HYBRID POST COMBUSTION NO_x CONTROL

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Abstract

Hybrid Post Combustion NO_x Control systems consist of either a combination of selective catalytic reduction (SCR) techniques (i.e., in-duct SCR combined with air heater SCR) or, more commonly, selective non-catalytic reduction (SNCR) in combination with SCR. These Hybrid systems can offer substantial benefits in reduced cost and enhanced performance; however, their applicability is very unit specific. This paper will document the current utility experience and review the results of several demonstrations as well as present a tool by which utilities can:

- determine the applicability of Hybrid Post Combustion NO_x Control to meet their NO_x reduction goals,
- select the best configuration, and
- develop the design parameters necessary to implement the technology.

Introduction and Background

Promulgation of increasingly stringent regulations limiting NO_x emissions from utility boilers has created a need for technologies capable of achieving high levels of NO_x reduction. Selective catalytic reduction (SCR) is capable of achieving the desired reductions; however, high costs and/or technical limitations caused by unique boiler configurations often make stand-alone SCR a less than optimum solution. Hybrid Post Combustion NO_x Control systems offer the high levels of NO_x reduction necessary for compliance and can often overcome the limitations caused by unique boiler configurations.

Description of Hybrid Post Combustion NO_x Control Configurations Options

There are four different configurations which fall under the general heading "Hybrid Post Combustion NO_x Control." Each configuration has its own individual benefits and applicability. The first application would be the application of selective noncatalytic reduction (SNCR) with in-duct SCR. This application utilizes the NH_3 slip from the SNCR process as part or all of the NH_3 for the SCR reaction. This Hybrid configuration can be further categorized according to the type of SNCR reagent used, urea or NH_3, and by whether or not supplemental NH_3 is injected upstream of the SCR.

The second option is to combine an in-duct SCR with an air heater SCR. Typically a single NH_3 injection grid is installed upstream of the in-duct SCR. NH_3 slip from the in-duct SCR provides the inlet NH_3 for the air heater SCR.

The third option is the combination of SNCR with an air heater SCR. The utilization of an air heater SCR differentiates this option from option 1 due to the unique characteristics of the air heater SCR. The fourth option is the combination of SNCR with both in-duct SCR and air heater SCR.

Benefits of Hybrid Post Combustion NO_x Control

The application of a Hybrid system must offer direct benefit over alternative technologies (typically stand-alone SCR) to justify consideration by the end user. The benefits offered vary according to the Hybrid configuration selected as well as many boiler specific parameters. Below we present a qualitative assessment of several of the benefits. A quantitative assessment would require a boiler specific evaluation including capital and operating cost estimates, which are addressed in detail in EPRI TR-105693, “Hybrid Post Combustion NO_x Control - Feasibility and Recommendations.”

Higher Overall NO_x Reduction Possible without Extensive Unit Modifications. Any of the four Hybrid configurations discussed above will offer a higher level of NO_x reduction compared to a stand-alone SCR, if the quantity of catalyst is limited by space available or by allowable pressure drop. This limitation applies to some degree for most retrofit applications.

Lower System Pressure Drop. For a given quantity of NO_x reduction, a Hybrid system will typically have a lower pressure drop than a stand-alone SCR. If the configuration utilizes SNCR the lower NO_x concentration at the SCR inlet will decrease the volume of catalyst necessary and therefore the pressure drop. Air heater SCR achieves NO_x reduction with little or no increase in pressure drop compared to the original air heater. Therefore, if the Hybrid system utilizes an air heater SCR to reduce the volume of in-duct catalyst required, the total system pressure drop will be less than if the entire reduction was achieved with in-duct SCR.

Lower NH_3 Slip. With a Hybrid system incorporating air heater SCR, it is possible to achieve the same emissions reductions as an equivalent stand-alone SCR at lower NH_3 slip. This may be critical on systems where the slip must be limited to ultra low values to avoid air heater fouling and or fly ash contamination.

Operational Flexibility. Hybrid Post Combustion NO_x Control offers the benefit of operational flexibility allowing the utility to optimize operation for specific, and frequently changing, operating conditions.

The first scenario where this approach would be applicable is to comply with seasonal NO_x limitations. Many regulations which are in place or being considered include lower emission limits during the "ozone season" (May 1 through September 30) than during the remainder of the year. If a Hybrid system consisting of SNCR and SCR is designed to meet the lower NO_x emission limit, it is likely that the SCR alone would meet the higher limit. Compared to a stand-alone SCR, which would have to be designed to meet the lower limits, the Hybrid system would have substantially less catalyst, reducing the initial capital cost as well as catalyst replacement costs.

The second scenario where a Hybrid system would add operational flexibility is for load following units with moderate or low capacity factors. Unless the emissions averaging period is long (i.e., 30 days), most utilities will design the NO_x reduction system to achieve the regulatory limit at the most stringent design point, typically full load. The majority of the time, however, the unit will be operating at moderate or low loads, which typically have less stringent NO_x reduction requirements. In this scenario the Hybrid system consisting of SNCR and in-duct SCR would be designed to provide the NO_x reduction requirements at full load. At lower loads the SNCR injection rate would be decreased and below a specified set point would be shut down completely. The load at which the SNCR system could be shut down would be dependent on the NO_x reduction capability of the SCR which would improve at lower loads due to the lower inlet NO_x and lower space velocity.

Utility Experience with Hybrid SCR

Three utility Hybrid SCR systems have been installed and tested in the United States as demonstration projects: San Diego Gas and Electric's Encina Power Plant Unit 2, Southern California Edison Company's Mandalay Generating Station Unit 2, and Public Service Electric and Gas's Mercer Generating Station Unit 2. These Hybrid systems have achieved emission reductions as high as 95 percent. Further details will be presented at the DOE conference and are available in EPRI TR-105693 “Hybrid Post Combustion NO_x Control - Feasibility and Recommendations.”

Hybrid Post Combustion NO_x Control Applicability

As stated previously the applicability of Hybrid Post Combustion NO_x Control is very unit-specific. The issues that affect applicability which are addressed in detail in the EPRI report are as follows:

- NO_x reduction required
- uncontrolled emissions
- allowable system pressure drop
- space availability
- structural limitations of existing boiler
- NH_3 slip limit

Selecting the Optimum Hybrid Configuration

There are several steps in selecting the optimum configuration for a Hybrid system. EPRI TR-105693 presents a detailed guideline of the selection process. A spreadsheet software program is included with the report to assist the engineer in estimating the performance and cost of different configurations. The spreadsheet program will be demonstrated at the conference.