SCR for NO_x Control in Coal-fired Power Plants

Johnson Matthey Catalysts

The McIlvaine Company

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New FGD and DeNOx Approaches

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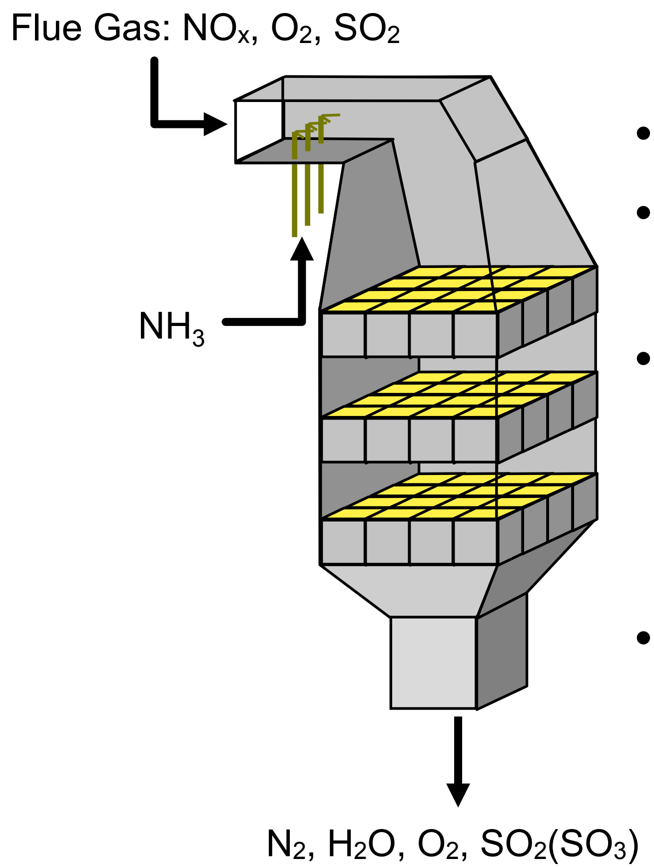
ENVIRONMENTAL CATALYSTS AND TECHNOLOGIES

SCR Basics – Quick Review



- SCR = Selective Catalytic Reduction
- Purpose is to reduce NO_x (NO & NO_2) from combustion exhaust
- Ammonia (NH_3) is injected into flue gas as reducing agent. Flue gas passes through catalyst layers installed in a reactor
- NH_3 reacts with NO_x on the catalyst surface to form nitrogen and water vapor

$$4NO + 4NH_3 + O_2 \xrightarrow{\text{Catalyst}} 4N_2 + 6H_2O$$

$$2NO_2 + 4NH_3 + O_2 \xrightarrow{\text{Catalyst}} 3N_2 + 6H_2O$$

SCR Catalyst Types

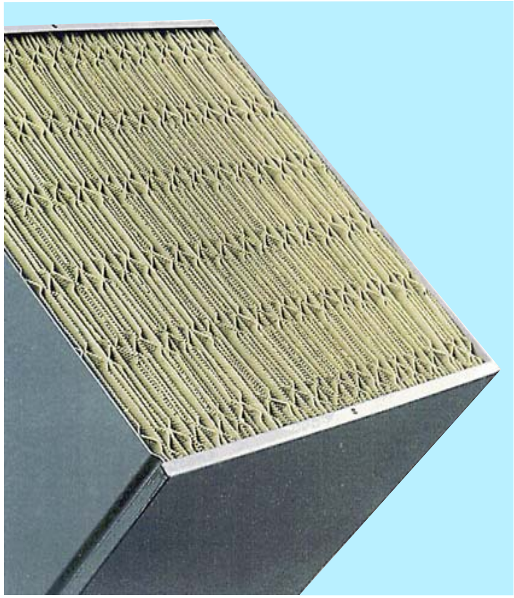
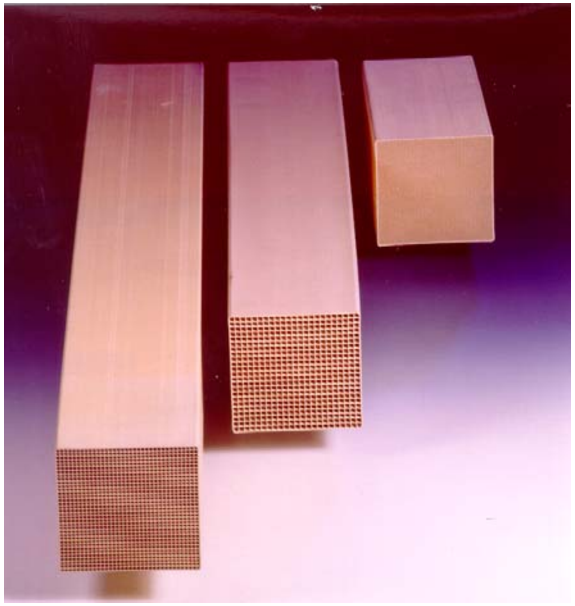


Plate-Type

- Ceramic material on SS substrate
- Individual flexible plates
- Rectangular flow channels
- Ideal for particulate-laden flue gas



Honeycomb

- Homogenously extruded ceramic
- Rigid structure, square channels
- High cell density, high surface area
- Ideal for particulate-free flue gas

SCR Presence in the US

- Appeared in late 1980s / early 1990s
- Proven technology for achieving low NO_x emission rates
- ~260 Utility coal-fired units with SCR (135,000 MW)
- 100s of combustion turbines (SC/CC)
- 1000s of stationary diesel engines
- Marine applications
- Off-road mobile applications
- On-road mobile applications

Traditional Approach for Coal-fired Applications

- High-dust SCR configuration (directly downstream of boiler outlet)
- Reactors with 2 or 3 initial catalyst layers, 1 or 2 empty spare layers
- 80-90% deNOx, emission rates < 0.05 lb/MBTU
- $\leq$2 ppm NH_3 slip at end of catalyst lifetime
- Catalyst management a major concern due to fly ash plugging and deactivation
  - Frequent catalyst change-out, 2-3 years between additions/replacement
  - Replacements with new, used, regenerated catalyst

New Approaches and Developments for SCR

- >90% deNOx with low NH_3 slip
- New applications
- Catalyst product improvement
- Hg oxidation, co-benefit

High deNOx, 90-95%+

- Traditional approach for high deNOx
  - over-injecting ammonia
  - excess catalyst volume
  - Trade-offs include higher cost and high ammonia slip
- Improve NH_3-NO_x mixing for low ammonia slip (< 2 ppm)
  - NH_3:NO_X distribution ≤ 5% RMS typical for up to 90% deNOx
  - For higher deNOx, NH_3:NO_X distribution ≤ 2.5% RMS
  - Sophisticated flow modeling tools (CFD, physical) used for design
- Development of advanced NH_3 slip control catalysts
  - High deNOx, low NH_3 slip
  - Extend catalyst operating life

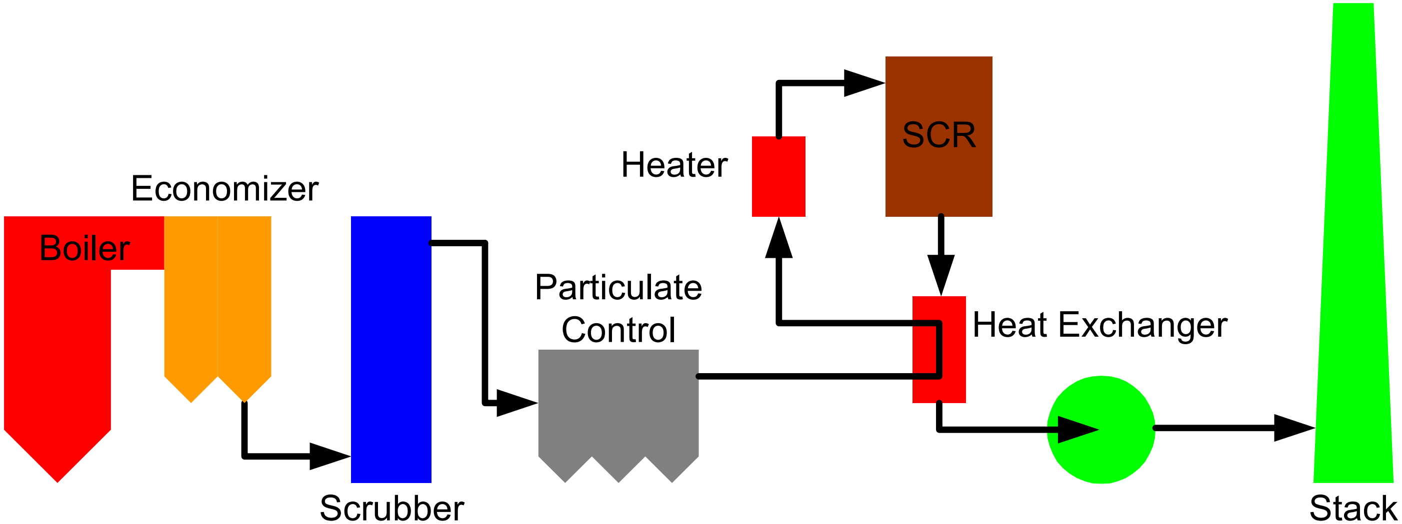
New SCR Applications

- SCR for US lignite-fired units
  - High ash concentration, high alkali concentrations (K, Na) – risk for fast catalyst deactivation, fouling
  - First TX lignite-fired unit with SCR started in 2009
  - 3 units now operating
  - Investigating SCR for ND lignite firing
- Investigating use with cement kilns
  - Produce high NO_x
  - High ash exhaust gas – high risk for catalyst
  - SCR would likely be in “low-dust” configuration, downstream of ESP or baghouse

Other “Challenging” SCR Applications

- Flue gas with particulate deactivates catalyst – poisoning, fouling, erosion
- Biomass combustion – high risk of poisoning by alkalis and phosphorus
- Waste (trash) combustion – high risk of poisoning by heavy metals and acid gases
- Tail-end SCR configuration – downstream of particulate collection
  - Prevents fast catalyst deactivation
  - High cell density/surface area catalyst, lower volume requirement
  - Allows long catalyst lifetime, avoid frequent catalyst maintenance
- Trade-offs with Tail-end SCR
  - Position where flue gas temperature is low
  - Operating target of 400 – 540 °F may require flue gas reheating
  - Cost to install and operating flue gas reheating equipment

Tail-End SCR



- Typical configuration for European WTE plant SCR installations
- SCR after scrubber/particulate collection equipment
- Long catalyst life expected
- Special catalyst formulations for low temperature, 400 – 540 °F
- Low concentrations of SO_2, SO_3 required

Continuous Catalyst Product Improvement

- High deNOx activity, low SO_2 oxidation activity – reduce volume, cost
- Poison resistance – extend catalyst life
- Special formulations for high temperature operation
- Low temperature operation
- Ammonia slip control – extend catalyst life, achieve high deNOx rates
- Enhance Hg oxidation

Hg Oxidation, $Hg^0 \rightarrow Hg^{2+}$

- Mercury emission control from Coal combustion
  - Activated Carbon injection or other Novel sorbents
  - Capture in wet FGD
  - These methods work better on Hg^{2+}
- Hg oxidation is a co-benefit of SCR catalyst
- Hg oxidation rate strongly dependent on
  - Presence of halogens in flue gas – Cl, Br
  - Temperature, < 700 °F
  - Catalyst formulation and volume
- Catalysts being developed with enhanced Hg oxidation capability while preserving performance on deNOx and SO_2 oxidation

Thank You!

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