A NEW APPROACH FOR HYBRID SNCR/SCR FOR NOx REDUCTION

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SUMMARY

While the conventional approach for NOx reduction is to employ SCR, this paper presents a conceptual approach to low NOx emissions with flexibility for minimizing the negative impact of SCR's NH3 slip and increased SO3 emissions.

NOx REDUCTION TECHNOLOGY REVIEW

SNCR is a low capital cost, post-combustion technology for incremental NOx reduction (up to 35%) using a gas-phase reaction. The optimum ammonia chemical utilization is from 1700 F to 1900 F. SNCR operation is a trade-off between NOx removal and NH_3 slip.

Selective Catalytic Reduction (SCR) is "selective" because it only removes oxygen (O_2) from nitrogen compounds. SCR can remove up to 90% of the NOx, but SCR has two negative impacts on plant operation.

- NH3 Slip
  - ABS (ammonia bisulfate) Formation by reaction with SO3 – air heater deposition & fly ash adsorption
  - NH3 Ad/Absorbed on Fly Ash - in byproduct ash & wastewater discharge
- Increased SO3 Emissions – catalyst oxidation of SO2 to SO3
  - ADP (acid dew point) Temperature Increase – ductwork corrosion impacts
  - Plume Opacity Increase – visible plume with potential opacity violations

These impacts are the long-term impacts with "aged" catalyst. NH_3 slip is generally limited to 2 ppm to avoid fly ash contamination and ABS deposits in the air heater. For dry ash, 1 ppm NH3 slip is ~70 ppm NH3, where most requirements for fly ash utilization is less than 100 ppm NH3

CATALYST REPLACEMENT & NH3 SLIP

Catalyst activity decreases over the life of the catalyst. For this conceptual assessment, catalyst life is assumed at 20,000 hours, after which the activity in the top layer has degraded to ~70%, at which time NH3 slip exceeds 2 ppm at 90% NOx removal. The subsequent layers will be assumed to have degraded to about half of the above layer's activity. Conceptually, the total activity of the catalyst layers would be:

- Initial – 3 initial fresh catalyst layers, the total catalyst "activity" is 3.0 and zero NH3 slip
- Spare catalyst layer addition
  - Before spare layer is added → 2.4 activity with 2 ppm NH3 slip
  - After spare layer is added → 3.4 activity with no NH3 slip

  The 2.4 activity establishes the baseline activity to maintain less than 2 ppm NH3 limits for 90% removal

- First catalyst layer replacement
  - Before layer replacement → 1.9 activity with > 2 ppm NH3 slip
  - After layer replacement → 2.6 activity with 1.8 ppm NH3 slip
- Second Layer replacement
  - Before → 1.5 activity with ~3 ppm NH3 slip
  - After → 2.3 activity with ~2 ppm slip

From this conceptual analysis, after each catalyst layer replacement, the total catalyst "activity" is lower than the baseline activity and the NH3 slip starts at a higher slip than the prior to the replacement.

HYBRID SNCR/SCR

The objective of this new approach to Hybrid SNCR/SCR is to use a lower NOx removal in the SCR to control NH_3 slip and a smaller amount of catalyst to reduce the increased SO_3 from SCR:

- Conventional Hybrid – SNCR with In-Duct SCR, between the economizer outlet & the AH inlet, usually with operation at higher gas velocities than conventional SCR reactors & with horizontal gas flow.
- New Hybrid Approach – SNCR with a separate, conventional SCR reactor (vertical with down-flowing gas)

The new Hybrid approach allows for SNCR operation at the top of the optimum curve to maximize NOx removal, while producing a high NH_3 slip - 50% removal with 40 ppm slip. Optimum SNCR should be able to reduce the NOx to ~0.20 lb/MMBtu. The addition of SCR with 2 catalyst layers would only need about 70% removal to achieve 0.05 lb NOx/MMBtu. The lower NOx removal should limit NH3 slip at to less than 1ppm.

ECONOMICS

Hybrid SNCR/SCR capital cost (~$1,000 per ton NOx) is greater than conventional SCR (~$850 per ton NOx). The higher Hybrid capital cost is offset by:

- Ash Disposal – Fly ash contaminated with NH_3 usually cannot be sold as a byproduct and is assigned a value of $20/ton for off-site disposal cost - $267/ton of NOx
- Urea – Hybrid SNCR/SCR has only a slightly higher urea cost ($398) compared to SCR ($352) → differential urea cost of negative $46 per ton of NOx
- Replacement Power – differential power cost for catalyst pressure drop (4 vs 2 catalyst layers) – $24/ton NOx
- Catalyst Replacement – Catalyst replacement for the new Hybrid should be less than conventional SCR due to the lower NOx removal. To complete this conceptual analysis, the catalyst activity degradation needs to be verified by actual operating experience.

The total net operating cost differential is up to $245 per ton of NOx removed for Hybrid – which is greater than the capital cost differential for SCR (~$150per ton of NOx).

RECOMMENDATION

- Determine the "fate" of the NH3 slip and SO3 as the flue gas from the SCR goes thru the air heater (including wash water), ESP & FGD
- Correlate the catalyst activity degradation with NH3 slip and NOx removal on a regular basis – not just when the catalyst OEM needs the data