Circulating Dry Scrubber Applicability
For
Industrial and Small Utility Boilers

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Discussion Outline

- Acid Gas and CDS Technology Discussion
- CDS Process and Performance
- CDS Case Study
- CDS O&M Considerations
### B&W FGD and Acid Gas Control Technologies

#### Dry Sorbent Injection
- 50 - 60% SO$_2$ removal, primarily SO$_3$ and HCl
- May use hydrated lime or trona
- Inject before particulate control device
- May impact fly ash disposal
- Lowest capital investment

#### Spray Dryer Absorber
- Up to 97% SO$_2$ removal
- Lower sulfur fuels (<1.5% sulfur coal)
- Pebble lime reagent slaked on site
- Particulate control follows scrubber
- Dry byproduct – limited beneficial use
- Low capital and operating costs when it fits

#### Circulating Dry Scrubber
- Up to 98+% SO$_2$ removal
- Higher sulfur fuels (>1.5%)
- Pebble lime reagent hydrated on site
- Particulate control follows scrubber
- Dry byproduct – limited beneficial use

#### Wet Scrubber
- Up to 98+% SO$_2$ removal
- High sulfur fuels (>1.5%)
- Limestone reagent
- Scrubber follows particulate removal
- Generally marketable byproduct – gypsum
- Broader range of applicability
## CDS vs. SDA

<table>
<thead>
<tr>
<th>CDS Advantage</th>
<th>SDA Advantage</th>
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<tbody>
<tr>
<td>Higher fuel flexibility</td>
<td>Lower capital cost</td>
</tr>
<tr>
<td>Independent water and SO₂ control</td>
<td>Lower lime consumption (w/ Recycle)</td>
</tr>
<tr>
<td>Control of absorber inlet gas flow</td>
<td>More efficient turndown</td>
</tr>
<tr>
<td>Only large power consumer is ID Fan</td>
<td>Smaller and lower fabric filter</td>
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<tr>
<td>No slurry handling</td>
<td>Reduced pneumatic handling</td>
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**Both Technologies:** dry byproduct, equivalent water consumption, carbon steel construction, small footprint, no wastewater treatment or wet stack required
CDS Technology Path

- **1960’s**: CFB Boiler development
- **1970’s**: Lurgi (Germany) developed CDS process and installed first industrial units in Germany
- **1980’s**: CDS applied to municipal waste incinerators. 1984 50 MW demonstration for SO2 control in Germany
- **1990’s**: 1995 First commercial unit in the US at 44 MW. 1995 84 MW at another site later
- **2000’s+**: Applied to larger and larger units with the largest currently ~400 MW
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CDS Applications

CDS can be applied to a range of fuels

• Utility and Industrial Boilers
• Coal
• Biomass
• Pet coke
• Waste Incinerators
• High HCl/SO2 ratio
CDS Components

CDS

Hydrated Lime Bin

Raw Gas

ID Fan

ID Fan

Byproduct Recirculation Air Slides

PJFF

Clean Gas

ID Fan
Mass Balance Diagram
# CDS Process Basics

- Simple and reliable process
- Long solids retention time
- Water evaporation independent of sorbent feed rate
- No limitation on SO$_2$ / SO$_3$ concentrations
- Very high SO$_2$/SO$_3$ removal efficiencies up to 98+% 
- High flexibility regarding changing SO$_2$ concentrations
- No precollection of ash needed
- Application for other flue gas cleaning purposes (biomass, waste)
Typical CDS Guarantee Levels

Emissions

- \( \text{SO}_2 \) - 0.06 lb/mmbtu
- \( \text{SO}_3 \) – 0.004 lb/mmbtu
- \( \text{HCl} \) – 0.0029 lb/mmbtu
- Filterable Particulate – 0.010 lb/mmbtu
- Total Particulate – 0.018 lb/mmbtu
- Hg – coal dependent
- Dioxins/Furans – limited data available
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## Case Study

<table>
<thead>
<tr>
<th></th>
<th>WTE</th>
<th>Industrial Boiler</th>
<th>Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW</td>
<td>32 MW&lt;sub&gt;e&lt;/sub&gt;</td>
<td>65 MW&lt;sub&gt;s&lt;/sub&gt;</td>
<td>205 MW&lt;sub&gt;e&lt;/sub&gt;</td>
</tr>
<tr>
<td>Inlet Load</td>
<td>HCl 1.0 lb/mmbtu (755 ppm)</td>
<td>SO&lt;sub&gt;2&lt;/sub&gt; 2.5 lb/mmbtu (1,040 ppm)</td>
<td>SO&lt;sub&gt;2&lt;/sub&gt; 3.2 lb/mmbtu (1,400 ppm)</td>
</tr>
<tr>
<td>Removal (Emission)</td>
<td>95% (0.05 lb/mmbtu)</td>
<td>95% (0.12 lb/mmbtu)</td>
<td>98%+ (0.06 lb/mmbtu)</td>
</tr>
<tr>
<td>Lime Consumption</td>
<td>1,020 lb/hr</td>
<td>2,900 lb/hr</td>
<td>14,700 lb/hr</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>1.5 – 3 %</td>
<td>1.5 – 3 %</td>
<td>~2%</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>14 inwc</td>
<td>14 inwc</td>
<td>14 inwc</td>
</tr>
<tr>
<td>Water Consumption</td>
<td>22 gpm</td>
<td>72 gpm</td>
<td>220 gpm</td>
</tr>
<tr>
<td>Maintenance Costs</td>
<td>$17 - 20 / kW</td>
<td>$15 – 17 / kW</td>
<td>$15 / kW</td>
</tr>
<tr>
<td>Capital Expenditure (material only)</td>
<td>$180 / kW</td>
<td>$150 / kW</td>
<td>$130 / kW</td>
</tr>
</tbody>
</table>
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"O&M Considerations"

- Fuel – sulfur, chloride
- Water supply – solids, chloride
- Absorber outlet temperature
- Power consumption
  - >80% of power consumed by the ID Fan
- Lime consumption
- Reagent supply
  - Spare hydrators
  - On-site hydration > 2,200 lb/hr hydrated lime required
Stoichiometry

Design Stoichiometry is dependent on:

- Removal efficiency
- Approach to the water dew point
- HCl-content in raw gas
- Hydrated lime quality
- Solids retention time in the absorber
- Reactive alkaline particles in fly ash
- Agglomeration of recycled solids
Lime Hydrators

- Continuous operation
- Dry product
- Filter bag replacement
- Lime quality dependent
Water Supply and Injection System

- Multiple water injection points
- Online removal and replacement
- Adjustable depth for optimization
Solids Handling

- Byproduct composition
- Air slides
- Flow control gates
- Screw pumps
Today’s Takeaways

• CDS is a mature technology but is fairly new technology in the US
• Simple process that is generally low maintenance
• CDS can be applied to a range of fuels
• High acid gas removals can be achieved
Thank you!