FINAL TECHNICAL REPORT
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Project Title: **DEMONSTRATION OF ULTRA-LOW NO_X AND SO_X RETROFIT TECHNOLOGY IN COAL-FIRED BOILERS**

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ABSTRACT

A promising new technology for the combined removal of NO_x and SO_x from a coal-fired boiler has been investigated. The retrofit-technology uses oxygen-enrichment in conjunction with potassium carbonate injection at specific points in the boiler for the combined removal of NO_x and SO_x. This is achieved through injection of oxygen at specific points in the boiler to maintain fuel-rich zones at high temperature for sufficient time for the fuel-bound Nitrogen to be converted to N_2 instead of NO_x. Simultaneously, Potassium Carbonate, a fine powder, is injected in specific locations of the boiler at high temperature conditions for the sulfur compounds to be converted to Potassium Sulfate. The Potassium Sulfate, which is water soluble, is captured in the bag house or ESP, separated from the ash and could be used as a fertilizer with a possibility of resale associated with it. The report presents results from the demonstration of this technology in the Babcock and Wilcox Company's 1.5 MW_{th} Pilot Boiler, the Small Boiler Simulator (SBS) that has been used extensively as a first step for demonstration of a new technology. Tests were performed using IL coal #6 which is known for its higher sulfur content. The test matrix includes testing of the air-fired baseline, followed by oxygen-enrichment, independent Potassium Carbonate injection and a combination of oxygen-enrichment and Potassium Carbonate injection into the boiler. Emissions measurements are performed at the end of the convective pass and include measurements of NO_x, SO_x, O_2, CO_2, CO and measurement of carbon content in the ash (LOI) etc. Results of the above mentioned tests are presented. Also, the utility of the technology for mercury capture has been investigated by measuring the mercury content in the ash. An analysis of the economics has also been carried out showing the promise of this technology. In general the above technology does well for SO_x reduction and in part for NO_x reduction. The LOI is dramatically reduced helping with the sales of the ash. No obvious effect of Potassium Carbonate on Mercury speciation was seen.

Pages <u>1-24</u> contain proprietary information

EXECUTIVE SUMMARY

Demonstration of a new retrofit technology for the combined removal of NO_x and SO_x along with reduction in LOI and possible reduction in Hg was undertaken in this study. Oxygen enrichment of the fuel rich zones for NO_x reduction, known from earlier work, was implemented for conversion of fuel-bound Nitrogen to molecular nitrogen. This is known to work if the temperature is kept high enough, in fuel rich zones for a long residence time through a well known mechanism. Potassium carbonate injection for the removal of SO_x, tested earlier in a different study, was also carried out. The potassium carbonate was expected to convert to potassium sulfate, which could then be sold as a fertilizer. It was expected that the oxygen enrichment would aid with the reduction of carbon content in the ash as well leading to a saleable byproduct. The combined effect on the reduction of Hg was expected.

Testing was conducted in Babcock and Wilcox's Small Boiler Simulator facility using IL coal #6. Lances were manufactured and installed for oxygen injection and the burner inlet was modified for potassium carbonate injection. The Potassium Carbonate used was in powder form and was fed using a feeder. The powder was mixed with a small amount of air and injected into the primary air zone of the flame.

Testing comprised base line testing, along with oxygen enrichment, followed by potassium carbonate (sorbent) injection, which was then followed by combined oxygen enrichment, and sorbent injection. Testing was conducted for various different conditions and the most optimum conditions were found for all the various scenarios.

Results indicated oxygen enrichment to be a proven way of reducing NO_x from fuel bound coal. The oxygen enrichment was carried out in the burner zone using minimal amounts of oxygen. Results also showed that Potassium Carbonate injection was very useful for the reduction of SO_x, up to 98 % recovery, with a slight increase in NO_x. The combined effect of oxygen enrichment with sorbent addition was able to curtail this increase in NO_x to some extent. It is expected that the reason for this was the competing effect of sorbent vaporization with a delay in coal devolatilization rate, which is needed for the NO_x reduction mechanism to work. A different area for the injection of potassium carbonate has been suggested as a result as to not interfere with the NO_x reduction mechanism. Another possible explanation of the NO_x increase with K_2CO_3 injection may be the strong oxidizing tendency towards Nitrogen compounds of Potassium Peroxide, which is formed in the boiler under the conditions of the experiment.

The unburned carbon content in the ash was reduced to around 2% with oxygen enrichment and was reduced to very low and almost insignificant values with the sorbent and sorbent with oxygen enrichment cases, respectively. All the above cases denote a positive sign for the sales of ash as a by-product with the lower carbon content.

Mercury analysis indicated that there was no obvious consequence of injecting potassium carbonate on the mercury speciation.

Finally, an economic evaluation comparing the current used technologies of Flue Gas Desulfurization and Selective Catalytic Reduction for SO_x and NO_x removal were compared with the economics of retrofitting with a potassium carbonate injection facility and oxygen enrichment infrastructure. The economics suggest that plant sizes below 300 MW_e would be economically viable with the current technology.

Deposition of potassium sulfate in areas of the convective pass posed a problem and it is recommended that this be taken up in a future investigation in discussions with boiler manufacturers. The long-term effect of potassium sulfate deposits on convective pass and boiler tubes needs to be investigated as well. It is recommended that the potassium carbonate be injected in an area other than the primary air zone and preferably in the secondary air zone for a combined effect with oxygen enrichment to occur.

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