Area of focus for this presentation.
Summary

► ENGINEERING PROBLEM:
- For the sorbent injection systems ADA installs for coal fired power plant units, the injection array that transports the sorbent into the power plant’s flue gas stream needs to be optimized to achieve the best distribution as possible into the plant’s particulate collection equipment.

► METHOD FOR SOLUTION:
- The models built in STAR-CCM+ are used to locate and optimize the best horizontal and vertical positions for injection lances in the duct to provide as uniform a distribution of sorbent as possible across the particulate collection device inlet plane.
- The method ADA uses to complete its optimization effort, is by utilizing point injectors strategically placed in a baseline array and depth arrangement, determined specifically for the duct geometry and flow field characteristics.

From there the flue gas flow field patterns are analyzed, including velocity streamlines and cross sections of high and low velocity regions to place the point injectors in the correct position to achieve the best distribution at a given reference plane in the model.

- The metric used for determining an optimized solution is by analyzing the ‘Percentage Root Mean Square’ (% RMS) value after each model change iteration. The goal with utilizing this metric is to minimize it as much as possible from the baseline solution. The closer the % RMS value is to zero the more even the distribution is in the gas stream at that given plane.

► BENEFIT TO ADA:
- Utilizing CCM+ for this analysis allows ADA to achieve an engineered solution for the sorbent injection array design. An optimized grid design aids with the usage of sorbent injection chemical. The better the distribution, the more efficient the pollutant capture is, which translates to less sorbent costs for ADA’s customers.
Geometry Build

- Geometries are built using the CCM+ imbedded CAD program due to relative simplicity of the fluid regions.
- Geometries are built to full scale per plant record drawings including major internal features that will influence flow (i.e. turning vanes, large structural supports, etc.).
Meshing

Mesh development:

- For the main fluid domain, the Absolute minimum size is made to be approximately the size of the smallest feature or by calculating the hydraulic diameter between the smallest fluid gap in the geometry (i.e. space between two turning vanes).

  Absolute target size for the larger areas through the ductwork is typically set between 6-10 inches depending on the size of scale of the geometry. This is done to keep the volume mesh size reasonable and appropriate for the region/feature being meshed.

- The boundaries of the smaller features in these geometries are typically broken out from the main fluid domain boundary so that individual mesh refinements can be made in these locations for a more accurate solution. Turning vanes and like small features are primarily included in this additional refinement procedure.

- Typical cell ranges from ADA models are from 3,000,000 to 10,000,000 depending on the geometry.
Flow Field

Physics Selection and Flow Field Development:

- Steady state solution.
- K-Epsilon Turbulence.
- Fluid modeled as an ideal gas.
- Segregated temp and flow.

Turbulence is kept at default value at the model inlet as not to artificially influence the flow field results. Turbulence aids in distribution, but we want it to develop (or not develop) as a result of the geometry.
Flow Field Analysis

Velocity scalar cross section views.
Flow Field Analysis

- Velocity scalar cross section views.

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Flow Field Analysis

- Velocity scalar cross section views (final plane of interest = Model Outlet):
Flow Field Analysis

- Velocity streamline views.
Flow Field Analysis

- Velocity streamline views.
Lagrangian

Particle Injection Setup and Distribution Analysis:

- Point injector created for each injection lance tip including:
  - Rosin-Ramler distribution.
  - Bulk density.
  - Mass flow rate.
  - Initial velocity and direction.
Distribution Analysis

- Baseline array:

  ![Diagram of LANCE arrays with depth levels](image)

  - LANCE 1
  - LANCE 2
  - LANCE 3
  - LANCE 4
  - LANCE 5
  - LANCE 6

  - Depth Level 1
  - Depth Level 2

  Duct Cross Section
Distribution Analysis

- Baseline array results:
Distribution Analysis

- Baseline array results at plane of interest (model outlet):

![Distribution Analysis Diagram]
Distribution Analysis

- Optimized array:

```
<table>
<thead>
<tr>
<th>LANCE 1</th>
<th>LANCE 2</th>
<th>LANCE 3</th>
<th>LANCE 4</th>
<th>LANCE 5</th>
<th>LANCE 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>
```

DUCT CROSS SECTION
Distribution Analysis

► Optimized array results:
Distribution Analysis

- Optimized array results at plane of interest (model outlet):

FINAL % RMS:
~3.0% LESS THAN THE BASLINE.
Q & A ?