CFD Evaluation of Fuel Lean Gas Reburn (FLGR™) and Selective Non-Catalytic Reduction in Owensboro Municipal Utilities' Elmer Smith Station

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INTRODUCTION

A Computational Fluid Dynamics (CFD) modeling study has been conducted to evaluate the application of overfire air (OFA), Fuel Lean Gas Reburn (FLGR™), and Selective Non-Catalytic Reduction (SNCR) to reduce NOx emissions from Owensboro Municipal Utilities' Elmer Smith Station. Smith Station Unit 1 is a nominally rated 150 MWe single-wall cyclone fired boiler with three barrels. FLGR™ is a NOx control technology for fossil fuel fired boilers developed and licensed by the Gas Research Institute (GRI) that involves injection of natural gas into the fuel lean zone of the upper furnace (Pratapas *et al.* 1999). The quantity of reburning fuel is less than in conventional reburning processes. The resulting flue gas remains overall fuel lean, and no additional OFA is required. The analyses indicated that OFA alone has the potential to reduce NOx emissions from a baseline level of 1.59 lbs-NOx/MMBtu to 0.39 lbs-NOx/MMBtu with sufficient staging. This presentation summarizes the modeling results associated with utilizing both lean reburning and SNCR in addition to OFA to further reduce the NOx emissions at Elmer Smith Station

CFD MODELING

The computational tools used in this study simulate reacting and nonreacting flow of gases and particles, applicable to gaseous diffusion flames, pulverized-coal flames, liquid sprays, reacting two-phase flows and other oxidation/reduction systems. *BANFF* is Reaction Engineering International's (REI) proprietary threedimensional, gas-phase turbulent reacting flow code, and *GLACIER* adds physical models to treat two-phase flows. These software tools have been applied to a wide variety of industrial systems encompassing utility boilers, pyrolysis furnaces, gas turbine combustors, rotary kilns, waste incinerators, smelting cyclones and others.

The Computer Assisted Reduction Method (CARM), developed by professor J.Y. Chen (1997), provides an automated approach for developing reduced chemical mechanisms from fully detailed mechanisms based on steady state assumptions (Cremer *et al*. 2000). A 12-step reduced mechanism, retaining 16 major species, was developed and used to represent NOx chemistry associated with lean reburning and SNCR in this study. The detailed mechanism used to generate the reduced mechanism was a modified Miller-Bowman mechanism created by Glarborg, *et al* (1997). The modifications to the Miller-Bowman mechanism included recent findings on hydrocarbon and nitrogen chemistry and the mechanism itself consisted of 438 reactions involving 65 species. This reduced mechanism was tested under both plug flow reactor (PFR) and perfectly stirred reactor (PSR) conditions over a range of gas temperatures, stoichiometric ratios, urea concentrations, and initial NO levels and compared well with results from the detailed mechanism. This 12-step reduced mechanism was implemented into the REI's proprietary CFD combustion codes to provide estimates of NOx reduction due to lean reburning and SNCR in Elmer Smith Unit 1

RESULTS AND DISCUSSION

The lean reburning strategies involved injecting 6% of the furnace heat input as natural gas above the overfire air ports in the furnace. Two levels of injectors were utilized, one level with five ports along the rear wall and one level with six ports along the front wall. The lean reburning strategies were simulated to examine the effects of nozzle diameters and front/rear and nozzle/nozzle biasing of the gas injection on NOx and CO emissions. The SNCR injection strategies were also simulated to determine the extent that SNCR injection could improve NOx reduction when implemented in conjunction with lean reburning. Two injector elevations were utilized. Both elevations had eight total injectors, six on the front wall and two on the side walls.

All evaluations were based on predicted lower furnace results with barrels staged to a stoichiometry of 0.90. NOx levels with OFA alone were 0.39 lbs/MMBtu. The lean reburning and SNCR results may be summarized as follows:

- Predictions of lean reburning performance indicate that NOx reductions from 25-30% using 6% heat input as natural gas should be achievable with stack CO emissions increasing approximately 10 ppm.

- Predictions of lean reburning combined with SNCR indicate that at least 40-45% NOx reduction should be achievable with less than 5 ppm ammonia slip. Optimization of the reagent injection by utilizing lances in the convective cavities would probably increase NOx reduction significantly.

- Predictions of lean reburning and SNCR are very dependent on gas temperature. All predictions were based on predicted gas temperatures for the upper furnace of this unit. Measured temperature data, which would have been useful for comparison, were not available at the time of this study.

- Further optimization of the SNCR injection design (such as lances) has the potential to further improve NOx reductions. Only one SNCR injector design (injector locations, droplet size and velocity, reagent NSR, etc) was evaluated in the SNCR study.

CONCLUSIONS

The predictions of NOx reduction performance with lean reburning in Elmer Smith Unit 1 are consistent with previously reported levels of 30-40% using up to 7% natural gas (as percentage of heat input). Predictions in Elmer Smith Unit 1 indicate that combining lean gas reburning with SNCR, NOx reductions of at least 45% should be obtainable with less than 5 ppm ammonia slip and 10 ppm increase in stack CO emissions.

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