Combined Combustion and Post Combustion NOx Reduction in a 20 MMBtu/hr Slagging Coal Combustor-Boiler

by
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For the past decade Coal Tech has been developing and testing an air cooled, slagging coal combustor attached to an industrial boiler. It is rated at 20 MMBtu/hr thermal input. Air cooling reduces the combustor wall heat transfer by approximately one-half compared to a completely water cooled slagging combustor. The emissions of SO2 are reduced by the injection of calcium based sorbents into the combustor. NO_X emissions are reduced by staged combustion with fuel rich operation in the combustor and final combustion in the boiler. Between 1987 and 1993, a first generation design of the 20 MMBtu/hr combustor-boiler was tested at an industrial site in Central Pennsylvania. Using the results from these tests, a second generation 20 MMBtu/hr combustion system was installed at an industrial park in Philadelphia in 1995. Over the past year, this system has been operated a total of 75 days, and tests are continuing.

With sorbent injection into the combustor, up to 80% reductions in SO_2 emissions, to as low as 0.22 lb/MMBtu/hr, have been measured in low sulfur coal. Separately, sorbent injection in the combustion gas stream, downstream of the combustor, yielded reductions of up to 90%, to as low as 0.2 lb/MMBtu.

In both combustor designs, the NO_X emissions were reduced by increasing fuel rich operation to a 0.7 to 0.8 stoichiometric ratio. In the current combustor, NO_X emissions as low as 0.32 lb/MMBtu were measured. This compares with NOx levels of 0.7 to 1 lb/MMBtu under fuel lean conditions in the combustor. However, the amount of unburned carbon increased with decreasing combustor stoichiometry.

To reduce the unburned carbon while retaining high NO_X reductions, tests were implemented with the injection of sorbents in the combustion gases downstream of the combustor. Dozens of tests were performed, and substantial NO_X reductions were measured in all cases. Tests were per-formed under fuel rich and fuel lean combustor conditions, with different sorbents, and different injection methods. A typical result was measure din one group of tests in which the NO_X emissions were reduced from 0.4 lb/MMBtu under fuel rich combustor conditions to as low as 0.07 lb/MMBtu, and from 1.1 lb/MMBtu under fuel lean combustor conditions to 0.2 lb/MMBtu.

These results are highly significant in that they represent the first time that such very low NO_X emission levels have been measured in this slagging combustor. Two environmental test goals in the US Department of Energy project under which these tests were performed have now been achieved. The measured SO_2 emissions of 0.2 lb/MMBtu are one-half the 0.4 lb/MMBtu goal for this project, and the measured NO_X emissions of 0.07 lb/MMBtu are over one-half of the 0.2 lb/MMBtu project goal. Representative results from the NOx reduction tests will be given in the presentation. It is planned to continue these tests in the present combustor and to apply these results to larger boilers.