SNCR-Fuel Additive Based Hybrid Technology for Low NO\textsubscript{x} Pulverised Coal Combustion

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Objectives

• Briefly discuss NO\textsubscript{x} technologies
• Discuss the applicability of Fe-based additives
• Present the findings of an investigation into the combination of selective non-catalytic reduction (SNCR) and Fe-based additives
The NO$_x$ Problem

- Air quality has become an international health issue
- Nitrogen oxides largely to blame
- Released during combustion-related power generation
- Prominently from coal
- But coal is in decline...
- Or is it?

NO\textsubscript{x} Formation

- Thermal NO\textsubscript{x}
- Prompt NO\textsubscript{x}
- Fuel NO\textsubscript{x} \rightarrow Volatile and char oxidation


1º NO\textsubscript{x} Abatement Options

- Low NO\textsubscript{x} Burners (LNBs)
- Over-fire air (Air Staging)
- Reburning
- Flue gas recirculation (FGR)


2° NO\textsubscript{x} Abatement: SNCR and SCR

- Selective Non-Catalytic Reduction (SNCR) $\rightarrow$ low cost + moderate NO reduction + moderate risk of ammonia slip
- Temperature range: 875-1175 C
- Selective Catalytic Reduction (SCR) $\rightarrow$ high cost + high NO reduction + low risk of ammonia slip + subject to fouling
- Temperature range: 150-600 C
- Various catalysts have different properties
- Iron oxide investigated as a fouling-free catalyst
Fe-based Additives

- Iron reacts with NO and CO in the flame in a redox reaction
- Fe-based additive found to increase coal pyrolysis → increasing combustion efficiency + flame temperature
- Influences char/volatile spit → favours volatile split

So, can using this additive affect SNCR utilization?
Experimental Setup

- 100 kWth combustion test facility
- Fe-based additive delivered to primary air with coal
- Ammonia, entrained in N₂, injected into section optimised for high NOₓ reduction and a low ammonia slip (T=1050 C)
- NO, O₂, CO and CO₂ analysed at flue gas


- Coal baseline
- SNCR
- Fe Baseline
- Fe + SNCR
• NO reduction due to SNCR increased by up to ~10%
• The amount of ammonia involved in reducing NO increases by over 10% at low NSRs
• Greater amount of Fe-based additive leads to greater ammonia utilisation and hence NO reduction

Actual Effect vs Predicted Effect

- SNCR efficiency should reduce with decreasing initial NO concentration.
- A coefficient ‘k’ is used to represent this drop in efficiency.
- E.g. $k=0.8 \rightarrow 80\%$ of original SNCR efficiency and $k=1 \rightarrow$ no drop in efficiency.
- When the Fe-based additive is used, there is a lower initial NO concentration.
- So NO concentration in the flue gas should be within range of k values.
- Instead, SNCR efficiency has increased.

Possible Mechanism for Ammonia-Fe Interaction

- Iron oxide has been previously tested as a catalyst for SCR
- \( Fe^{3+} \) ion acts as a binding site for ammonia
- Facilitating NO reduction by removing reliance on radicals to initiate the SNCR reaction mechanism


So, what does this mean for operators?

- One option: Reduce ammonia usage and maintain NO reduction
- Or: Maintain ammonia usage and greatly improve NO reduction

Using the Integrated Environmental Control Model (IECM) to calculate the effect on the OPEX of a 650 MW coal power plant when a SNCR’s NOx reduction is increased from 30% to 45%:

- Use of the Fe-based additive is far more economically viable (assuming a cost of £45/ton) than increasing ammonia usage.

Thanks for listening!

Any Questions?