Impact of Mixing on Performance of Dry Sorbent Injection/Activated Carbon

Tony Licata
Introduction

- How do we achieve lower emissions of Hg and SO$_3$?
- What is the impact of mixing on sorbent usage?
- What tools are available to predict performance?
Babcock PAC 300-312 MW
2/27 to 3/5
Study Object

• Modeling study will provide a design to improve the RMS (distribution) of sorbent in the flue gas that will enhance Hg or SO$_3$ removal.
  - Improved mixing increases NTUs which allows system to maintain higher removals and higher sorbent utilization
  - Mixing required
    • Location and number of mixers
    • RMS<10%

• Use existing test and new modeling data to develop a model that will estimate:
  - Amount of sorbent required
  - Performance
RMS/NTUs Performance Predictions

• ESPs
• SCRs
• FGDs

Definition - Transfer of a gaseous component (absorbate) from the gas phase to a liquid (absorbent) phase through a gas-liquid interface

• Number of contact stages required to achieve a required % removal
• Mixing increases contact or reduces required NTUs
• Can relate RMS to NTUs completeness of mixing
• Improved mixing increases NTUs which allows system to maintain higher removals and relatively high utilization of sorbents
NTU vs. % Capture

NTU = - Ln (1-% removal)
Static gas mixer

SGM for mixing of gas:
- concentrations
- temperatures
- volume flows

Working principle:
leading edge vortices created by gas flows arriving at shaped plates under an angle of attack generate turbulences for mixing purposes
Static Mixer

- Delta Wings Can either be used to direct inject sorbent or as cross mixers after injection to achieve optimum mass transfer.
Direct Injection

Vortex Mixer

Vortex Circulation

Carbon Injection
Cross Mixers
Impact of RMS on NH$_3$ Slip

Source of data - FERCO Engineering
Impact of RMS on ESP Performance

ESP Efficiency, %

Velocity, % Standard Deviation

- Ideal Distribution
- Design Conditions (I.G.C.I)
- Poor Distribution
# Delta Wing® Modeling Case II Study

Description: Duct A sorbent injection upstream of hot ESP, long straight duct with 2–45° elbows and expansion section to ESP 6 injection nozzles

<table>
<thead>
<tr>
<th>Without Delta Wing Mixers</th>
<th>With Delta Wing Mixers</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMS = 15.6%</td>
<td>RMS = 1.5%</td>
</tr>
<tr>
<td>Max. Deviation</td>
<td>Max. Deviation</td>
</tr>
<tr>
<td>+23.8%</td>
<td>+3.0%</td>
</tr>
<tr>
<td>-36.2%</td>
<td>-2.3%</td>
</tr>
</tbody>
</table>
**Delta Wing® Modeling Case II Study**

**Description:** Duct B Air heater outlet to ESP inlet, 8 injection nozzles, 3 - 90° elbows & 2 - 45° bends

<table>
<thead>
<tr>
<th>Without Delta Wing Mixers</th>
<th>With Delta Wing Mixers</th>
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<tbody>
<tr>
<td>RMS = 22.4%</td>
<td>RMS = 2.2%</td>
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<tr>
<td>Max. Deviation</td>
<td>Max. Deviation</td>
</tr>
<tr>
<td>+24.4%</td>
<td>+5.7%</td>
</tr>
<tr>
<td>-58.5%</td>
<td>-2.7%</td>
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</table>
## Delta Wing® Modeling Case III Study

**Description:** Air heater outlet with short duct to expanding ESP inlet

<table>
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</thead>
<tbody>
<tr>
<td><strong>RMS</strong> = 15.4%</td>
<td><strong>RMS</strong> = 5.7%</td>
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<tr>
<td><strong>Max. Deviation</strong></td>
<td><strong>Max. Deviation</strong></td>
</tr>
<tr>
<td>+36.7%</td>
<td>+ 10.0%</td>
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<tr>
<td>-29.7%</td>
<td>- 12.0%</td>
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Full duct mixing with Delta Wing® cross mixer

Delta Wing is a proprietary technology provided under license to Babcock Power from Balcke Dürr
Sorbent Injection

W/O Mixers

With Mixers
Observations

• Low RMS required to meet high performance levels
• Lowering RMS reduces sorbent usage
• RMS + (NTUs) predictive tool
• Physical modeling faster and more accurately predictive performance than CFD
• Delta Wing mixers can be used to lower RMS
Thank You

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