Flow Modeling for Chemical Processing

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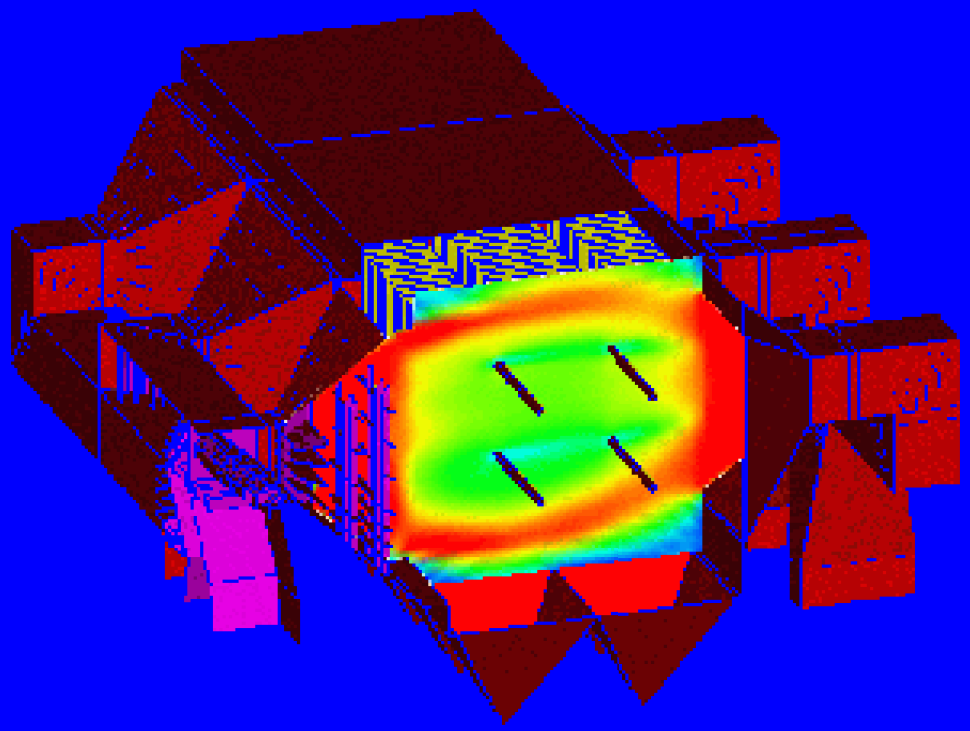
Outline

- Introduction
- Flow Problems in Chemical Processing
- Flow Modeling
- Examples
- Summary
- Questions

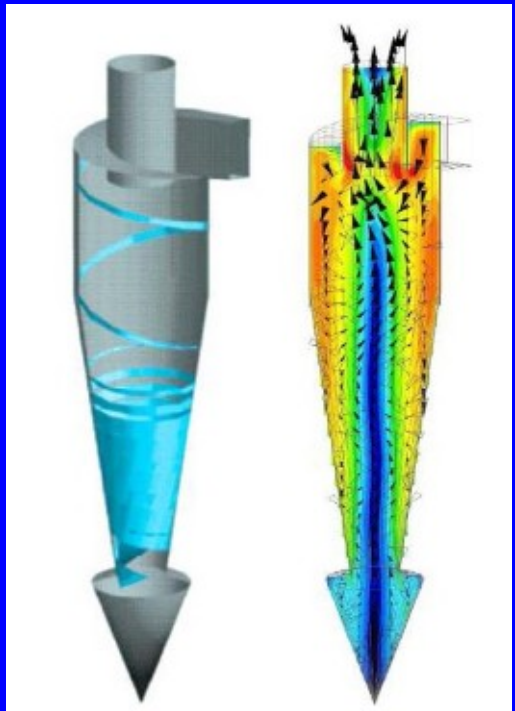
Flow problems can involve...

- mixing
- drying
- filtration
- dispersion
- injections
- chemical reactions
- heat or mass transfer
- uniformity



Why Perform Modeling?

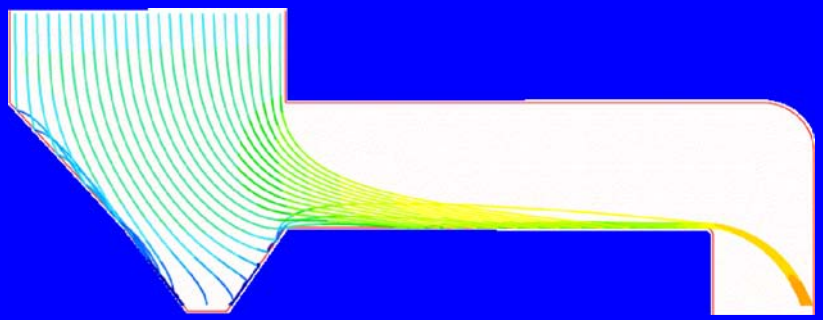
- optimize pollution control
- prevent erosion
- maximize efficiency
- reduce waste product
- improve design
- evaluate equipment
- increase throughput
- improve product quality



Calculated paticle trajectories (left) and velocities (right) within cyclone.

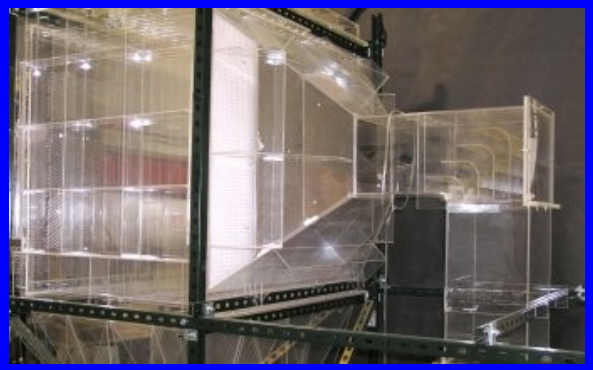
Use for Plant Maintenance

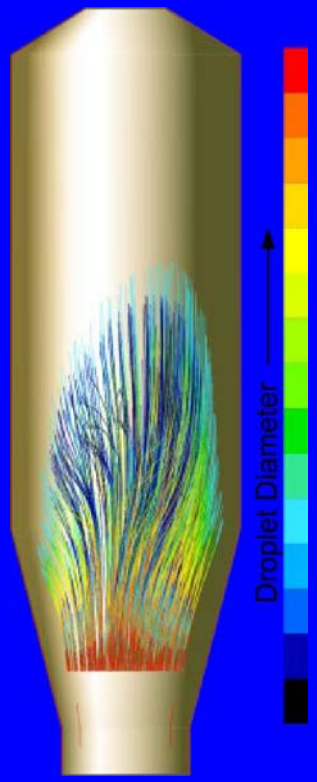
- Avoid heat exchanger pluggage
- Minimize tube bank erosion
- Reduce corrosion
- Eliminate flow-induced vibration
- Minimize particulate build-up



Use for Plant Emissions

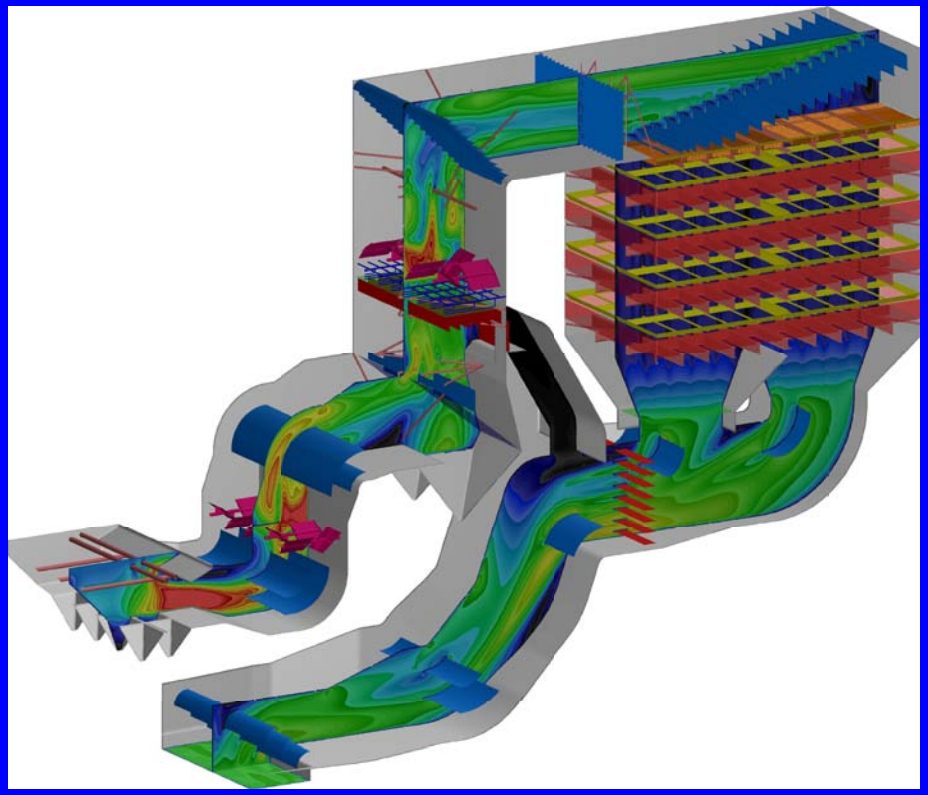
- Optimize particulate capture systems
- Burner analyses
- Balance burner air / fuel flows
- Scrubber design enhancement
- Optimize SCR/CO catalyst performance
- Stack Continuous Emissions Monitor assessment





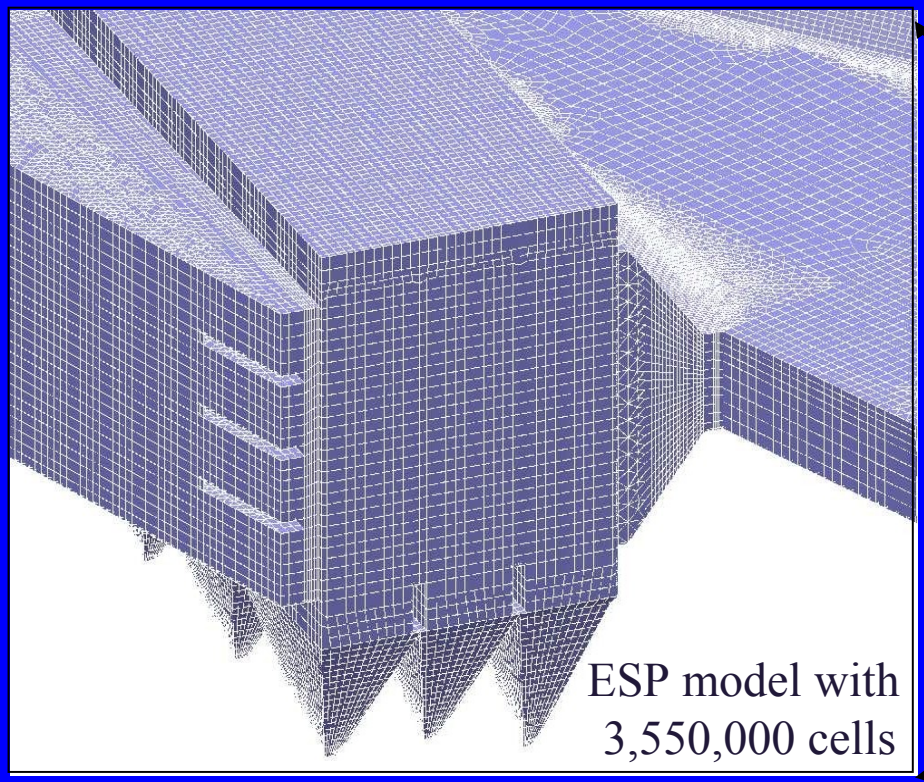
Flow Modeling: CFD

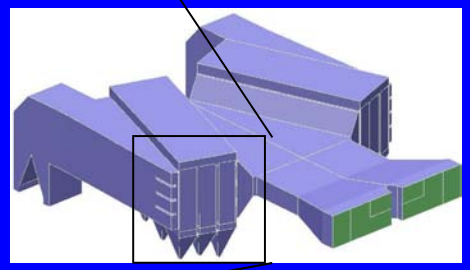
- Numerical simulation of flow
- Utilize high speed computers and sophisticated software
- Calculate flow properties
  - velocity
  - pressure
  - temperature
  - species
  - particle streamlines

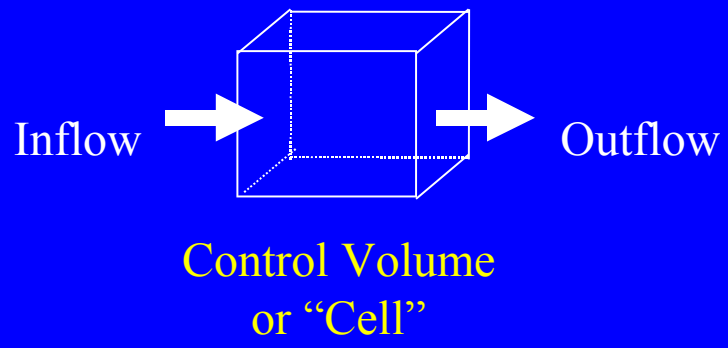


Flow Modeling: CFD

- Control Volume Approach
  - Divide the flow domain into distinct control volumes
  - Solve the Navier-Stokes equations (Conservation of Mass, Momentum, Energy) in each control volume

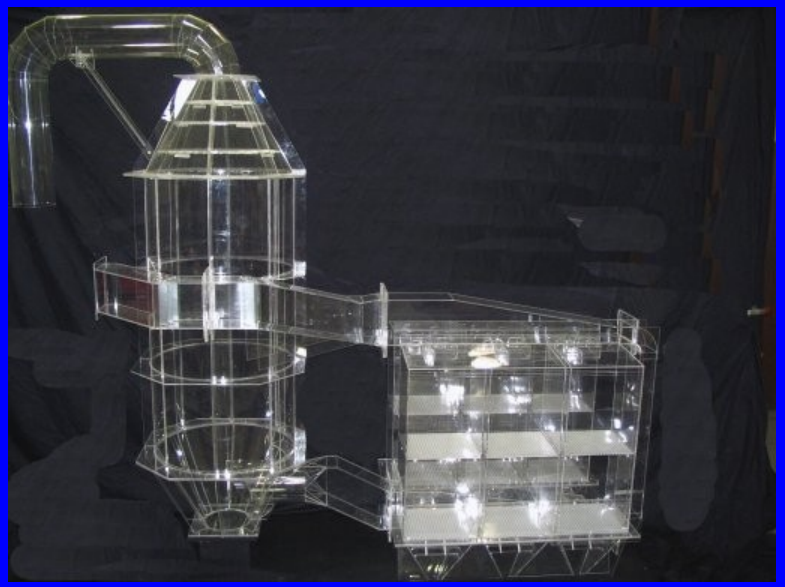


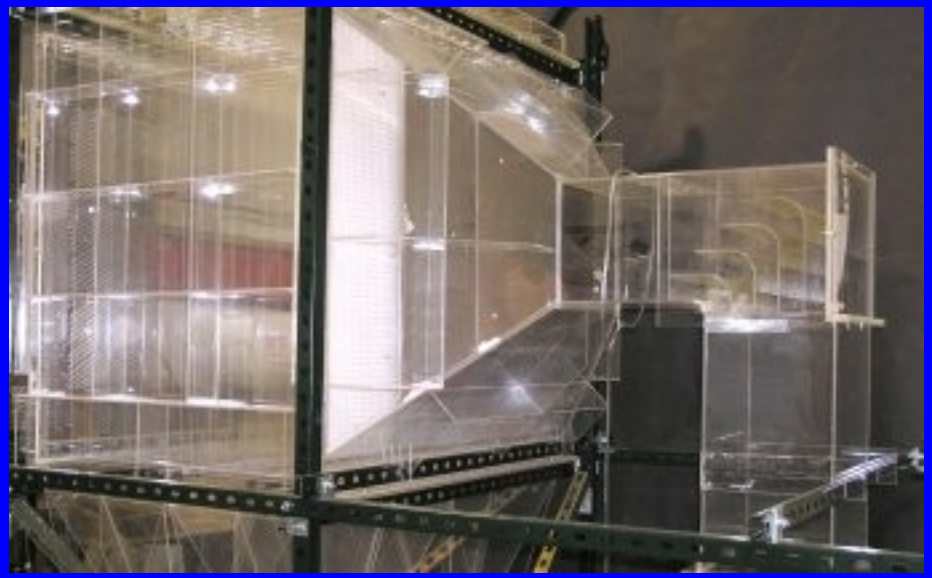




Flow Modeling: Physical

- Scaled cold flow modeling
- Plastic & metal components





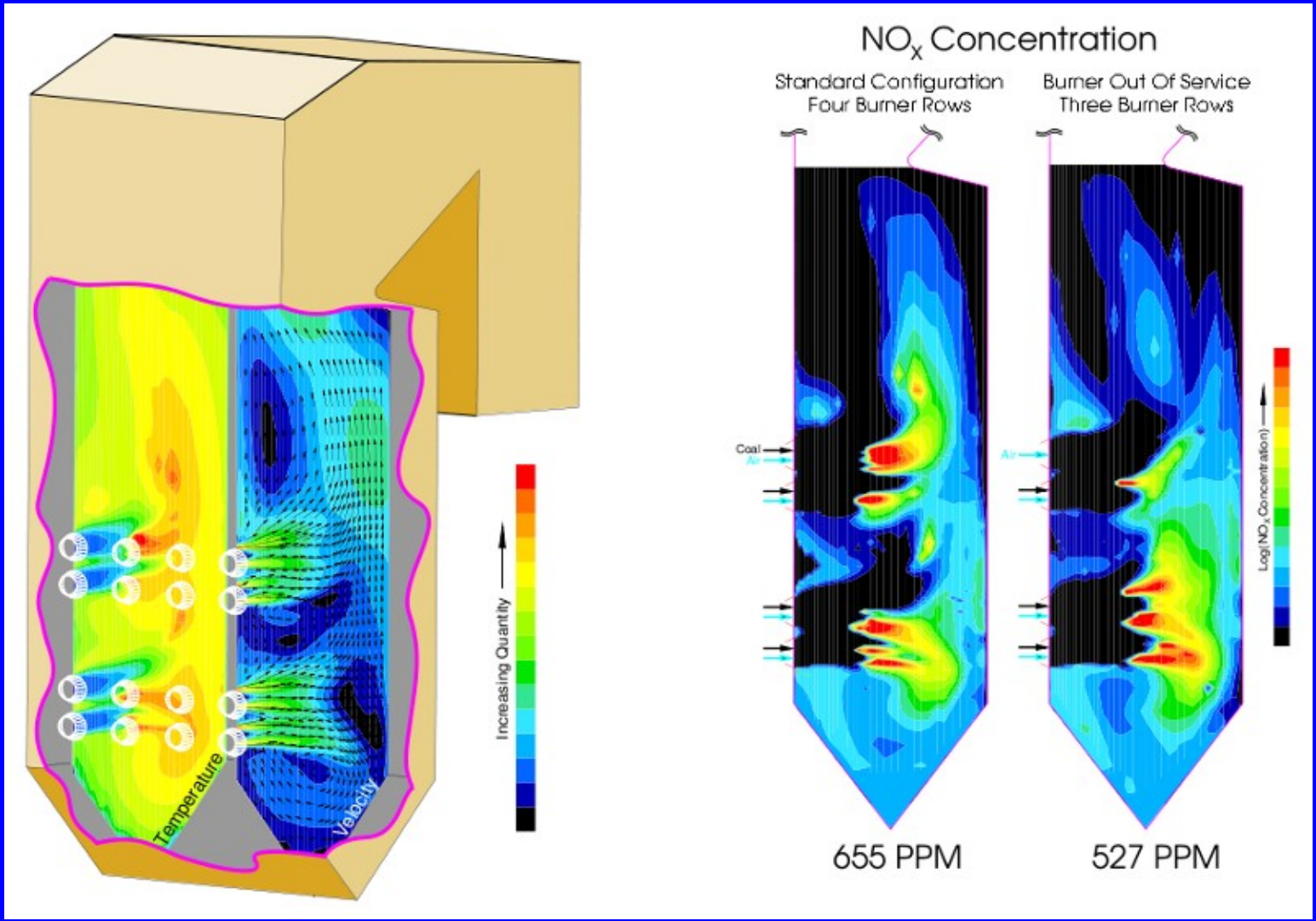
Flow Modeling: Physical

- Lab representation of geometry
- Typical scale 1:8 to 1:16
- "Cold flow" modeling
- Visualize flow with smoke
- Simulate ash deposition
- Measure flow properties
  - Velocity
  - Pressure
  - Mixing via tracer gas

Pros and Cons

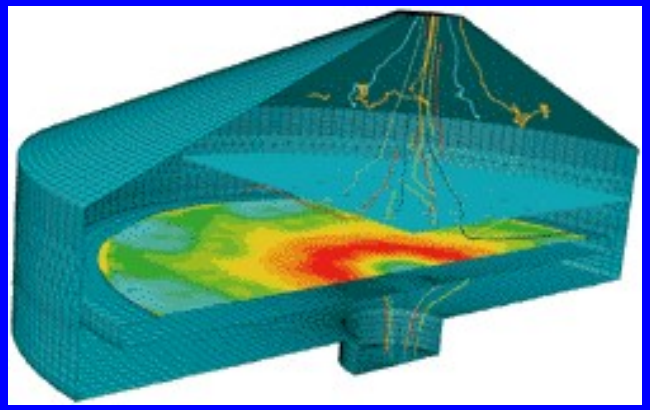
	CFD Model	Physical Model
Accuracy	√	√
Schedule	√	
Modeling Cost	√	
Scale	√	
Particulate Layout		√
Heat Transfer	√	
Chemical Reaction	√	
Visualization	√	√
Touch & Feel		√
Storage	√	
Particle Paths	√	

Example: Combustion



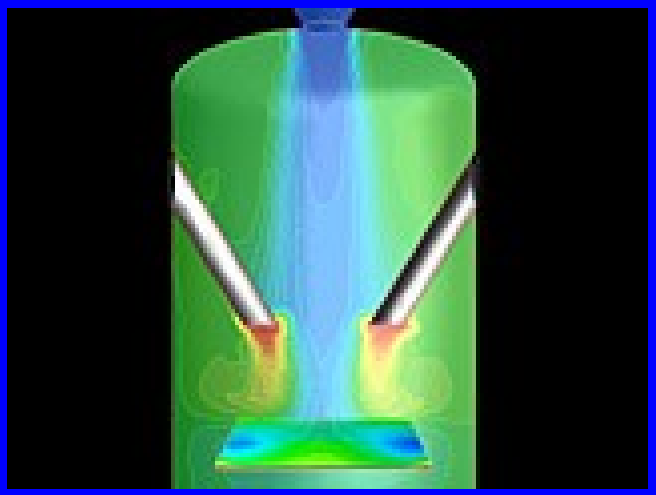
Example: Chemical Vapor Deposition

- investigate mixing of carrier & purge gases
- investigate coating thickness uniformity
- parametric simulations to determine potential design modifications



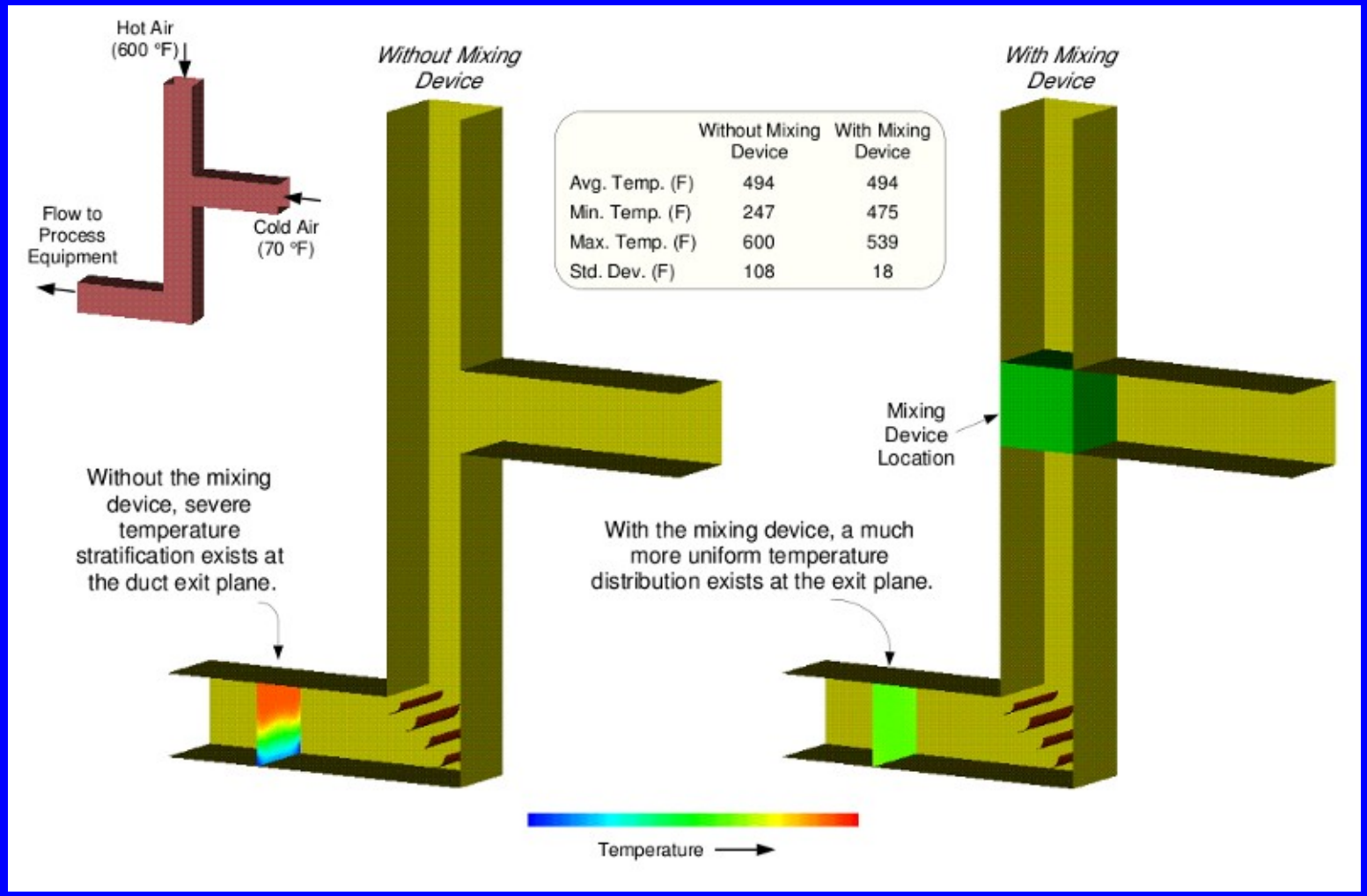
(c) Ansys Inc.

(c) wikipedia.org

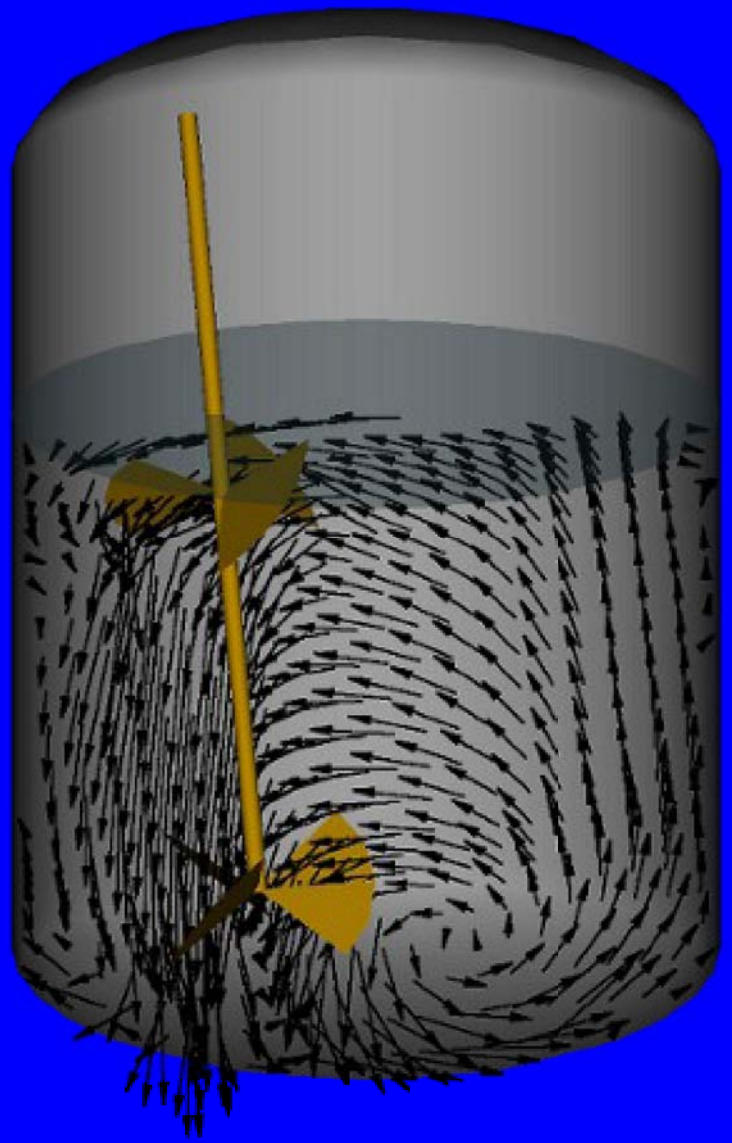


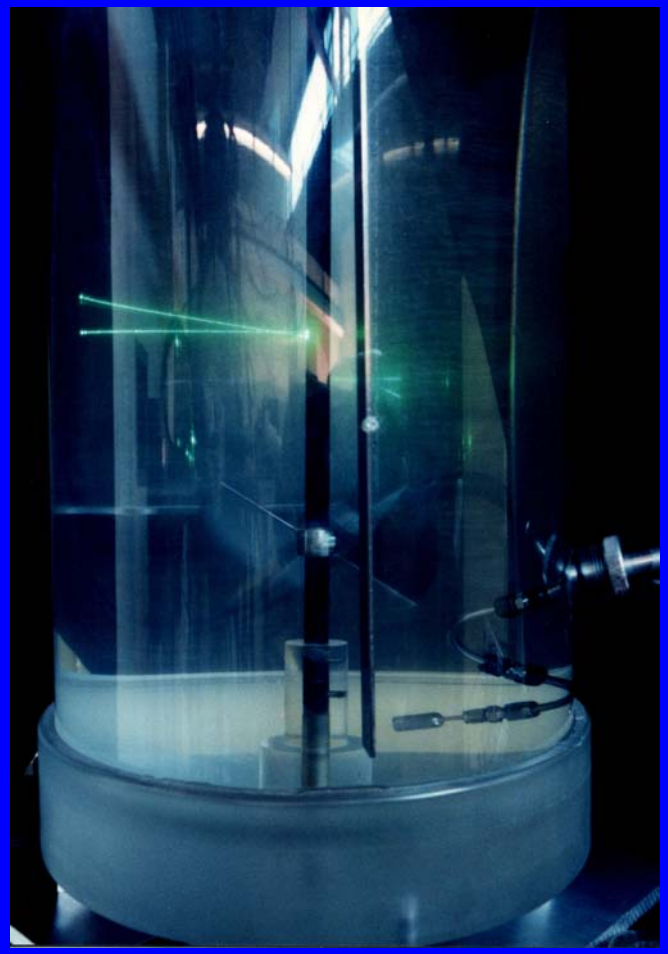
(c) Software Cradle Co. Ltd

Example: Static Thermal Mixer



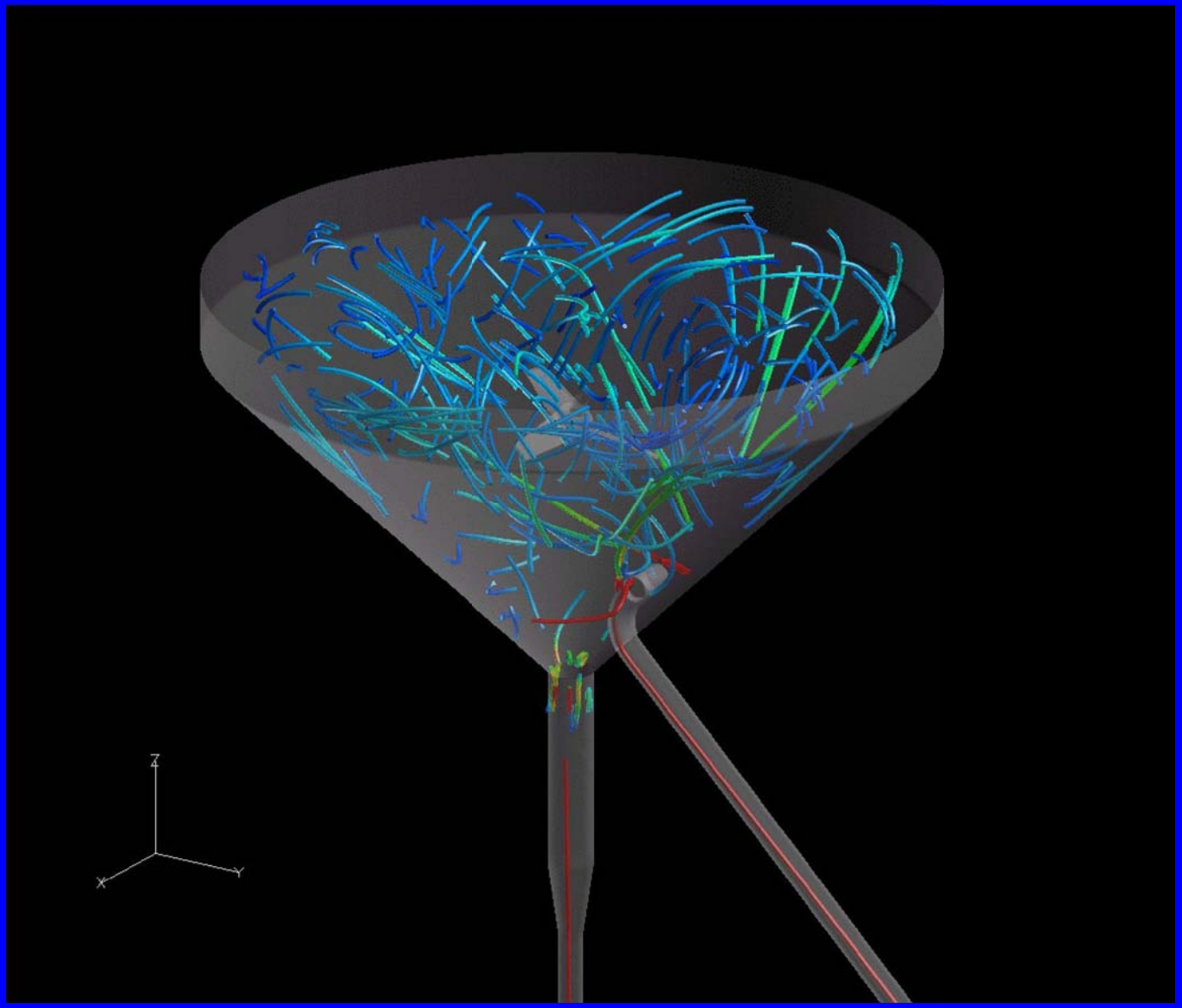
Example: Liquid Mixing Tank



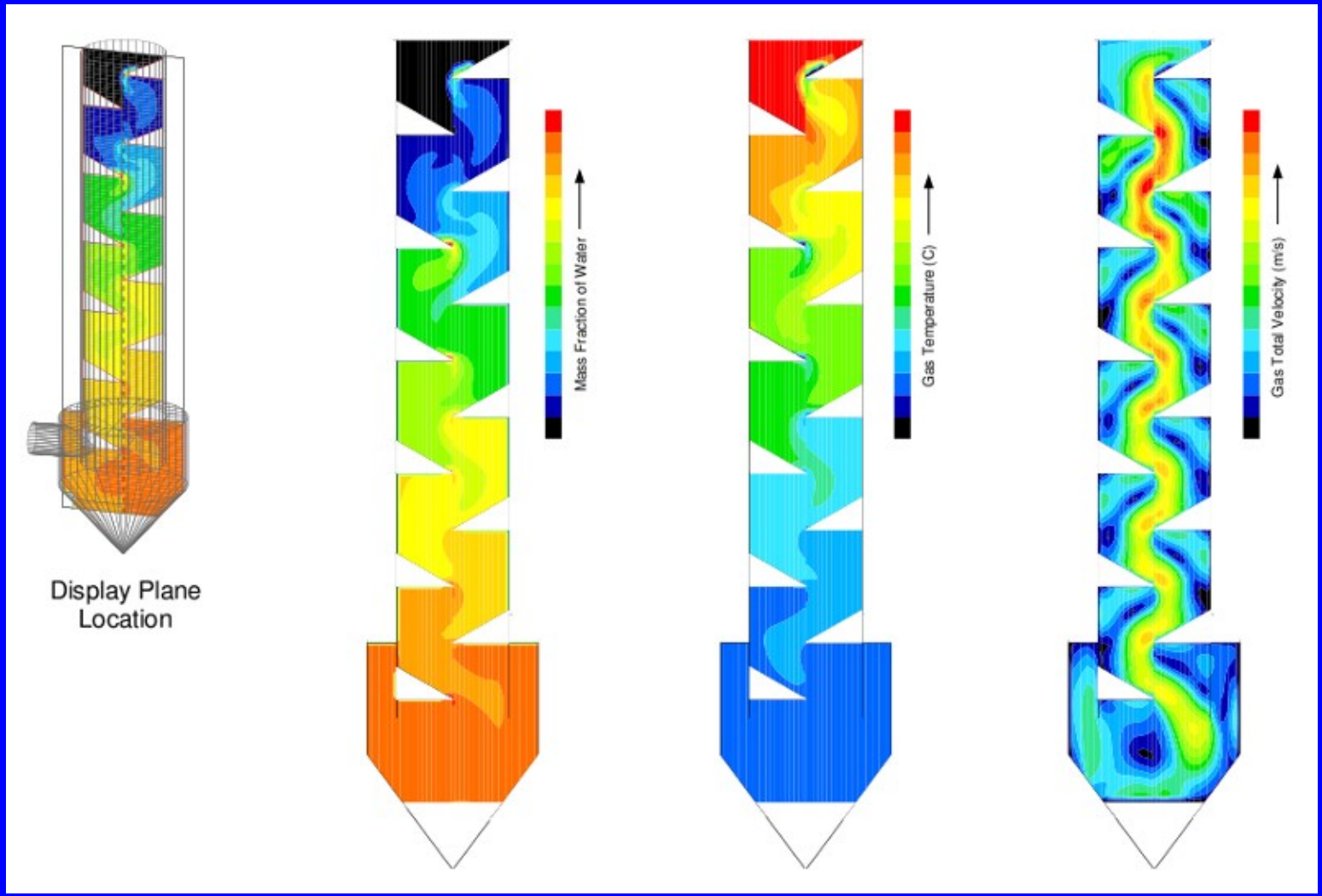


avoid small unmixed regions in tank

Example: Mixing Tank

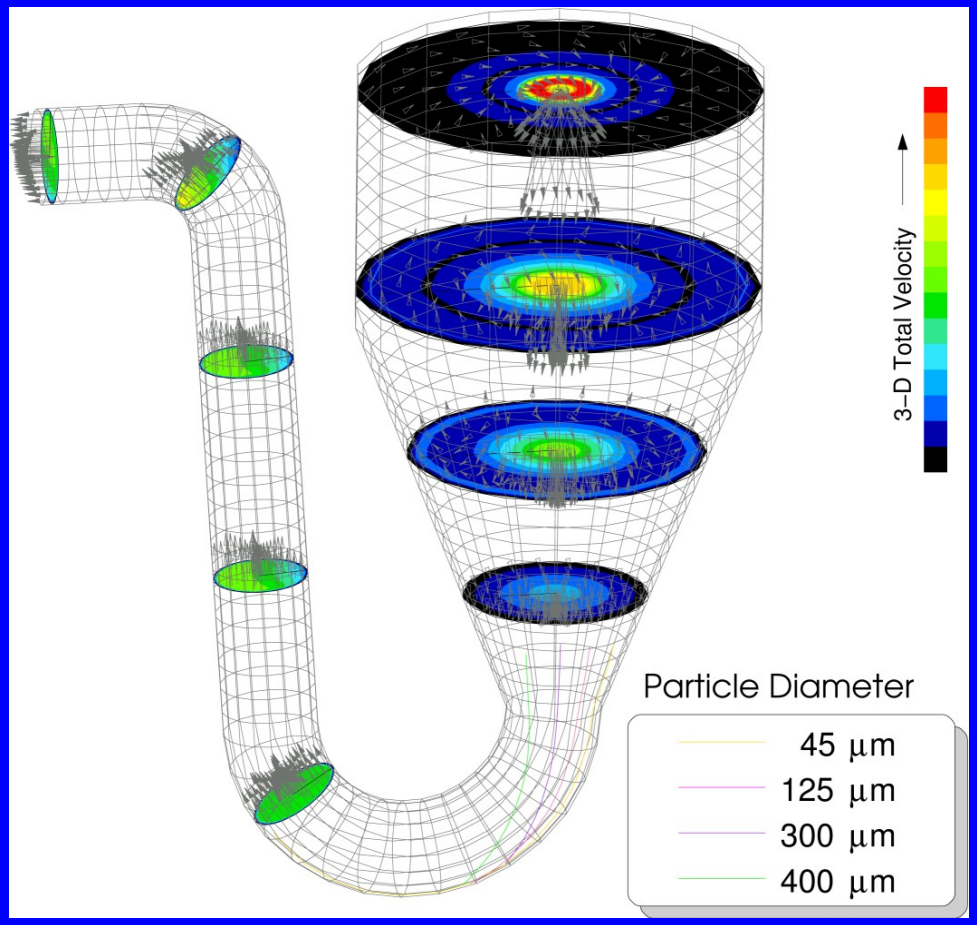


Example: Drying Tower



complete drying using minimal energy

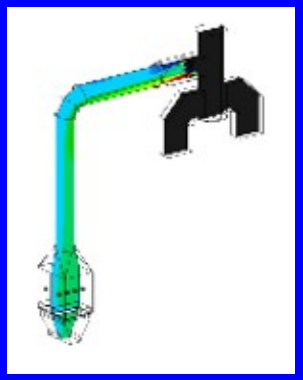
Example: Spray Drying

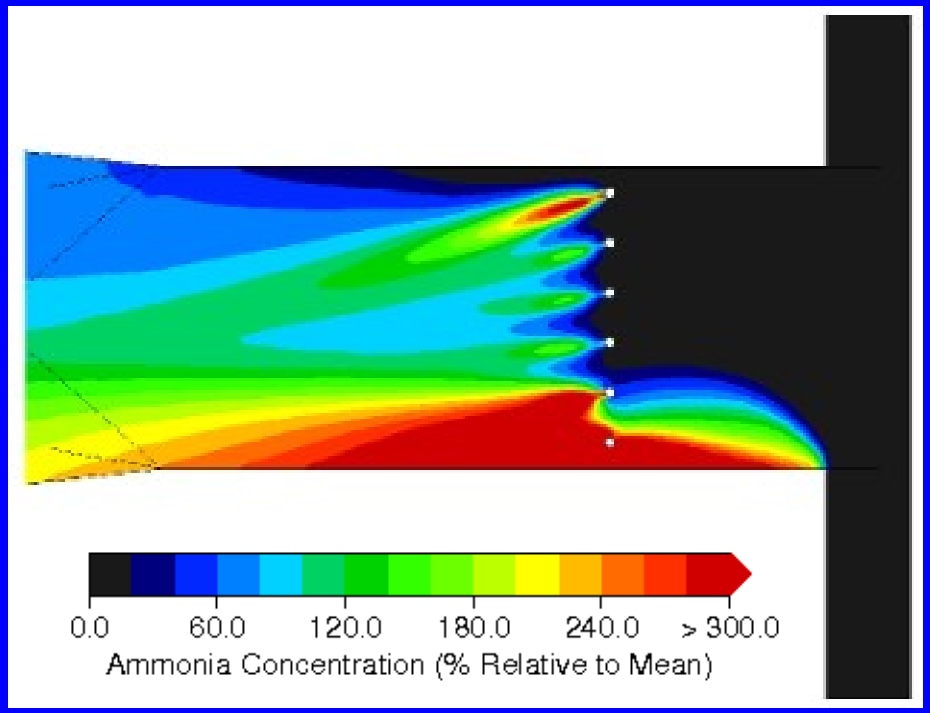


- lab model for testing
- CFD model for impact location
- avoid material buildup

Example: Gas Injection

maximize efficiency of catalyst

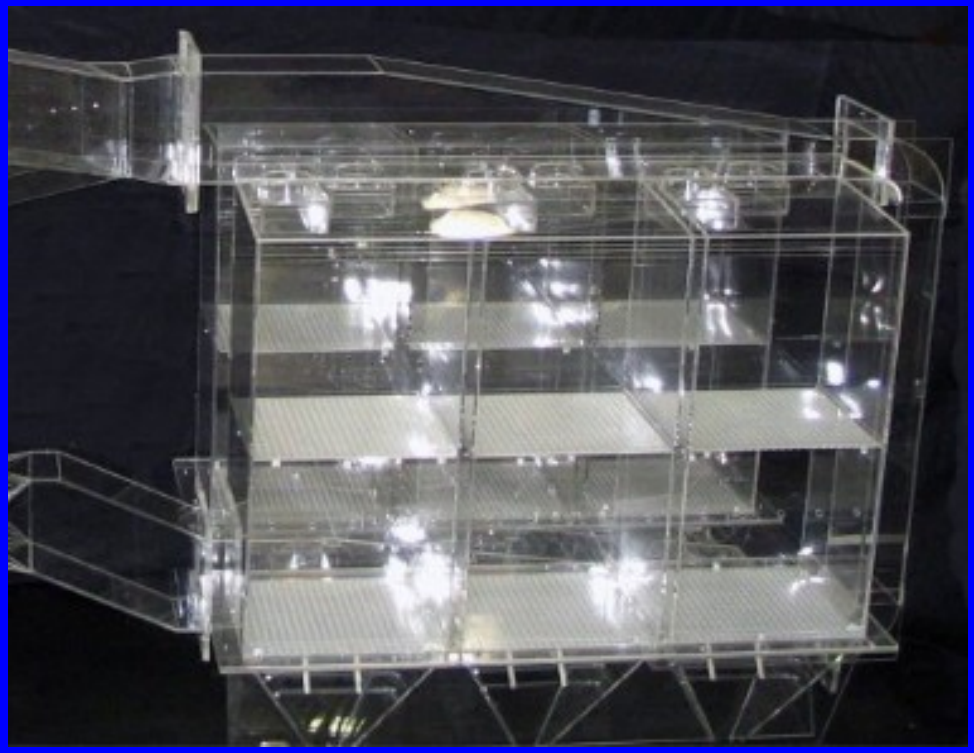


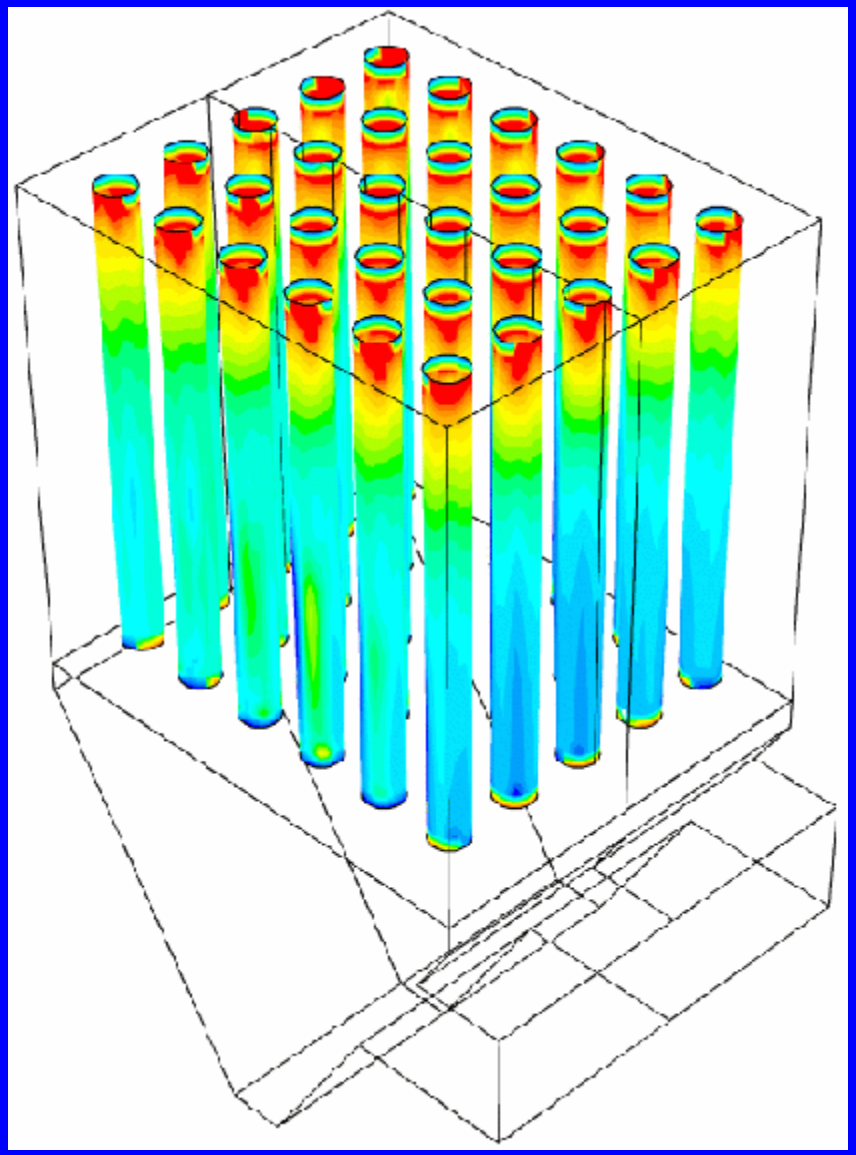


design and optimize AIG for SCR operations

Example: Particulate Control (FF)

increase bag life & reduce dP

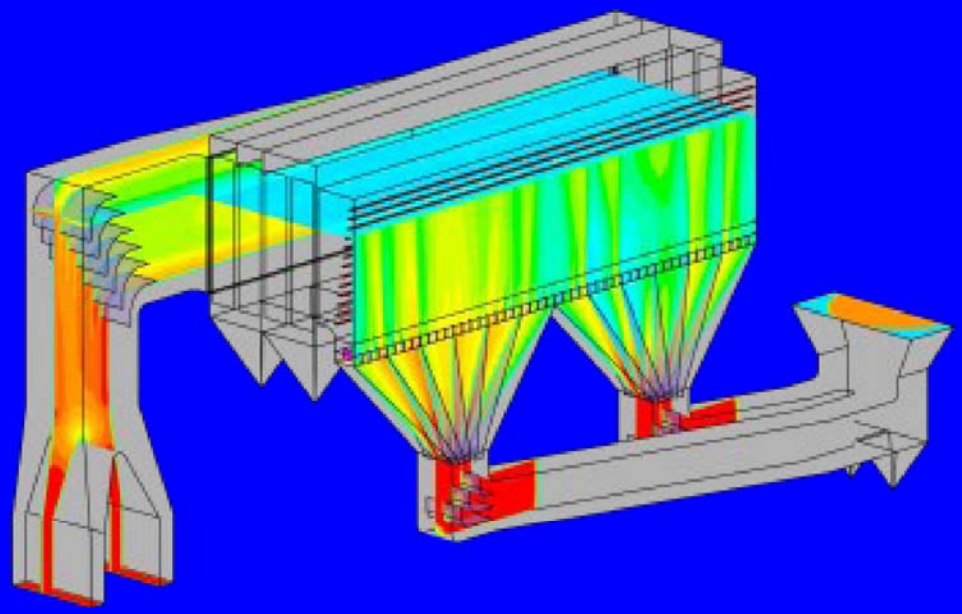




- want flow field to meet ICAC-F7 guidelines

Example: Particulate Control (ESP)

maximize particle capture



- modeling to help ensure flow field meets ICAC-EP7 standards

Summary

- Many issues may be addressed via flow modeling
- Insight into process allows trials in less expensive settings
- The best modeling method should be based on the problem, matching the strengths of the method to the specific situation

Questions?

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- Airflow Sciences is at Booth #444 at ChemShow