Application of Fuel Lean Gas Reburn (FLGRä) Systems

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The Gas Research Institute (GRI) has developed and recently granted licenses to companies that can offer a simple and low cost means of reducing NO_x from coal fired boilers by 30-45%. Fuel Lean Gas Reburn (FLGR™) has been installed and tested on four full-scale boilers: a 90 MW roof-fired and a 140 MW tangentially-fired boiler with existing low NO_x firing system; a 340 MW cyclone-fired unit and a 320 MW wet-bottom wall-fired with characteristically high baseline NO_x levels. FLGR™ systems employ patented process and gas injector designs to reduce NO_x as much as 45% using as little as 7% natural gas input. FLGR™ does not require an overfire (burnout) air system to achieve these NO_x reductions while maintaining acceptable stack exhaust levels of CO.

The FLGR™ system design approach involves a combination of furnace measurements to characterize baseline NO_x, O_2, CO, loss of ignition (LOI) and temperatures under full and part load conditions. The results from this furnace mapping are used in conjunction with conventional Computational Fluid Dynamics (CFD) based modeling of the furnace. The CFD modeling and furnace measurements are used to more fully characterize the furnace flow fields temperature profiles and gaseous species concentrations affecting the design of the FLGR™ Metering and Injector System (MIS).

In each of the demonstrations, an advanced, patented numerical modeling simulation software tool developed with GRI support has been applied to assist in the final design and specification of the optimized MIS. This software tool is called Linear Integral Moment (LIM) and represents the state-of-the-art in combustion simulation. Unlike traditional combustion modeling approaches, the LIM software is a true simulation tool because it allows prediction of the time-varying flow and chemical species fields throughout a combustion system. When applied for FLGR™ applications, it also provides an assessment of overall system performance (NO_x reduction per unit of natural gas injection) and emission levels (lb/10^6 Btu, ppm). The LIM modeling results have been used to assist in the selection of the location, levels, number, jet velocity, flow rates and orientation of gas injectors for FLGR™ installations.

Each of the demonstrations of FLGR™ included comprehensive testing programs that covered baseline and performance optimization field measurements. In units tested to date, baseline NO_x levels ranged from just under 0.4lb/10^6 Btu on the tangentially-fired boiler to slightly above 1.4 lb/10^6 Btu on the wet-bottom, wall-fired demonstration. The design performance goals for the demonstrations included final NO_x rate (lb/10^6 Btu), percent NO_x reduction, percent natural gas of total heat input and CO (corrected to a prescribed percent O_2).

The four demonstration tests have resulted in NO_x reductions ranging from 33% to 45% at full load. The gas requirements to achieve these reductions have varied from about 3% to 7% of boiler heat input. Key boiler operating parameters that are shown to influence the maximum percent NO_x reduction achieved (at a given load) are excess oxygen levels, baseline average NO_x levels, and CO.

Tests have confirmed that the limiting factor for FLGR™ performance is CO. As greater amounts of natural gas are injected in the upper furnace, the process reaches conditions of chemistry, temperature and mixing where complete fuel burnout (CO to CO2) without the addition of completion (over fire) air is hindered. The process optimization testing program that follows system start-up attempts to establish the gas injection operating guidelines that ensure that the maximum NO_x reduction is achieved within acceptable constraints on CO and other operational limits (e.g., LOI).

Engineering designs, modeling studies and test results from the demonstration FLGR™ systems installed and tested to date, combined with the patents issued and applied for, are the “know how” and intellectual property that GRI licenses to the FLGR™ providers. Current licensees to FLGR™ are ESA Environmental Solutions, Ltd. and Fuel Tech, Inc. NGB Technologies is licensed to LIM.

FLGR™ was recently combined with a urea-based, SNCR present at the 320 MW wet bottom wall-fired unit to test “co-injection” of gas/urea. This technology is called Amine Enhanced Fuel Lean Gas Reburn (AE-FLGR™). A separate paper on AE-FLGR™ testing is being presented at the DOE SNCR/SCR Conference May 20-21, 1999. The AE-FLGR™ paper reports data showing that NO_x is reduced between 50-70%, depending upon load.

FLGR™ is a commercially available NO_x control technology for achieving between 30-45% reductions at installed capital costs of between $5-10/kW depending upon unit size and number of units licensed. This capital cost assumes that a natural gas supply (line) capable of delivering up to about 10% of total heat input is at boiler house. Units that currently use natural gas for ignition/warm-up usually have this capacity.

Future plans for technology transfer/deployment of FLGR™ and AE-FLGR™ include a GRI sponsored workshop in Chicago, June 17-18, 1999. There will be an opportunity to visit a boiler with a newly installed FLGR™ system. The next generation of (commercial) FLGR™ systems may employ additional sensors and controls to automatically regulate the gas injection for best NO_x performance (NO_x reduction per unit of natural gas) within acceptable CO limit.