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Project Summary

Wall-Fired Boiler Design Criteria for Dry Sorbent SO_2 Control with Low-NO_x Burners

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Recently, attention has focused on dry sorbent SO_2 control technology which, in conjunction with low-NO_x burners, can reduce two main acid rain precursors, SO_2 and NO_x. This report assesses the impact of Limestone Injection Multistage Burner (LIMB) technology on wall-fired utility boilers for both new and retrofit designs.

Past and ongoing development work is reviewed to form a basis for the remaining evaluations.

Historical and projected design trends are examined for unit sizes, heat release rates, fuel properties, and air pollution control systems. Riley Stoker wall-fired boilers are used for the survey and compared with the entire wall-fired, coal-fired utility boiler population.

The influence of dry sorbents and staged combustion burners on boiler design is reviewed and potential problem areas are noted. The review covers the sorbent (including storage and handling), the boiler and its appurtenances, and related flue gas cleanup and handling systems. In addition, a selection rationale is developed for selecting a potential host site for demonstrating the LIMB process.

A generic process design is developed for LIMB systems for both new units and as retrofits to existing units. Three unit sizes are considered — 200, 400, and 600 MWe. Capital and annualized cost estimates are prepared.

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

Renewed interest is being expressed in Limestone Injection Multistage Burner (LIMB) technology as a low cost SO_2 and NO_x control approach for coalfired boilers. During the 1960s and 1970s the technology was investigated with little success. Recent activity has focused on gaining a better understanding of the process fundamentals. This activity has demonstrated that LIMB can be a simple, cost effective control strategy to reduce emissions from coal-fired power plants and utility boilers.

Simultaneous NO_x/SO_2 control systems are applicable to both new and retrofit units. LIMB technology involves the use of low-NO_x distributed-mixing burners with injection into the furnace of an alkali-based solid sorbent for SO_2 removal. The U.S. Environmental Protection Agency (EPA) is taking a leading role in funding the development of such emission control techniques.

One of the major objectives of the EPA's LIMB program is to assess the impact of LIMB technology on utility boiler design. This project develops boiler design criteria for application of dry sorbent SO_2 control technology with low-NO_x burners. It consists of four major tasks:

- A review of the dry sorbent injection technology data base.
- Historical and projected design trends and the implication of implementing the LIMB process.
- Development of a selection rationale for candidate host sites.

- Generation of a generic process design for both new and retrofit units, including capital and annualized cost estimates.

The work was performed by Riley Stoker Corporation and its subcontractors, Energy and Environmental Research Corporation and Stone and Webster Engineering Corporation.

Procedure

The first portion of this project is a review of the dry sorbent data base. It is intended to provide background information on dry sorbent SO_2 control technology. It includes a review of past and ongoing investigations from fundamental SO_2/CaO reaction kinetics to full-scale boiler demonstrations. The data are used later in the project to evaluate the implications of LIMB technology on boiler design, cost, effectiveness, and operability.

Five areas are covered in the report:

- A description of the LIMB process.
- A review of parametric studies of sorbent injection.
- A review of past and planned boiler demonstrations.
- A summary of known and expected impacts of LIMB on boiler operation, availability, and downstream equipment (e.g., electrostatic precipitator) performance.
- A review of possible combinations of LIMB with post-treatment systems.

To aid in evaluating the design changes or features necessary to incorporate dry sorbent SO_2 control on Riley Stoker pulverized-coal-fired boilers, a survey was conducted, going back to 1957. This survey is directed at wall-fired (single or opposed) units but also included the Riley Stoker Turbo Furnace pulverized-coal-fired boiler population for informational purposes. The survey focuses on units with capacities greater than 100 MW. General design and operational parameters are compiled and curves plotted for ease in projecting design trends. For example, furnace geometry and heat releases are shown with respect to time period. By comparing to the entire wall-fired coal-fired boiler population, Riley Stoker units are shown to be representative of the overall group of steam generating units.

The use of dry sorbents to capture SO_2 and its influence on power plant performance is contained in the project report. Field trials, pilot scale results, laboratory tests, engineering analyses, and fundamental process information are used to assess the potential problems which might be caused by the use of dry sorbents in power plants. Each component of the steam generator, its auxiliaries, and associated equipment is evaluated, and potential problems are assessed. Most often, use of dry sorbent injection will not cause any problems in power plant operation; sometimes, minor problems are expected. Three potential problem areas have been identified:

- The uncertainty of the influence of dry sorbent injection on slagging in the radiant furnace and fouling on the convective heat recovery surfaces.
- Increased problems in collecting flyash due to higher resistivities and increased dust loadings.
- Disposal of flyash and dry sorbent wastes because of larger (double) amounts of material and the lack of experience in handling waste which may undergo an exothermic reaction during water sluicing.

The report, utilizing information developed earlier in the project, identifies a selection rationale which can be used in determining an optimum host site. This rationale is used to select potential host sites for retrofit of LIMB technology in order to provide capital and operating costs in another area of the project. The methodology selected can be used to select an individual unit or a complete utility power station. The report covers three broad areas:

- Description of the selection rationale method.
- Retrofit application criteria.
- Identification of candidate units for application of LIMB technology.

The methodology chosen is a decision analysis type. Not all wall-fired coal-fired units or stations are candidates for conversion. Each should be evaluated on its own merits and the potential risks considered before any decisions are made to move ahead. In the selection rationale process, macro and micro views are considered. Objectives are listed and classified as essential or desirable and are not necessarily limited to technical considerations. Economics, space availability, and sorbent type are equally strong factors. Three important areas of concern are: operational features, retrofit requirements, and being representative of current design practice.

The report identifies 42 units suitable for further consideration for retrofit of LIMB SO_2/NO_x control technology. The units were selected from the population of wall-fired pulverized coal utility boilers in the 150-300 MW size range located within the 31-state region east of or bordering the Mississippi River. Regulatory, technical, and economic issues have been considered in developing the list.

A generic process design is developed for low NO_x/SO_2 control systems using dry sorbent injection for SO_2 control on wall-fired coal-fired steam generating units. Second generation low-NO_x burners are utilized for NO_x reductions. Two major categories are considered: those for new unit designs, and those for retrofit of existing units. Additionally, both low and high sulfur coals are utilized for the new unit designs. In each of the three broad categories of units, three sizes are considered, 200, 400, and 600 MWe.

The generic process designs consider various components and systems from sorbent delivery to stack discharge and ash/sorbent collection and disposal. Equipment specifications were developed and, for retrofit units, necessary design changes were incorporated into individual components.

The report develops capital cost estimates for new 200, 400, and 600 MW units burning high sulfur coal and also low sulfur coal. In addition, retrofit requirements are costed out for existing units burning high sulfur coal. Capital cost estimates are also prepared for the new, high sulfur coal plants with two different SO_2 control systems: one set of plants had LIMB in combination with a supplemental dry scrubber, and the other had a wet limestone scrubber.

Total plant costs and differential cost estimates are developed for the various scenarios. Letters of inquiry were sent to various vendors to secure budget estimates for major balance of plant equipment associated with LIMB technology. Boiler costs were supplied by Riley Stoker.

The EPRI Economic Premises dated December 15, 1982 are used for preparing the costs reported herein. The supplement used for retrofit of existing plants was issued May 1, 1983. All estimates were prepared to EPRI Class II tolerances, representing a significant improvement in the quality of the figures over that originally asked for in the study.

The high sulfur fuel used was Illinois No. 6 coal. The low sulfur fuel was Gillette Powder River Basin coal. Limestone was selected for the various analyses performed. Note that, since this study was initiated, the focus on sorbents has shifted, and calcium hydroxide is currently being favored. However, since this study was quite far along, the analyses were

done for limestone. Major conclusions are unchanged.

In all of the case studies, the LIMB-only alternative is the least expensive regardless of size. LIMB-only is acceptable as an SO_2 control technology for retrofit applications. New units require the combination of LIMB and a dry scrubber or the use of a wet scrubber to meet NSPS requirements of 70-90% SO_2 removal.

Results and Discussion

Two of the major precursors of acid rain are NO_x and SO_2. A major source of these precursors is the combustion of coal, much of which takes place in utility boilers for the generation of electricity. The incentives for developing new, simple, cost effective control strategies to reduce emissions are increasing rapidly. One technology — limestone injection in conjunction with multistage (low-NO_x) burners — appears to be viable for both retrofit and new unit designs.

Combined with dry scrubber technology in the back end, LIMB can meet or exceed New Source Performance Standards (NSPS) criteria. In addition, LIMB-only or LIMB in conjunction with back-end clean-up is consistently under the cost of wet flue gas desulfurization (FGD) systems as noted in this report. Cost comparisons are made on the basis of capital investments (dollars per kilowatt based on a January 1986 start-up), levelized busbar power costs in mills per kilowatt hour, and the cost per ton of SO_2 removed. Three plant sizes are used in the comparison studies, 200, 400, and 600 MWe. Additionally, LIMB-only, LIMB with a supplemental dry scrubber, and a wet scrubber system are compared on each analysis.

Costs are obtained for the various technologies from vendor quotations, and estimates are generated based on an EPRI Class II design and cost estimate classification. This puts the project contingencies in the 15-30% range. The vendor quotations are supplemented with recent design studies and purchase costs adjusted to the current cost index. Labor is computed based on labor/material ratios for similar work and adjusted for site conditions and expected average labor rates.

Table 1 represents the cost comparisons arrived at in the report. Only the 400 MWe plant size is used here for the sake of brevity. Low sulfur coal is used for LIMB-only with 70% SO_2 removal, while high sulfur coal with 90% SO_2 removal is used for LIMB with a dry scrubber and the wet FGD system.

Table 1. *Cost Comparisons*

	LIMB-Only	*LIMB W/DS*	*WET FGD*
Capital Costs ($/kW)	*49*	*178*	*274*
Levelized Busbar Costs (mills/kW-hr)	*20*	*27*	*33*
Cost Per Ton of SO_2 Removed ($/ton)	*860*	*910*	*1110*

The comparison shows LIMB-only to be the least costly alternative, although it would not meet present NSPS demands. LIMB with a supplemental dry scrubber can meet the criteria in a cost effective manner.

Conclusions

Based on the work accomplished in this project, LIMB with a supplemental dry scrubber is cost effective and viable (able to meet NSPS requirements) for the reduction of the major acid rain precursors, NO_x and SO_2. On a dollars per ton of SO_2 removed basis, LIMB with a supplemental dry scrubber is approximately 80% the cost of a wet FGD system regardless of whether the plant size is 200, 400, or 600 MW. The cost per ton of SO_2 removed is made up of fixed operating costs, capital costs, variable operating costs, and consumables cost.

The report shows that, on the basis of the extensive studies performed, LIMB should be a major consideration for utilities when reductions in NO_x and/or SO_2 are necessary. Demonstrations, including and in addition to the EPA sponsored project at Ohio Edison's Edgewater plant, would not only provide proof-of-concept, but confirm capital and operating cost levels for the technology.

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The complete report, entitled "Wall-Fired Boiler Design Criteria for Dry Sorbent SO_2 Control with Low-NO_x Burners," (Order No. PB 88-113 485/AS; Cost: $38.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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