



Hybrid solutions for **NOx** control

Kevin R. Dougherty, Vice President of Business Development and Marketing at Fuel Tech, Inc., looks at the hybridization of urea-SNCR and SCR technologies for cost-effective NOx control.

Boiler owners and operators have long investigated techniques for reducing NOx from stack emissions. A wide range of options are available for effective control between the burner zone, where NOx is formed, and the final emission at the stack. These include fuel switching, combustion modifications such as low NOx burners, over-fire air (OFA) and rich-reagent injection (RRI) in the combustion zone as well as post-combustion processes such as gas re-burn (GR), selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR).

Each of these control technologies has inherent capital and operating costs that vary with site-specific factors, and each has potential balance-of-plant concerns. In addition, many of these technologies interact

with each other. Changes in the fuel may require design modifications in post-combustion controls such as GR, SNCR and SCR systems. Changes to the flame stoichiometry may lead to increased CO, unburned carbon and ash properties that can also affect post-combustion controls.

Potentially, two or more available means of NOx control can be compatibly combined to reduce NOx wherein the end result is more cost-effective than the sum of its parts. Hybrid combinations of SNCR and SCR are a particularly flexible method for effecting moderate to deep NOx reductions of up to 80 percent, but at cost ranges typically well below those of a fully engineered SCR retrofit.

Fuel Tech's NOxOUT Cascade process is a patented SNCR/SCR hybrid system that

“The hybridized systems provide high levels of NOx reduction with operating costs lower than traditional SNCR and capital costs at a fraction of traditional SCR”

has been installed in utility and industrial furnaces both as demonstration and commercial projects. In all cases, the NOxOUT Cascade systems have provided significant improvement in the efficiency of chemical utilization versus conventional SNCR, and

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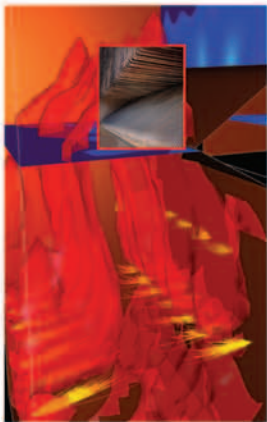
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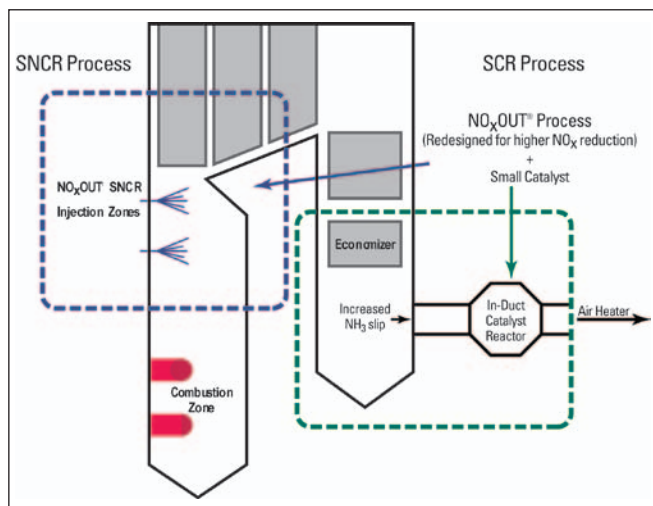
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increased NOx reduction versus standalone SCR. These improvements result in lower operating costs for the SNCR system, along with decreased SO₂ to SO₃ oxidation and gas side pressure drop versus an equivalent SCR. Used correctly, this lessens the risks associated with SO₃-induced ammonium bisulfate formation and plume opacity.

SNCR/SCR Cascade theory

The NOxOUT Cascade process is more than a combination of an SNCR and downstream SCR. The term 'hybrid' refers to a blending of the original technologies, which enhances their ability to work with one another. This synergistic process provides improvements in chemical utilization and overall NOx reduction. Each NOx reduction technology provides process strengths that make the NOxOUT Cascade combination more flexible and effective than the sum of its parts.



SNCR is typically applied in the furnace, where relatively high temperatures serve to initiate the breakdown of urea for effective NOx reduction. The technology is limited to temperatures high enough to ensure very low ammonia slip in the flue gas stream exiting the furnace.

SCR is typically performed after the boiler economizer section where the catalytic surface provides sites that permit the ammonia and NOx to react at very high efficiency. The extent of NOx reduction is often limited by the local ammonia to NOx ratio, the flue

gas temperature, the size of the catalyst reactor and the permissible un-reacted ammonia 'slip'. The catalyst size is limited by the available space, the resulting gas-side pressure drop, the oxidation of SO₂ to SO₃, and the amount of capital investment required for construction.

SNCR/SCR hybridization utilizes a more favorable low-temperature SNCR injection to provide substantially improved NOx reduction and increased utilization of the injected urea solution to minimize operating cost. The improved SNCR performance produces an increase in the resulting ammonia slip and takes advantage of the downstream SCR catalyst's ability to utilize that ammonia slip for NOx reduction.

The SNCR system can be used as the primary source of reduction with an in-duct SCR, as a trim to a relatively large SCR, or anywhere between the two. The role of the SNCR system can be adjusted automatically

as daily load variations, fuel modifications, or even seasonal NOx requirements change.

Cost and performance

The total capital requirement for the catalyst retrofit will increase as the catalyst size and retrofit complexity increase. The key to minimizing lifecycle NOx reduction costs is to find the appropriate

balance between annualized capital charges and operating costs for the remaining life of the system. The challenge for SCR retrofit is to minimize the capital requirement. The challenge for SNCR use is minimizing required reagent. Designing NOxOUT Cascade

75%
Overall NOx reduction
from a modified SNCR/
SCR process

systems suggests optimizing lifecycle costs for a specified level of NOx reduction.

A modified SNCR/SCR process can be effective for approximately 75 percent overall NOx reduction. Pre-catalytic NOx reduction of 50-60 percent from the SNCR system requires only 38-50 percent reduction from the SCR portion, and only 57 percent of the catalyst volume required for standalone SCR. An 'in-duct' catalyst may be used on a site-specific basis to fulfill this half-sized volume requirement.

The NOxOUT Cascade can be less than one-third of the capital cost of a full-scale SCR while reducing 96.2 percent of the NOx tons of a full scale SCR system on a 12-month operating basis. These performance values are based on 13 hours per day at full load operation during most of the year, with six hours of operation at 100 percent MCR during the spring and fall months. The SNCR subsystem can provide an estimated 25 percent NOx reduction in standalone mode at low load (50 percent MCR) operation, which closes the gap in performance at higher boiler loads. The full scale SCR may not be able to provide any NOx reduction at 50 percent boiler load, due to flue gas temperatures at the SCR catalyst being too low to sustain operation.

NOxOUT Cascade represents more than a simple combination of two NOx control strategies. The hybridized systems provide high levels of NOx reduction with operating costs lower than traditional SNCR and capital costs at a fraction of traditional SCR. ■

	NOxOUT Cascade	Full-scale SCR
Boiler size (MW)	600	600
NOx reduction (%)	75	85
Typical installed capital cost (\$/KW)	80	250
Total NOx tons reduced (annual)	12,117	12,804



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