SCR Catalyst Selection Considerations

McIlvaine Hot Topic Hour
October 21st, 2010
Cormetech Approach

• Understand the unique perspectives and challenges for individual utilities and/or plants
  – Not all utilities/plants have the same drivers

• Utilize strong experience and knowledge base in combination with strategic collaborations to provide full range of solution options
  – Catalyst Technology Advancements
  – Optimization Tools
  – Strategic Collaboration
Integrated Management Considerations

- Catalyst Type
- Performance
- System/BOP
- Outage Planning

- HC
- Plate
- Corrugated

- NOx
- Hg
- SO2 conv.
- Life/NH3 Slip
- New vs. Regen
- Guarantees

- Fuels & Additives
- AIG design/tuning
- APH/PM/scrubber
- Power Generation Mix
- Operating Load Profile

- Schedule
- Duration
- Layer actions
- Maintenance
Catalyst Management

Current Active Projects:

1. **Continuous Improvement**
   - Activity & SO₂ conversion → Improved $ per K/AV

2. **Advanced Hg Oxidation catalyst**

3. **Selective Decomposition of Ammonia**

4. **Proven Evaluation Tools**

5. **Strategic Collaboration**
Advanced Hg Oxidation catalyst

- **Drivers**
  - CAMR vacated but still anticipate Federal and State rules to require 90% reduction (basis coal pile to stack)
  - Will it be 90%? Will it be a rate? How does the requirement effect technology selection/applicability (fuel)/cost?

- **Timing**
  - Expected Rule 2011 → compliance 2014?

- **Market Needs**
  - What is anticipated oxidation need from SCR?
  - What is anticipated contribution from APH, ESP, FGD, etc.?

- Elemental

- Oxidized

- Particle-bound

(\(\text{Hg}^0\))

(\(\text{Hg}^{2+}\))

(\(\text{Hg}_{(p)}\))

Flowchart showing interactions between Boiler, DeNOx - Hg Oxidation, Air Heater, Particulate Control Device, FGD, and Stack.
Simultaneous SCR Reactions:
DeNO$_x$ - Hg Oxidation and Reduction – SO2 oxidation

**Desired Reactions:**

\[
\begin{align*}
\text{NO} + \text{NH}_3 + \frac{1}{4} \text{O}_2 & \rightarrow \text{N}_2 + \frac{3}{2} \text{H}_2\text{O} \quad \text{(NO}_x\text{ Reduction)} \\
\text{Hg} + 2 \text{HCl} + \frac{1}{2} \text{O}_2 & \rightarrow \text{HgCl}_2 + \text{H}_2\text{O} \quad \text{(Hg Oxidation)}
\end{align*}
\]

**Undesired Reactions:**

\[
\begin{align*}
\text{HgCl}_2 + \text{NH}_3 + \frac{1}{4} \text{O}_2 & \rightarrow \text{Hg} + 2 \text{HCl} + \frac{1}{2} \text{N}_2 + \frac{1}{2} \text{H}_2\text{O} \quad \text{(HgCl}_2\text{ Reduction by NH}_3) \\
\text{HgCl}_2 + \text{SO}_2 + \text{H}_2\text{O} & \rightarrow \text{Hg} + 2 \text{HCl} + \text{SO}_3 \quad \text{(HgCl}_2\text{ Reduction by SO}_2) \\
\text{SO}_2 + \frac{1}{2} \text{O}_2 & \rightarrow \text{SO}_3 \quad \text{(SO}_2\text{ Oxidation)}
\end{align*}
\]
Co-Benefit Improvement Strategy

Increase Rate of Desired Reactions:

\[ \text{NO} + \text{NH}_3 + \frac{1}{4} \text{O}_2 \rightarrow \text{N}_2 + \frac{3}{2} \text{H}_2\text{O} \quad \text{(NO}_x \text{ Reduction)} \]

\[ \text{Hg} + 2 \text{HCl} + \frac{1}{2} \text{O}_2 \rightarrow \text{HgCl}_2 + \text{H}_2\text{O} \quad \text{(Hg Oxidation)} \]

- Advanced SCR Catalyst!

Decrease Rate of Undesired Reactions:

\[ \text{HgCl}_2 + \text{NH}_3 + \frac{1}{4} \text{O}_2 \rightarrow \text{Hg} + 2 \text{HCl} + \frac{1}{2} \text{N}_2 + \frac{1}{2} \text{H}_2\text{O} \quad \text{(HgCl}_2 \text{ Reduction by NH}_3) \]

\[ \text{HgCl}_2 + \text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{Hg} + 2 \text{HCl} + \text{SO}_3 \quad \text{(HgCl}_2 \text{ Reduction by SO}_2) \]

\[ \text{SO}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{SO}_3 \quad \text{(SO}_2 \text{ Oxidation)} \]

- Advanced SCR Catalyst!
Advanced Hg Oxidation
MHI/Cormetech Joint Development

- **Additional Features**
  - Much lower negative impact from reducing species
  - Designed for high durability over time
  - Can be used alone or in combination with existing catalyst
  - Reduced total compliance cost
Selective Decomposition of Ammonia

**Drivers:**
- NH3/NOx maldistribution requires periodic tuning and limits NOx reduction achievable
  - NH3 in excess in some areas due to maldistribution can lead to downstream equipment fouling
- Continued pressures on total NOx emissions

**What is value of:**
- Reduced tuning costs
- DP savings
- Reduced fouling
- High NOx Reduction (95%+)
**SDA Catalyst**

- **US Patent 7658898 (joint Cormetech–MHI patent)**
- **Reaction network for SDA catalyst:**

**DeNOx:**
\[ \text{NO} + \text{NH}_3 + 1/4\text{O}_2 \rightarrow \text{N}_2 + 3/2\text{H}_2\text{O} \]

**SO\textsubscript{2} oxidation:**
\[ \text{SO}_2 + 1/2\text{O}_2 \rightarrow \text{SO}_3 \]

**NH\textsubscript{3} oxidation:**
\[
\begin{align*}
4\text{NH}_3 + 3\text{O}_2 & \rightarrow 2\text{N}_2 + 6\text{H}_2\text{O} \\
4\text{NH}_3 + 5\text{O}_2 & \rightarrow 4\text{NO} + 6\text{H}_2\text{O} \\
4\text{NH}_3 + 7\text{O}_2 & \rightarrow 4\text{NO}_2 + 6\text{H}_2\text{O} \\
2\text{NH}_3 + 2\text{O}_2 & \rightarrow \text{N}_2\text{O} + 3\text{H}_2\text{O}
\end{align*}
\]

**SO\textsubscript{3} reduction:**
\[ \text{SO}_3 + 2\text{NH}_3 + \text{O}_2 \rightarrow \text{SO}_2 + \text{N}_2 + 3\text{H}_2\text{O} \]

*SDA catalyst incorporates NH\textsubscript{3} oxidation functionality (without increasing SO\textsubscript{2} oxidation)*

*Reaction equations for standard SCR catalyst*

*Dominant NH\textsubscript{3} oxidation reactions*

*Not active*

*Low activity (1-2 ppm)*
Developed kinetic model for SDA catalyst
- Predict DeNOx, NH$_3$ oxidation, and SO$_2$ oxidation activity
- Utilized 15 sets of fresh performance data

Proposed system layer arrangement:

- Flue gas flow
- Layer 1: SDA Catalyst
- Layer 2: Standard SCR Catalyst

Ran simulations:
- Catalyst surface area vs. RMS at 90%, 95%, and 99% DeNOx
- Two case studies (compare SDA system vs. standard catalyst):
  - 90% DeNOx and 99% DeNOx
Impact of $\text{NH}_3/\text{NO}_x$ RMS on Catalyst Surface Area (or Catalyst Volume for Constant Pitch)

Constant average $\text{NH}_3$ slip = 2 ppm
Surface area reference basis is standard catalyst at 90% DeNOx and 5% RMS
Evaluation Tools

• Multiple Tools/Capabilities Including:
  – Fuels management tool
  – Additives Analysis
  – Laboratory Analysis
  – AIG Design/Tuning
  – Lifecycle management economic evaluation tool
  – Expanded operating temperature range
Strategic Collaboration

- Cormetech and CoaLogix are pleased to announce the collaboration of the two of the leading Supply and Technology Companies for SCR Services

Announced: August 10, 2010
Cormetech & CoaLogix
Core Competencies & Capabilities

**Cormetech**
- SCR Catalyst Manufacturing
- SCR System Application/Management Experience
- Technology Advancements in Hg oxidation, SDA, SO$_3$ mit., etc.

**CoaLogix**
- Regeneration Technology/Experience
- SCR Management Experience
- SO$_3$ and Hg mitigation (FLSmidth Agreement)
Cormetech & CoaLogix

• Key Benefits of Cormetech Certification
  – Combination brings 360° Catalyst Mgmt Service
  – Integrated performance solutions and warranties
  – Simplified and consolidated purchasing and inventory management & supply assurances
  – Long-term SCR catalyst management commitment
  – Integrated technology to assure lowest compliance cost

*Future will be focused on Implementation of Regeneration & Advanced Technologies to meet New Air Emissions Challenges*