SNCR System – Design, Installation, and Operating Experience

David L. Wojichowski
De-NOx Technologies LLC, 22 Partridge Lane, East Hampstead, NH 03826
E-Mail: dwojichowski@de-nox.com, Telephone (978) 828-4321, Fax (605) 238-4450

Summary

SNCR is a mature technology for moderate, i.e. 40-60% reduction, of uncontrolled NOx in high temperature combustion gasses. The techinique was originally pioneered by Exxon using ammonia as the reagent. The patents on this technology expired in the late 80’s. In the early 1980’s, EPRI received two process patents for the same basic techniques, only using urea instead. One was for the oxygen rich environment and the other for fuel rich at even higher temperatures. These basic patents have now also expired. The mechanics of the two techniques differ mainly in that ammonia injection is gaseous and urea is liquid. Otherwise, both use very similar fluid injection and control techniques.

SNCR systems are often the technology of choice for applications requiring moderate, i.e., 40-60% NOx reduction and has been proven many times over. Broken down into its most basic chemistry, the technique requires thorough mixing of the reagent into the furnace chamber with at least 0.5 seconds of residence time at a temperature above 1600F and below 2100F. Optimally, the reagent is usually injected into the furnace at approximately 1900 - 1950F which is a good tradeoff between the competing reaction of oxidation of ammonia to NOx and maximizing the residence time prior to the low temperature limit. Hence the location, design, and atomization characteristics of the injectors are critical considerations.

Under laboratory conditions, NOx reductions in excess of 90% has been demonstrated. Unfortunately, these conditions are never observed in reality. The closest approach to these ideals are seen in waste incinerators, wood fired units, and some CFB’s. These units have in common ample residence time above the minimum reaction temperature, base loaded conditions, and furnace dimensions which allow for effective dispersion of the reactant through the entire furnace cross section. In broad terms, these units routinely demonstrate 50% NOx reduction at a Normalized Stoichiometric Ratio (NSR) of 1.0 with less than 10 ppm ammonia slip.

Larger utility boilers have reported lower performance mainly due to the size of the units, inaccessible areas for injection, and load following control issues. NOx reductions in the range of 25 – 50% are common.

The most common side effects of SNCR are injector burn-out, localized boiler corrosion, and plume formation. At solid waste incinerators, a combination of high temperatures, high chlorides, and slagging operation have been known to reduce injector lifespans to 6-10 weeks. The net result on Operations has been frequent tip replacement and operation with a fraction of the optimum number of injectors. Often 25 MW boilers operate with as few as four wall injectors and accept the lower performance/higher slip which result. Alternate designs are now being used which improve on this situation by using higher classes of mettalurgy with greater wall thickness and easily replaceable lances.

Localized boiler corrosion is most noted with liquid reagents. In particular, waterwall thinning is common in the immediate vicinity of the injectors. This is suspected to be caused by droplet impingement on the unprotected tubes from localized eddies. The operating solution is to overlay the immediate areas with Inconnel, further extend the injection tips into the furnace, and higher energy atomization. This concern also applies to convective surfaces located within 0.1 – 0.2 seconds of an injection nozzle.

The key to minimizing plume formation is to reduce the amount of ammonia slip. This requires a thorough knowledge of the boiler temperature profile and should be the first thing checked. Nozzles placed to high in the boiler will operate on the left side of the effective temperature curve and results in high slip. Nozzles arranged non-symmetrically will tend to overdose parts of the gas stream and under dose others. Low carrier air or steam flows can create droplets which are too large to evaporate quick enough as well as poor penetration into the middle of the furnace cavity. Prior to the availability of accurate and inexpensive in-situ ammonia monitors, on-going process detective work was limited to reagent consumption and controlled NOx concentrations from a CEM. This only told half of the story and limited the certainty in any optimization evaluation. With them installed, the operator can better correlate cause and effect as well as better manage reagent consumption and plume formation.

The life cycle cost of an SNCR system is one of the better values associated with NOx controls, especially on existing units. The capital cost could be as low as $5 per kW on very large facilities, or those base-loaded facilities not in need of sophisticated controls. More typical is a capital cost in the range of $10 – 20/kW. The system can be installed in 6-8 weeks with minimal boiler down-time – often tying in during scheduled 3 day outages. An operating cost in the neighborhood of $500 per ton of NOx removed is typical, due almost exclusively to reagent cost. This is cheaper than the installation of low-NOx burners and OFA injection, and achieves the approximate same end result.

Lately, there has been very promising results from combining SNCR with combustion modifications to achieve high NOx reduction without committing to the high capital cost of an SCR system. In most cases, SNCR and combustion modifications are quite compatible, yielding a combined NOx removal of 70-75 % NOx reduction at a capital cost of approximately $50/kW. This technique, in combination with NOx credits, will have broad appeal to medium power boilers in pursuit of NOx compliance at the minimum cost.