pressure

Cost of membrane-based CO₂ capture compared to post-combustion MEA-based capture at a 90% CCR depending on the membrane properties for cement plant

CO₂ liquefaction process

- No chemicals
  - Separation by phase change

- Flexible process
  - CO₂ product at conditions suitable for ship or pipeline transport

- Compact
  - CO₂ capture at high pressure

- Used as standard for oxy-combustion processes
Is there a role for \( CO_2 \) liquefaction in post-combustion capture from cement?
Membrane assisted liquefaction

CO₂ concentration at the interface is important
- Affects CO2 capture ratio
- Affects amount of recycle to membrane
- Membrane area
- Vacumm pump size and work

CO₂ concentration at interface depends on
- Membrane type
- Pressure differential across membrane
- Membrane area
Membrane assisted liquefaction

From CEMCAP cost estimation

• Around 60% of total direct cost of the MAL process is due to the membrane process

• Membrane itself, the vacuum pump and the flue gas compressor stand out as the most expensive pieces of equipment

• These three together account for around 80% of the membrane part costs, or 46% of the total direct costs

• Membrane accounts for 9% of the total direct cost
# Membranes considered

<table>
<thead>
<tr>
<th>Membrane in CEMCAP work</th>
<th>CO₂ permeance (Sm³/m².bar.h)</th>
<th>N₂ selectivity</th>
<th>O₂ selectivity</th>
<th>H₂O selectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.7</td>
<td>20</td>
<td>26</td>
<td>20</td>
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Membrane assisted liquefaction process performance
Summary

• Membrane assisted liquefaction process performance and cost is will vary significantly with membrane performance

• Critical to identify suitable membrane properties for the process for a given flue gas composition

• Membrane assisted liquefaction outperforms the 2 stage membrane process for post-combustion CO$_2$ capture
  • Thermodynamic proof irrespective of membrane type or performance (not included in this presentation)

• Techno-economic analysis of membrane processes presented in this work will be performed and compared
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