

# Fe-SNCR hybrid technology: Corrosion and NO<sub>x</sub> Emission reduction

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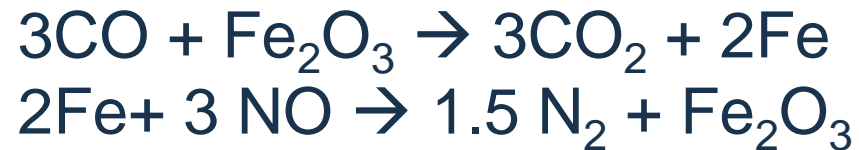
The Fuel and Energy Research Forum  
2<sup>nd</sup> Annual Meeting, 11<sup>th</sup> April 2018,  
The University of Sheffield

# Outline

- Fe- based additive
- SNCR
- Why SNCR-Fe based additive
- Findings of an investigation into the combination of SNCR and Fe-based additives

# Fe-based Additives (i)

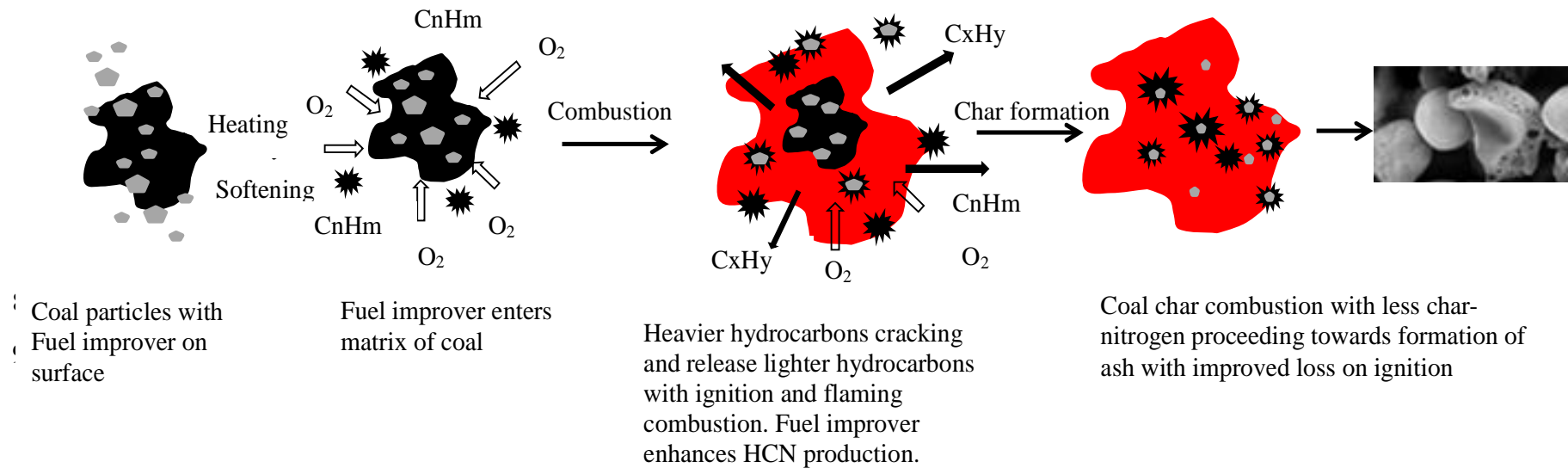
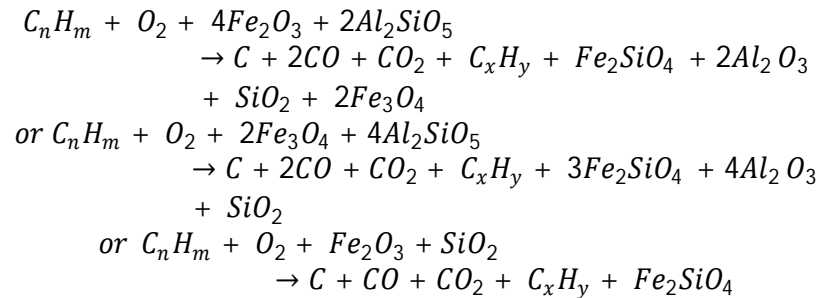
- Iron reacts with NO and CO in the flame in a redox reaction



Net reaction



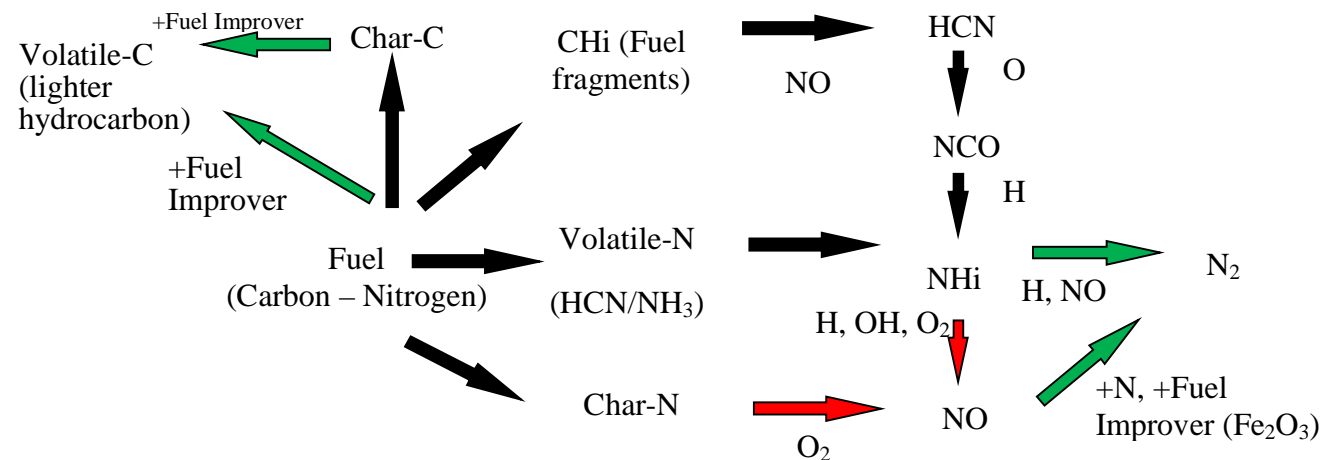
# Fe-based Additives (ii)





# Fe-based Additives (iii)

- Fe-based additive found to increase coal pyrolysis → increasing combustion efficiency + flame temperature
- Influences char/volatile split → favours volatile split



# 2<sup>o</sup> NO<sub>x</sub> Abatement: SNCR and SCR

- Selective Non-Catalytic Reduction (SNCR) → low cost + moderate NO reduction + moderate risk of ammonia slip
- Temperature range: 875-1175 C
- Selective Catalytic Reduction (SCR) → 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

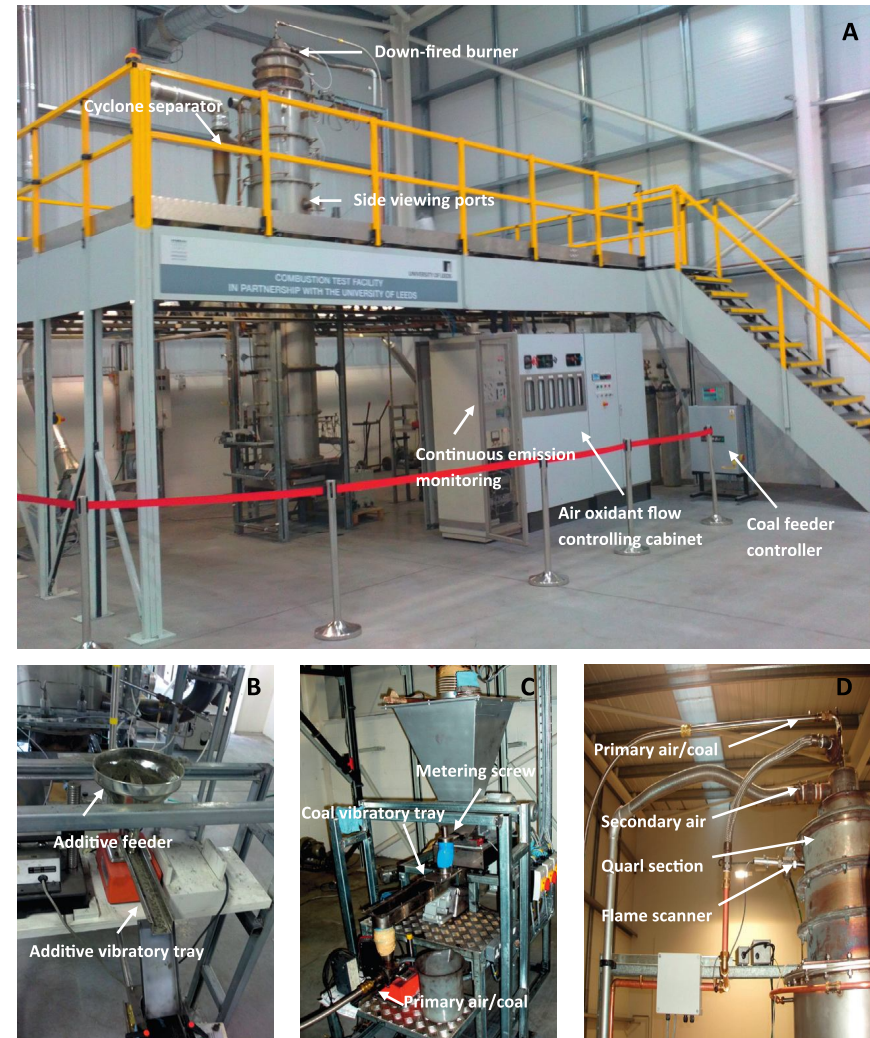


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So, can using this additive affect SNCR utilization?

# Experimental Setup

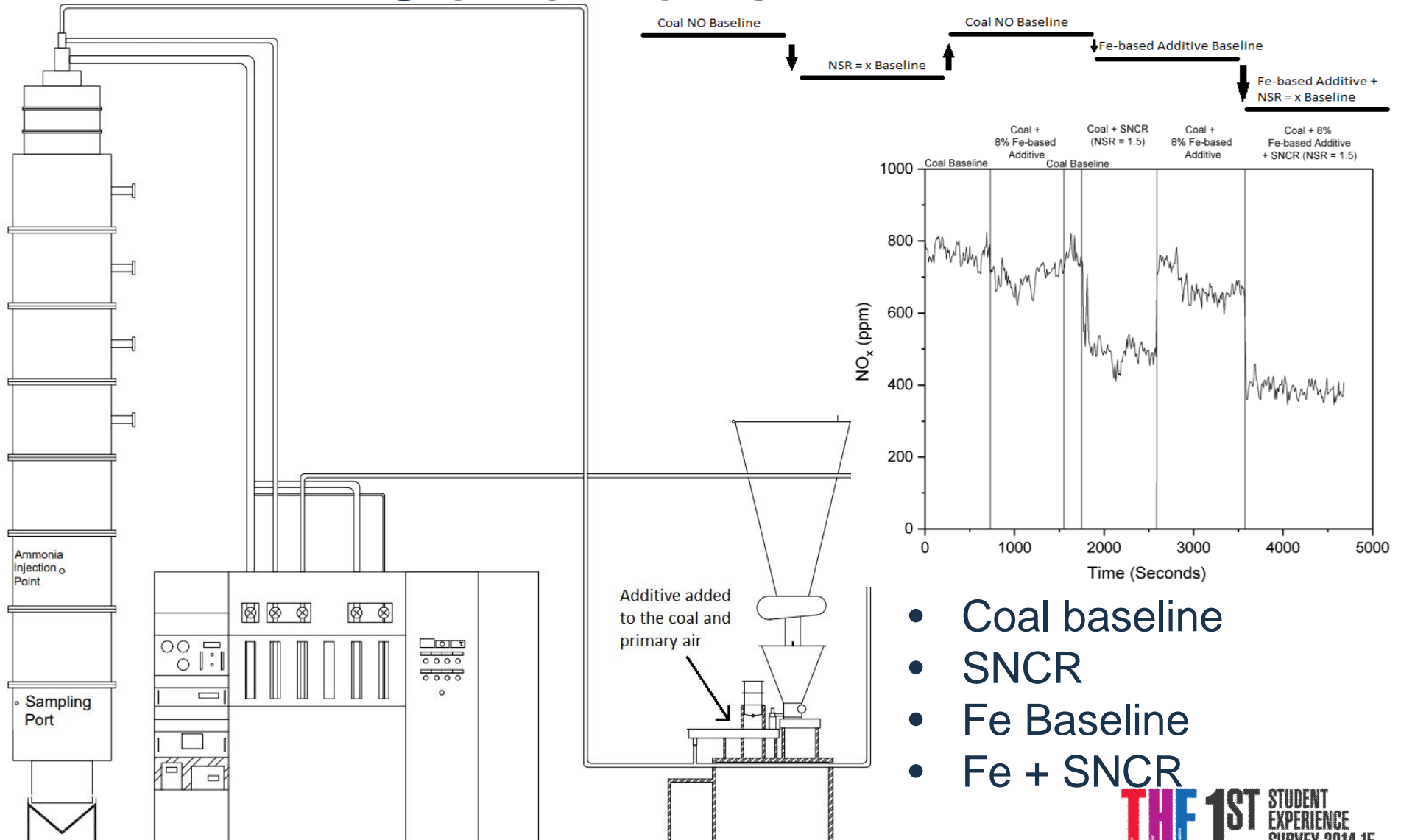
- 100 kWth combustion test facility
- Fe-based additive delivered to primary air with coal
- Ammonia, entrained in  $N_2$ , injected into section optimised for high  $NO_x$  reduction and a low ammonia slip ( $T=1050\text{ C}$ )
- $NO$ ,  $O_2$ ,  $CO$  and  $CO_2$  analysed at flue gas





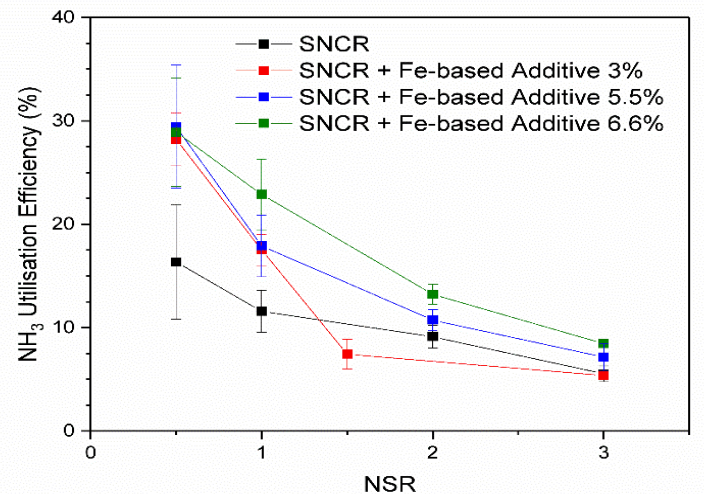
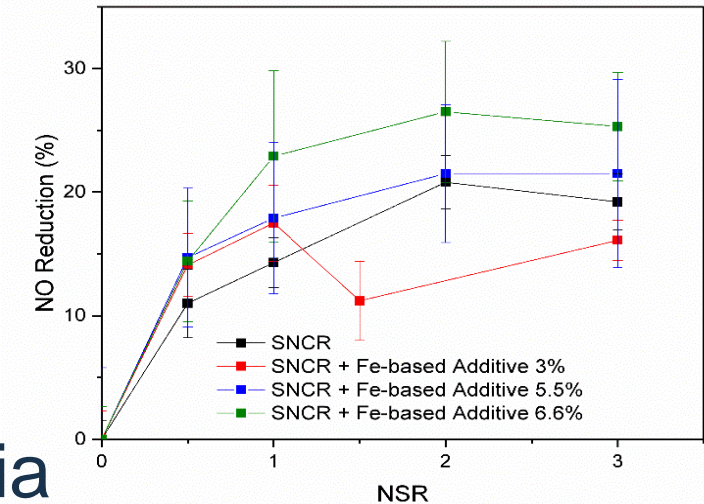
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# Test Procedure - Conditions



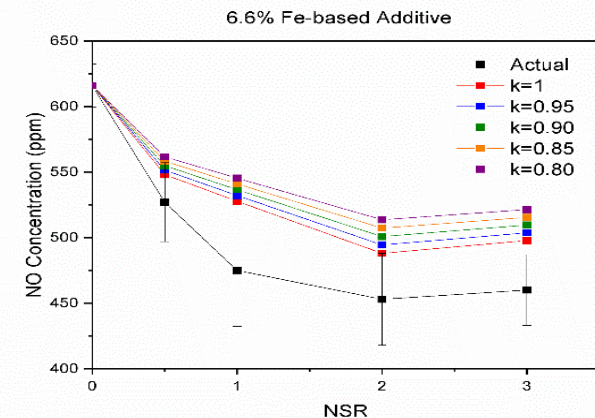
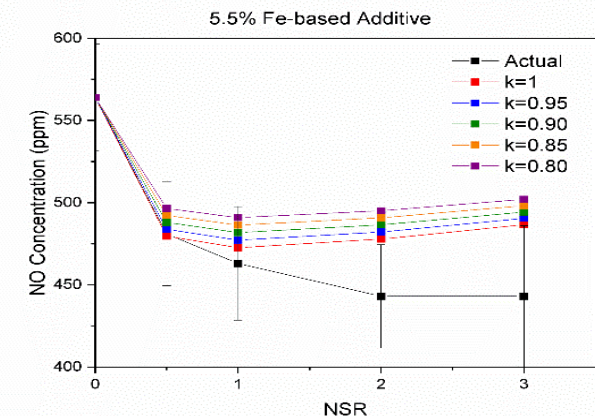
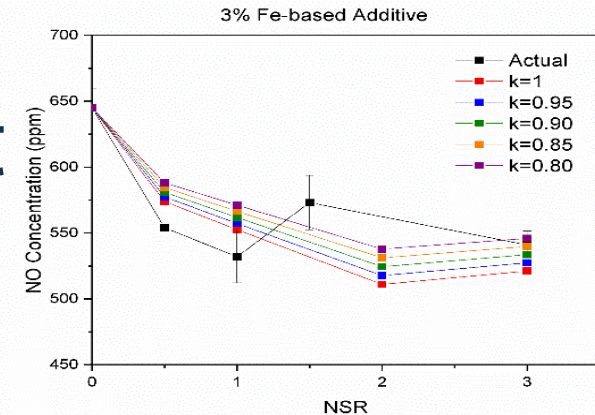
# SNCR Effectiveness

- NO reduction due to SNCR increased by up to ~10%
- 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



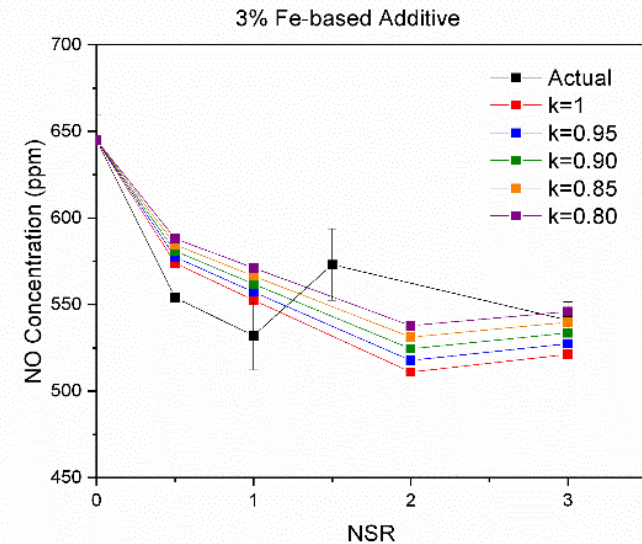
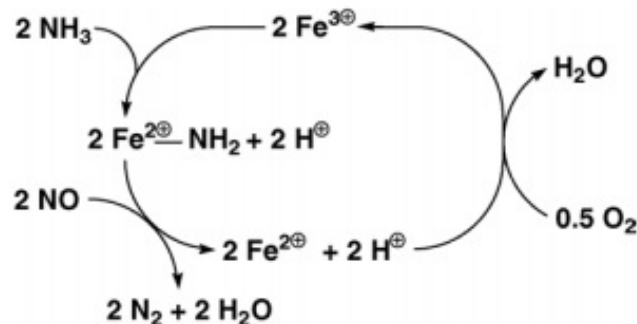


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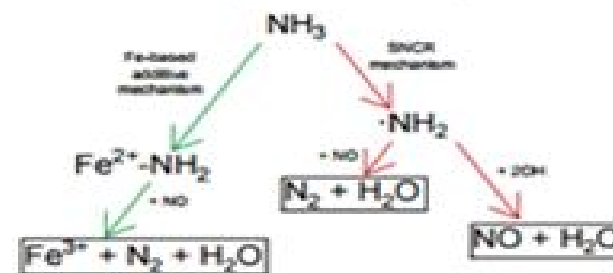
# Possible Mechanism for Ammonia-Fe Interaction

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

Apostolescu, N., Geiger, B., Hizbullah, K., Jan, M.T., Kureti, S., Reichert, D., et al. (2006) Selective catalytic reduction of nitrogen oxides by ammonia on iron oxide catalysts. *Applied Catalysis B: Environmental*, 62(1-2), 104-114.



Daood, S.S., Yelland, T., Nimmo, W. (2017) Selective non-catalytic reduction – Fe-based additive hybrid technology. *Fuel*, 208, 353-362.

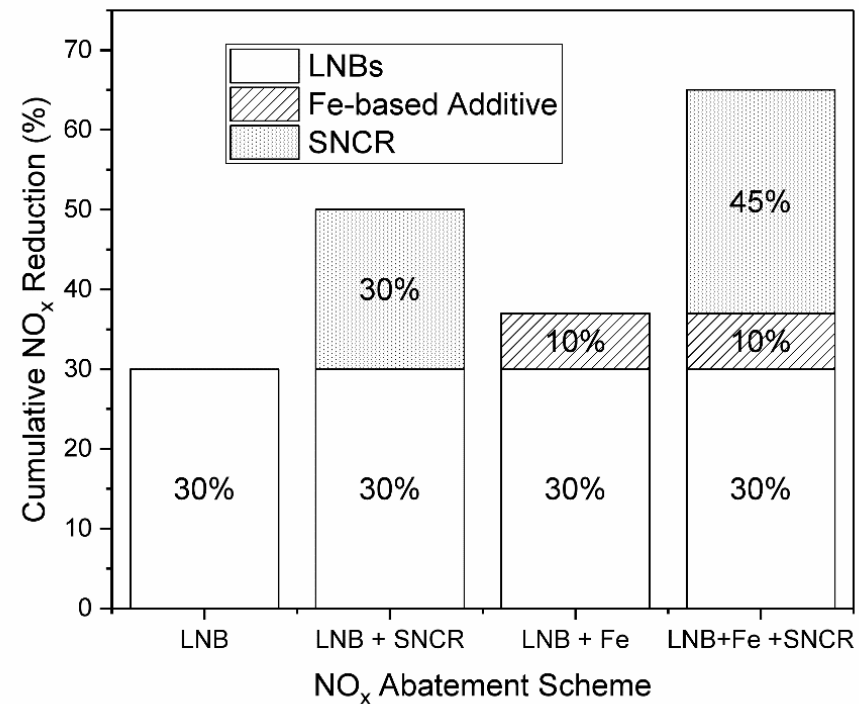
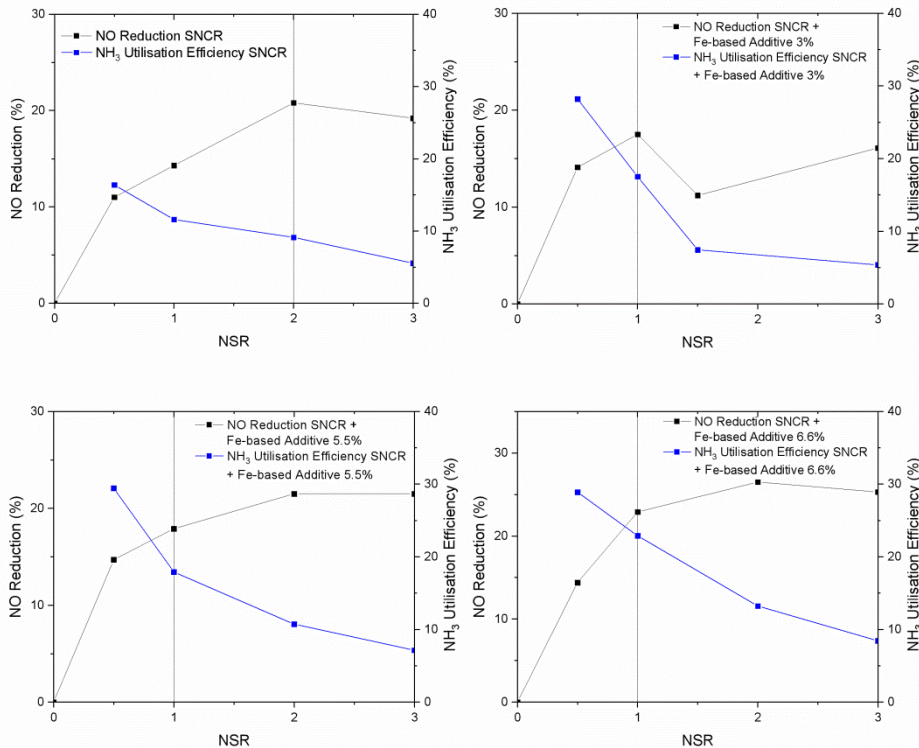


- Fe-based additive mechanism reaches maximum rate as Fe binding sites become full
- SNCR mechanism becomes more active
- However, OH/NH<sub>3</sub> ratio is high, so NO production reactions are more active than NO reduction reactions
- NO reduction decreases
- NH<sub>3</sub> utilisation efficiency decreases substantially



# 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





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# Thanks for listening!

## Any Questions?