Design, Installation, and Testing of Rich Reagent Injection in Conectiv's B.L. England Unit 1

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INTRODUCTION

Conectiv's B.L. England Unit 1 is a 138 MW cyclone fired boiler that was fitted with an overfire air (OFA) system during spring of 1999. Subsequent operation with the OFA system has demonstrated reductions of NOx emissions from the uncontrolled baseline of 1.2 lb/MMBtu to approximately 0.5 lb/MMBtu with less than 50-ppm CO stack emissions. The existing SNCR system, installed in 1995, reduces NOx emissions an additional 30% with less than 5-ppm ammonia slip. During the summer of 2000, a field demonstration in B.L. England Unit 1 showed that an additional 30% reduction in NOx emissions is achievable through judicious injection of aqueous urea in the fuel rich lower furnace, with no additional ammonia slip. This process, coined Rich Reagent Injection (RRI), combined with SNCR was shown to achieve NOx reductions of 55-60% with less than 5 ppm ammonia slip to yield full load NOx emissions from this unit of approximately 0.23 lb/MMBtu.

RICH REAGENT INJECTION (RRI)

Previous research has shown that the injection of ammonia or urea into the high temperature NOx containing flue gases in the lower furnace, using normalized stoichiometric ratios (NSR) of 1 to 4, can lead to noncatalytic NOx reductions of 80% or better under idealized conditions. While SNCR involves the injection of amine reagents into fuel lean combustion products at temperatures between 1700 and 2100^{o}F, reagent injection in the RRI process occurs at significantly higher gas temperatures within the combustion zone of the lower furnace. With support from the Electric Power Research Institute's (EPRI) Cyclone NOx Control Interest Group (CNCIG), Reaction Engineering International (REI) has developed, implemented, and tested an enhanced chemistry model with their proprietary computational fluid dynamics (CFD) code *GLACIER* to simulate this process in cyclone fired furnaces. Numerical and experimental investigations have shown that significant NOx reductions, with little to no ammonia slip, can be obtained in cyclone-fired furnaces utilizing RRI. The RRI process results in little to no ammonia slip in comparison to SNCR. However, chemical utilization has been found to be reduced from that experienced with SNCR.

CFD BASED RRI DESIGN IN BL ENGLAND UNIT 1

Utilizing the new CFD model, REI performed the process design for an RRI system in Conectiv's B.L. England Unit 1. The process design was constrained to utilize the existing SNCR equipment in units 1 and 2. Locations for eight injection ports were identified through the modeling. CFD predictions of RRI performance showed NOx reduction varying between 10 and 35% (beyond reductions obtained with OFA) utilizing equivalent reagent flow rates. Simulations showed that due to the highly stratified flow in the lower furnace, improper reagent injection could result in little to no reduction in NOx emissions, and even a net increase in certain circumstances. Through proper placement of injectors and specification of nozzle characteristics, NOx reductions up to 33% were predicted with less than 1-ppm ammonia slip, utilizing eight injectors.

Based on the CFD analysis, eight RRI injection ports were installed. The temporary installation was designed to allow testing of the new RRI system in combination with the existing SNCR system in unit 1. The CFD analysis indicated that significant modifications to the existing SNCR injectors were warranted in order to achieve the predicted RRI performance. However, no significant modifications were made to upgrade the nozzle materials or cooling design to take into account the severe lower furnace conditions.

TEST RESULTS

RRI alone was able to reduce NOx emissions up to 30% beyond OFA reductions with less than 1-ppm ammonia slip. RRI in combination with SNCR yielded NOx reductions of 55% beyond OFA levels with less than 5-ppm ammonia slip. Sensitivities to NSR, nozzle characteristics, and injector location were observed and found to be consistent with the CFD model predictions. NOx reduction was found to be nearly maximum at NSR = 2, chemical utilization dropping sharply at higher reagent flow rates. Limited testing under reduced load conditions (80 MW) yielded similar RRI performance. The air-cooled injection nozzles were found to adequately withstand the lower furnace environment for the duration of the testing.

CONCLUSIONS

The ability of the RRI process to significantly reduce NOx emissions from staged cyclone fired furnaces operating with overfire air has been demonstrated. NOx reductions of 30% with less than 1-ppm ammonia were obtained with RRI under full load conditions in Conectiv's B.L. England Unit 1, a three barrel, 138 MW cyclone fired furnace. RRI in combination with SNCR was found to yield up to 60% NOx reduction under full load conditions, to reduce NOx emissions from this unit to as low as 0.23 lb/MMBtu, with less than 5 ppm ammonia slip. The field testing confirmed the CFD model predictions and demonstrated the importance of accurate CFD modeling to a successful RRI design. Data suggests that in other units possessing increased residence times in the lower furnace, RRI performance should be higher than those achieved in B.L. England Unit 1.

An additional demonstration of RRI is planned in a 480 MW cyclone fired furnace during the summer of 2000. The applicability of RRI to other furnace types is currently under evaluation.

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