Presentation Summary

Title: Selective Non-Catalytic Reduction, a practical approach to NOx control

Presented at DOE- FETC Conference on Selected Catalytic and Non-Catalytic Reduction for NOx Control, Pittsburgh, PA, May 21-22, 1999.

Authors

Bauke Van Kalsbeek
DNX Engineers Ltd.
12685 Shelly Lane, Santa Ana, CA 92705
Tel: 714-997-7418, Fax : 714-771-7574, E-mail: bvanka@aol.com

Frank L. Thompson
Nebraska Public Power District
68601/1414 15th Street
P.O. Box 499
Columbus, NE 68602-0499
Tel: 402-563-5696, Fax 402-563-5235, E-mail: flthomp@nppd.com

Introduction

Pending state air quality regulations, resulting from EPA's recent Ozone Transport Rulemaking proposal, are expected to restrict NOx emissions from boilers located in 23 Eastern and Midwestern states to 0.15 lb/MMBtu by May 1, 2003. It has been estimated that over 300 coal-fired boilers will be affected by the new rules and will require additional NOx control.

SNCR Applications

Selective Non-Catalytic Reduction (SNCR) is a cost-effective NOx control method that can provide medium range reduction. In cases where higher NOx reduction is required, SNCR can be used in combination with other control techniques such as low NOx burners or combustion modifications. If used as a first stage in a hybrid SNCR/SCR system, catalyst size can be reduced, resulting in lower capital and operating cost.

The SNCR Process

In the SNCR process a reagent, ammonia (NH_3), creates a reducing atmosphere in a temperature zone of 1700 to 2000 F. The chemical reaction between NOx and NH_3, through several intermediary reactions, converts NOx into nitrogen and water. The reagent can be provided in the form of anhydrous ammonia, aqueous ammonia or urea. Anhydrous ammonia is the lowest cost reagent and will result in the simplest system. Aqueous ammonia or urea can be used when required by safety regulations.

Key factors for good SNCR performance are the gas temperature and the reagent distribution in the flue gas. Reagent injection and mixing, with the aid of air or steam to provide the momentum for penetration or atomization, must take place within the optimum temperature window. Actual gas temperatures can be determined through measurements with a temperature probe or from boiler design data. Kinetic and fluid dynamics computer models are used to determine system performance and evaluate the mixing conditions.

Injection System

The most common and simplest injection system uses wall injectors, installed between boiler tubes. Operation at varying boiler loads can be accommodated with multiple injection levels, allowing for injection into the optimum temperature window at each load. In large boilers, wall injectors may not provide sufficient penetration, and an injection lance may be needed for good reagent distribution. An example of an innovative, patented lance design is presented in the following case study.

Case study

Nebraska Public Power District (NPPD) conducted an experimental test program to evaluate the feasibility of SNCR on a utility boiler. For this program, they selected their 105 MW Sheldon Station cyclone boiler, which burns low sulfur, low chlorine Powder River Basin coal. As part of the project, a unique, patented ammonia injection system, using a retractable, air-cooled lance, was developed and tested.

Finding the correct SNCR temperature window was an important step. It was estimated that a suitable temperature window could be found in the superheater area. Thermal mapping across the boiler cavity was done with a thermocouple attached to the existing sootblowers. The true gas temperatures were then calculated by applying an empirical correction factor. This method was much simpler than the more common testing method with a water cooled shielded probe and was considered to provide sufficient accuracy. It was found that, during operation at the most common load range between 80 to 90 MW, the suitable temperatures were just in front of the finishing superheater. A new sootblower penetration for the injection lance was installed at this location during a regular outage.

The injection lance was designed with a conventional sootblower mechanism for insertion and retraction. The lance consisted of concentric tubes, with ammonia vapor fed to the inner and cooling air to the outer passage, and a series of injection nozzles spaced to cover the entire boiler width. The cooling air, which also served as carrier to distribute the ammonia into the boiler, was mixed with ammonia vapor inside the lance just prior to injection. Temporary compressors provided the needed air.

Anhydrous ammonia, supplied from a temporary tank, was used for the test because of its low cost and its availability in agricultural Nebraska. Although many utilities are reluctant to use anhydrous ammonia, NPPD felt that it could be dealt with safely by implementing proper procedures. Aqueous ammonia could have been used as well.

The lance was tested during normal boiler operation over a 14 day period. As expected, NOx reduction was greatest, 53 percent, in the 80 to 90 MW (gross) load range. At higher loads, the temperatures at the injection location where higher than desired, and NOx reduction was lower. This could be remedied in a permanent system by installing an additional injection lance further back in the cooler convection pass for operation at high loads. The NOx emission rate over the entire load range (while on load control), at an NH3/ NOx mole ratio of 1.0, was 0.47 lb/MMBtu, representing 47 percent reduction over baseline. Higher NOx reduction, with increased ammonia slip, was obtained at higher mole ratios.

Ammonia slip was 5 PPM or less at the 1.0 mole ratio injection rate. After the 14 days of operation, no noticeable deposits (due to possible formation of ammonium salts) were observed in the boiler or air heater. Also, there was no stack plume (due to possible ammonium chloride formation) visible during operation in the ambient temperature range from -10 F to + 50 F. Slag buildup was a concern at the lance location, but this was controlled through normal operation of the two adjacent sootblowers, which kept the lance clean. The air cooling was able to maintain the lance at low temperature and no mechanical problems were encountered.

Test Conclusions

The test confirmed that SNCR can be a practical and effective NOx control technique for large boilers, with little or no impact on boiler operation. The injection lance proved to be an attractive alternative to wall injectors. The lance can be retracted for inspection or when not needed while the boiler is in service. Although the testing was done with anhydrous ammonia and air cooling, the lance design can be adapted to aqueous ammonia injection and steam cooling as well.