SO$_3$-Monitoring in Flue Gas of a Power Plant
Application & Results
SO$_3$-Monitoring in Flue Gas

- Introduction
  - SO$_3$ / H$_2$SO$_4$
  - The SO$_3$ Challenge

- Spectral evaluation
  - Components to be monitored
  - Calibration

- Analyzer Setup

- Field Test Results

- Benefits of real time monitoring

- Discussion
SO$_3$-Monitoring in Flue Gas
SO₃-Monitoring in Flue Gas

: SO₃-presentation in a coal fired power plant:

- **SO₃-formation:**
  
  - In the furnace from Sulfur in coal (typ. 1 – 2% of SO₂):
    
    \[
    \begin{align*}
    S + O_2 & \rightarrow SO_2 \\
    2 SO_2 + O_2 & \rightarrow 2 SO_3
    \end{align*}
    \]
  
  - In the catalyst of a DeNOx plant (typ. + 1 – 2 % of SO₂):
    
    \[
    \begin{align*}
    2 SO_2 + O_2 & \rightarrow 2 SO_3
    \end{align*}
    \]

- **Additional SO₃ in a power plant:**

  - Injection of SO₃ for improving dust removal efficiency in an ESP (although this is a dying technique in the US as most of these will be retired in the next few years, this is still prevalent in China and elsewhere)
SO$_3$-Monitoring in Flue Gas

- SO$_3$ converts in humid gas into H$_2$SO$_4$:

- H$_2$SO$_4$-mist is generating corrosion problems and plumes at stack exit
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- SO$_3$ is a problem because:
  - Increased stack opacity (blue plume)
  - Corrosive
    - Ductwork
    - Air Heater

- Companies inject compounds like Trona, hydrated lime or sodium bi-sulphate to reduce SO$_3$ emissions.

- These are commonly referred to as dry sorbent injection systems (DSI).

- To date, this injection is uncontrolled.
Laboratory approach & spectral evaluation

- Measurement of single components with FTIR spectrometer
  - SO₂
  - SO₃
  - H₂O
  - H₂SO₄
- Selection of optimal measurement wavelengths
- Design of MCS03 filter set up
- Measurement with FTIR spectrometer and MCS03 photometer in parallel
- Calibration of MCS03 photometer
- Investigation interferences of other flue gas components
- Compensation of interferences
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- SO$_2$/SO$_3$ measurement setup & calibration via catalyst

Diagram:
- SO$_2$ and Air are fed into a massflow controller.
- The mixture flows to a heated catalyst at 450°C for SO$_3$ formation.
- The output is then passed through a heated evaporator at 220°C.
- Subsequently, it moves through heated tubes at 220°C.
- Finally, it enters a heated cell at 200°C and is analyzed by an FTIR analyzer.
- The exhaust leaves the system.
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- **H$_2$SO$_4$ Calibration via evaporator/steamer**

  - Evaporator calibration

  ![Diagram](image.png)
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- Spectra of SO$_2$, SO$_3$, H$_2$SO$_4$

- SO$_2$, catalyst at 20 °C
- SO$_2$/SO$_3$ mixture, catalyst at 450 °C
- H$_2$SO$_4$
SO$_3$-Monitoring in Flue Gas

- Calibration results for MCS03

![Graph showing calibration results for SO$_2$, SO$_3$, and H$_2$SO$_4$](Calibration SO$_2$, SO$_3$, and H$_2$SO$_4$, fieldtest MCS100E HW)
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Results from Lab evaluation:

- $\text{SO}_2$, $\text{SO}_3$, $\text{H}_2\text{SO}_4$ can be measured with one multi-component NDIR photometer

- The ‘real’ result is the sum of $\text{SO}_3 + \text{H}_2\text{SO}_4$

- Parallel monitoring of $\text{SO}_2$, $\text{H}_2\text{O}$, $\text{CO}_2$, $\text{NO}$, $\text{NH}_3$, $\text{HCl}$… gives a full picture
  - Control of SCR NH3 injection and slip, slurry injection for FGD
  - Reductions of HCl, Hg, SO2 and NOx.
The SO₃ monitoring system ‘MCSO3’
- MCS100E analyzer in HW system design

- Equipped with
  - Heated sample probe
  - Heated sampling system

- Measured gas components: SO₂, SO₃, H₂SO₄ and H₂O

- SO₃ and H₂SO₄ are reported as SOₓ

- Other monitored components (optional): NO, CO₂, CH₄, O₂

- Internal calibration filter for routine calibration w/o test gas
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- Field test installation with MCSO3
  - Coal fired power plant
  - Location: USA
  - In operation 18 months
  - Required quarterly maintenance on sample probe

- Technical Details
  - Mounting Location: Stack (400’)
  - Temp: 120 F
  - SO2: 20ppm
  - NOx: 10ppm
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- 24-h data w/o SCR operation during night
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- Controlled Condensate comparison:
Benefits of real time SO3 Monitoring:

- Feed back control for the SO3 reduction system
  - Cost savings in reduced trona/hydrated lime injection can be substantial
  - Reduced cost of fly ash disposal

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<thead>
<tr>
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<tbody>
<tr>
<td>Trona / Hydrated Lime Injection Rate</td>
<td>0.75 ton/hr</td>
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<tr>
<td>Trona / Hydrated Lime Cost</td>
<td>$220 $/ton</td>
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<tr>
<td>Total Usage / year</td>
<td>6570 tpy</td>
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<tr>
<td>Total Cost / year</td>
<td>$1,445,400 /year</td>
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<tr>
<td>Theoretical % efficiency increase</td>
<td>10% /year</td>
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<tr>
<td>Theoretical $ Savings</td>
<td>$144,540 /year</td>
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Benefits of real time SO3 Monitoring (cont):

- Reduced instances of “blue plume”
  - Currently only controlled by sight

- Reduction of heat exchange exit temperature – higher process efficiency

- Reduced corrosion in ductwork and air pre-heater
  - Lower maintenance costs

- Increase efficiency of Hg removal

- Additional integration of other “acid gas” and measurement components could provide a broad based “control loop” solution
  - NH3 – NOx for SCR control
  - HCl for DSI control
Thank you for your attention.
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