Flow Modeling: Boiler and AQCS

with dual fuel burning

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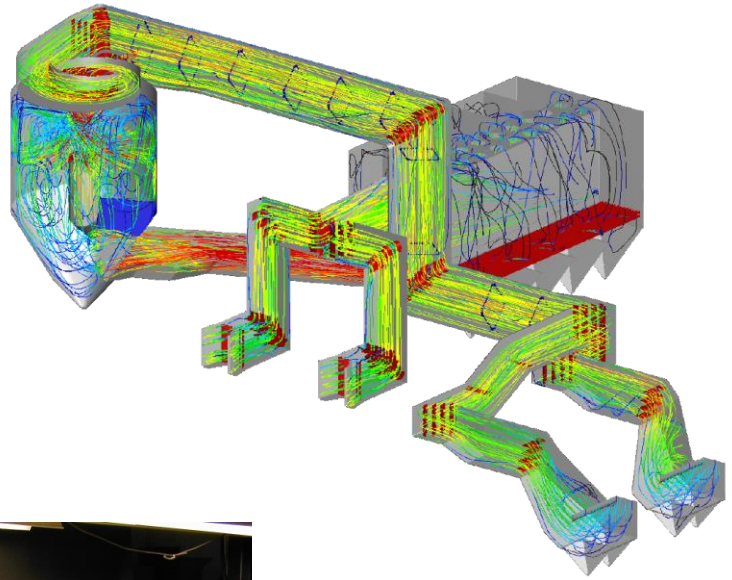
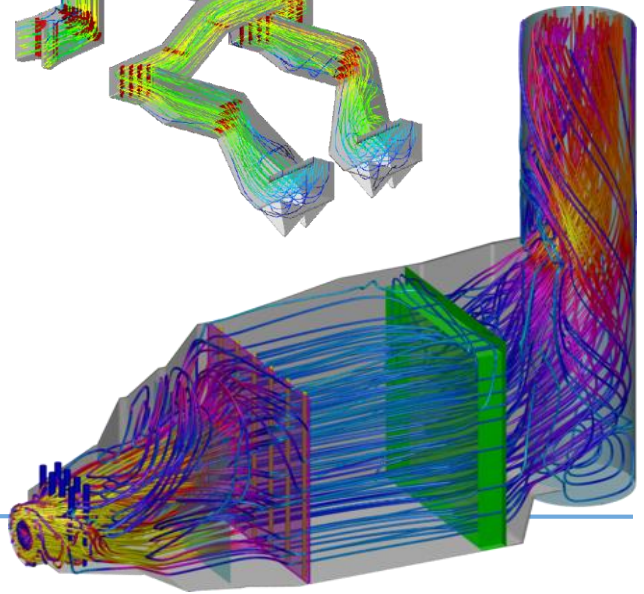
WPCA/Duke Co-Firing Seminar
Spartanburg, SC
October 2, 2019

Agenda

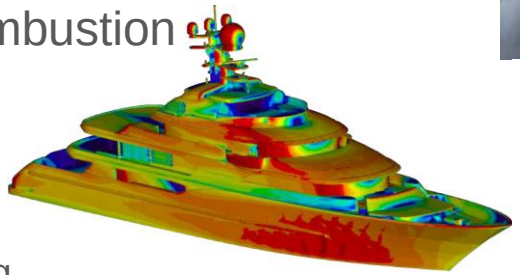
- Flow Modeling Basics
- Applications
  - Boiler performance, heat rate
  - AQCS optimization
  - Gas leak detection

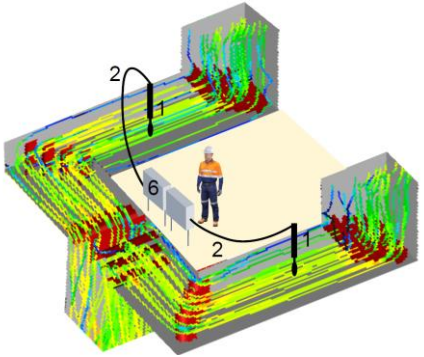


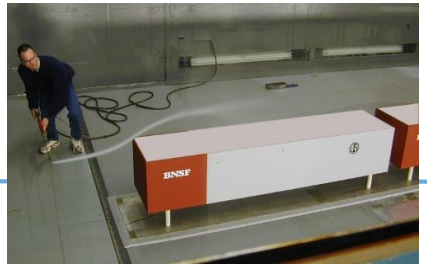


About Airflow Sciences

- Expertise is with fluid dynamic engineering, heat transfer, thermodynamics, and combustion
- In business since 1975
- Consulting Engineering Services
  - CFD simulation
  - Laboratory prototype fabrication/testing
  - Wind tunnel testing
  - Field testing
- CFD Software Development
- Flow Test Equipment
- Flow Calibration Lab







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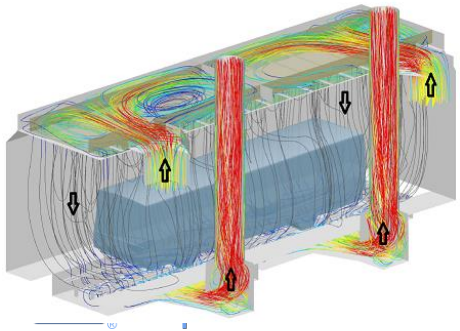
About your speaker

- Flow modeling and testing for 31 years
- Entire career at Airflow Sciences (started as summer intern)
- Rocket scientist at heart – degree is in aerospace engineering
- Focus on power industry, optimization of boilers and AQCS
- Occasional work in auto, aerospace, food processing, and other industries
- Father of 4, husband of 1
- Decent volleyball coach, mediocre golfer

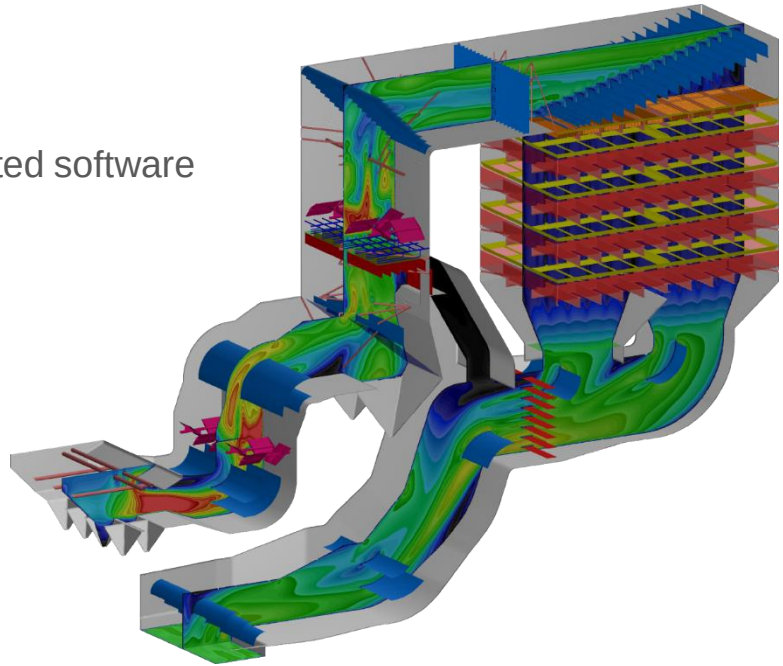


Flow Modeling Basics

- Physical flow model
  - Scale representation of actual geometry
  - Use Typical scale 1:8 to 1:16
  - “Cold flow” modeling
  - Visualize flow with smoke
  - Simulate ash deposition
  - Measure flow properties
  - Velocity
  - Pressure
  - Species and temperature mixing

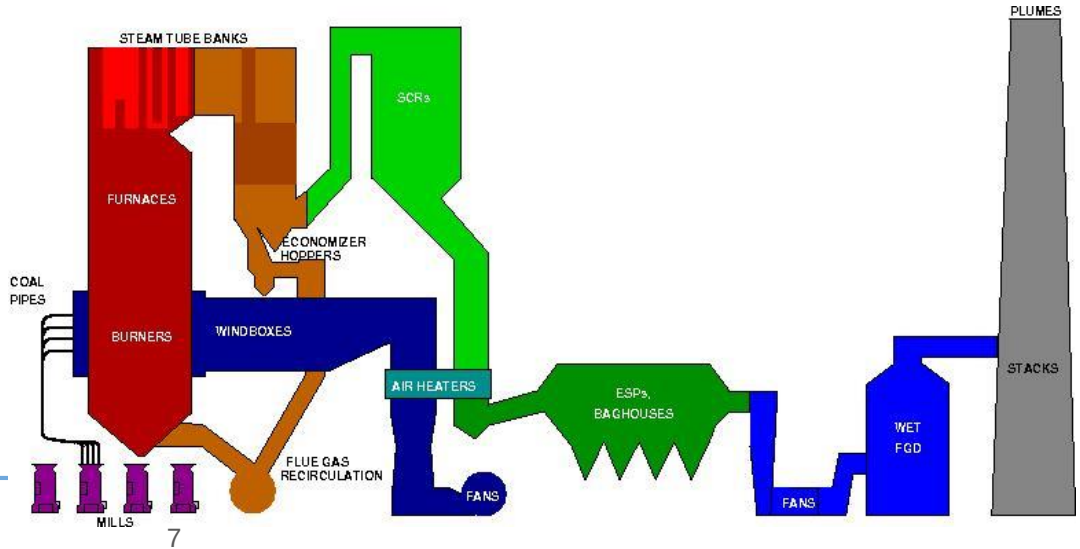
Flow Modeling Basics

- Computational Fluid Dynamics (CFD)
  - Numerical simulation of flow
  - Utilize high speed computers and sophisticated software
  - Calculate flow properties
  - Velocity
  - Pressure
  - Temperature
  - Chemical species tracking
  - Reactions and combustion
  - Particle streamlines



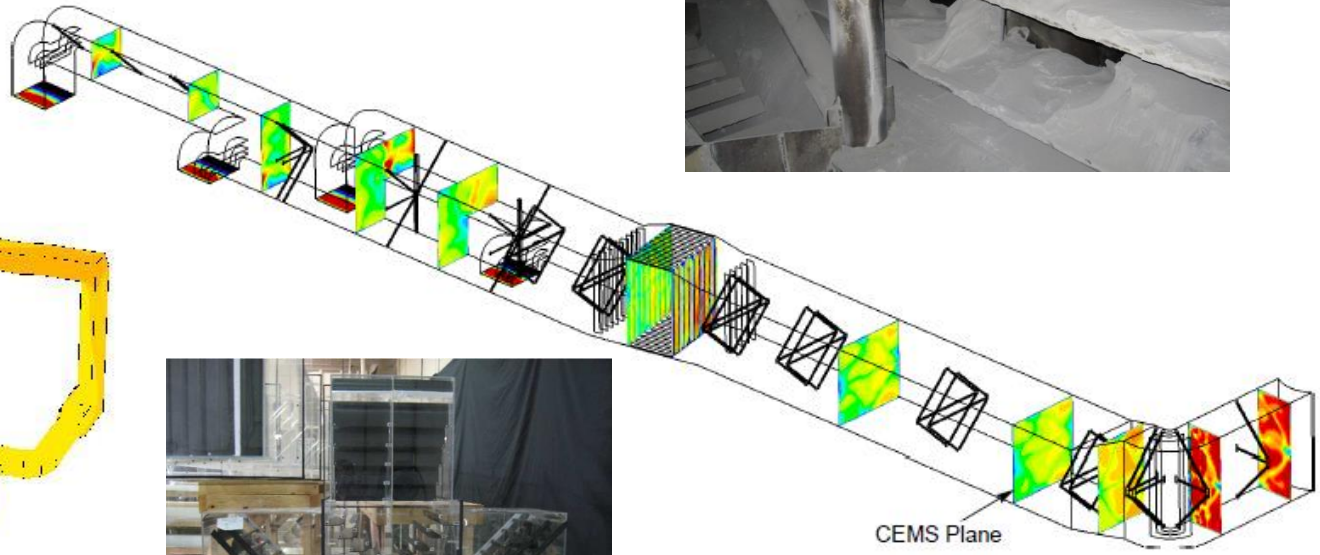
Flow Modeling Applications

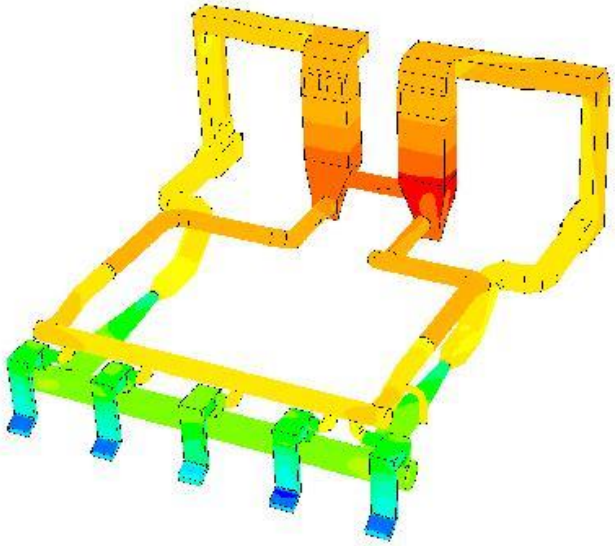
- Modeling can optimize equipment “Fan-to-Stack” and beyond
  - Fans and ductwork
  - PA/SA/OFA/fuel balance
  - Furnace combustion, NOx, slagging
  - Backpass heat transfer, erosion
  - SCR
  - Air heater
  - Sorbent injection
  - ESP/PJFF
  - FGD
  - Stack
  - Dispersion, plumes
  - Water, steam, condenser



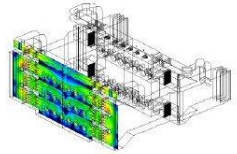
Fans and Ductwork

- Velocity patterns, erosion
- Pressure drop
- Ash accumulation

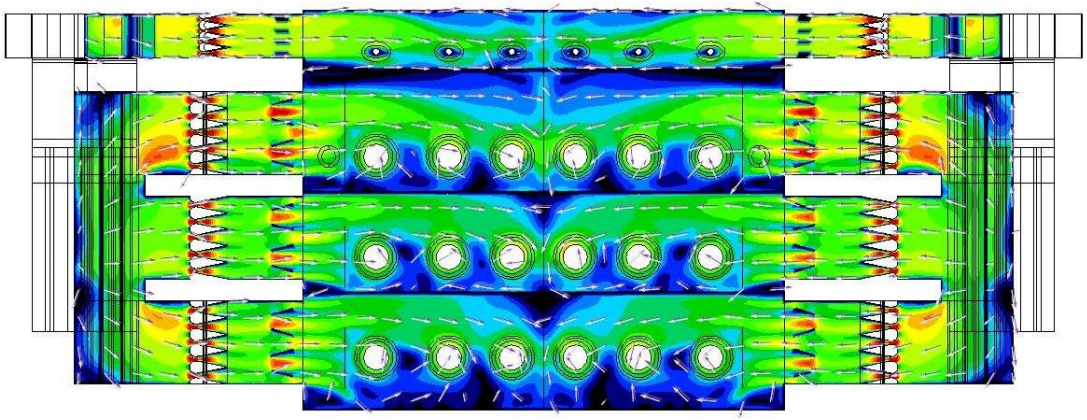


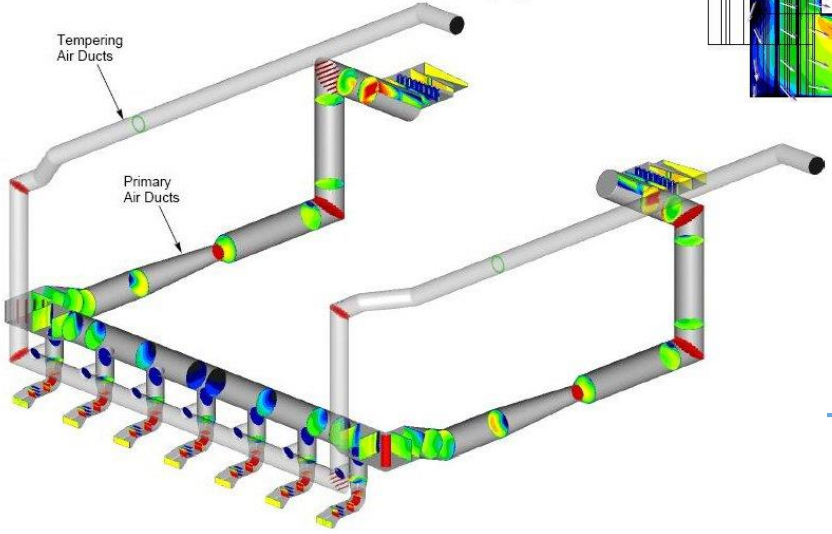


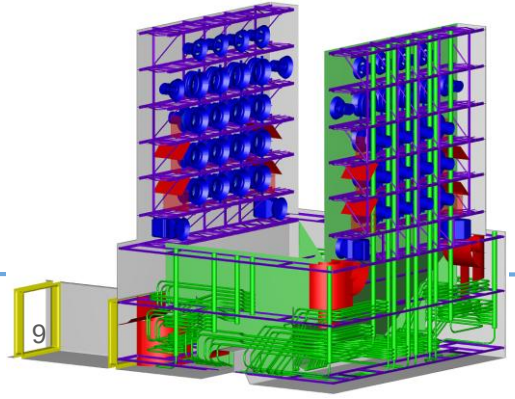
PA/SA/OFA/Fuel Balancing



- Optimize combustion
  - Balance PA flows
  - Equal coal flow per burner
  - Windbox and OFA balance

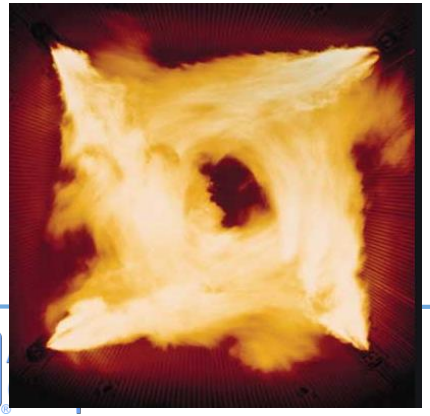


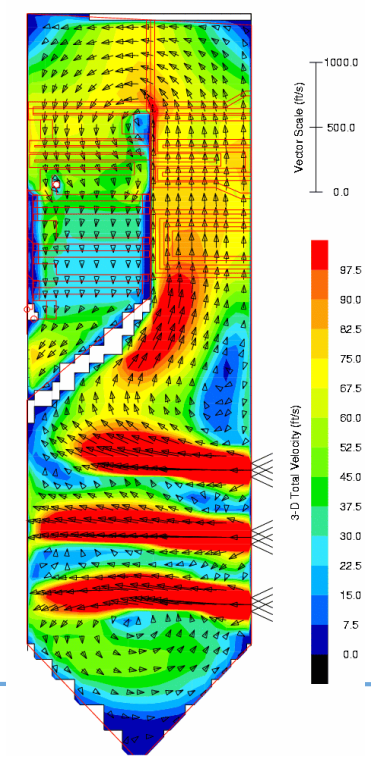


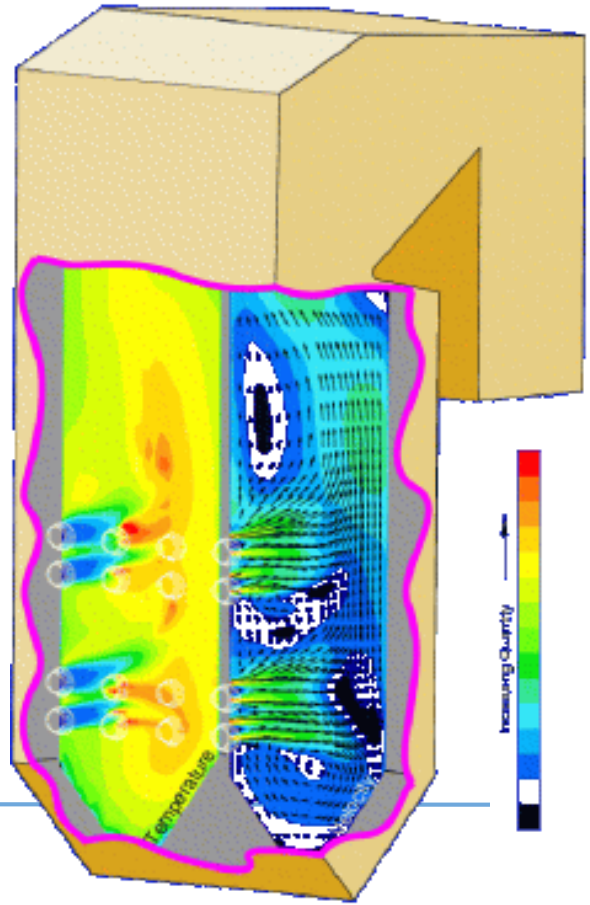


Furnace Combustion, NOx, Slagging

- Coal, gas, or dual firing
  - Reduce NOx
  - Minimize LOI
  - Improve heat transfer
  - Avoid corrosion
  - Decrease slagging
  - SNCR

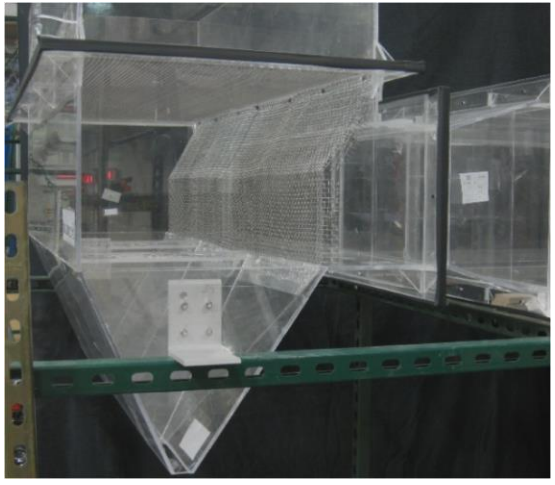


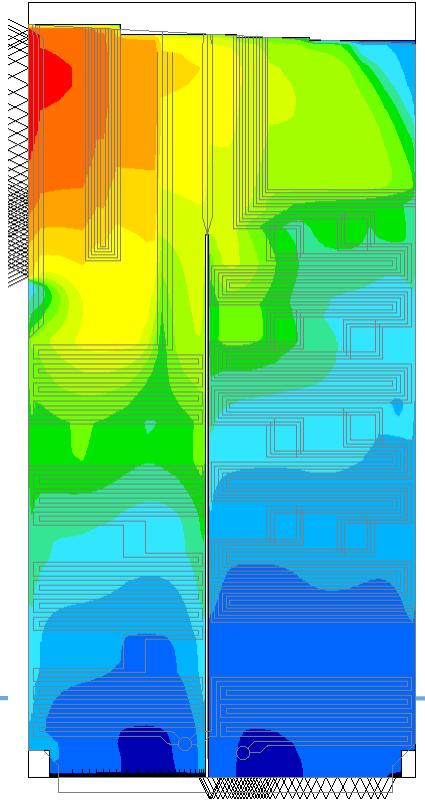


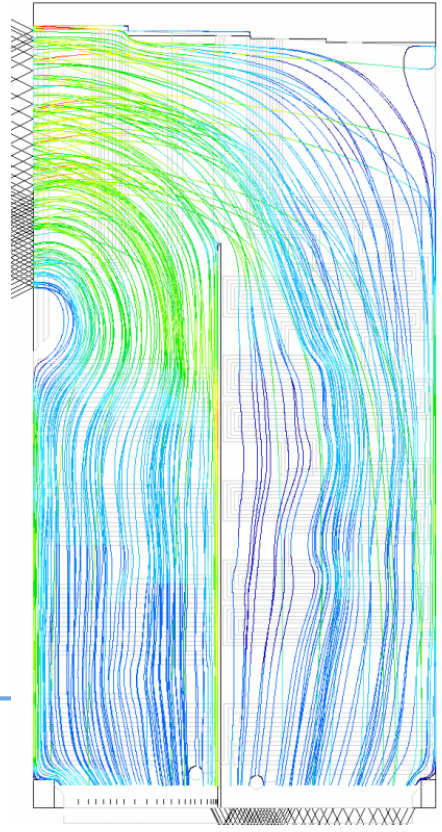


Backpass, Heat Transfer, Erosion, Economizer

- Gas and particulate flow profiles
- Ash impacts on tubes and walls







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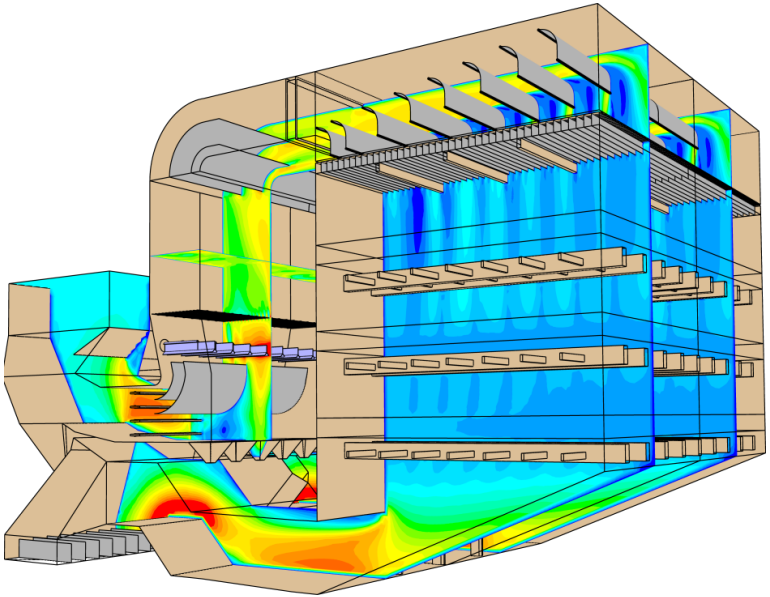
SCR Flow Modeling

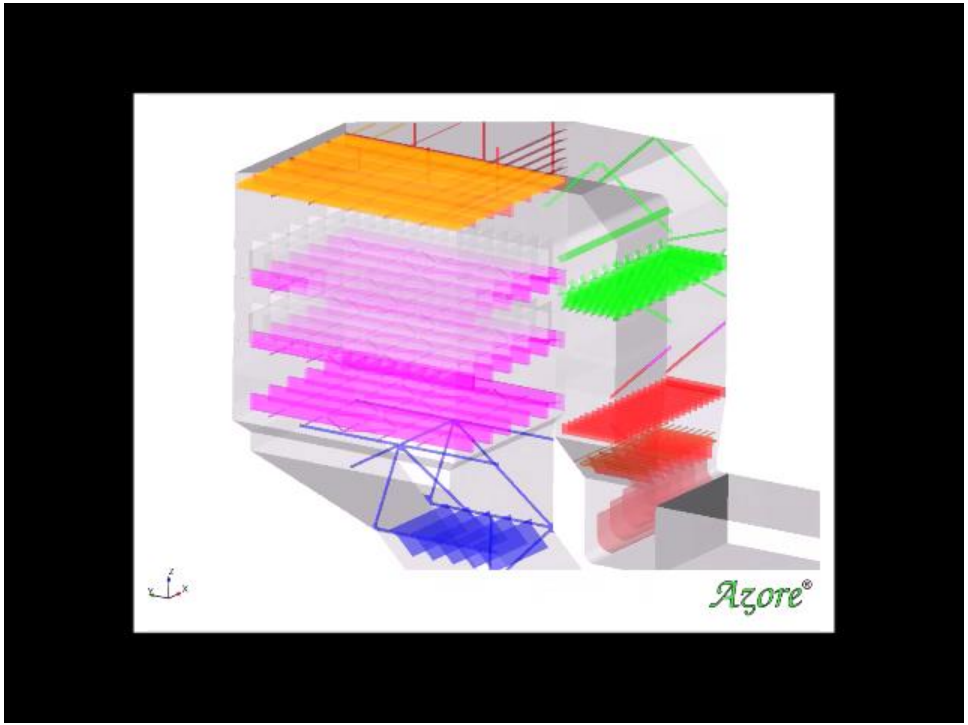
Performance goals for SCRs:

- Uniform ammonia-to-NOx ratio
- Uniform velocity at AIG
- Uniform velocity at the catalyst
- Vertical flow entering catalyst
- Uniform temperature at catalyst
- Minimize pressure loss
- Capture LPA with screen/baffles
- Minimize pluggage potential
- Minimize erosion potential

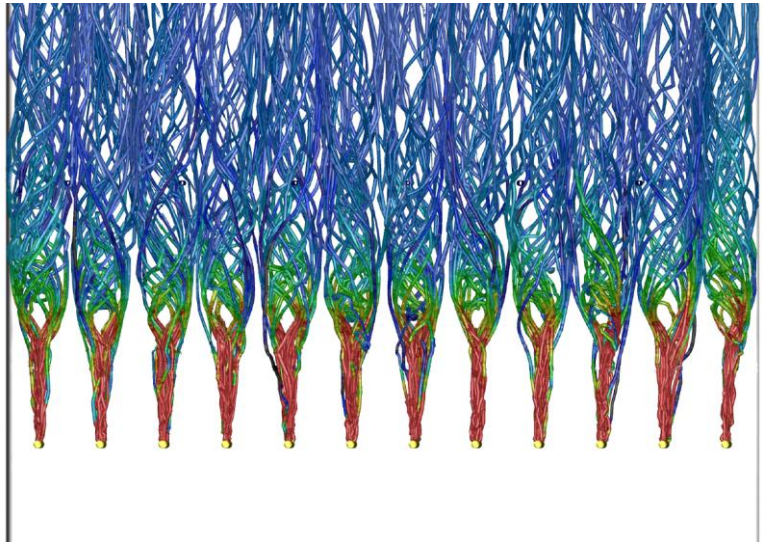
SCR Flow Modeling

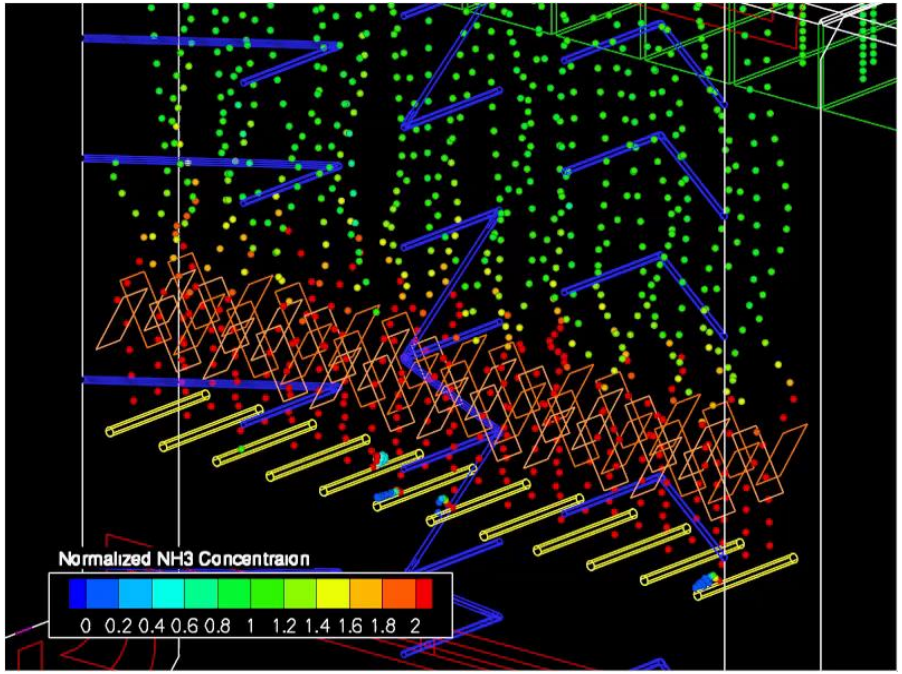


SCR Flow Modeling



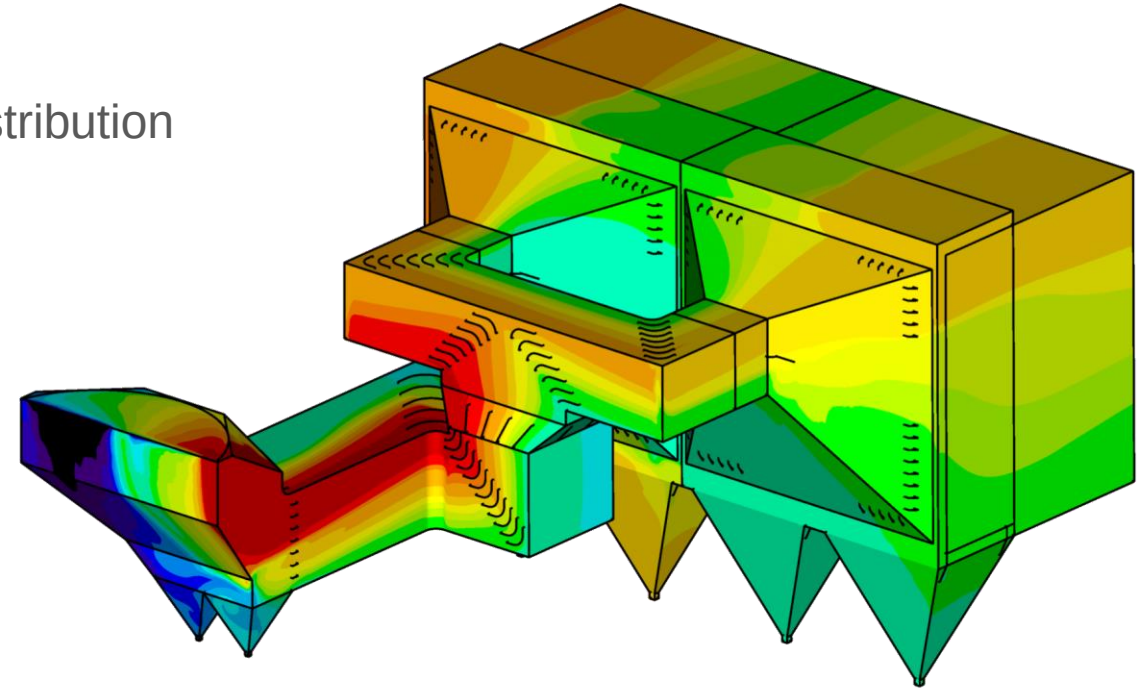
SCR Ammonia Mixing





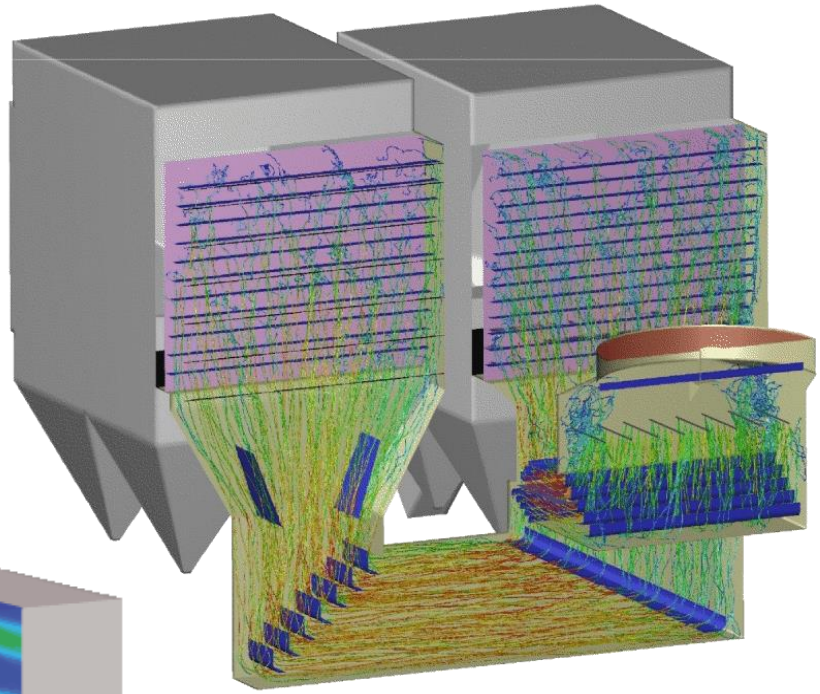
Air Heaters

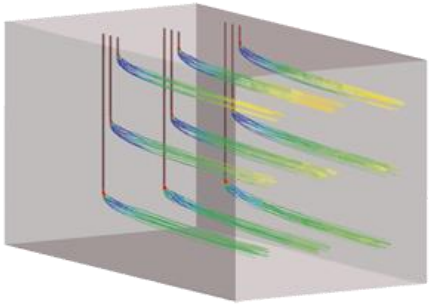
- Flow and temperature distribution
- Pluggage
  - Particulate
  - ABS
  - Inleakage

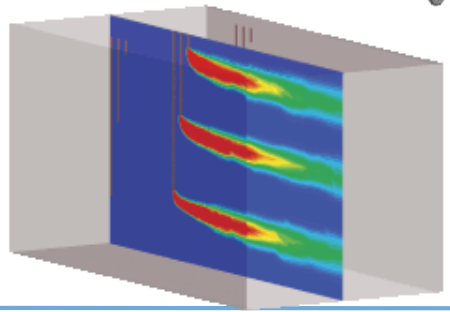


Sorbent Injection

- Injection upstream of baghouse or ESP
  - Activated carbon
  - Lime, Trona, SBS, etc.
- Uniform injection
- Mixing
- Maximize residence time

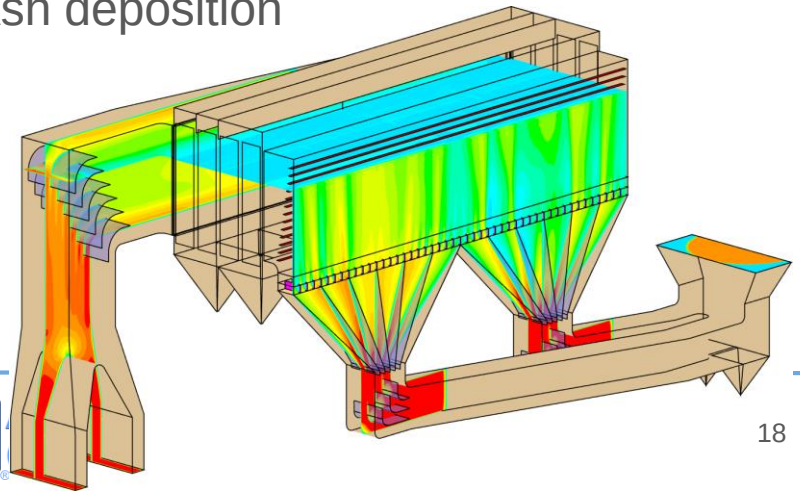






ESP / PJFF

- Flow uniformity
  - ICAC flow uniformity guidelines
  - Flow balance
  - Velocity distribution
- Pressure loss
- Ash deposition



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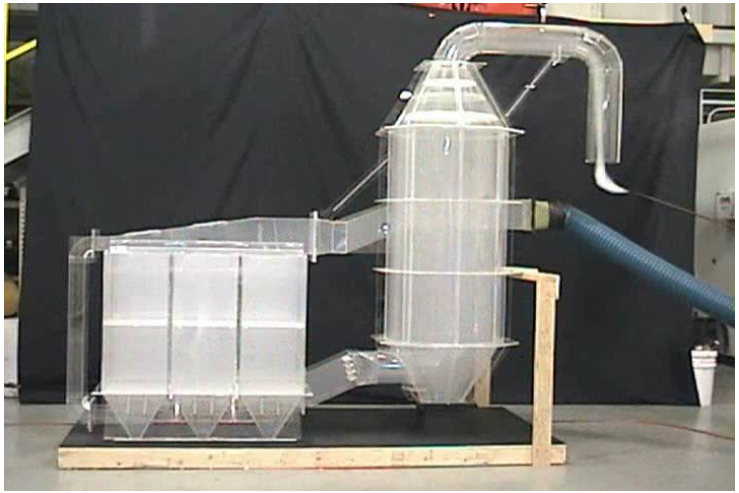
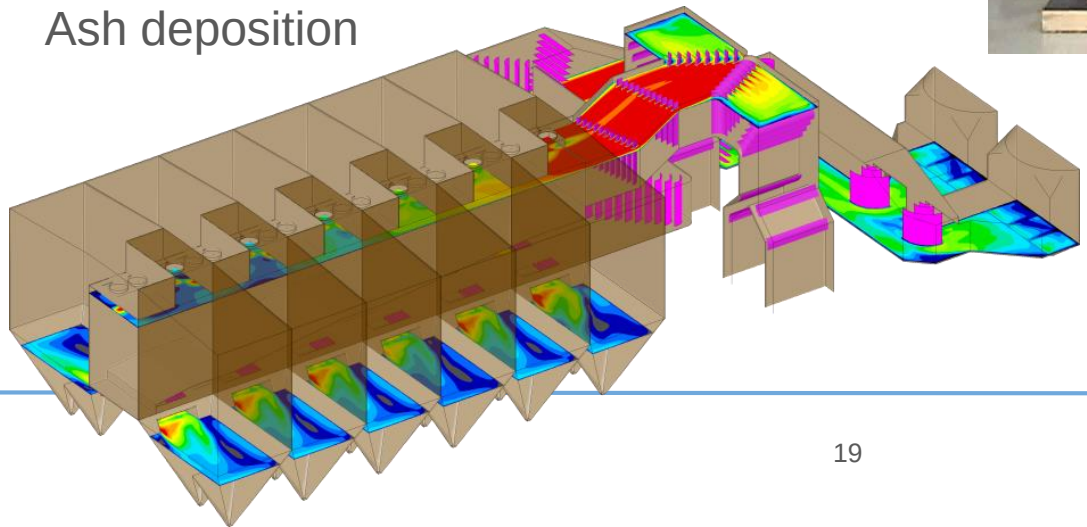
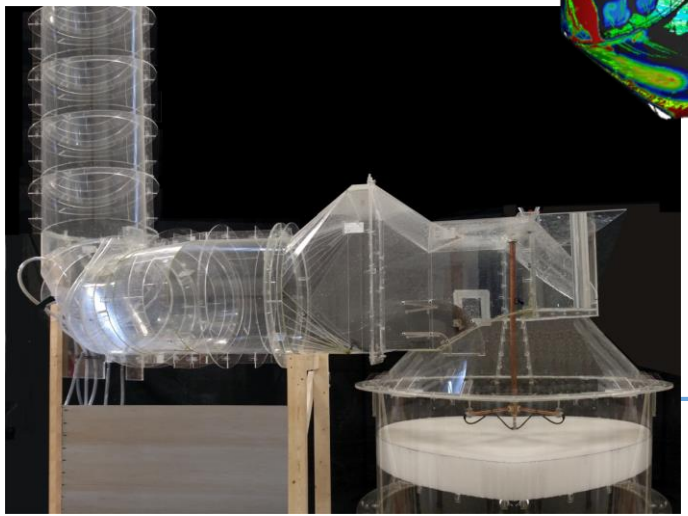
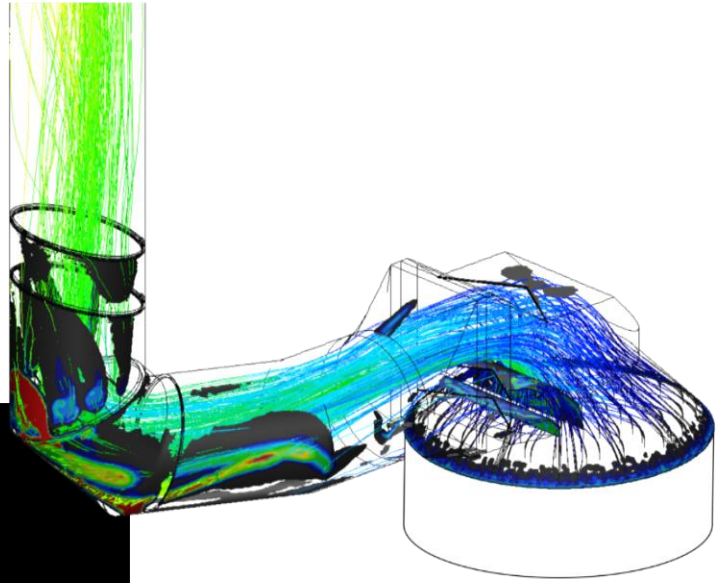


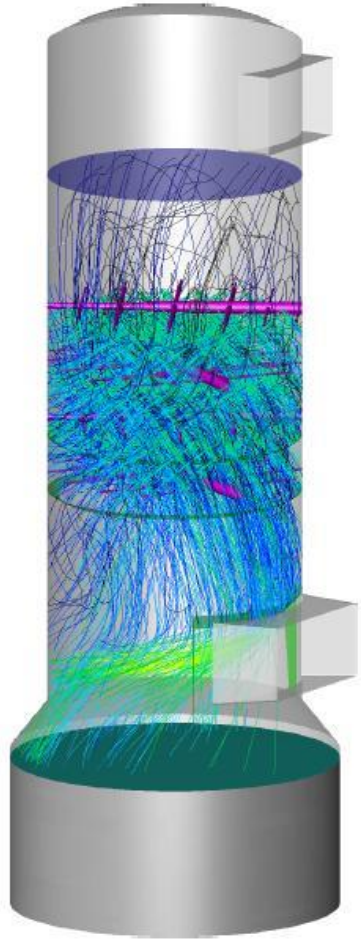


Wet FGD

- Flow uniformity
- Pressure loss
- Droplet patterns
- Spray pull-back

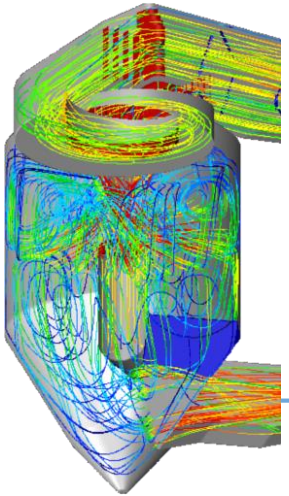


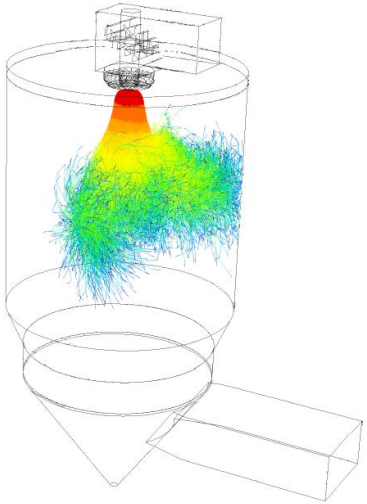


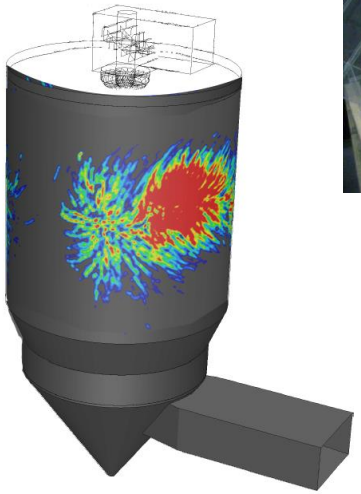


SDA

- Flow uniformity
- Pressure loss
- Flow balance
- Deposition

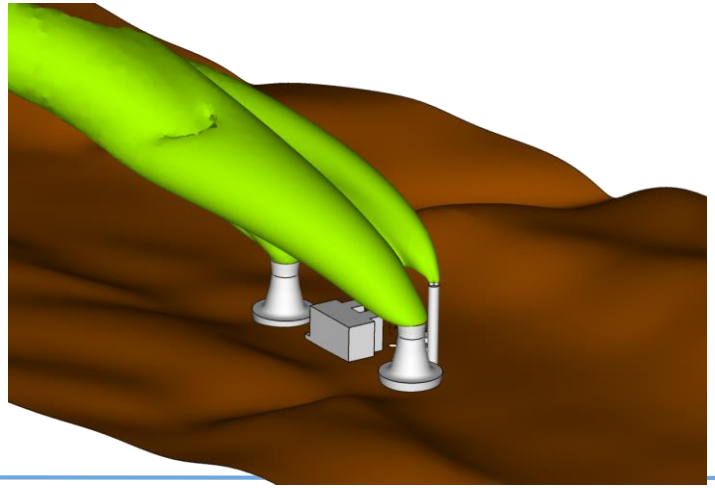




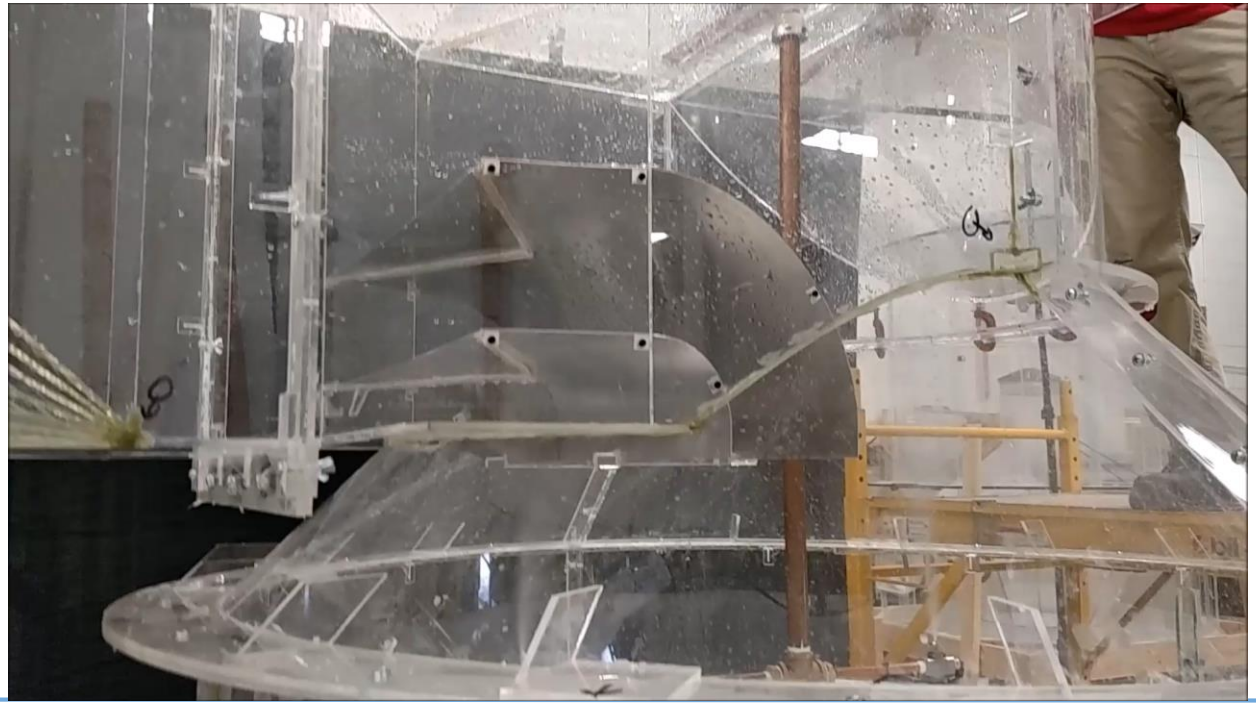


Stacks

- Flow distribution at CEMs
- Droplet collection
- Plume downwash

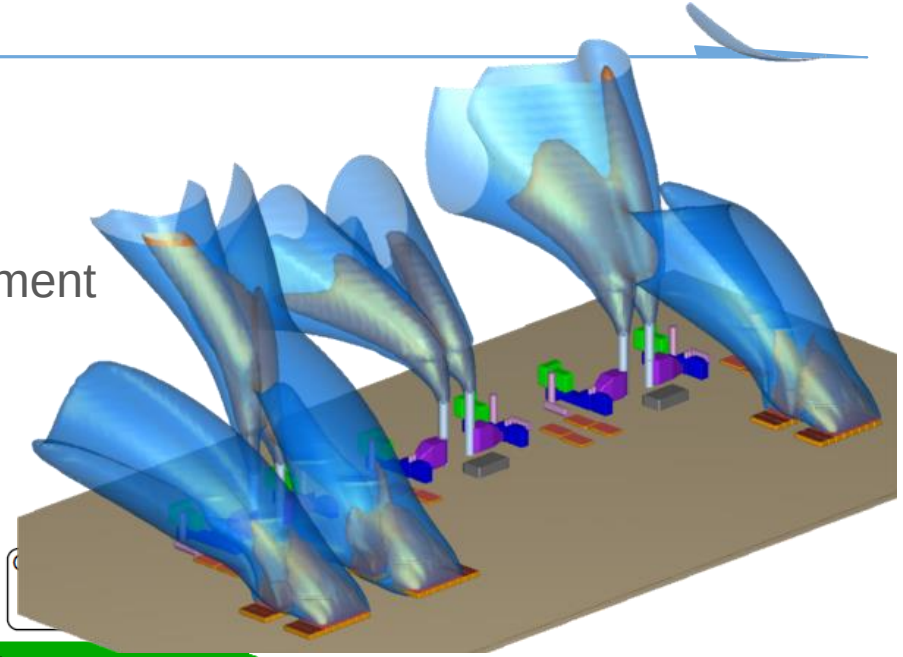


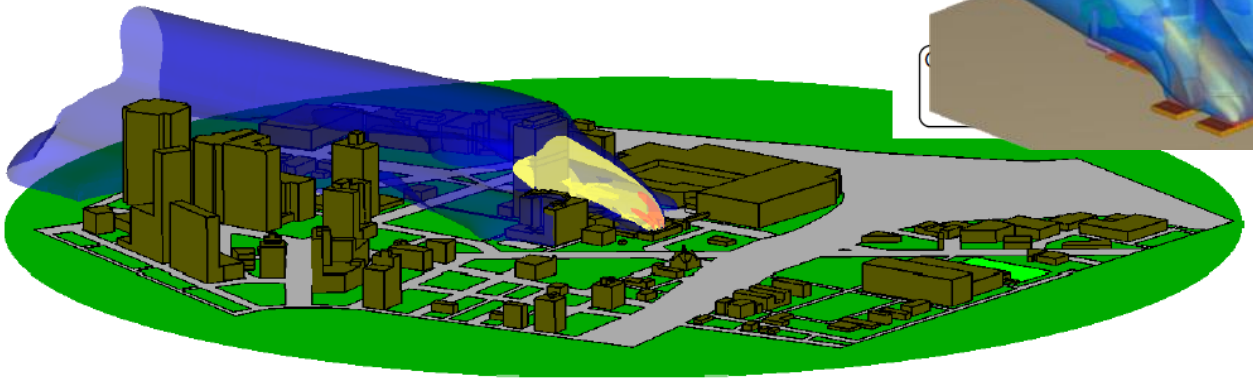
Wet Stacks



Plume Dispersion

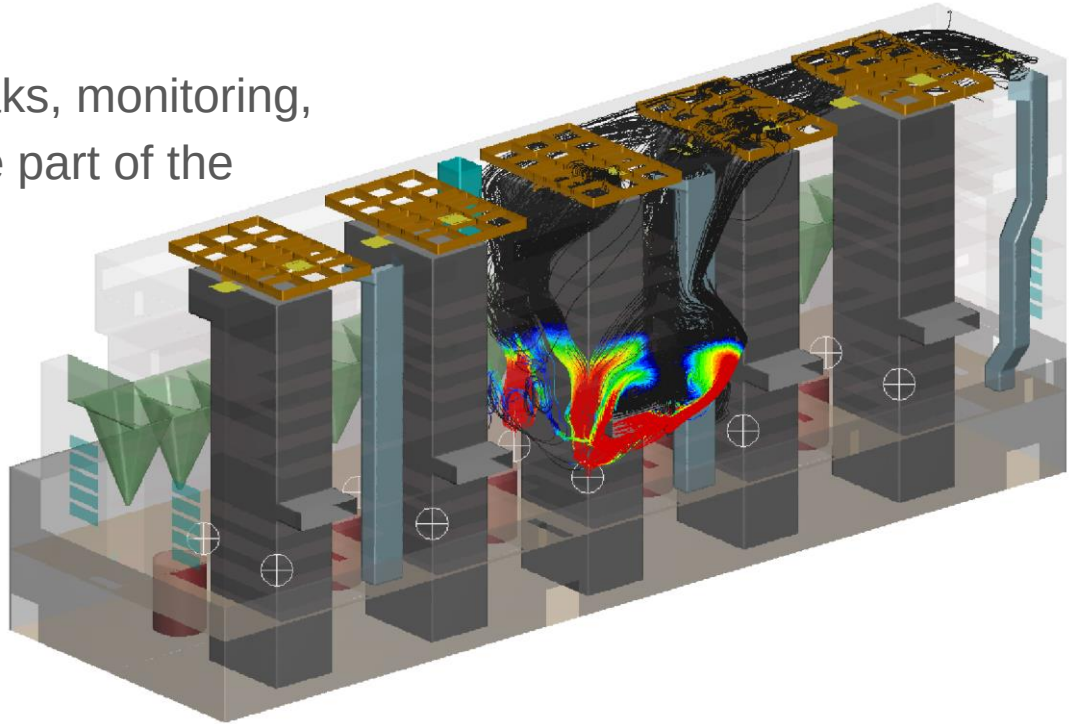
- Flow patterns to surrounding environment
- Impact on nearby equipment





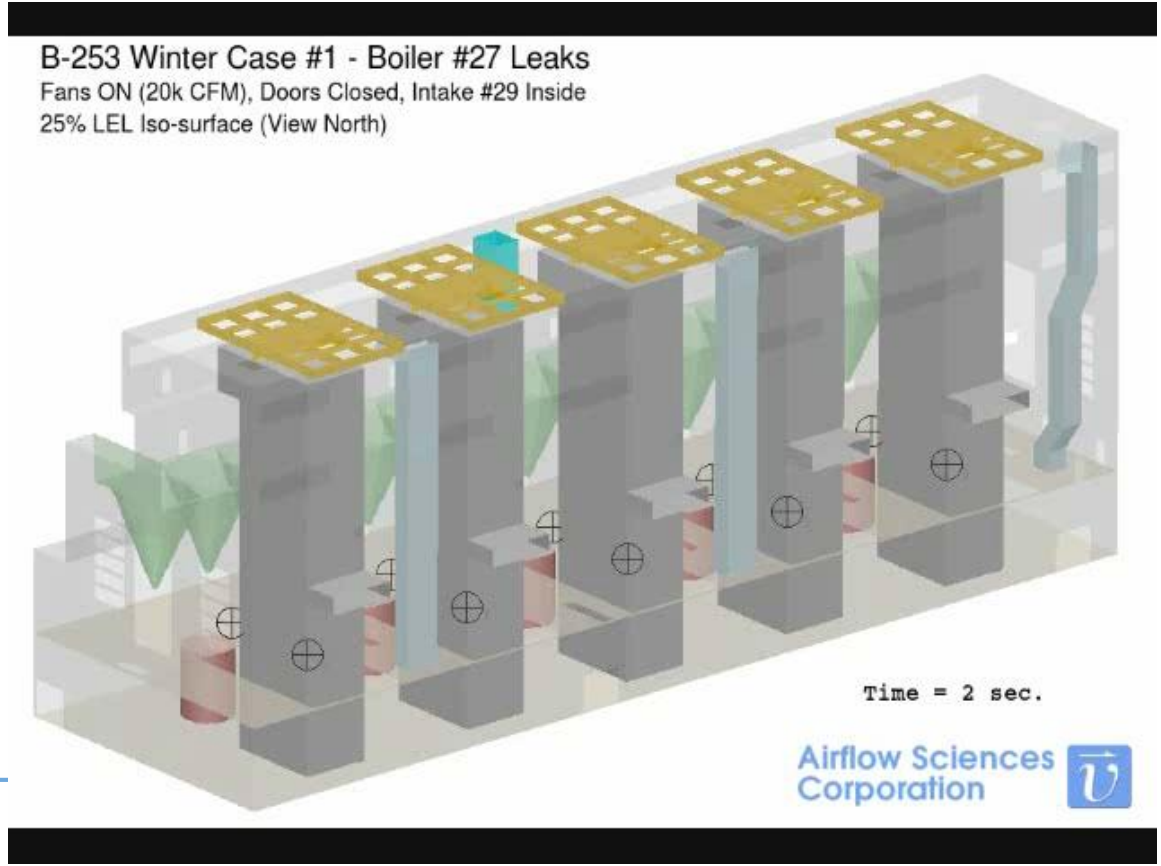
Leak Detection

- Natural gas firing at former coal plants creates new safety hazards
- CFD modeling of potential leaks, monitoring, and ventilation options can be part of the design solution



Leak Detection

- Gas leak tracking



Summary

- CFD and physical flow modeling are proven engineering tools to analyze flow-related issues and equipment
- Applicable to coal, gas, and co-firing plants
- Can be used to optimize air, gas, particulate, and liquid flows “from the fan to the stack”

Questions & Contact Information

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