United States
Environmental Protection
Agency

Air and Energy
Engineering Research Laboratory
Research Triangle Park NC 27711

Research and Development

EPA/600/S7-88/020 Jan. 1989

EPA

Project Summary

Evaluations of Electrostatic Precipitator Performance at Edgewater Unit 4 LIMB Demonstration

John P. Gooch and James L. DuBard

The EPA is sponsoring a demonstration of Limestone Injection Multistage Burners (LIMB) technology at Ohio Edison's Edgewater Station Unit 4, which employs a wall-fired boiler of 105 MW electric generating capacity. The boiler is equipped with large electrostatic precipitator (nominal SCA 600 ft²/1000 acfm* at 528,000 acfm) of modern design that was retrofitted in 1982. This report describes extensive laboratory- and pilot-scale studies, as well as preliminary on-site tests at Unit 4.

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

Coal-fired utility boilers account for approximately 70% of the SO_x emissions and 20% to 25% of the NO_x emissions in the U.S. These emissions are believed to be precursors of acid precipitation. The coal-fired electric generating capacity east of the Mississippi River (approximately 180,000 MW) accounts for 16 million tons of SO_x and 4 to 5 million tons of NO_x discharged into the atmosphere annually. Only about 10% of the coal-fired utility boilers in the eastern U.S. are subject to SO_x and NO_x emission controls under the New Source Performance Standards (NSPS). A significant reduction of SO_x and NO_x emissions may require retrofit applications of emission control technology to the existing boiler population.

LIMB technology is a retrofit SO_x and NO_x emission control technology which may be applicable to a significant number of existing wall-fired and tangentially fired boilers. LIMB technology involves injecting a calcium-based sorbent directly into a furnace that is equipped with low-NO_x burners. Since 1986, the development of LIMB technology has focused on furnace injection of hydrated lime, at about 2200°F, with subsequent humidification of the combustion gas downstream of the heat exchangers. The particulate matter suspended in the combustion gas stream (fly ash and partially sulfated sorbent) must be collected in an existing electrostatic precipitator (ESP).

Candidates among existing boilers for a retrofit application of LIMB technology are mostly equipped with small ESPs that were designed to collect low-resistivity fly ash from high-sulfur coal combustion. These ESPs typically have specific collection areas (SCA) less than 300 ft²/1000 acfm. A retrofit application of LIMB technology will result in changes in the suspended particulate matter that

*Readers more familiar with metric units may use the conversion factors listed near the end of this summary

present a difficult challenge to these ESPs.

The EPA is sponsoring a demonstration of LIMB technology at Ohio Edison's Edgewater Station Unit 4, which employs a wall-fired boiler of 105 MW electric generating capacity. This particular unit has a large ESP (nominal SCA 600 ft^2/1000 acfm at 528,000 acfm) of modern design that was retrofitted in 1982.

LIMB tests, with furnace injection of pulverized limestone, began during 1984 in a 1 million Btu/hr pilot coal combustor. The early tests focussed on calcium utilization and SO_x removal issues, but some data were also obtained on the changes in dust resistivity, mass loading, and particle size distribution that impact ESP performance. During 1985, the emphasis in LIMB development shifted to furnace injection of hydrated lime. Measurements of the changes in dust properties caused by LIMB were used to perform preliminary estimates of the impact of LIMB on the Edgewater Unit 4 ESP, using the mathematical model. The data from the pilot coal combustor were also used to estimate the impact of LIMB on small ESPs with SCAs in the range of 200 to 300 ft^2/1000 acfm. The experimental data and the results of mathematical modeling have been reported.

The master plan for a demonstration of LIMB technology included preliminary tests of the impact of LIMB on the EPA mobile pilot ESP. The pilot ESP was refurbished and installed on a combustion gas sidestream from a heating plant boiler in Oromocto, New Brunswick, for the purpose of evaluating operating problems and performance upgrading methods prior to the Edgewater demonstration project. However, satisfactory boiler operation with LIMB could not be achieved in the allotted time period before the pilot ESP was moved to the Edgewater demonstration site. Therefore, the pilot coal combustor was the only significant source of data on LIMB dust properties prior to the preliminary LIMB trials at Edgewater Unit 4 during September, 1987. Following the preliminary LIMB trials, which were conducted without humidification of the combustion gas stream, extensive tests of the impact of humidification on ESP performance were conducted during January and February 1988. Results of these tests have been reported.

Summary of Results and Conclusions

This section summarizes the principal findings related to the impact of LIMB on ESP performance, both from the preliminary LIMB trials at Edgewater Unit 4 and from tests in the pilot coal combustion facility with a laboratory ESP installed on the combustion gas stream. The principal findings cover dust resistivity, electrical and mechanical operation, dust loading and particle size distribution, electrode dust accumulation and cleaning, and mass emissions and opacity.

Dust Resistivity

Edgewater Unit 4

- During baseline operation, the dust resistivity measured *in situ* at the ESP inlet averaged $3x10^{10}$ ohm-cm at 350°F.
- During operation with LIMB, the dust resistivity was too high to be measured accurately with the point-plane *in situ* resistivity probe. The measured values were in the range of $1x10^{12}$ to $5x10^{12}$ ohm-cm, at 300° to 360°F, but the actual values are believed to have ranged as high as $1x10^{14}$ ohm-cm.

Pilot Facility

- Laboratory measurements of LIMB dust resistivity indicated values as high as $1x10^{14}$ ohm-cm at the operating temperatures experienced in the Edgewater Unit 4 ESP.
- Cold-side combustion gas stream humidification was found to be an effective means of moderating LIMB dust resistivity. The resistivity values (measured both *in situ* and in the laboratory) dropped over two orders of magnitude at temperatures of approximately 220°F, representing about a 100°F approach to the adiabatic saturation temperature.
- LIMB dust resistivity is expected to be below $1x10^{12}$ ohm-cm within a 100°F approach to saturation, and below $1x10^{10}$ ohm-cm within a 50°F approach to saturation.

Electrical Operation

Edgewater Unit 4

- During baseline operation, there was no evidence in the measured transformer-rectifier secondary voltage-current curves of any electrical or mechanical malfunction.
- During operation with LIMB, there was severe electrical malfunction caused by the high resistivity of the precipi-tated LIMB dust. Electrical degradation began in the ESP inlet field and progressed to the fifth field within three to four hours of operation with LIMB. Electrical degradation resulted in the immediate onset of back corona at the threshold voltage for primary corona. There was no working voltage range which would permit useful electrification of the ESP.

Pilot Facility

- Furnace sorbent injection caused severe electrical degradation of the laboratory ESP. Humidification within a 100°F approach to saturation was necessary to permit useful electrification of the ESP.
- At a fixed operating voltage applied to the laboratory ESP, the operating current increased with increasing humidification and closer approach to saturation.

Mechanical Operation

Edgewater Unit 4

- During an internal inspection of the ESP after furnace sorbent injection, there was no evidence of any serious electrode misalignments or electrode cleaning difficulties. The ESP appeared to be in good mechanical operating condition. However, problems were encountered with the ash removal system during the LIMB tests.

Dust Loading and Particle Size Distribution

Edgewater Unit 4

- LIMB had an adverse impact on the mass loading and particle size distribution of dust entering the ESP. The overall mass loading increased by about a factor of two.
- During operation with LIMB, the mass loading increased by about a factor of 10 in the particle size range from 0.5 to 1.0 μm. This is the particle size range where ESPs are least efficient and the particulate emissions contribute most strongly to plume opacity.

Pilot Facility

- Furnace injection of hydrated lime resulted in changes in the suspended particulate matter that were consistent with data from the preliminary LIMB trials at Edgewater Unit 4. At a typical Ca/S stoichiometry of about 2, the overall mass loading increased by a factor of 2 to 3, and the fine particulate mass loading increased about tenfold.

Electrode Dust Accumulation and Cleaning

Pilot Facility

- There was a rapid accumulation of dust deposits on the laboratory ESP electrodes during furnace sorbent injection and combustion gas stream humidification. Dust deposits on the high voltage discharge electrodes built up very rapidly.
- There was no difficulty in cleaning the ESP electrodes by mechanical rapping, even at a close approach to adiabatic saturation. LIMB dust was removed more easily than the fly ash from pulverized coal combustion.

Mass Emissions and Opacity

Edgewater Unit 4

- During baseline operation, the ESP operated with a clear stack. Opacity readings were in the range of 1% to 2%.
- During operation with LIMB, opacity rose rapidly to the 20% limit after electrical degradation began in the fifth ESP field. Steady state operation of the ESP with LIMB was not achieved during the preliminary trials. Furnace sorbent injection had to be stopped after 3 to 4 hours to avoid exceeding the opacity limit.
- Mathematical modeling of the ESP performance during cold-side humidification of the combustion gas stream indicated that the performance will be satisfactory within a 100°F approach to saturation because of the large size of the ESP.

Pilot Facility

- There was no catastrophic spontaneous reentrainment from the laboratory ESP electrodes of humidified LIMB dust, as humidification was increased all the way to the point of adiabatic saturation.
- Spontaneous reentrainment of precipitated LIMB dust occurred in large agglomerates which did not affect the measured outlet gas opacity. In an operating ESP, these agglom-erates would be quickly recollected.
- The outlet gas opacity decreased (concurrently with the increasing operating current) with increasing humidification and a closer approach to saturation.
- The outlet gas opacity decreased by several percentage points after the laboratory ESP electrodes were rapped. This performance improvement is a result of the improved electrical operating condition obtained with cleaner electrodes.

Future Work

A long term demonstration of LIMB technology with humidification is planned at Edgewater during the last part of CY 1988. The test plan for the demonstration includes evaluations of the performance of the full scale ESP with humidification. Pilot-scale studies are also planned with the EPA pilot ESP system. These experiments will focus on performance enhancements which may be achieved with electrode modifications and humidification on ESPs with smaller SCA values that are more typical of the potential LIMB retrofit candidate population than the large ESP installed at Edgewater.

Metric Equivalents

Readers more familiar with metric units may use the following equivalents to convert from the nonmetric units used in this summary:

Nonmetric	Multiplied by	Yields metric
Btu/hr	0.293	W
cfm	0.000472	m^3/s
°F	5/9 (°F - 32)	°C
ft^2	0.0930	m^2
ton	907.18	kg

John P. Gooch and James L. DuBard are with Southern Research Institute, Birmingham, AL 35255.
The complete report entitled, "Evaluations of Electrostatic Precipitator Performance at Edgewater Unit 4 LIMB Demonstration," (Order No. PB 89-109 177/AS; Cost: $15.95, cost subject to change)will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Air and Energy Engineering Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

Official Business
Penalty for Private Use $300

EPA/600/S7-88/020