McIlvaine Hot Topic Hour
Air pollution control for gas turbines

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Topsøe
- A global supplier of catalysts and technologies

Subsidiaries
Haldor Topsoe, Inc.
Haldor Topsøe International A/S, Denmark
Haldor Topsoe India Pvt. Ltd. India
ZAO Haldor Topsøe, Russia
Subcontinent Ammonia Investment Company ApS (SAICA)
Topsoe Fuel Cell A/S, Denmark
Our business areas

- Fertiliser industry
- Heavy chemical and petrochemical industries
- Refining industry
- Environmental and power sector
- Renewables
… and a leading market player

- Market share between 15-25% for established products
- Supplier of solutions for 50% of new ammonia plants built within the last decade
- More than 60% of ammonia is produced worldwide on Topsøe catalyst
- Supplier for 40% of catalysts for production of ultra-low sulphur diesel
- 30% market share of hydrogen catalysts
- 30% market share of FCC pretreatment catalysts
- References account for 60% of the world's industrial production
Technologies cont.

- **Environmental technologies**
  - DeNOx (SCR DNX® catalyst): Removal of nitrogen oxides
    - Coal fired power plants
    - Gas fired boilers
    - Diesel and gas engines
    - Waste incinerators
    - Co-Gen units
    - Single cycle
    - Furnaces
    - FCC unit
    - Other refinery processes
    - Hydrogen units
  - WSA: Sulphur removal
  - SNOX™: Combined WSA/DeNOx
  - CATOX/REGENOX: VOC removal
Haldor Topsoe’s SCR Catalyst Products

- Homogeneously Corrugated Composite SCR Catalyst
- TiO$_2$ with V$_2$O$_5$ as the principal active component including WO$_3$
- Design temperature range: 300 – 1,050°F
  - low temperature SCR → higher V:W ratio
  - high temperature SCR → low V:W ratio (low V to no V catalyst is optimal choice for simple cycle SCR if no dilution air is used)
DeNOx catalyst production - “3-step approach”

- Corrugated catalyst based on a glass fibre structure
- TiO$_2$ and other raw material are used to provide the porous structure
- Impregnation with V$_2$O$_5$ and WO$_3$ to generate the active catalytic sites
- Front edge reinforcement for all applications
Catalyst Performance – Benefits of a meso- and macro-pore

Flue gas flow

- NO
- NO
- NO
- N₂

Micro-pores
Homogeneous pore system

Micro-pore
Meso-pore
Macro-pore

Tri-modal pore system
Catalyst Performance

New Jersey Combined Cycle GE7FA DNX® Catalyst Installed (2001)

Guarantees:

- 3.5-ppmvdc Outlet NOx
- 86% DeNOx
- 5-ppmvdc NH₃ slip
- 2.0 in. wc draft loss
- 3-yrs life
Catalyst Performance

Alabama Combined Cycle Siemens 501F
DNX-929 Catalyst Installed (2010)

<table>
<thead>
<tr>
<th>Test</th>
<th>Before Brand X Catalyst Replaced</th>
<th>Guarantees</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outlet NOx</td>
<td>ppmvdc</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>NH$_3$-slip</td>
<td>ppmvdc</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>SCR Inlet Temp.</td>
<td>deg. F</td>
<td>600 - 650</td>
<td>-----</td>
</tr>
<tr>
<td>29% NH$_3$ Injection Rate</td>
<td>gph</td>
<td>&gt; 500</td>
<td>394</td>
</tr>
<tr>
<td>SCR Draft loss</td>
<td>in. wc</td>
<td>&gt; 2.75</td>
<td>1.6</td>
</tr>
<tr>
<td>Service Life</td>
<td>Hours</td>
<td>----</td>
<td>40,000</td>
</tr>
<tr>
<td>Power Generation</td>
<td>MW</td>
<td>156.4</td>
<td>-----</td>
</tr>
</tbody>
</table>

✓ Power Output increased by 3.7 MW
✓ Ammonia usage decreased by over 50%
HTI Experience

- Utility Boilers: 80 units
- Combustion Turbines: 352 units
  - including (> 800 F up to 1,050 F): 135 units
- Refinery & Industrial Boilers, Heaters: 328 units
- Stationary Diesel and Gas Engines: 56 units

Total Experience: 816 units

* Additional HTAS experience of ~ 400 units includes refinery units.

* Leading supplier of Combustion Turbine, Refinery, and Industrial DeNOx catalyst in the US.
SCR Process Basics

- SCR = Selective Catalytic Reduction
- Purpose is to reduce NOx from flue gas.
- A reducing agent, most commonly ammonia (NH₃), is injected into the flue gas via an Ammonia Injection Grid (AIG).
  - The NH₃ must be distributed thoroughly into the gas stream prior to the catalyst.
  - The mixed gas then passes through the catalyst layers where the NH₃ reacts with NOx on the catalyst surface and in the pores to form N₂ and H₂O vapor.

Flue Gas: NOx, SOx, CO₂, O₂

Clean Gas: N₂, H₂O, O₂, SO₂, (SO₃)
SCR Design Considerations

Performance Requirements
(NOx Reduction, NH₃ slip, DP, Service Life)

Exhaust Gas
(Composition, Flow, Temp)

Load Dispatch
(AGC, Bandwidth)

System Mal-distribution
(Flow, NH₃/NOx, Temp)

CO Catalyst Placement
(NO₂/NOx Ratio)

AIG, Mixer Plates, Seal Design
(Location, Mal-distribution, Type)

Catalyst Formulation and Volume
SCR Design Considerations

Ammonia / NOx Mal-distribution

NH₃-slip, ppm

DeNOₓ, %

3% RMS
5% RMS
7% RMS
9% RMS
11% RMS
15% RMS
SCR Design Considerations

Flow Mal-distribution

DeNOx, %

NH₃-slip, ppm

10% RMS
15% RMS
20% RMS
25% RMS
What’s New - Basic HRSG layouts

CO-SCR

Air → Compressor → Gas

CO catalyst 420-480°C
SCR catalyst 320-360°C

SCR-CO

Air → Compressor → Gas

SCR catalyst 320-360°C
CO catalyst 320-360°C

CO-SCR

Air → Compressor → Gas

CO catalyst 320-360°C
SCR catalyst 320-360°C

SCR-CO

Air → Compressor → Gas

SCR catalyst 320-360°C
CO catalyst 260-280°C
New Developments for CO (DNO) Catalyst

Pennsylvania Plant: NOx Catalyst (DNX-929), CO Catalyst (DNO-1920) Installed (April 2011)

DeNOx Guarantees:
- 12.24 lb/hr Outlet NOx
- 90% DeNOx @ 10-ppmvdc NH$_3$ slip
- 2-yrs life

CO Guarantees:
- 98% Outlet CO Conversion
- 41% Outlet VOC (C6+) Conversion
- 2-yrs life
Thank you
Questions

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