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Project Summary

Evaluation of Innovative Combustion Technology for Simultaneous Control of SO_x and NO_x

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Results are reported on the operation of a 13.8 kW (47,300 Btu/hr) Limestone Injection Multistage Burner (LIMB) furnace. Furnace characterization, general sorbent survey, and calcium silicate test results are presented. Several candidate sorbent materials for the full scale LIMB demonstration at Edgewater Station in Ohio were evaluated. SO_2 capture was measured while firing Pittsburgh No. 8 coal (2.6% sulfur) and natural gas spiked with SO_2. Sorbent was injected at 1210°C (2210°F). With a furnace quench rate of 260°C/s (468°F/s), the average residence time at reaction temperatures was 1.3 s. At Ca/S molar ratios of 2, Vicron 45-3 limestone reduced SO_2 emissions 38% from baseline levels. Increased SO_2 capture rates of 60-69% were measured for various calcitic atmospheric hydrates. Dolomitic sorbents were able to achieve captures of 73-75% and showed no significant difference between atmospheric and pressure hydrates. With the addition of sodium bicarbonate ($NaHCO_3$) at molar Ca/Na = 15, captures of 83 and 88% were possible for the calcitic and dolomitic hydrates, respectively. Sodium bicarbonate was evaluated as a fuel additive as well as a sorbent additive.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background

The environmental impact of nitrogen and sulfur oxides (NO_x and SO_x) emissions from fossil fuel power stations has been an area of major concern. Because of the possible link between these emissions and environmental problems such as acid rain, the U.S. Environmental Protection Agency (EPA) has been involved in developmental studies of in-furnace control technologies. The reduction of NO_x emissions through staged burner systems has been developed and demonstrated in the field. One method to achieve simultaneous reductions in SO_x emissions is the injection of a sorbent material in or just downstream of the flame zone. Because of early efforts in which a staged low NO_x burner was combined with limestone sorbent injection through the burner itself, the technology has been called Limestone Injection Multistage Burner or LIMB. More recently, the term "LIMB" has become generic and includes in-furnace sorbent injection using materials other than limestone and injection locations somewhat removed from the burners.

As part of EPA's developmental studies into control technologies for SO_x and NO_x emissions, a contract was entered into by EPA to operate and collect data from its pilot-scale Innovative Furnace. Since October 1, 1984, this contract has provided operation, maintenance, and design support as well as planning, data reduction, and reporting the results of the experimental program. Operation of the Innovative Furnace under this contract ended on September 31, 1985. This project report presents information on the facility design, experimental procedures, sorbents, results, and conclusions. A Quality Control Evaluation Report is included in the main body of the project report.

Test Facility

EPA's Innovative Furnace is a down-fired, refractory lined cylinder with an internal diameter of 15.2 cm (6 in.). The plant is nominally rated at 29.6 kW (100,000 Btu/hr, thermal) on either a gaseous fuel or pulverized coal. Burner swirl is fully adjustable and the amount of staging may be selected by primary, secondary, and tertiary air flows. The furnace was equipped with SO_2, CO, CO_2, NO/NO_x, THC, and oxygen continuous monitors. Particulate samples were collected on glass fiber filters by a prototype method.

Facility Operation

A standardized test plan for the evaluation of sorbents and sorbent/additive mixtures was followed. The plan called for holding the furnace firing conditions constant while varying the sorbent type, feed rate, injection point, and fuel type. A test matrix was devised in which each sorbent would be evaluated under similar conditions according to the standardized test plan.

Before testing a new sorbent, procedures to ensure correct feeding were followed. The feed rates required to obtain Ca/S ratios of 1 and 2 in the combustion zone were calculated from chemical analysis of the sorbent. The sorbent feeder was recalibrated for each sorbent of different bulk density. If the new sorbent material contained an additive, the sorbent and additive were thoroughly mixed for 30 minutes.

Sorbents

Table 1 summarizes the physical and chemical analyses of the sorbents tested.

Results and Conclusions

Table 2 summarizes the SO_2 removal efficiencies for some of the sorbent/coal/additive combinations tested in this study.

The major environmental conclusions of the evaluation program are:

- Testing with Pittsburgh No. 8 coal gave a good representation of the performance of the candidate demonstration sorbents with the Boich mine demonstration coal.
- At Ca/S molar ratios of 2, maximum measured SO_2 capture efficiencies were 38% for Vicron limestone, 69% for Marblehead calcitic atmospheric hydrate, and 75% for Ivory Finish pressure hydrated dolomitic lime.
- Increased SO_2 capture efficiencies occurred at higher Ca/S ratios; however, calcium utilization efficiencies decreased.
- A 17-20% increase in SO_2 capture efficiency resulted when the promoter $NaHCO_3$ was added to the reaction zone at a Ca/Na molar ratio of 15.
- The promotional effect was maxim-

Table 1. Sorbent Analysis

Sorbent	Mass Mean Particle Diameter (μm)	BET Surface Area (m^2/g)	Chemical Properties (wt %)					
			Ca	Mg	Na	H_2O	CO_2	SO_4
Vicron Limestone	11.0	1.01	39.01	0.49	0.022	BDL	43.6	0.04
Fisher Technical Grade $Ca(OH)_2$	NR	12.8	55.0	0.26	BDL	23.2	1.2	BDL
PC III Calcium Silicate	NR	12.0	36.9	NR	NR	6.4	11.6	BDL
Grantsville DPH	NR	24.7	34.0	23.2	BDL	24.2	2.4	BDL
Henderson DPH	NR	16.5	31.5	21.4	BDL	24.5	1.8	BDL
Southwestern Public Utilities CAH	NR	NR	57.3	NR	NR	NR	NR	NR
Mercer CAH	7.10	17.8	50.5	0.4	0.098	22.0	BDL	BDL
Kemikal CAH	3.88	18.0	49.0	1.0	0.075	23.2	1.2	BDL
Marblehead CAH	7.79	14.3	50.3	0.49	0.01	21.6	1.2	0.13
Detroit Lime CAH	8.33	14.9	50.2	0.51	0.02	22.4	0.4	0.21
Black River CAH	5.53	13.3	49.7	1.6	0.01	21.6	BDL	BDL
Kemidol DAH	19.71	20.6	29.9	18.5	0.17	22.4	3.2	BDL
Ivory Finish DPH	13.72	18.4	18.1	18.1	0.01	23.6	2.8	BDL

BDL = Below Detection Limits.
CAH = Calcitic Atmospheric Hydrate.
DAH = Dolomitic Atmospheric Hydrate.
DPH = Dolomitic Pressure Hydrate.
NR = Not Reported.

Table 2. Summary of SO_2 Capture

Sorbent	Additive	Additive Location	Fuel	Ca/S Molar Ratio	SO_2 Reduction (%)
Vicron 45-3 Limestone	none	--	Pitt #8	2	38
Mercer CAH	none	--	Pitt #8	2	59
Kemikal CAH	none	--	Pitt #8	2	62
Marblehead CAH	none	--	Pitt #8	2	69
Detroit Lime CAH	none	--	Pitt #8	2	60
Black River CAH	none	--	Pitt #8	2	61
Kemidol DAH	none	--	Pitt #8	2	73
Ivory Finish DAH	none	--	Pitt #8	2	75
BNL Portland Cement	none	--	CH_4/SO_2	2	14.6
BNL Portland Cement	none	--	Pitt #8	2	9.7
Marblehead CAH	$NaHCO_3$	w/sorbent	Pitt #8	2	79
Marblehead CAH	$NaHCO_3$	w/fuel	Pitt #8	2	83
Kemidol DAH	$NaHCO_3$	w/sorbent	Pitt #8	2	84
Kemidol DAH	$NaHCO_3$	w/fuel	Pitt #8	2	85
Marblehead CAH	none	--	Pitt #8 Demo	2	70
Marblehead CAH	none	--	Pitt #8	1.5	55

ized when $NaHCO_3$ was mixed with the coal rather than with the sorbent, possibly indicating a process for vaporization and deposition for the additive.

- The PC III (Portland Cement) sorbent tested in EPA's Pilot Furnace was unable to provide a significant reduction in SO_2 emissions. The performance of the material was well below that of other sorbents tested to date.

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The complete report entitled "Evaluation of Innovative Combustion Technology for Simultaneous Control of SO_x and NO_x," (Order No. PB 87-188 926/AS; Cost: $24.95, subject to change) will be available only from:
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