Developments in CO₂
Compression and Purification Unit (CPU)
for Oxy-fuel Combustion Power Plant

Introduction

Key Findings:
- The developments of this technology are led by several gas suppliers, including: Air Products, Air Liquide, Linde and Praxair.
- The application of a CPU leads to near zero emissions from oxy-fuel power plants in addition to producing high purity CO₂ (>99%).
- Different CPU technologies have been investigated in several oxy-fuel demonstration (≤30 MW) projects.

Novel Process Concept

Chemical reactions in the ozone CPU process:
- NO + O₃ → NO₂ + O₂
- CO₂ + NaOH → NaHCO₃
- SO₂ + 2 NaHCO₃ → Na₂SO₃ + H₂O + 2CO₂
- 2NO + 2NaOH → NaNO₂ + NaNO₃ + H₂O
- NO + NO₂ + 2NaOH → 2NaNO₂ + H₂O
- NO₂ + Na₂SO₃ → N₂ + Na₂SO₄

Figure 1 Modelling schematic of ozone-scrubbing for CPU by AspenPlus.

Future Work

- The feasibility and tech-economic analysis will be modelled using an established oxy-CFBC power plant with ozone CPU by AspenPlus.
- Experimental investigation of the performance of ozone oxidation and scrubbing for the oxy-derived CO₂ will be conducted when completing its feasibility and tech-economic analysis.

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Overview of Current CPU

Comparison between current and ozone CPU technologies for oxy-fuel power generation

<table>
<thead>
<tr>
<th></th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
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<tbody>
<tr>
<td>Current CPU technologies</td>
<td>• Existing experience.</td>
<td>• High CAPEX, OPEX and energy penalty.</td>
</tr>
<tr>
<td></td>
<td>• High purity CO₂ (&gt;99%) proven.</td>
<td>• Corrosion issues.</td>
</tr>
<tr>
<td>Ozone CPU</td>
<td>• Avoid corrosion of compressor.</td>
<td>• Only proved for simultaneous removing NOₓ and SO₂.</td>
</tr>
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<td></td>
<td>• Reduce the size of CPU.</td>
<td>• The feasibility and tech-economic analysis haven’t been investigated for the CPU.</td>
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Current

Oxy-derived CO₂

FGC → Pre-compressor → Scrubber and Drier → Compressor → Cryogenic and Liquefaction → Product CO₂

NO₂, SO₂, HCl and HF → NO, SO₂, Hg and H₂O → CO₂ for Storage or EOR → O₂, N₂ and Ar

Oxy-derived CO₂ → Scrubber and Drier → Compressor → Cryogenic and Liquefaction → Product CO₂

Table 1 Gas composition after ozone oxidation.

<table>
<thead>
<tr>
<th>Mass Flow</th>
<th>Units</th>
<th>Before (FLUEGAS)</th>
<th>After (FLUEGAS)</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂</td>
<td>kg/hr</td>
<td>4391.09</td>
<td>4409.52</td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>kg/hr</td>
<td>0.02</td>
<td>1.73</td>
<td></td>
</tr>
<tr>
<td>NO₂</td>
<td>kg/hr</td>
<td>1.13</td>
<td>0.01</td>
<td>99%</td>
</tr>
<tr>
<td>SO₂</td>
<td>kg/hr</td>
<td>690.34</td>
<td>655.82</td>
<td>5%</td>
</tr>
<tr>
<td>SO₃</td>
<td>kg/hr</td>
<td>43.31</td>
<td>86.44</td>
<td></td>
</tr>
<tr>
<td>O₃</td>
<td>kg/hr</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Previous literature results:
- 99% NO, 90% NO₂ and ~100% of SO₂ was removed at PH 11 before compression.
- Byproduct: Sodium nitrate → Fertilizer  Sodium sulphate → Paper production

Conclusions

- A novel process concept of ozone oxidation and alkali scrubbing technology with CPU has been proposed in this work and will be studied in AspenPlus.
- This has the potential to remove the need for the pre-compressing and flue gas cleaning step within conventional CPU trains.
- The impacts of impurities, gas quality control and cost are the main concern to develop the oxy-fuel CO₂ purification technology.

References

1. Z. Wang, Simultaneous Multi-Pollutants Removal in Flue Gas by Ozone. 2014.