



Project Summary

Evaluation of Simultaneous SO₂/NO_x Control Technology

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The Clean Air Act Amendments of 1990 (CAAA) have led to accelerated research into novel sulfur dioxide (SO₂) and nitrogen oxide (NO_x) control technologies for coal-fired industrial boilers. One of these technologies combines sorbent injection and selective non-catalytic reduction for simultaneous SO₂/NO_x removal. The work presented herein concentrated on characterizing three process operational parameters of this technology: injection temperature, sorbent type, and reductant/pollutant stoichiometric ratio. A slurry composed of a urea-based solution (NO_x OUT A or NO_x OUT A+) and various calcium-(Ca-) based sorbents was injected at a range of temperatures and reactant/pollutant stoichiometries in a natural-gas-fired, pilot-scale reactor with doped pollutants. Up to 80% reduction of SO₂ and NO_x at reactant/pollutant stoichiometric ratios of 2 and 1.5, respectively, was achieved. SO₂ emission reductions from slurry injection were enhanced moderately when compared with dry sorbent injection methods, possibly caused by sorbent fracturing to smaller, more reactive particles. Emissions from ammonia (NH₃) slip (unreacted nitrogen-based reducing agent) and nitrous oxide (N₂O) formation were reduced in comparison with other published results, while similar NO_x reductions were obtained. Increased carbon monoxide (CO) emissions, caused by the decomposition of urea, were moderate. Emissions of CO, NH₃, and N₂O for the enhanced urea solution (NO_x OUT A+) were substantially less than the levels observed dur-

ing urea (NO_x OUT A) injection. The injection of the urea-based solution enhanced SO₂ removal, probably because of the formation of (NH₄)₂CA(SO₄)₂ · H₂O. The results of this pilot-scale study have shown high reduction of both SO₂ and NO_x.

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).

Introduction

The project work reported here was initiated through a Cooperative Research and Development Agreement (CRADA) between EPA and Nalco Fuel Tech, a commercial licensor of a urea-based reducing agent injection technology for NO_x reduction.

Experimental testing of Nalco Fuel Tech's urea-based NO_x OUT A and NO_x OUT A+ reducing agents for NO_x control, in combination with Ca-based sorbent injection for SO₂ control, was conducted from June to November 1991. Testing was performed at EPA's Environmental Research Center in Research Triangle Park, NC, in a pollutant-doped, natural-gas-fired 50,000 Btu/h (15 kW) furnace.

The project scope of work included testing furnace sorbent injection of several Ca-based sorbents to remove SO₂ from flue gas. The tested sorbents came from a single source of commercially prepared slaked lime [Ca(OH)₂], limestone (CaCO₃), and quicklime (CaO). A comparison of



SO₂ removal efficiency was made between dry and slurry injection. The effect of Ca(OH)₂ sorbent particle size was also studied.

Slurry sorbent injection was found to be superior to dry injection for SO₂ removal. Dry injection of Ca(OH)₂ achieved a maximum of 60% SO₂ removal (at a Ca/S ratio = 2), while the Ca(OH)₂ slurry removed 72%. Removal efficiency with Ca(OH)₂ was superior to that with CaCO₃ in both dry (43%) and slurry (58%) testing. CaO was tested in slurry form by slaking to form Ca(OH)₂ slurry, and compared to the commercially prepared Ca(OH)₂. The slaked CaO proved identical in its SO₂ removal performance to the commercially prepared Ca(OH)₂.

Both NO_xOUT A and NO_xOUT A+ achieved maximum NO_x removal when injected at a temperature of about 1,100 °C. Almost no difference in the two reducing agents existed at the optimum temperature; approximately 80% NO_x removal was observed for both reducing agents. At temperatures higher than the optimum, NO_x removal efficiency dropped quickly. At about 1,170 °C, the reducing agents be-

gan producing NO_x, caused probably by high temperature oxidation of the NH₃ produced by urea decomposition. At temperatures lower than the optimum, NO_x removal efficiency gradually decreased.

Varying the molar ratio of reducing agent (urea) to baseline NO_x, or N/NO_x, showed that increasing N/NO_x to a value of near 2 produced significant improvement in NO_x removal. Further N/NO_x increases had little or no effect on removal efficiency.

The work mentioned above also entailed characterizing NH₃, N₂O, and CO emissions produced by injecting the reducing agent over a range of temperatures and N/NO_x. Each reducing agent produced maximum NH₃ slip (unreacted nitrogen-based reducing agent) at the lower injection temperatures; around 821 °C, the amount of slip was about 140 ppm for both NO_xOUT A and NO_xOUT A+. As injection temperature increased, NH₃ slip for the NO_xOUT A decreased quickly, while slip from NO_xOUT A+ dropped off almost completely at around 875 °C. At 900-1,000 °C, slip generated by NO_xOUT A gradually decreased to a level of about 60 ppm. Throughout this temperature re-

gime, NO_xOUT A+ produced negligible NH₃ slip (<10 ppm).

CO emissions produced by NO_xOUT A rose gradually from about 20 ppm at 800 °C to a maximum of 25 ppm at 1,100 °C. NO_xOUT A+ produced low CO at 800-1,000 °C (<10 ppm), with a maximum of 50 ppm around 1,100 °C.

N₂O production by NO_xOUT A was negligible at lower injection temperatures (approximately 25 ppm), but increased with injection temperature to a maximum of 200 ppm at approximately 1,150 °C, about 42% of the NO_x reduced. NO_xOUT A+ produced only moderate levels of N₂O (typically <40 ppm, less than 20% of the NO_x reduced) over the entire temperature range. A maximum of about 30 ppm was observed at around 1,150 °C.

Aqueous ammonia solution was injected to ensure that these results would be reproducible on other facilities. Available data for NO_x removal using aqueous ammonia injection showed comparable results to others' work. These data validated improvements shown by this work with both NO_xOUT solutions and suggested the applicability of these results to other facilities.

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The complete report, entitled "Evaluation of Simultaneous SO₂/NO_x Control Technology," (Order No. PB94-114741/AS; Cost: \$27.00; subject to change) will be available only from:

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U.S. Environmental Protection Agency
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*U.S. Government Printing Office: 1994 — 550-067/80136

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