An Efficient Ammonia-based SRU Tail Gas Desulfurization Process
1. Ammonia-based desulfurization
2. EADS Process
3. Ammonia Slip and Aerosol Generation Control
4. SRU Tail Gas Treatment
What is Ammonia-based Desulfurization?

Reaction between SO\(_2\) and NH\(_3\) to produce ammonium sulfate.

\[
\begin{align*}
SO_2 + H_2O + xNH_3 & \rightarrow (NH_4)_xH_{2-x}SO_3 \quad (1) \\
(NH_4)_xH_{2-x}SO_3 + \frac{1}{2}O_2 + (2-x)NH_3 & \rightarrow (NH_4)_2SO_4 \quad (2)
\end{align*}
\]

\[
2NH_3 + SO_2 + \frac{1}{2}O_2 \rightarrow (NH_4)_2SO_4
\]

1 ton SO\(_2\): 0.5ton NH\(_3\) \rightarrow 2 ton (NH\(_4\)_2SO\(_4\))
Ammonia: Pro & Con

Properties of NH₃
- Gas at atmospheric pressure, easy to liquefy
- Dissolves easily in water
- Highly alkaline, Highly reactive

High reactivity of NH₃
- High absorption efficiency
- Low liquid recirculation
- Low system pressure
- Low power consumption

Technical challenges
- Easy to evaporate
- Easy to react with acidic molecules and yield aerosol

Technical challengers
Efficient Ammonia-based Desulfurization (EADS) Technology

- JET’s patented technology
- Efficient and economical
- Successfully addressed ammonia slip and aerosol issues

**Applications**

<table>
<thead>
<tr>
<th>Boiler/power plant flue gas desulfurization</th>
<th>Sour/acid gas treatment + SRU tail gas treatment</th>
<th>FCCU &amp; Sintering machine flue gas desulfurization and PM control</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 90 projects</td>
<td>• 11 projects</td>
<td>• 4 projects</td>
</tr>
<tr>
<td>• 200+ absorber installations</td>
<td></td>
<td></td>
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</tbody>
</table>
EADS Applications: Acid Gas Treatment

- Refining Acid gas containing
- Sulfuric acid production
- Condensation
- Sulfur recovery
- Incineration
- Incineration
- SO₂

Fossil fuel

Combustion (Boiler/Heater)

H₂S, SO₂, COS, CS₂

Ammonia absorption system
More Stringent Air Quality Regulations

GB 31570-2015: the most stringent emission regulations for refineries in the world

SO₂ emissions:
≤ 400 mg/Nm³ for any refineries in China
≤ 100 mg/Nm³ For strictly controlled areas
1. Ammonia-based desulfurization
2. EADS Process
3. Ammonia Slip and Aerosol Generation Control
4. SRU Tail Gas Treatment
Process Mechanism

Clean Flue Gas

Scrubbing/Demisting

Ammoniating

Absorption

Cooling/Evaporation

Separation/Drying

Incineration

- $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$
- $\frac{1}{2} \text{O}_2 + (\text{NH}_4)_2\text{SO}_3 + \text{H}_2\text{SO}_3 \rightarrow 2 \text{NH}_4\text{HSO}_3$
- $2 \text{NH}_4\text{HSO}_3 + 2 \text{NH}_3 \rightarrow (\text{NH}_4)_2\text{SO}_4$
- $2\text{H}_2\text{S} + 3\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{SO}_2$
- $(\text{NH}_4)_2\text{SO}_4 \rightarrow \text{solid}$
- $(\text{NH}_4)_2\text{SO}_3 + \text{H}_2\text{SO}_3 \rightarrow 2 \text{NH}_4\text{HSO}_3$

NJRTE Environmental Technology
Process Systems

- Incineration system
- Flue gas system
- Absorption system
- Oxidation system
- Ammonium sulfate system
EADS Technology: Features and Advantages

High SO₂ removal efficiency: **98% or higher**

Environmentally friendly: *low emission, no waste water or solid, less energy consumption*

Favorable economics: *Lower CAPEX & OPEX (3.8 ton AS/ton NH₃)*

High turndown ratio: **30 – 110%**

Absorbent: *gaseous, liquid, or aqueous ammonia*

Flexible and customized system design
1. Ammonia-based desulfurization
2. EADS Process
3. Ammonia Slip and Aerosol Generation Control
4. SRU Tail Gas Treatment
Ammonia in the product
Total ammonia consumption

Ammonia recovery
• A key performance index for ammonia desulfurization
• Directly reflects the utilization of ammonia

Reduce ammonia loss
• Ammonia slip: Free ammonia that escapes with treated flue gas
• Aerosol: Unstable particles of ammonium sulfite, which eventually break down to \( \text{SO}_2 \) and ammonia and are difficult to capture
Ammonia Loss: Challenge of Ammonia Desulfurization

- Low ammonia Recovery rate
- High ammonia recovery rate
Ammonia Loss Control Strategies

- Optimized temperature and pH control
- Precise ammonia addition control
- Complete oxidation
- Patented demising system
• **Collision between particles with different sizes**, which vibrate at different amplitudes when ultrasound is applied.

• **Fluid attraction between particles** due to the gas velocity relative to particles.

• **Precipitation of particles on the wave loop** of a standing sound wave caused by acoustic radiation pressure, greatly increasing the possibility of particle collision.
• 4X410 t/h coal-fired boilers
• Competitive ammonia-based FGD unit installed in 2008
• Ammonia slip and “ammonium sulfate rain”

Sinopec Qilu Petrochemical

Exhaust plume

(NH₄)₂SO₄ seepage

Solid material carried out by clean flue gas
<table>
<thead>
<tr>
<th><strong>Boiler:</strong></th>
<th>4×410t/h coal fired boilers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Start-up:</strong></td>
<td>2012</td>
</tr>
<tr>
<td><strong>Contract:</strong></td>
<td>EPC, retrofit of a 2008 competitive system</td>
</tr>
<tr>
<td><strong>Desulfurization efficiency:</strong></td>
<td>&gt; 98%</td>
</tr>
<tr>
<td><strong>SO₂ emission:</strong></td>
<td>&lt; 40 ppmv</td>
</tr>
<tr>
<td><strong>Ammonia Recovery:</strong></td>
<td>&gt; 99.2% (from 74.9%)</td>
</tr>
<tr>
<td><strong>Ammonia slip:</strong></td>
<td>&lt; 3 mg/Nm³ (from 62.1 mg/Nm³)</td>
</tr>
<tr>
<td><strong>Total OPEX saving:</strong></td>
<td>$3.7 MM (power, AS, NH₃)</td>
</tr>
</tbody>
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Topics

1. Ammonia-based desulfurization
2. EADS Process
3. Ammonia Slip and Aerosol Generation Control
4. SRU Tail Gas Treatment
Replace the complicated TGTU with simple ammonia desulfurization unit.
Ammonia Desulfurization vs. Reduction TGTU

- Simpler process
- 35-50% less capital cost
- 40-60% less operating cost
- Higher total sulfur recovery efficiency ($\geq 99.95\%$)
- Lower $SO_2$ emissions: 20 ppmv (SCOT: 70 - 140 ppmv)
## Installations: SRU + Tail Gas Treatment

<table>
<thead>
<tr>
<th>Client Name</th>
<th>Capacity, tpd</th>
<th>SO₂ emission ppmv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yili Xintian Coal Chemical Co., Ltd.</td>
<td>130 + 26</td>
<td>20</td>
</tr>
<tr>
<td>Inner Mongolia Boda Shidi Chemical Co. Ltd.</td>
<td>140 + 28</td>
<td>40</td>
</tr>
<tr>
<td>Liaoning Datang International Fuxin Coal-to-SNG Co., Ltd.</td>
<td>150 + 30</td>
<td>20</td>
</tr>
<tr>
<td>Yancon Cathay Coal Chemicals Co., Ltd.</td>
<td>60 + 18</td>
<td>20</td>
</tr>
<tr>
<td>China National Chemical Engineering Group Corporation Shanxi Yiye Energy Investment Co., Ltd</td>
<td>60 + 20</td>
<td>40</td>
</tr>
<tr>
<td>Datang International Hexigten Coal-to-SNG Co., Ltd.</td>
<td>160 + 35 (Phase I)</td>
<td>20</td>
</tr>
<tr>
<td>Yitai Xinjiang Energy Co., Ltd., Yili Project</td>
<td>2*80 t/d sulfur</td>
<td>20</td>
</tr>
<tr>
<td>Yitai Xinjiang Energy Co., Ltd., Ganquanbao project</td>
<td>91 + 11.5</td>
<td>15</td>
</tr>
<tr>
<td>Inner Mongolia Connell Chemical Industry Co., Ltd.</td>
<td>10.8 + 2.4</td>
<td>28</td>
</tr>
<tr>
<td>Hanggin Banner Yitai chemical industry Co., Ltd.</td>
<td>2*60 + 24</td>
<td>40</td>
</tr>
<tr>
<td>Hebei Qianhai Petrochemical Co., Ltd.</td>
<td>43 + 8.6</td>
<td>40</td>
</tr>
</tbody>
</table>
• Designed flow rate: **120,000 SCFM**
• SO\textsubscript{2} concentration: **4,500 ppmv**
• AS post treatment: **Shared with boiler FGD system**
• Ammonia source: **from aqueous ammonia purification system**
Datang International, Hexigten Coal-to-SNG Co., Ltd.

Technical parameters from 48-hour performance test

<table>
<thead>
<tr>
<th>NO.</th>
<th>Unit</th>
<th>Designed value</th>
<th>Operation value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flow rate</td>
<td>SCFM ≤ 121,000</td>
<td>26,100</td>
</tr>
<tr>
<td>2</td>
<td>Inlet SO\textsubscript{2}</td>
<td>ppmv ≤ 4,410</td>
<td>4,310</td>
</tr>
<tr>
<td>3</td>
<td>Outlet SO\textsubscript{2}</td>
<td>ppmv ≤ 70</td>
<td>27.7</td>
</tr>
<tr>
<td>4</td>
<td>Desulfurization efficiency</td>
<td>% ≥ 98</td>
<td>99.4</td>
</tr>
<tr>
<td>5</td>
<td>Outlet NH\textsubscript{3}</td>
<td>ppmv ≤ 8</td>
<td>3.4</td>
</tr>
<tr>
<td>6</td>
<td>Ammonia recovery</td>
<td>% ≥ 97</td>
<td>99.2</td>
</tr>
</tbody>
</table>
Thank You!

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