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:

$NO + O_3 \rightarrow NO_2 + O_2$

$CO_2 + NaOH \rightarrow NaHCO_3$

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

$SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$

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

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

$NO_2 + Na_2SO_3 \rightarrow N_2 + Na_2SO_4$

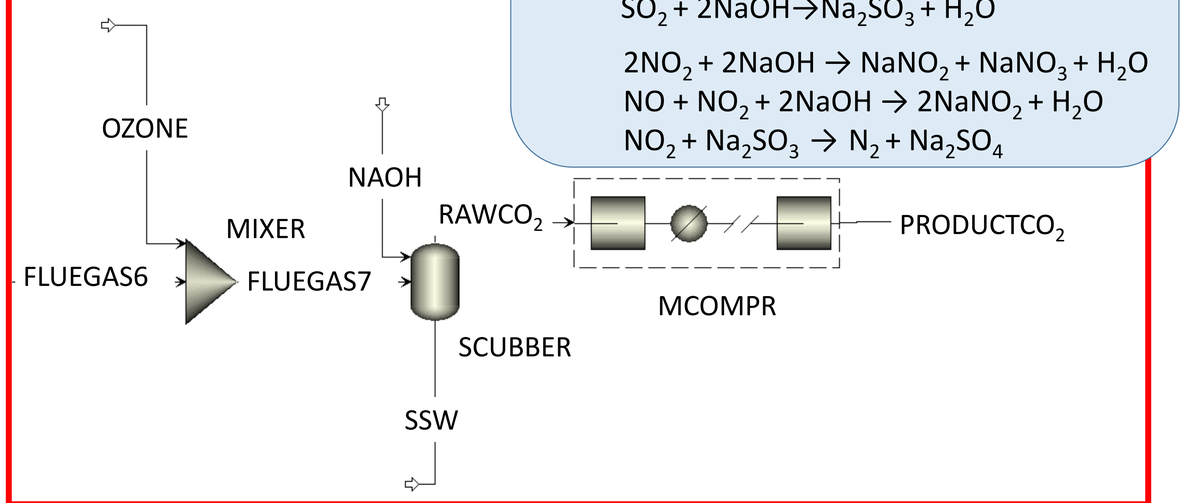

Figure 1 Modelling schematic of ozone-scrubbing for CPU by AspenPlus.

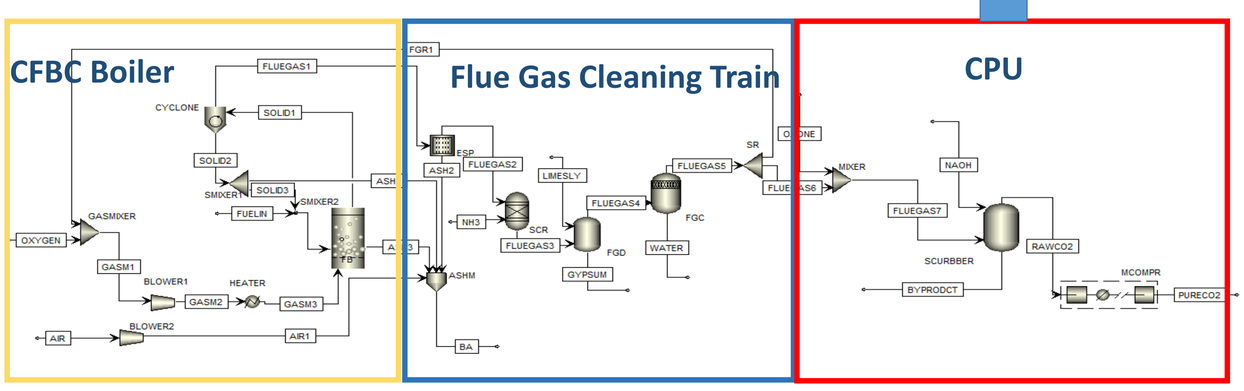

Figure 2 Modelling schematic of oxy-CFBC power plant with ozone-scrubbing for CPU by AspenPlus.

Overview of Current CPU

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

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

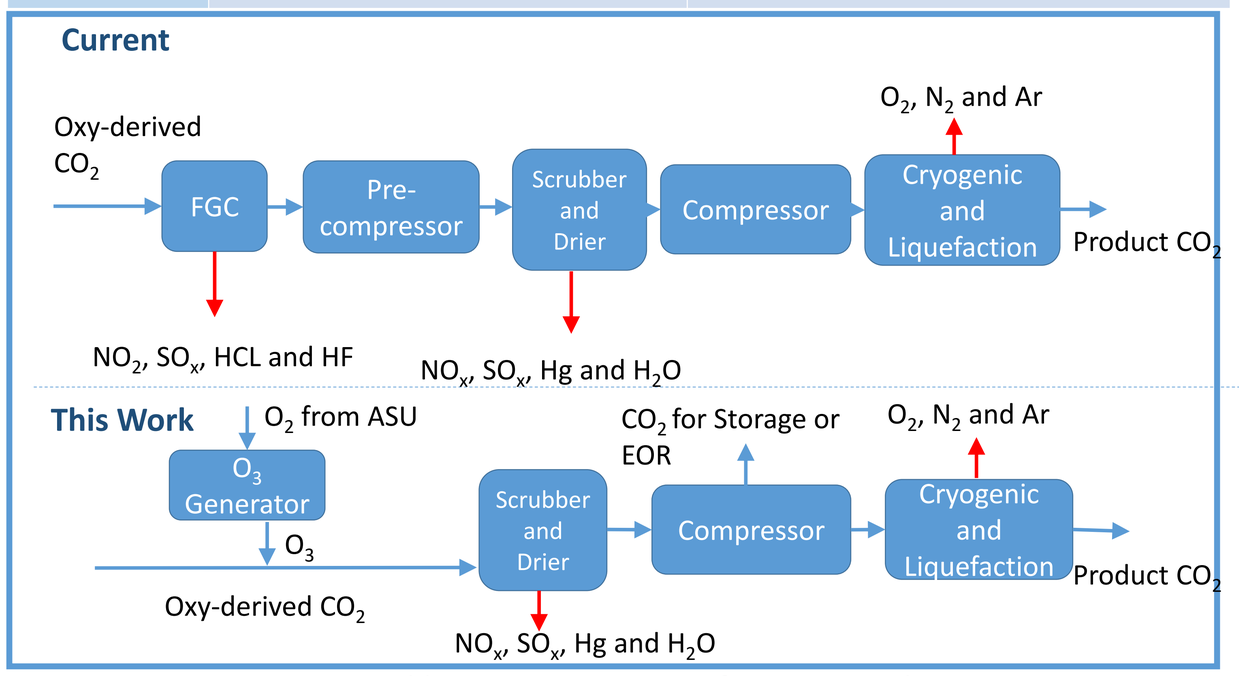

Table 1 Gas composition after ozone oxidation.

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	
O3	kg/hr			

Previous literature results:

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

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.

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 CO_2 purification technology.

References

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

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