Air Products – Flue Gas Purification

Project Title:

Flue Gas Purification Utilizing SO_X/NO_X Reactions During Compression of CO_2 Derived from Oxyfuel Combustion

Technology Area:	**Technology Maturity:**
Oxy-Combustion	Pilot, flue gas, 2.45 tonnes CO_2/Day

Primary Project Goal:

Air Products and Chemicals is designing and developing a system for purifying an oxy-combustion derived flue gas by utilizing the reactions of sulfur oxides (SO_X) and nitrogen oxides (NO_X) that occur during compression, leaving behind a pressurized, pure stream of carbon dioxide (CO_2).

Technical Goals:

- Design and construct a 15-atm reactor system for the removal of SO_X and NO_X from actual oxy-combustion derived CO_2-rich flue gas.
- Evaluate reactor performance based on effluents at different pressures and water recycle rates.
- Characterize the reactor effluents to asses any change in performance.
- Develop an engineering model to describe the 15-atm purification reactor performance.

Technical Content:

Acidic gases must be removed from a CO_2 stream prior to pipeline transportation to avoid corrosion and to comply with purity requirements for applications such as enhanced oil recovery (EOR) and geological storage. In order to address this requirement, Air Products and Chemicals is developing a novel approach to remove SO_X and NO_X from the flue gas by converting them to sulfuric acid and nitric acid.

In order to determine the effect of pressure on sulfur dioxide (SO_2) and nitric oxide (NO) conversion, previous experiments were performed where one standard liter per minute (sl/min) of gas was supplied at both 8 atm and 15 atm. The results are shown in the Table 1.

Table 1: Pressure vs. Conversion

	15 atm			**8 atm**		
	Inlet	**After Compressor and Receiver**	**Conversion**	**Inlet**	**After Compressor and Receiver**	**Conversion**
ppm SO_2	900	20	98%	950	150	84%
ppm NO_X	500	50	90%	390	120	68%

Clearly, the conversion rate increases significantly with pressure. Therefore, it is logical to assume that these contaminants can be removed during the compression of CO_2.

The flue gas pilot development unit (PDU) within this project will include three main units, as indicated below: the scrubber/condenser, the compressor, and the reactor. Fine particulate ash and acid mist in the flue gas will need to be removed prior to compression to avoid damage to the compressor.

The compressor will increase the pressure of the gas from near atmospheric to approximately 16 atm in a multistage adiabatic compressor unit. After the initial compression, the flue gas will be cooled prior to entering the reactor. In the reactor, the flue gas will be contacted with water to obtain complete conversion of SO_2 to sulfuric acid and high conversion of NO_X to nitric acid.

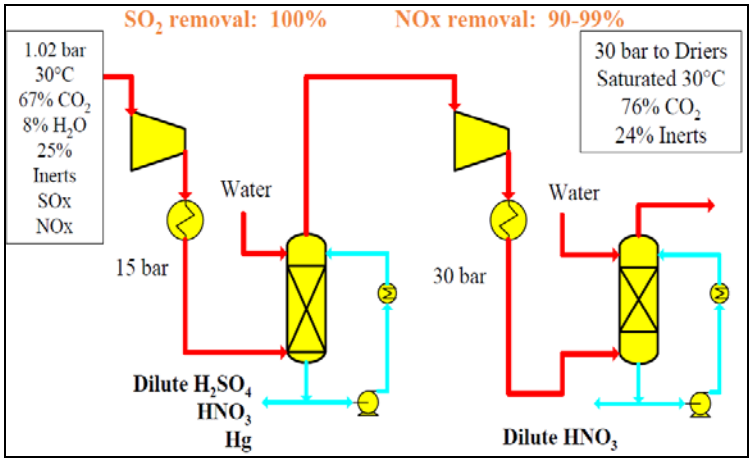

Figure 1: Flue Gas Pilot Development Unit (PDU)

The flue gas will be a 0.3 MWth slip stream supplied by the host site, Alstom Power from a 15 MWth oxy-combustion unit. An estimated composition of the flue gas has been supplied in Table 2.

Table 2: Estimated Flue Gas Composition

Component	% (vol)
CO_2	70 - 80
H_2O	5 - 10
O_2	5 - 8
N_2	7 -13
Ar	3 - 6
SO_2	2500 - 5000 (ppm)
NO_X	1000 - 2000 (ppm)

Technology Advantages:

By incorporating an efficient NO_X and SO_X removal system with a compressor, the need for low NO_X burners, flue gas desulfurization (FGD), and $DeNO_X$ systems are greatly reduced or eliminated for oxy-combustion plants. In particular, this system allows for a degree of freedom to optimize any upstream purification needs and target reduction in size or removal of upstream equipment for the retrofit of an existing plant or the construction of a new plant.

R&D Challenges:

The main challenge is to obtain sufficient data for engineering design and to further develop the understanding of the effect of residence time, pressure, and temperature on the unit performance. The prolonged presence of acid gases in the system and the presence of such gases at high pressures in the

compressor may lead to the requirement of more advanced materials of construction.

Results To Date/Accomplishments:

- Developed a simulation of the flue gas PDU and modeled the reactions occurring within the reactor.
- Conducted simulations to understand the influence of liquid to vapor flow rates on SO_2 and NO_2 conversions as well as overall residence time in the reactor.
- Developed a design specification for the reactor and auxiliary equipment.
- Selected desired compressors.
- Completed construction and installed reactor system at host site.
- Completed initial test campaign.

Planned Activities:

- Evaluate the performance of reactor-based flue gas.
- Develop an engineering model and perform sensitivity analysis.
- Perform small-scale testing of SO_X/NO_X removal.
- Finalize step up to pilot scale for CO_2 purification and compression.

Final test results will not be available until the September 2010 project completion date.

Available Reports/Technical Papers/Presentations:

Fact Sheet. "Flue Gas Purification Utilizing SO_X/NO_X Reactions During Compression of CO_2 Derived from Oxyfuel Combustion." http://www.fe.doe.gov/fred/factsheet.jsp?doc=6356&projtitle=Flue Gas Purification Utilizing SO_X/NO_X Reactions During Compression of CO_2 Derived from Oxyfuel Combustion. (Accessed 9/16/2009).

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