Nitrogen Evolution with Oxy-fuel Combustion

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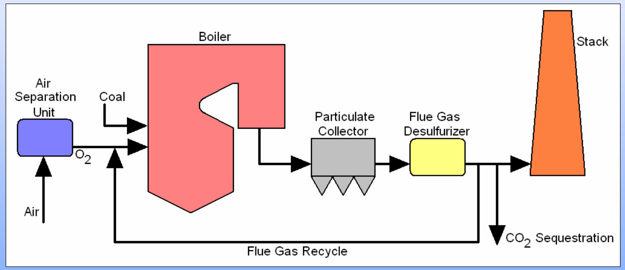
Background

Oxy-fuel combustion has been previously demonstrated on pilot-scale reactors showing the feasibility of producing a sequestration-ready CO_2-rich stream. These reported tests; however, also showed a significant reduction in NO_x emissions. Since the majority (~80%) of NO_x emissions from coal-fired boilers originates from fuel-N and not atmospheric N_2 it is unclear what mechanisms are responsible for the lowered NO_x emissions.

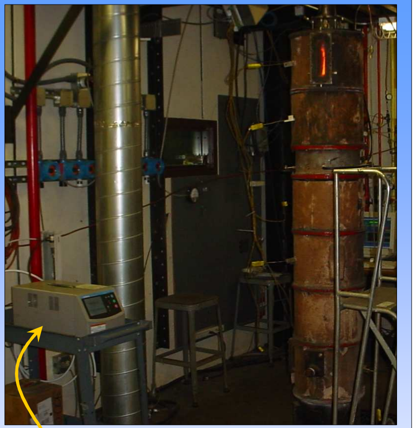
Understanding of how NO_x emissions are reduced in oxy-fuel combustion will lead to the ability to optimize a system for NO_x abatement.



Oxy-fuel combustion for coal fired power plants:
Produces a sequestration-ready CO_2-rich stream and lower NO_x emissions

Objectives

1. Demonstrate NO_x reduction with oxy-fuel combustion (relative to air combustion) in laboratory conditions.
2. Determine the mechanisms by which NO_x reduction is obtained in using oxy-fuel combustion.

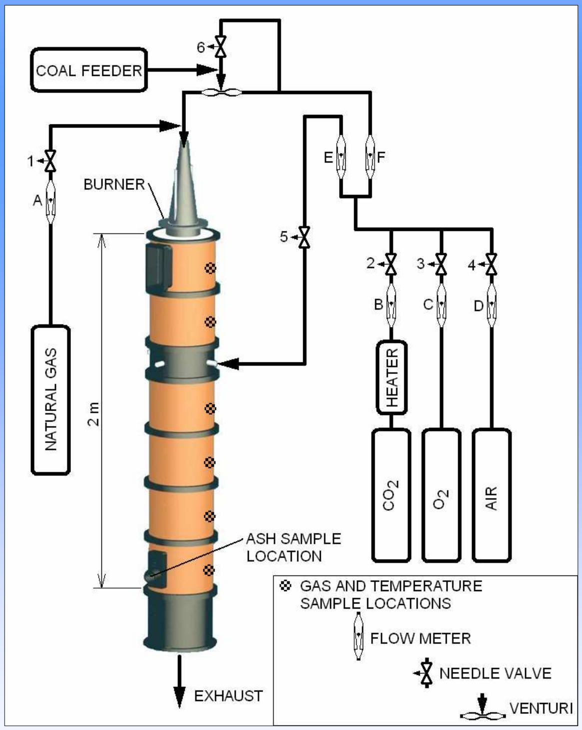


HORIBA PG-250
Portable Gas analyzer

- **NO**
- **O_2**
- **SO_2**
- **CO**
- **CO_2**

Near-burner Window

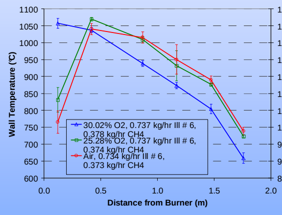
Research Facilities



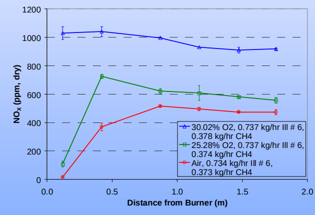
Multi-fuel Reactor
Configured for Staged Oxy-fuel Combustion

Results – fuel lean combustion

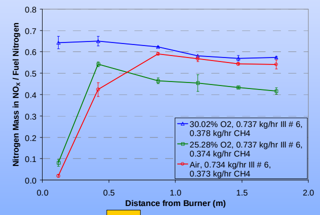
Wall Temperatures

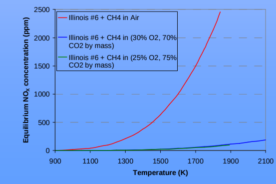


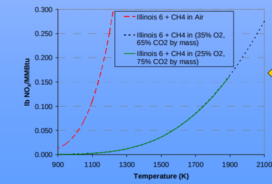
Raw NO_x Data



Fuel Specific NO_x







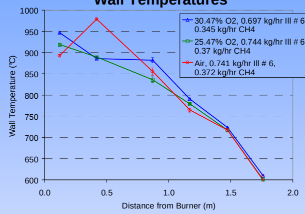
Falling NO_x concentrations may be due to low equilibrium values in oxy-fuel combustion.

Results – staged combustion

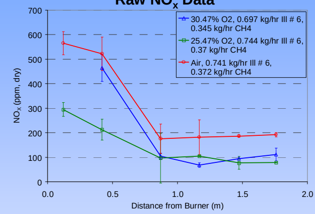
$$\text{fuel specific } NO_X \approx \frac{\left[\frac{NO_{measured}(ppm)}{1,000,000}\right]\dot{M}_{reactants}}{\dot{M}_{fuel-N}}$$

Total Mass Flow Rates (kg/hr)					Stoichiometry				
Coal	CH_4	Air	O_2	CO_2	Oxidizer to Burnout Section	Primary Stage SR	Sec. Stage SR	Oxidizer Mass % O_2	Oxidizer Molar % O_2
0.741	0.372	16.8	-	-	28%	0.75	1.05	23.3%	21%
0.744	0.370	-	3.886	11.37	28%	0.75	1.04	25.5%	32%
0.697	0.345	-	3.562	8.127	28%	0.73	1.02	30.5%	38%

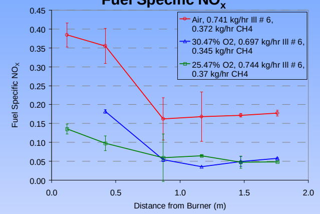
Wall Temperatures



Raw NO_x Data



Fuel Specific NO_x

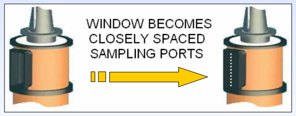


Conclusions

1. In fuel-lean combustion, equilibrium values of NO_x are significantly lower in oxy-fuel cases than in air. This provides a greater driving force for thermal destruction of NO_x in oxy-fuel combustion.
2. In staged combustion:
   - Rapid destruction of NO_x occurred in the fuel-rich zone for all cases.
   - Oxy-fuel cases produced two thirds less NO_x than an air case.
   - The difference in NO_x between oxy-fuel and air cases appears to originate from differences in NO_x formed close to the burner. The reduction is therefore attributed to lower formation rates and not to a reduction in NO_x after formation.

Future Work

1. Collect NOx data with increased spatial resolution near the burner by replacing a near-burner window with sampling ports:



2. Staged air combustion with O_2 enrichment to determine the importance of O_2 concentration to NO_x formation independent of CO_2.
3. Staged combustion with initially high levels of NO (~500 ppm) in the reactants to determine the extent of reburning when products are recycled in oxy-fuel combustion.

Acknowledgements

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