

# REINHOLD ENVIRONMENTAL®



## **2022 Reinhold/PCUG Round Table Presentation**

Hosted by Duke Energy in the Charlotte Sheraton/Le Meridien  
Hotel, Charlotte, NC on June 27-28, 2022

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*Sustainable Solutions for Air, Water and Solids*



# **DSI Retrofits Save Large Midwestern Utility \$Millions**

Presented By: Craig Anderson  
June 2022

# Overview

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**DSI Retrofit Project Background**

**Plant and DSI System Description**

**DSI Retrofit Project**

**DSI Retrofit Results**

# Overview

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**DSI Retrofit Project Background**

Plant and DSI System Description

DSI Retrofit Project

DSI Retrofit Results

# DSI Retrofit Background

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- Large 4-unit coal-fired power plant
- Installed 4 DSI systems (non-UCC) to meet SO<sub>3</sub>/sulfuric acid mist (SAM) reduction requirements
- Were experiencing constant plugging and other maintenance problems with their DSI System
  - » DSI systems were not balanced pneumatically
  - » Employed a third-party maintenance crew to unplug all lances, for each unit, each shift
- Hydrated lime use to achieve SAM emissions compliance was excessive as compared to expected usage (relative to UCC's database)

# Overview

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DSI Retrofit Project Background

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DSI Retrofit Results

# Plant Description

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- 4-units
- Each unit approximately 500 MW
- Use Eastern Bituminous coal
- Units equipped with the following
  - » PC Boilers
  - » SCR (not all units)
  - » Hot-side ESPs (not all units)
  - » Pulse jet fabric filters (PJFF's)
  - » Wet FGD
  - » Hydrated lime based DSI systems for SAM control

# Pre-Retrofit DSI Systems Description

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- Two hydrated lime storage silos per unit
  - » Use an enhanced hydrated lime product
- Truck unloading
  - » Truck unloading conditioning system not used
- Three feed trains per unit
  - » Two operating and one common spare
- Four injection locations per unit
  - » Two ducts per unit
  - » Inject at economizer or SCR outlet (depending on unit) in both ducts and at PJFF inlet (both ducts)

# Pre-Retrofit DSI Systems Description

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- Each feed train conveying line split to each duct at each injection location
  - » Distances/pressure drops not balanced after each split
- Multiple splitters in series prior to lances
  - » Also not balanced
- Standard lances (straight pipe)
  - » Manual air purge from compressed air hoses
  - » Each lance purged each shift, with manual rodding as needed

# Pre-Retrofit DSI Systems Description

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- Blower and electrical buildings
- Chiller, dehumidifier, and heat exchanger for each convey line
  - » Existing dehumidifiers capable of meeting dryness specs for hydrated lime
  - » However, maintenance was needed to bring them back to proper operation

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# Scope of DSI Retrofit Project

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- Verified conveying air conditioning
- Add fourth feed train to units as needed
- Separate conveying lines such that each feed train serves one injection location per unit
- Replace multiple splitters in series with one, properly designed balanced splitter per injection location
- Equal-length hoses to each lance
- CFD modeling for each injection location
- New ports and UCC COBRA II Lances for each injection location, based on CFD modeling results

# Verified Conveying Air Conditioning Design

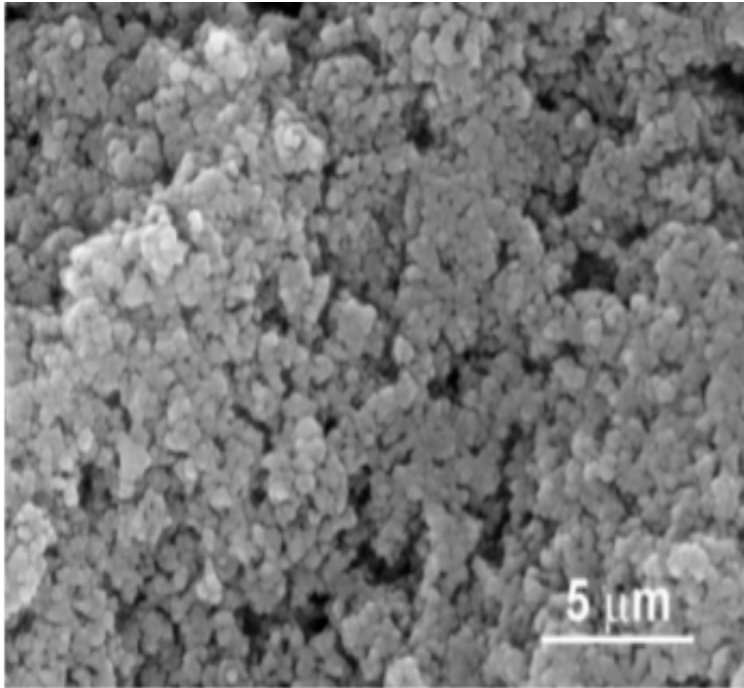


# Reasons to Condition Conveying Air

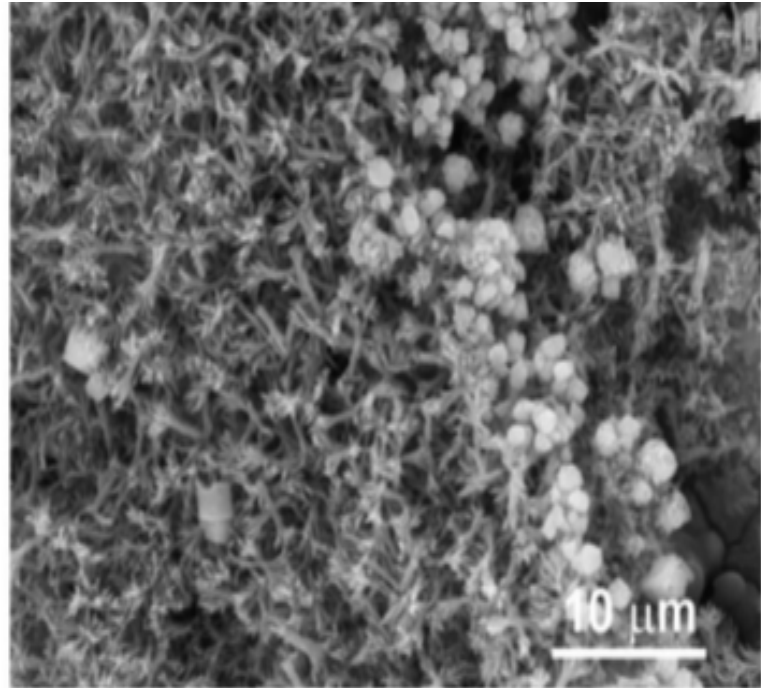
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- Conveying to Duct
  - » Prevent condensation in convey lines by keeping convey air above dew point
  - » Prevent hard-scale calcium carbonate formation and build up in the lines
    - › Carbonate is “stickier” than hydrated lime

# Calcium Carbonate Formation



$\text{Ca(OH)}_2$



$\text{CaCO}_3$

Influence of relative humidity on the carbonation of calcium hydroxide nanoparticles and the formation of calcium carbonate polymorphs P. López-Arcea , L.S. Gómez-Villalba , S. Martínez-Ramírez,b,c , M. Álvarez de Buergoa , C. Domingoc , R. Forta

# Calcium Carbonate Formation

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- $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$
- Both temperature and moisture increase reaction
- Moisture allows  $\text{CO}_2$  to react with solid hydrated lime particles (dissolution of hyd lime at the water absorbed surface)
- It has been found that the reaction will not occur at a Relative Humidity of less than 8%\*

\* Kinetics of the Reaction of  $\text{Ca(OH)}_2$  with  $\text{CO}_2$  at Low Temperature

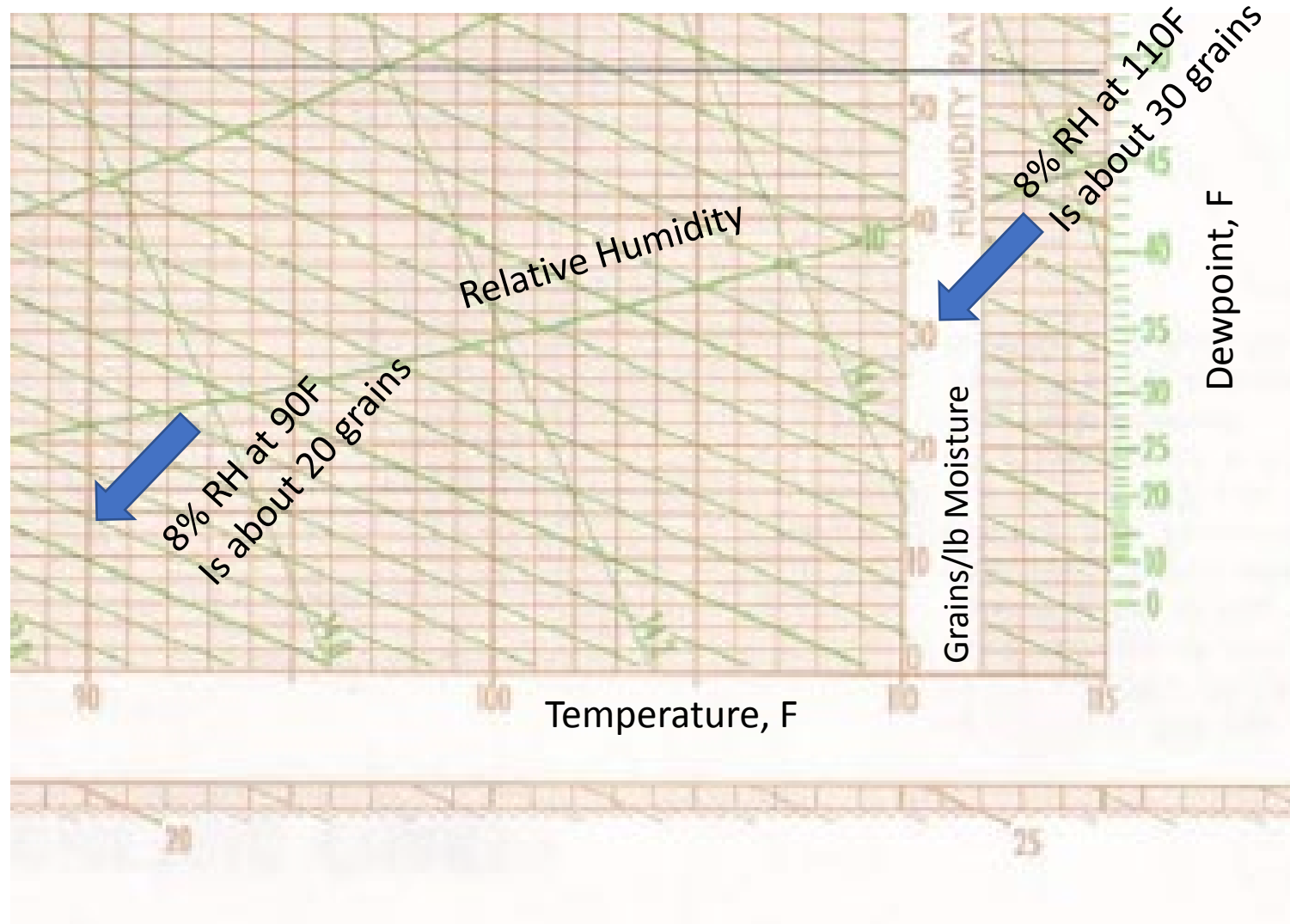
Shin-Min Shih\*, Ch'un-Sung Ho, Yuen-Sheng Song, and Jyh-Ping Lin  
Department of Chemical Engineering, National Taiwan University, Taipei, Taiwan 106, Republic of China

# Moisture and Temperature Specifications

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- UCC recommends conveying temperature below 110°F
  - » Temperature is important factor for carbonate formation
- UCC recommends sizing dryer to RH of < 8% over full temperature range
  - » Remember that cooler temperatures result in higher RH at a given moisture level

# Moisture and Temperature Specifications



# Heat Exchangers

- Air-to-air heat exchanger
  - » Ideally keep conveying line temperature between 60 and 110F to improve reliability
    - › Too hot leads to carbonate formation and plugging
    - › Too cold can lead to conveying problems (possible condensation and some carbonate formation due to higher RH)
  - » Also monitor dewpoint
  - » Dehumidifier/chiller needed with heat exchangers to prevent condensation in convey lines



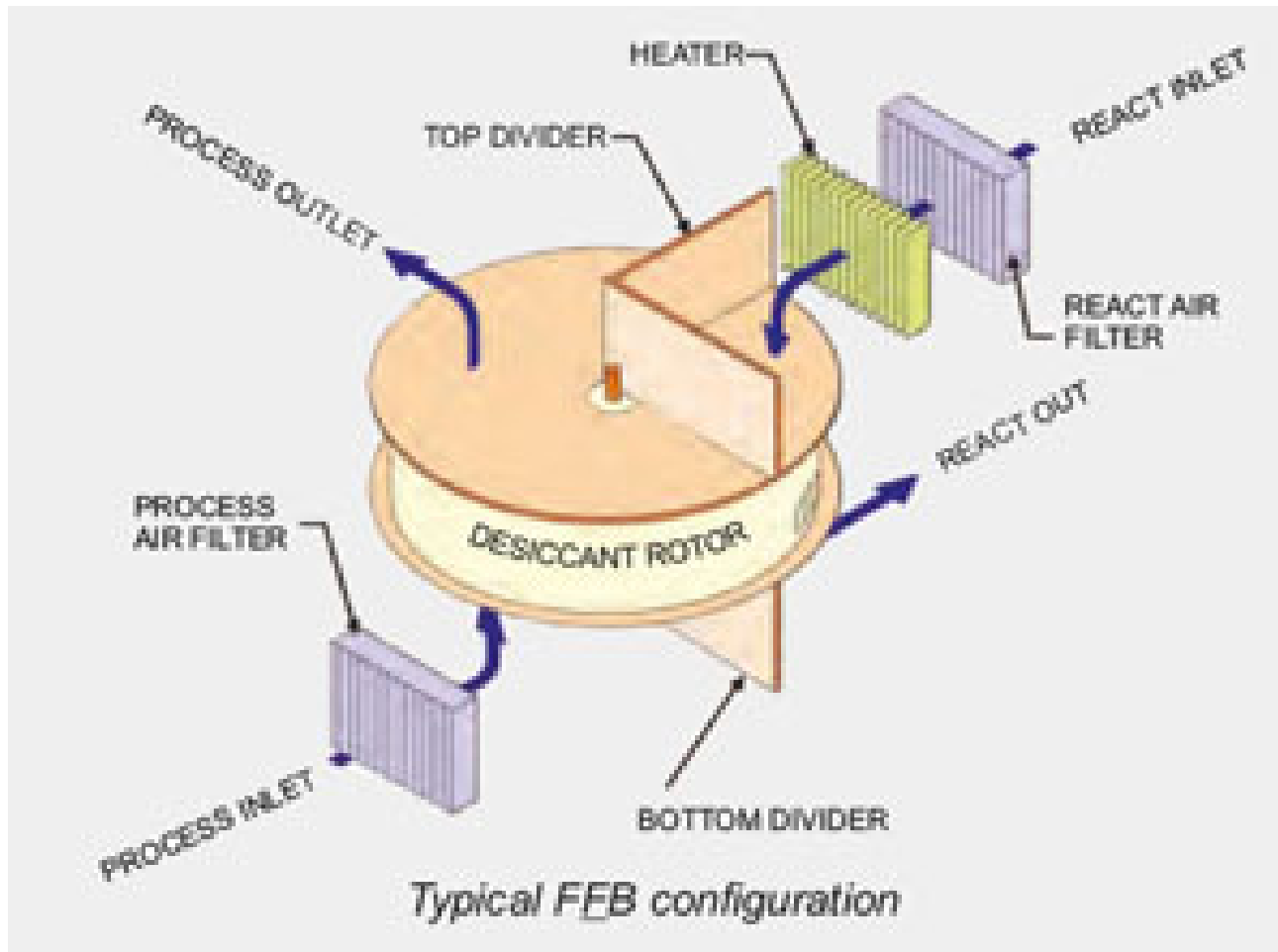
# Dehumidifiers/Chillers

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- Dehumidifier/Chiller for conveying air
  - » Eliminates condensation possibility
  - » Allows system to be designed for proper temperature and moisture level to prevent carbonate build-up
  - » Need both chiller and desiccant
    - › Desiccant-only can lead to condensation in lines under some ambient conditions
    - › Chiller only cannot create proper conditioning



# Polishing Desiccant Dryer



# Common Problems from Poor Conveying Design

Routine Elbow  
Unplugging  
Operation



# Conveying System Design

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- Proper velocities throughout system
- Sorbent/air ratios
  - » Common problem with over-designed systems using low injection rates
  - » Not important factor if properly dry conveying air
- Equal pressure drops to lances
- Avoid splitters in series
- Rubber components to prevent buildup
  - » Elbows and splitter outlet lines
- Constant inner diameters
  - » Prevent flow disruptions



# Splitter

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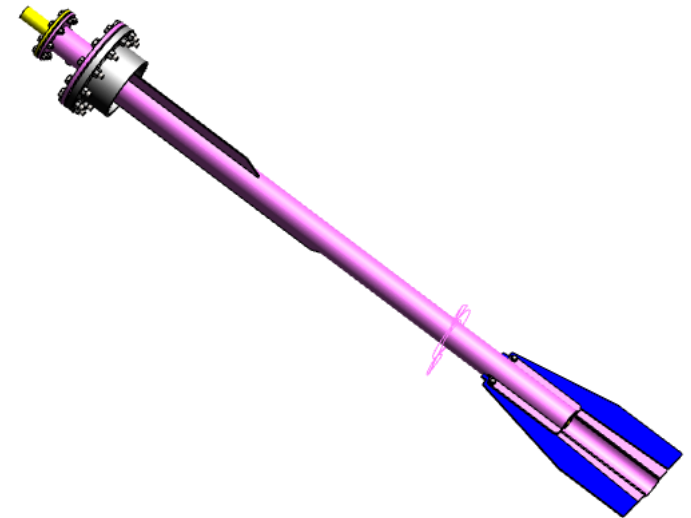
- Precision machined cone diverter to eliminate dead space
  - » Reduces/eliminates plugging
- Flow Straightener to ensure even flow into splitter
- Even distribution to each leg of splitter
- Equal length hoses to lances
- 40D feet of vertical pipe before splitter



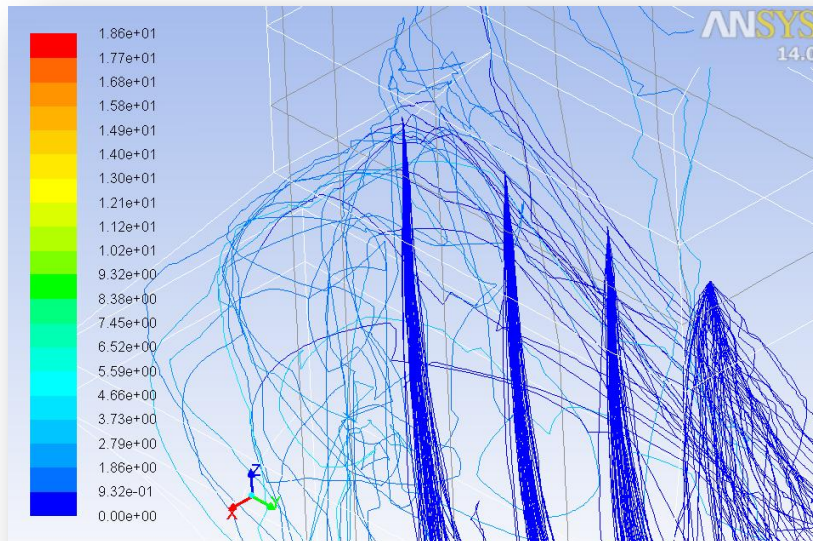
# UCC COBRA™ Lances

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- Advantages UCC-patented COBRA™ Lance
  - » Improved sorbent dispersion on short residence time and “difficult” flue gas ducts
  - » Allows less lances to be used
  - » Optimizes sorbent usage
  - » 20 to 35% Sorbent Reduction

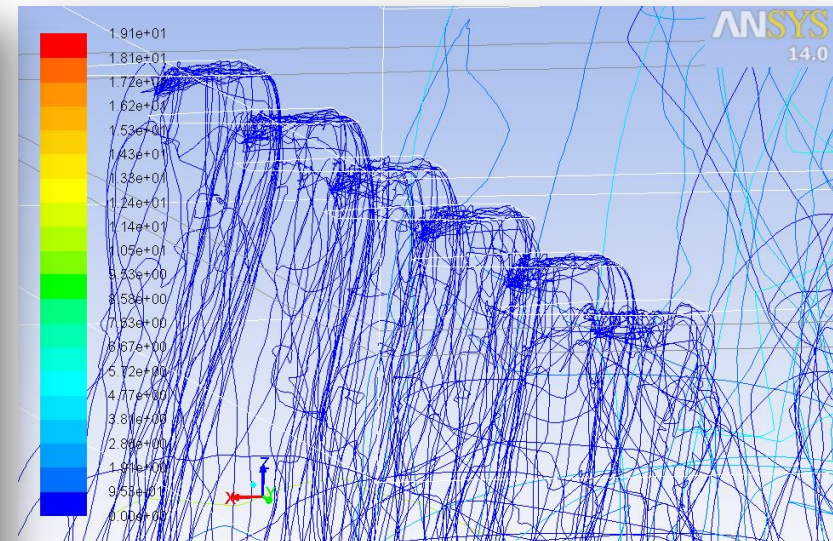


# COBRA™ Lances



Particle Traces Colored by Particle Residence Time (s)

Dec 06, 2012  
ANSYS FLUENT 14.0 (3d, dp, pbns, rke)



Particle Traces Colored by Particle Residence Time (s)

Mar 14, 2013  
ANSYS FLUENT 14.0 (3d, dp, pbns, rke)

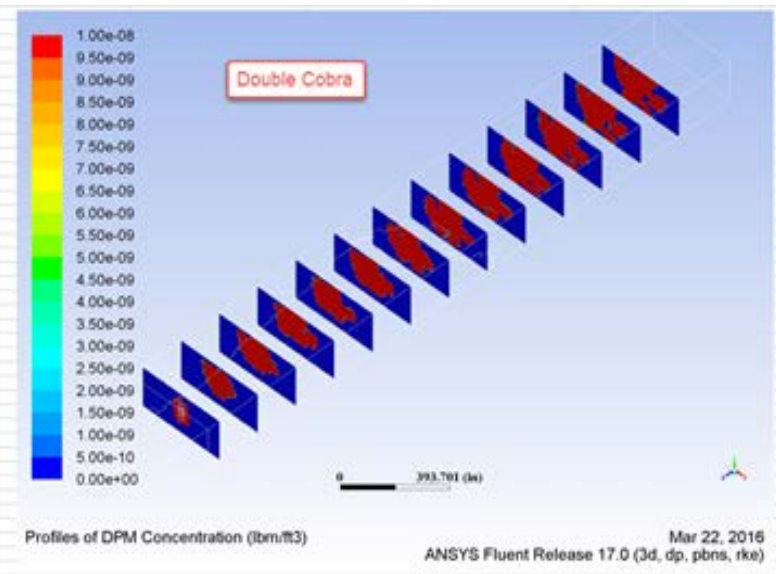
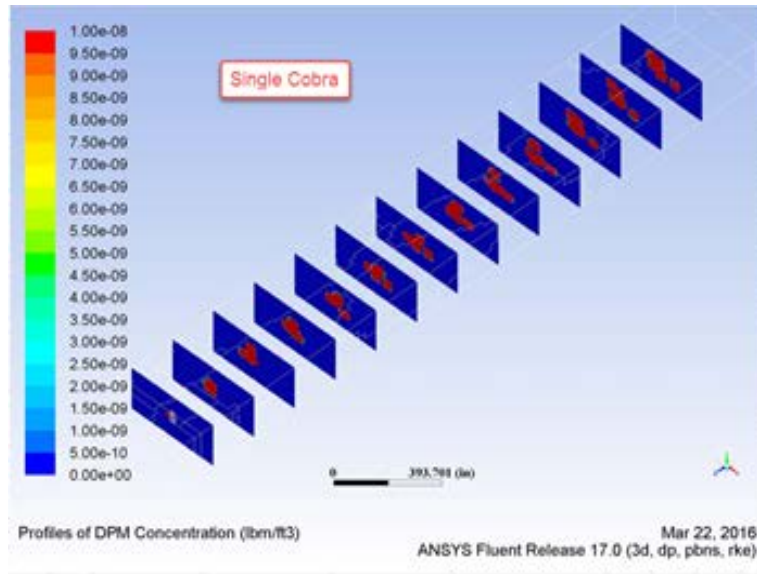
Standard Distribution Tip Dispersion

COBRA™ Lance Dispersion

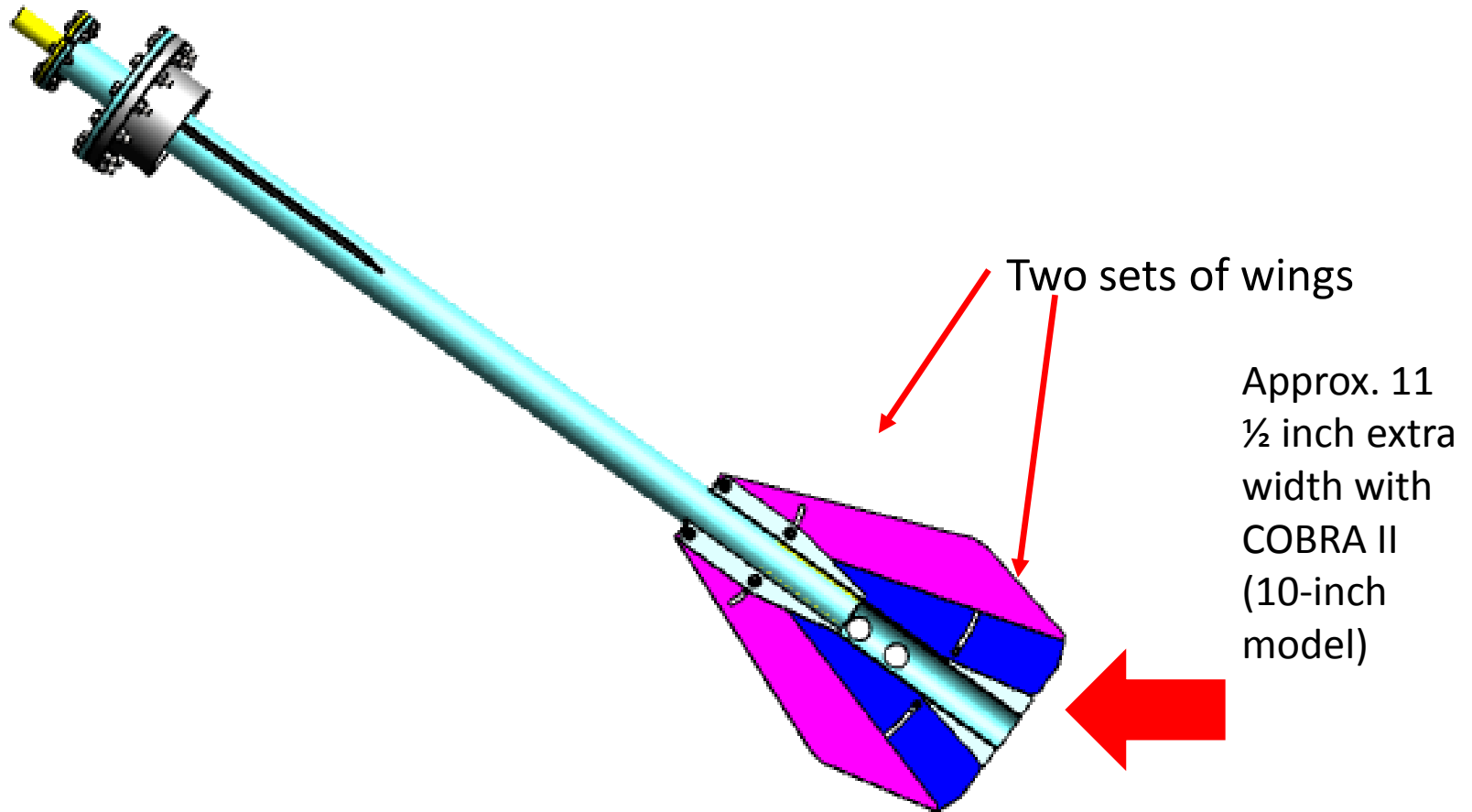
# Optimization Technology

## COBRA™ II Lances

- Next generation COBRA II™ Lances



# COBRA II™ Lance



# COBRA™ Lance Animation



# Standard Lance In Duct

## UCC Lance

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# COBRA™ Lance In Duct

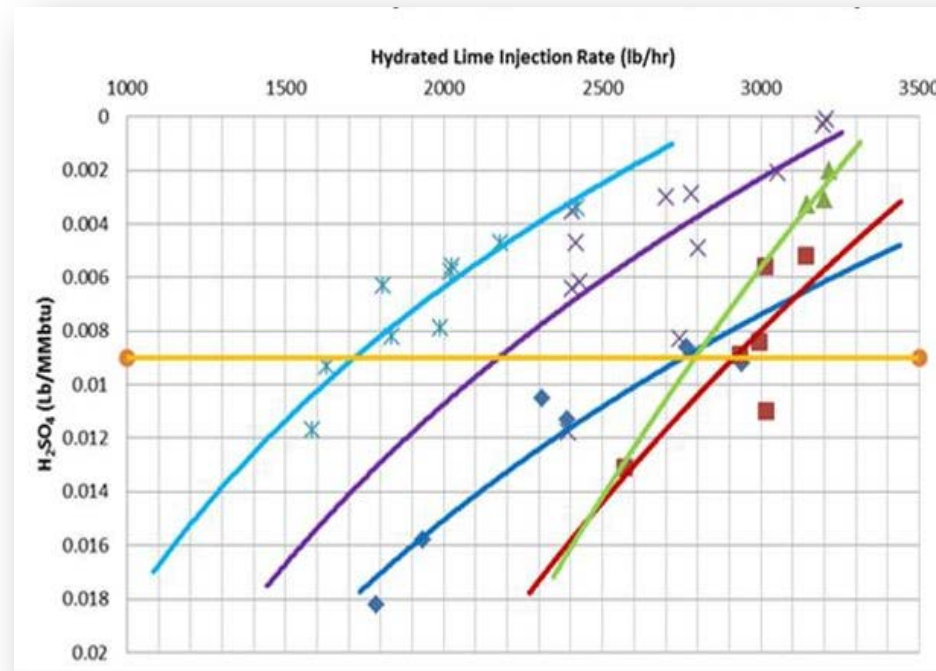
## UCC Lance

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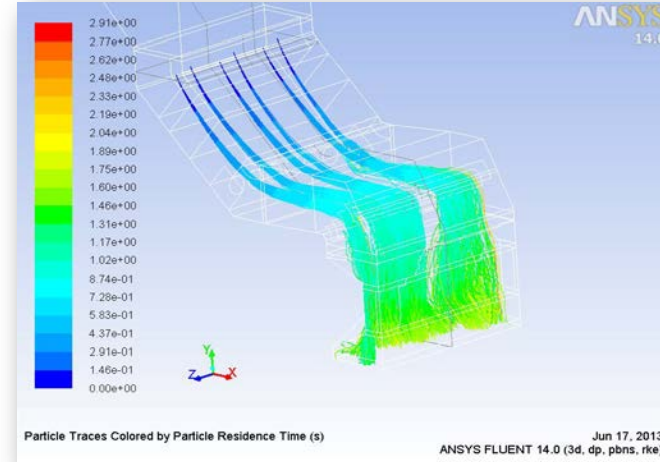
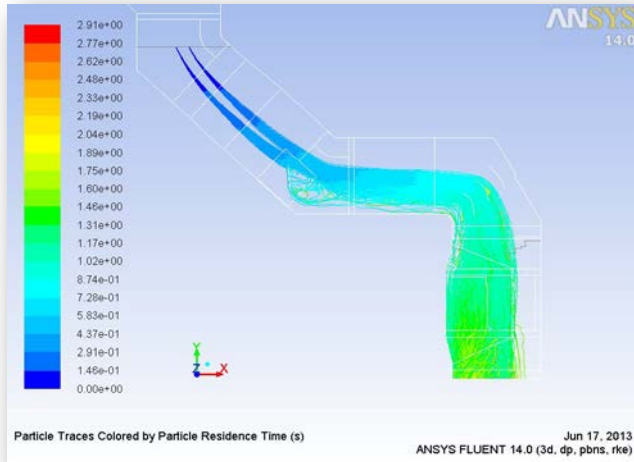
# Recent Examples of Sorbent Reduction with COBRA™ Lances

- 700 MW Unit using hydrated lime for SO<sub>3</sub> – 23% reduction
- 800 MW Unit using hydrated lime for SO<sub>3</sub> – 35% reduction
- > 1000 MW Unit using hydrated lime for SO<sub>3</sub> – 33% reduction

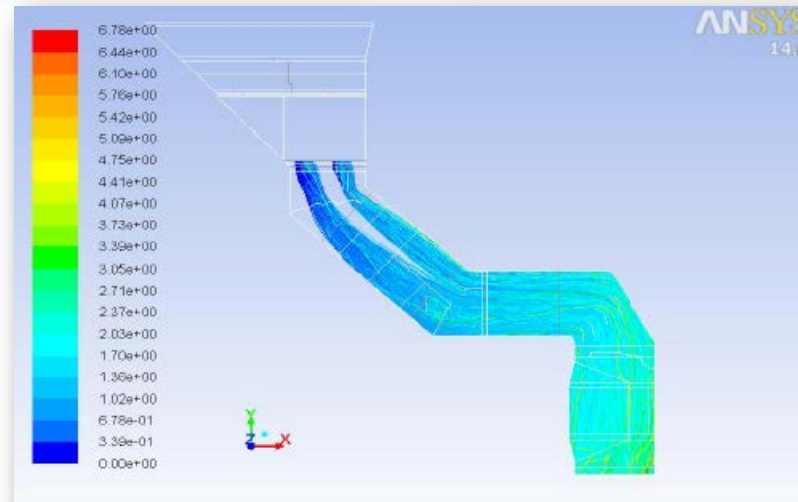


# CFD Modeling

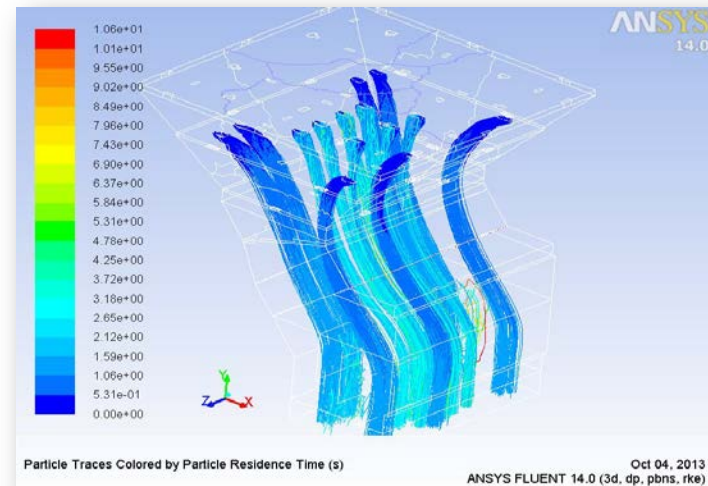
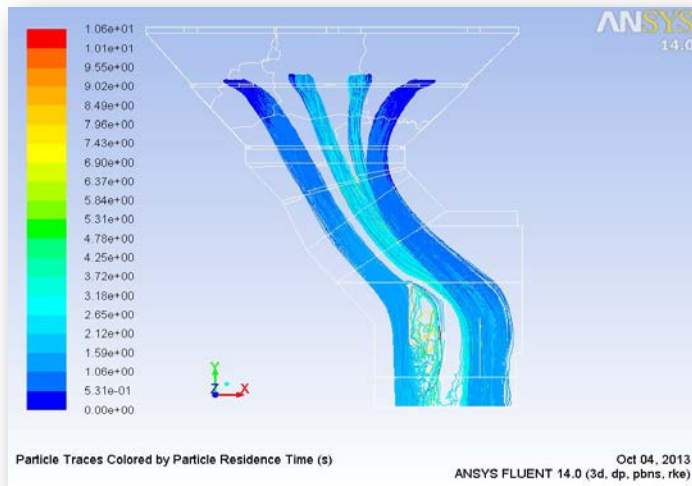
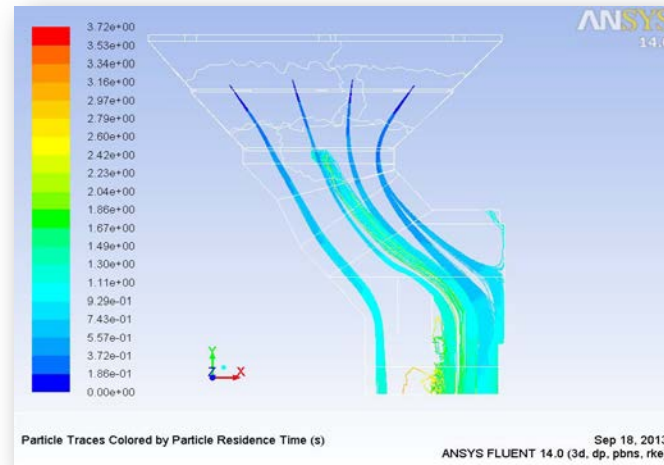
## Standard Lances



With  
COBRA  
Lances



# CFD Modeling



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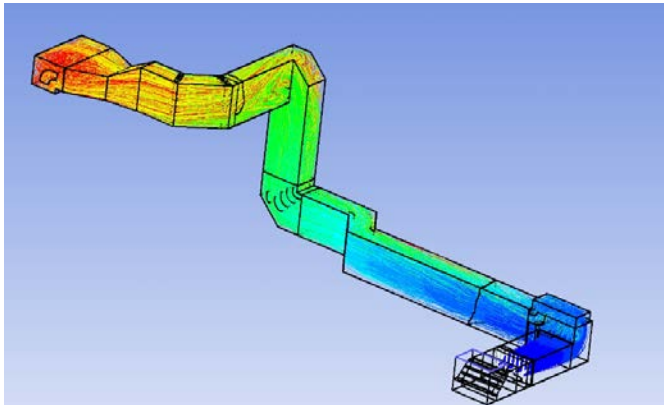
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- Distribution
  - » Hydrated lime flows to each injection location balanced
  - » Distribution to each lance balanced via hoses
- As a result:
  - » Plugging was substantially reduced
    - › Maintenance required on dehumidifiers to further reduce/eliminate plugging
  - » SO<sub>3</sub> reduction performance improved
  - » Hydrated lime consumption greatly reduced

# DSI Retrofit Results

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- Dispersion
  - » CFD Modeling improved lance placement
  - » COBRA II Lances improved dispersion, especially immediately downstream of lances
- As a result:
  - » Hydrated lime consumption significantly reduced



# DSI Retrofit Results

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- Bottom line:
  - » Substantial maintenance savings – no longer a need to unplug all lances each shift
  - » Only occasional maintenance needed
  - » Substantial hydrated lime consumption reduction
- Total annual savings from DSI retrofit in excess of \$3,000,000!

Approx. Total Hydrate Injection before UCC Retrofit	Approx. Total Hydrate Injection after Retrofit	Total Hydrate Savings
12,500 lbs/hr	7,000 lbs/hr	5,500 lbs/hr

# Questions

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# For More Information

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*For more information on UCC Environmental, please contact:*

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