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Project Summary

Evaluation of Boiler Design Modifications for Enhanced LIMB Application

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Under EPA sponsorship, a study was conducted to evaluate the technical and economic impact of designing wall-fired pulverized-coal units to incorporate dry sorbent sulfur control technology (LIMB). Conventional (non-LIMB) units were set up at three sizes (200, 400, and 600 MW) to burn a low sulfur (0.48%) subbituminous fuel. LIMB units were then set up to achieve 70% SO_x removal using dry sorbent injection. Standard cost estimating procedures were used to evaluate the cost differentials between the conventional and LIMB units. These cost data were used to establish removal cost trends as a function of calcium-to-sulfur (Ca/S) mole ratios and boiler size. The study concluded that it is technically feasible to achieve 70% sulfur removal in a unit burning low sulfur fuel using only dry sorbent injection. The results also showed that Ca/S ratios between 2.8 and 3.5 can be accommodated without radical alterations to state-of-the-art boiler configurations.

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 and Summary

The Environmental Protection Agency is engaged in a research program to develop improved control technologies for the emission of sulfur and nitrogen oxides (SO_x and NO_x) from the combustion of fossil fuels. These emissions are important due to their magnitude and apparent link to acid rain. The cause and potential solutions of the acid rain problem are still being debated; however, control of SO_x and NO_x from power plants is a major element in all proposed control strategies.

The choice of control techniques for acid rain will likely include a mix of technologies to achieve the mandated pollutant reduction at a cost that will minimize the impact on the nation and on specific geographical areas. Commercially available options include: coal switching, coal cleaning, and various types of flue gas desulfurization (FGD) systems. In addition, analysis indicates that low capital cost technology for retrofit to existing boilers would provide further flexibility in a control strategy even at moderate (e.g., 50%) SO_2 removal rates. One such technology is LIMB (acronym for Limestone Injection Multistage Burner), which is based on the injection of dry sorbents into the boiler for direct capture of SO_2 from the combustion gases. LIMB combines sorbent injection for SO_x control with the use of low-NO_x burners.

The EPA LIMB program was initiated in 1981, although work in related areas had been previously conducted by the EPA and others. The LIMB program is structured to provide an understanding of the controlling factors in the LIMB process and to establish a basis for the private sector commercialization of the technology.

This engineering study was performed for the EPA as part of the Agency's ongoing effort to investigate all the potential uses of sorbent injection for the control of SO_x emissions.

This investigation was performed to determine the technical and cost differentials within the scope of the study between a conventional utility boiler and a utility boiler designed to incorporate the LIMB process. Comparisons were made using nominal 200, 400, and 600 MWe units. The scope of the study considers only the boiler shell; auxiliary equipment (e.g., fans, precipitators, flue gas desulfurization equipment) is not addressed.

Both the conventional and LIMB units were designed to fire a low sulfur (0.48% by weight), subbituminous western coal. The overall procedure was: (1) a conventional boiler was designed for each of the three plant sizes to be studied; (2) a LIMB boiler was designed which gave the same output as its conventional sister unit (the LIMB unit included the alterations required to allow for 70% of the sulfur introduced into the boiler via the fuel to be removed by sorbent injection without additional downstream gas processing); and (3) a cost analysis was performed to determine the cost differentials between the LIMB and the conventional units.

Conclusions

The conceptual design work performed to date demonstrates that it is *technically* feasible to design a LIMB unit burning low-sulfur coal to accommodate Ca/S ratios between 2.8 and 3.5 without radically altering state-of-the-art boiler configurations. In addition, it was determined that, based on an economic analysis utilizing "LIMBCOST" (an EPA computer program), the limiting factors when optimizing with respect to the Ca/S ratio are thermodynamic (i.e., the lower limit on the Ca/S ratio was set by establishing the largest possible residence time cavity and still have a high enough gas temperature entering the convection pass to complete the required heat transfer to surfaces downstream of the cavity).

The conceptual design work also indicated that of the two principal LIMB design criteria (sorbent residence time to 980°C and quench rate to 870°C), residence time dominated unit configuration considerations. When the design residence time is achieved, acceptable quench rates typically follow.

Recommendations

The work performed to date suggests a need for continuing validation of some of the cost assumptions used in this study, to reflect actual experience as LIMB technology matures. The optimization work performed as part of this study used an AEERL in-house cost estimating program called "LIMBCOST." This program includes a number of algorithms and parameter values for: (1) sorbent injection system (materials handling) costs; (2) base unit capital costs; (3) fuel costs; (4) sorbent costs; (5) waste disposal costs; (6) costs of other consumables; and (7) maintenance and operating costs. Verifying these cost assumptions was beyond the scope of this study. Therefore, these study results can be considered initial estimates. In addition, no comparison was made to determine the tradeoff between LIMB and backend sulfur removal. Any true optimization would have to consider this issue.

From a technical standpoint, further investigations should consider the injection process and verification of the capture data provided by the EPA. These data are expected to be generated during the EPA's demonstration programs. However, for purposes of this study, it was assumed that: (1) the nozzles could indeed get the sorbent into the flue gas stream; (2) complete mixing was subsequently achieved after injection; and (3) the expected capture data provided by the EPA are valid.

Planned demonstration testing will provide the data to validate these assumptions and (if necessary) appropriately modify the results of this study.

Objectives and Approach

The work done in developing this report focused on three primary objectives:

1. Demonstrating the feasibility of designing boilers at 200, 400, and 600 MW to be compatible with the LIMB process.

2. Evaluating the cost differentials between these LIMB compatible units and boilers designed without the LIMB process incorporated (i.e., conventional units).

3. Establishing cost trends for these units as a function of both megawatt rating and Ca/S ratio.

The five-step approach used during this study consisted of:

1. Establishing design criteria for the boilers. This included defining steam conditions, fuel type, and the LIMB parameters to be used.

2. Designing conventional boilers at 200, 400, and 600 MW which used all of the design parameters established in step 1, except the LIMB design parameters.

3. Designing units with the same megawatt ratings used in step two, but this time incorporating LIMB parameters into the design.

4. Using standard cost estimating procedures to establish cost differentials between the conventional units and their sister LIMB units.

5. Using these cost differentials to establish and evaluate cost trends as a function of megawatt rating and design Ca/S ratio.

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The complete report entitled "Evaluation of Boiler Design Modifications for Enhanced LIMB Application," (Order No. PB 87-199 634/AS; Cost: $13.95, subject to change)
will be available only from:
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