Technical Paper

Comparison between forced oxidation limestone and magnesium enhanced lime FGD systems

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COMPARISON BETWEEN A FORCED OXIDATION LIMESTONE AND MAGNESIUM ENHANCED LIME FGD SYSTEM

INTRODUCTION

The Clean Air Act Amendment of 1990 was passed by Congress and signed into law by President Bush on November 15, 1990. The Acid Rain Title of the Clean Air Act requires SO_2 emission compliance in two phases from certain utility power plants. Phase I allowances require an emission level of no greater than 2.5 lb SO_2 per million BTU (MKB) by January 1, 1995, with a possible two-year extension for implementing 90% removal technologies provided allowances are available. Phase II allowances are capped at 8.9 million tons (approximately 1.2 lb/MKB) to be achieved by January 1, 2000 (with three-year extensions available for implementing deemed-clean coal technologies). This paper will deal with the impact of Phase I compliance and the choices in wet flue gas desulfurization (FGD) technology available to utilities burning high sulfur (i.e. 3-4%) coal.

WET FGD SYSTEMS

Schedule

Through our interaction with various utilities, we understand that many of the multi unit/plant utilities, in choosing wet FGD systems, will install them on their largest and highest polluting unit(s), and use the excess allowances to cover the smaller, less polluting units (the "big bang for the buck" theory). Some utilities will schedule these retrofit installations for commercial operation by January 1, 1995, convinced that the value of any excess credits created exceeds the cost of scrubber financing and operations. Other utilities may determine that the value of excess credits is less than their internal cost of financing and operations and will schedule operation prior to January 1, 1997. It is fair to say that many utilities will opt for the earlier date.

A typical schedule for a wet FGD system from award through design, fabrication, installation, and start-up should allow 36-40 months. Prior to scrubber award, the utility in conjunction with an architect/engineer (A/E) initiates permits, evaluates processes, evaluates A/E's and Contractors, writes a specification, obtains bids, and evaluates/negotiates those bids. This additional process requires approximately 12 months of effort. Consequently, it is not too early for utilities to earnestly begin the scrubber procurement process (see Figure 1) to meet the Phase I compliance date of January 1, 1995.

Given the time constraints on Phase I, utilities will look for commercially proven and reliable, high-efficiency processes, attaining 90-98% SO_2 removal on high sulfur coal burned in U.S. power plants. This requirement will give most utilities two distinct choices for proven wet FGD processes:

1. Limestone Controlled Oxidation (Forced or Inhibited)
2. Magnesium Enhanced Lime

Limestone Controlled Oxidation

The Limestone Forced Oxidation System (LSFO) is the predominant wet scrubbing system in the world. Of the 150,000 MW of existing wet scrubbers, roughly 50,000 MW are limestone-based with forced oxidation. Limestone is a favored reactant because it is inexpensive, typically $10-15/ton delivered. Forced oxidation is advantageous because it produces a stable (suitable for landfill) or saleable end product (gypsum); enhances dewatering capability; and eliminates scaling within the scrubber. Gypsum is being sold for nominal fees for use in wallboard plants, for agricultural uses and in the cement industry. Even if the gypsum is not sold, the enhanced dewatering capability requires less waste disposal area, which is attractive in congested areas. The scale-controlling benefits of forced oxidation permit greater scrubber availability.

A variation of the limestone forced oxidation system is the inhibited oxidation system. In this process, emulsified sulfur or sodium thiosulfate is added to the scrubber liquor to prevent oxidation to calcium sulfate, thus acting as a scale control agent. A side benefit is the possible growth of larger calcium sulfite crystals, should oxidation levels be sufficiently low, thus obtaining similar enhanced dewatering benefits. The inhibited oxidation system, therefore, enjoys the benefits of lower waste disposal and scale control. It does not produce a usable end product but uses less power, at a minimal increased chemical cost.

Magnesium Enhanced Lime

Magnesium Enhanced Lime (MEL) scrubbers have not enjoyed the worldwide popularity of the limestone forced oxidation system, but they have been quite popular in the Ohio Valley. There are over 8000 MW of MEL scrubbers in operation or start-up. Most are located in a beltway from Pittsburgh, PA to Evansville, IN, but there are MEL scrubbers operating on Units 1-3 at the Four Corners Plant of Arizona Public Service. The Ohio Valley MEL scrubbers are operated using a reagent naturally containing approximately 5% MgO. The Four Corners units use a locally blended lime product to achieve the same results.

The magnesium enhanced lime system offers some very outstanding benefits, but also has some disadvantages. First, the disadvantages:

1. Reagent cost - magnesium enhanced lime typically sells for $50-55/ton (compared to $10-15/ton for limestone). Even though approximately half as much MEL is required (due to molecular weight differences), this price differential is significant.

2. Dewatering capability - Although Dravo Lime Company and others are developing enhanced dewatering and bleed stream oxidation capabilities, and are operating some systems in the pilot stage, the magnesium enhanced lime system has not produced an oxidized product during commercial demonstration. Normally, MEL scrubber sludge is "fixated" with the addition of flyash and quick lime. This addition, along with the lessened dewatering capability, ultimately produces a product nearly 2 1/2 times the quantity produced by a comparable limestone forced oxidation scrubber system, as evidenced below.

<u>Secondary Dewatering Capability</u>

	Oxidized Limestone	Magnesium Enhanced Lime
Solids %	90-95	45-50
Quantity	X	2 1/2X

Despite the given disadvantages, the MEL system enjoys popularity due to the following outstanding advantages:

1. Installed cost - for comparable or superior performance (SO_2 removal) a MEL scrubber can be much smaller due to reduced liquor to gas ratio (L/G) requirements. The reduced L/G allows for fewer headers in the spray zone and combined lower flow/less retention time in the reaction tank in the lower zone of the tower. Both advantages significantly reduce the absorber tower height and the reaction tank depth. On a 250 MW absorber tower, A LSFO absorber tower requires 55% more volume and 49% more shell plate (See Figure 2.) In addition, the steel, building enclosure, foundations, HVAC, electricals, controls, valves, piping, and pumps would be significantly reduced. These savings (in relation to a LSFO scrubber) are estimated to be $40/KW.

2. Power - As can be seen in Table 1, the auxiliary power requirements for a MEL system are much lower due to:

   a. Reduced fan power due to lower ▲P.

   b. Significant pump power savings due to lower liquor to gas ratio (L/G).

   c. Reduced reagent preparation power since lime is merely slaked in lieu of the fine grinding required for a LSFO system.

   The MEL system requires less than half the power required in a LSFO system.

3. Higher SO_2 removal efficiency - MEL scrubber systems have been proven capable of routinely performing at 98% SO_2 removal even on 3-4% sulfur coals. For a limestone-based system to even approach 95% requires considerable L/G (power) and possibly the use of additives for some systems. With the prospect of allowance trading in the near term and an emission cap in the future, the efficiency advantage may become important.

Cost Comparison

B&W has developed cost estimates for several utility boiler scrubber projects along the Ohio Valley based on limestone forced oxidation and magnesium enhanced lime. The results indicate that the MEL scrubber enjoys a significant capital cost advantage, typically on the order of $40/KW (on an installed basis). Based on 6,100 hours of annual operation (70% plant capacity) and a 20% carrying charge, this equates to 1.3 mills/KW-hr.

On the operation side, the analysis indicates the cost of reagent transportation and disposal favors the limestone forced oxidation system.

Magnesium enhanced lime	2.0 mills/KW-hr.
Limestone	0.7
Difference	1.3 mills/KW-hr

In this analysis, the cost differences were inconsequential. Evaluation of most sites will demonstrate a financial bias favoring one system over the other. Each utility must compare the relative costs of capital equipment, reagent, operations and maintenance expenses and end use or disposal of the process by-product. The final decision is site sensitive.

CONCLUSION

With passage of the Clean Air Act Amendment of 1990 and the relatively brief period in which to meet Phase I Acid Rain constraints, utilities should turn to proven processes to fulfill their needs. Our analysis indicates that for those who decide to employ wet FGD systems, two wet FGD technologies will dominate Phase I implementation plans:

- Limestone controlled oxidation (forced or inhibited)
- Magnesium Enhanced Lime

The comparison of the two processes indicates a trade-off exists between installed costs and operating costs. The final decision will be sensitive to reagent and disposal cost analysis.

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Table 1

Process Comparison
500 MW, 3.0% Sulfur

Process	Limestone Oxidized	Magnesium Enhanced Lime
Capital, $/kw	+40	Base
Reactant, TPH	18.5	11.6
SO_2 Removal, %	95	98
Draft loss, in. wg	6.0	3.4
L/G	130	30
Booster fans, hp	1900	1100
Absorber pumps, hp	4182	915
Mills, pumps, hp	650	125
Total hp	5192	2140
Blower, hp	1540	N/A

Figure 1

Typical Wet Scrubber Schedule

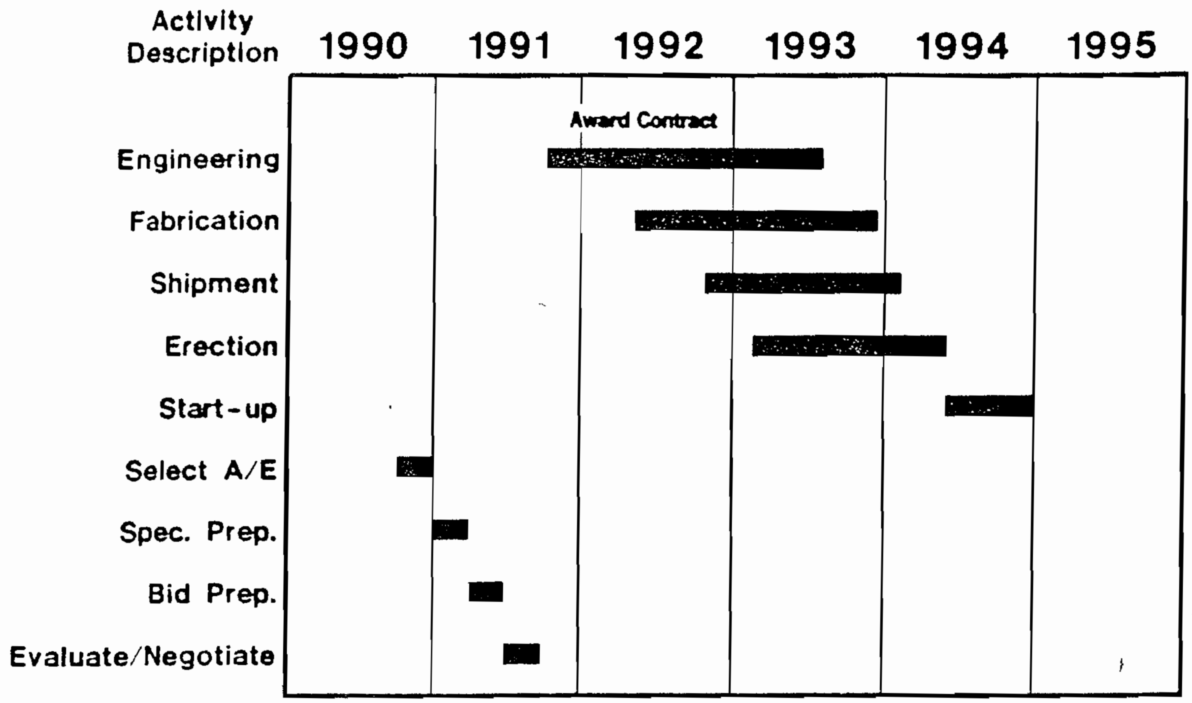

Figure 2

Absorber Towers 250 MW