# Developments in $CO_2$ 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 $CO_2$ (>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:**

$NO + O_3 \rightarrow NO_2 + O_2$

$CO_2 + NaOH \rightarrow NaHCO_3$

$SO_2 + 2\,NaHCO_3 \rightarrow Na_2SO_3 + H_2O + 2CO_2$

$SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$

$2NO_2 + 2NaOH \rightarrow NaNO_2 + NaNO_3 + H_2O$

$NO + NO_2 + 2NaOH \rightarrow 2NaNO_2 + H_2O$

$NO_2 + Na_2SO_3 \rightarrow N_2 + Na_2SO_4$

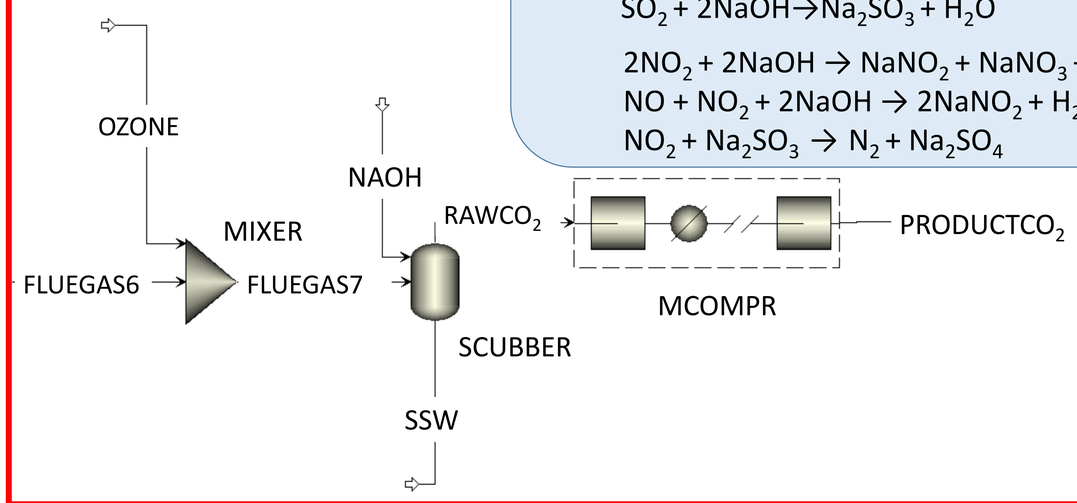


Figure 1 Modelling schematic of ozone-scrubbing for CPU by Aspen Plus.

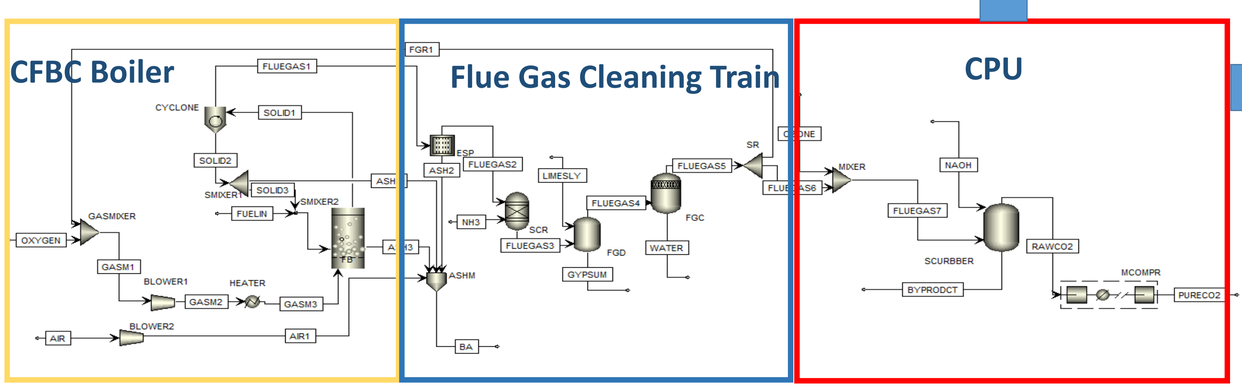


Figure 2 Modelling schematic of oxy-CFBC power plant with ozone-scrubbing for CPU by Aspen Plus.

## Future Work

- The feasibility and tech-economic analysis will be modelled using an established oxy-CFBC power plant with ozone CPU by Aspen Plus.
- Experimental investigation of the performance of ozone oxidation and scrubbing for the oxy-derived $CO_2$ will be conducted when completing its feasibility and tech-economic analysis.


Yongliang (Harry) Yan

Supervisors: Dr Peter Clough

Prof Ben Anthony

yongliang.yan@cranfield.ac.uk

www.cranfield.ac.uk


## Overview of Current CPU

Table 1 Comparison between current and ozone CPU technologies for oxy-fuel power generation

| | Advantages | Disadvantages |
|---|---|---|
| Current CPU technologies | • Existing experience.<br>• High purity $CO_2$ (>99%) proven. | • High CAPEX, OPEX and energy penalty.<br>• Corrosion issues. |
| Ozone CPU | • Avoid corrosion of compressor.<br>• Reduce the size of CPU.<br>• High $SO_X$ and $NO_x$ removal efficiency. | • Only proved for simultaneous removing $NO_x$ and $SO_x$.<br>• The feasibility and tech-economic analysis haven't been investigated for the CPU. |

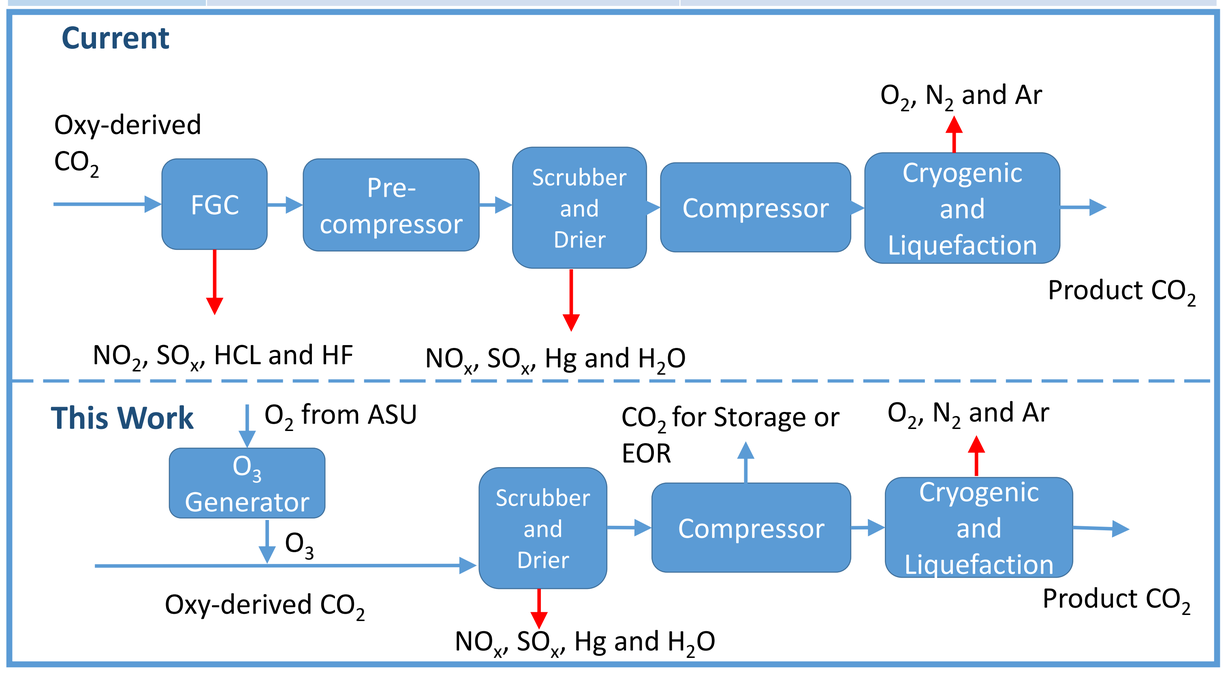


Figure 3 Schematic of current and ozone CPU technologies for oxy-fuel power generation.

| Mass Flow | Units | Before (FLUEGAS6) | After (FLUEGAS7) | % change |
|---|---|---|---|---|
| $O_2$ | kg/hr | 4391.09 | 4409.52 | |
| $NO_2$ | kg/hr | 0.02 | 1.73 | |
| **NO** | kg/hr | 1.13 | 0.01 | **99%** |
| **$SO_2$** | kg/hr | 690.34 | 655.82 | **5%** |
| $SO_3$ | kg/hr | 43.31 | 86.44 | |
| $O_3$ | kg/hr | 45.36 | | |

Previous literature results:

- 99% NO, 90% $NO_2$ and ~100% of $SO_2$ was removed at pH 11 before compression[1].
- Byproduct: Sodium nitrate → Fertilizer Sodium sulphate → Paper production[1]

## 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 Aspen Plus.
- 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 $CO_2$ purification technology.

## References


1. J. Zhang et al., "Simultaneous Removal of NO and SO 2 from Flue Gas by Ozone Oxidation and NaOH Absorption," Ind. Eng. Chem. Res., vol. 53, no. 15, pp. 6450–6456, Apr. 2014..