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Project Summary

Economics of Retrofitting Big Rivers Electric Corporation's Lime-Based FGD System to Organic-Acid-Enhanced Limestone Operations

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In 1982-83, Peabody Process Systems, Inc. (PPSI) conducted pilot plant tests at the R.D. Green Station of Big Rivers Electric Corporation (BREC). PPSI's final report of the pilot testing included comparisons of the operating costs of a lime-based full-sized absorber, to a retrofit limestone system enhanced with dibasic acid (DBA) or adipic acid. The site specific changes required for BREC to convert their existing lime FGD system to a limestone system enhanced by DBA or adipic acid, and the costs of making such a change are described in this paper. Results of this analysis indicated that an annual cost savings of $2.6 million could be achieved by converting the existing BREC lime system to an adipic-acid-enhanced limestone system, and an annual savings of $3.1 million could be achieved by converting to a DBA-enhanced system.

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

In 1982-83, Peabody Process Systems, Inc. (PPSI) conducted pilot plant tests at the R.D. Green Station of Big Rivers Electric Corporation (BREC). PPSI's final report of the pilot testing included comparisons of the operating costs of a lime-based full-sized absorber, to a retrofit limestone system enhanced with dibasic acid (DBA) or adipic acid. The economics did not include the cost of new equipment required to make the conversion. A second project was funded by the EPA to define the capital requirements necessary for the retrofit, thereby completing the economic comparison.

The existing R.D. Green Station has two 240 MW boilers that use an American Air Filter (AAF) flue gas desulfurization (FGD) system employing a spray tower absorber and dolomitic lime as a reagent. Dolomitic lime enhances SO_2 removal efficiency by accumulating dissolved alkalinity ($MgSO_3$), allowing a relatively low liquid-to-gas ratio (L/G) to be used for the system. Adipic acid and DBA enhance the performance of limestone scrubbing systems such that a mixture of limestone and DBA or adipic acid may be substituted for lime with minor changes to an existing FGD system.

This report addresses the site specific changes required for BREC to convert their existing lime FGD system to a limestone system enhanced by DBA or adipic acid, and the costs of making such a change. Results of this analysis, which was based on site specific capital and raw material costs, indicated that an annual cost savings of $2.6 million could be achieved by converting the existing lime system to an adipic acid enhanced limestone system, and an annual savings of \$3.1 million could be achieved by converting to a DBA-enhanced system.

Required Process Modifications

Prediction of Full-Scale SO_2 Removal Efficiencies with Limestone/Organic Acid

The BREC pilot plant test results could not be used to predict SO_2 removal efficiencies for the full-scale spray tower because wall effects reduced the spray zone mass transfer effectiveness for the pilot plant operations. An attempt was made to compare the existing BREC spray tower performance to that of the 10 MW Shawnee spray tower. Typically, larger diameter spray towers are more efficient than the 10 MW Shawnee spray tower; consequently, use of the 10 MW data for predicting full-scale performance should be conservative.

However, a direct comparison of the operation of the full-scale BREC spray tower to the Shawnee operations could not be made since much of the required process data (Mg^{++} concentration, pH, L/G, inlet SO_2 concentration, and temperature) were not available. For this reason, semi-empirical equations (developed by Bechtel for limestone scrubbing with adipic acid) were used to estimate full-scale liquid pumping requirements for achieving 90 percent SO_2 removal as a function of inlet SO_2 concentration.

Adipic acid and liquid pumping requirements for the retrofit were calculated for several inlet SO_2 conditions. Increased L/G rates would be obtained by increasing the rpm of the existing recycle pumps to the capacity of the existing motors. Calculation results showed that, even at the highest sulfur coal, there is sufficient pumping capacity for meeting compliance when 3,000 ppm of adipic acid is used.

Basis for Retrofit Equipment Design

The ultimate coal analysis typical of coal burned at BREC was used as a basis for combustion calculations, which assumed an excess air rate of 50 percent and a coal feed rate of 277,000 lb/hr* which were consistent with operating conditions measured in a series of test to evaluate the performance of BREC's ESP. Combustion calculation results were also consistent with measured values and were thus used as the basis for performing material balance calculations to establish required equipment sizes.

*1 lb = 0 454 kg.

Retrofit Equipment Required

The existing lime system would be converted by utilizing as much existing equipment as possible. Only a ball mill and organic acid feed system will be added. No changes to the absorption portion of the system were required.

An existing equipment list of the BREC FGD system was prepared jointly by PPSI and BREC. A site visit was made by PPSI engineers to determine possible use of existing equipment in the limestone retrofit and to locate sites for new equipment construction.

Existing lime silos will be used to store coarse limestone; however, the lime slakers will not be operated. Three 50 ton/hr* ball mills (one spare) will be housed in an electrically heated building near the existing silos. DBA or adipic acid storage and handling facilities will also be in the ball mill area. Conveyors have been priced to transport the crushed limestone from the storage silos to any of the three ball mill feeds. Supernate, tapped from a nearby 6 in.* line, will be used to slurry the limestone, and the organic acid will also be added to the ball mill. A crane was priced for new ball addition to the ball mill.

Tanks, pumps, and agitators for the limestone/organic acid feed system were sized and priced based on maximum coal feed rate and maximum sulfur coal. Note that costs for an electrical substation to provide power for the ball mills were not included: BREC felt that sufficient electrical capacity was available from existing equipment. If this substation were included, it would raise the capital costs by \$52,000.

*1 ton = 907 2 kg, 1 in = 2.54 cm..

Process Conversion Costs

To provide cost comparisons of various full-scale process alternatives, a base case of BREC was calculated, using the parameters of Table I. The typical operating load of 75 percent was obtained using BREC-projected load demands through 1995.

Potential process alternatives considered in this evaluation are:

- Limestone - with adipic acid addition.
- Limestone - with DBA addition.

Direct and indirect capital requirements for new equipment are summarized in Table 2. Capital requirements are based on equipment sizing for 100 percent load and maximum sulfur. The ball mills are very conservative since the limestone work index supplied by BREC for a typical quarry was 12. Other quarries were not surveyed but finding a work index of 10 or lower should not be difficult.

Operating costs shown in Table 3 were calculated based on typical conditions, since an unfair advantage for limestone/organic acid would result at maximum boiler load and coal sulfur. By using a fixed capital recovery factor of 20 percent, the annualized costs of a limestone/organic acid retrofit and the

Table 1. *Parameters Assumed for Base Case Calculations BREC's Green Station Unit No. 2*

Plant Load	=	*205 MW*
Module Gas Flow	=	*1,525,000 lb/hr/tower or 383,000 acfm/module* [a]
Inlet SO_2 Concentration	=	*2,550 ppm wet*
Lime Stoichiometry[b]	=	*1.02*
Lime Consumption	=	*12 tons/hr*
SO_2 Removal Required	=	*90%*
L/G (max.)	=	*57*
L/G (current)	=	*41*
CURRENT		
Recycle, Module A	=	*14,900 gpm*[c]
Recycle, Module B	=	*16,500 gpm*
Operation	=	*7,560 hr/yr*
Cake Solids	=	*42.0%*

[a] *1 ft^3 = 28.3 L.*
[b] *Moles Ca per mole SO_2 absorbed.*
[c] *1 gal. = 3.79 L.*

Table 2. *Cost Estimate Summary, BREC Limestone/Organic Acid Retrofit*

(1982 Cost Basis)

	Direct Investment ($1,000s)					
	Limestone/Adipic Acid			Limestone/DBA		
Description	Material	Labor	Total	Material	Labor	Total
Foundations, Site Preparation	50	50	100	50	50	100
Buildings	170	77	247	170	77	247
Structural Steel	94	56	150	94	56	150
Tank Heater				1	1	2
Process Tanks	4	2	6	24	8	32
Limestone Preparation	2,145	136	2,281	2,125	126	2,251
Pumps & Drives	18	4	22	18	4	22
Machinery	30	12	42	30	12	42
Insulation				6	6	12
Piping & Valves	105	65	170	105	65	170
Instrumentation	115	30	145	115	30	145
Electrical	173	108	281	173	108	281
Painting	1	4	5	1	4	5
Freight	25		25	25		25
Total Direct Costs	2,930	544	3,474	2,937	547	3,484
	Indirect Investment ($1,000s)					
Start-up Expenses		10	10		10	10
Field Expenses		20	20		20	20
Vendor Salary	100	20	120	100	20	120
Vendor Expenses	20		20	20		20
Vendor Overhead	100	20	120	100	20	120
Contingency	117	22	139	117	22	139
Vendor Profit @ 15%			585			587
Total Indirect Costs	337	92	1,014	337	92	1,016
Total Cost			4,488			4,500

Table 3. *Operating Cost Summary – Typical Operating Conditions[a] BREC Limestone/Organic Acid Retrofit*

(1982 Cost Basis)

	First Year Cost ($1,000s)		
	Lime	Limestone/Adipic	Limestone/DBA
Alkali			
Lime @ $60/ton	5,856		
Limestone @ $6.50/ton		1,222	1,222
Additive		931	418
Utilities			
Electricity @ $0.01369/kWh	215	378	378
Total	6,071	2,531	2,018
Savings Compared to Lime System	–	3,540	4,053

[a] *Typical Operating Conditions:*
Firing Rate = 100 tons/hr per boiler
3.0% sulfur coal
Lime Stoichiometry = 1.02 mole CaO/mole SO_2 removed
Limestone Stoichiometry = 1.05 mole $CaCO_3$/mole SO_2 removed

existing lime system were compared. The results shown in Table 4 indicate a yearly savings of $2,642,000 for limestone with adipic acid and $3,153,000 for limestone with DBA. These results would be different for other locations due primarily to variation in the cost differential between lime and limestone.

Table 4. BREC Limestone/Organic Acid Retrofit Projected First Year Cost Differential for Conversion from Lime
(1982 Cost Basis)

	Limestone/Adipic	Limestone/DBA
New Investment Annual Charge @ 20% ($1,000s)	898	900
New Annual Operating Costs ($1,000s)	-3,540	-4,053
Total Annual Savings		
$1,000s	2,642	3,153
mills/kWh	0.927	1.106

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J. David Mobley is the EPA Project Officer (see below).
The complete report, entitled "Economics of Retrofitting Big Rivers Electric Corporation's Lime-Based FGD System to Organic-Acid-Enhanced Limestone Operations," (Order No. PB 85-191 146/AS; Cost: $8.50, subject to change) will be available only from:

National Technical Information Service
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