Cost Effective Layered Technology for Ultra Low NOx Control

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Summary

Layering of NOx control technologies can be used to achieve cost effective ultra Low NOx levels previously obtained by Selective Catalytic Reduction (SCR). Advanced Combustion Technology Inc.(ACT), has supplied a combination of technologies to reduce the NOx emissions on a Tangentially fired boiler burning eastern bituminous coal to less than 0.15 lb/mmBtu.

The layering of technologies reduced NOx from the uncontrolled baseline of 0.7 lb/mmBtu to less than 0.15 lb/mmBtu. Low NOx burners, Separated Over Fire Air (SOFA), and High Energy Reagent Technology (HERT) systems were designed and supplied by ACT on a 400,000 lb/hr Tangentially fired coal boiler with three elevations of four (4) burners.

During the design phase, Computational Fluid Dynamics (CFD) modeling was conducted to simulate the performance of each system prior to implementation. The modeling was performed in stages to properly validate the model. An initial CFD model was conducted of the baseline burner and furnace region. Following a review each stage of NOx controlled was simulated to determine the impact on NOx and combustion. A field simulation and modeling was performed on the HERT system prior to completing the final system design. In each instance, the CFD model correctly simulated the final performance of the various NOx control technologies.

The Low NOx burners reduced the NOx to 0.48 lb/mmBtu. The SOFA system reduced the NOx to 0.28 lb/mmBtu and the HERT system controls the final NOx to 0.15 lb/mmBtu.

Low NOx burners stage combustion at the burner outlet to inhibit the formation of NOx. The SOFA system diverts air from the burner zone to the upper furnace for enhanced combustion staging. The HERT system injects a urea mist in a portion of the SOFA stream to mix with the furnace gases in the upper furnace region. The hot SOFA steam vaporizes the urea mist upon contact and allows for improved distribution and mixing over conventional SNCR systems. Only four (4) injectors, one (1) in each SOFA port, were required to achieve an average NOx reduction of 50% over the load range. The ammonia slip at all load points was less than 2 ppm at the air heater inlet. The HERT system functioned at average rate of $1,100 per ton of NOx removed while maintaining NOx below 0.15 lb/mmBtu.

The combination of the technologies reduced the overall NOx by over 78% and allows for the reduction of NOx to SCR levels at a fraction of the cost. All three systems were supplied and installed for the equivalent cost of $25/kw.

This combination of technologies was also applied for NOx reduction on a 125 Mw wall fired boiler burning #6 oil. The boiler was originally designed as a 110 Mw unit burning eastern bituminous coal. The coal burners have been converted to #6 oil and natural gas burners and the boiler output was increased to 125 Mw.

The circular register burners were subsequently upgraded to a low NOx burner design by ACT and the SOFA system was upgraded and optimized to improve the upper furnace combustion and CO burnout. The combination of the low NOx burners and SOFA system reduced the NOx from a full load baseline of 0.39 lb/mmBtu to 0.22 lb/mmBtu.

The NOx emission target for the boiler was reduced to 0.15 lb/mmBtu or less so ACT's HERT system was evaluated for this application. The HERT system feasibility testing was performed on the unit using ACT's portable test system. The portable test system consists of a urea metering module, a dilution water and mixing module, and high energy injectors designed for the specific application. The injectors utilize a carrier air stream in addition to the SOFA carrier air.

The injectors were tested in the SOFA ports and a level of observation ports. The full load NOx was reduced by nearly 38% using the HERT system from 0.19 lb/mmBtu to 0.118 lb/mmBtu with a flue gas ammonia slip of 6.2 ppm utilizing two (2) injectors. The overall NOx reduction using the layered technology is 67%. The total installed cost to supply these three systems on a boiler of this type is in the $7/kw range. A permanent system HERT system is currently being installed on the unit.

ACT's layered NOx control technology has been applied to a number of units of wall fired, T-fired and roof fired design burning coal and #6 oil with results similar to those described above. The layered technology approach achieves the cost effective NOx emission reductions.