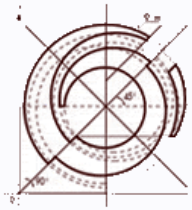
Feb. 13, 2004

CFD Modeling of Utility Boiler Components at ALSTOM Power Inc.

Galen Richards

ALSTOM

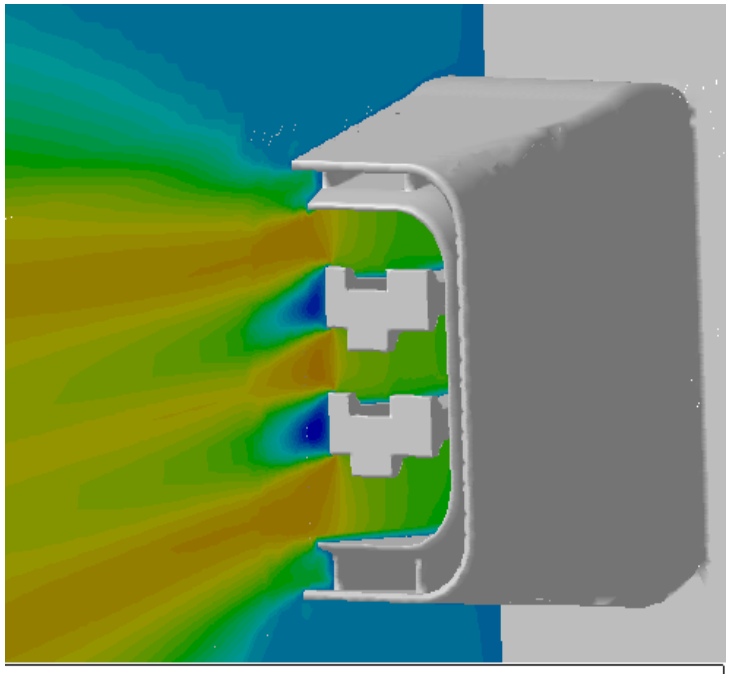


CFD at ALSTOM Power Inc.

ALSTOM

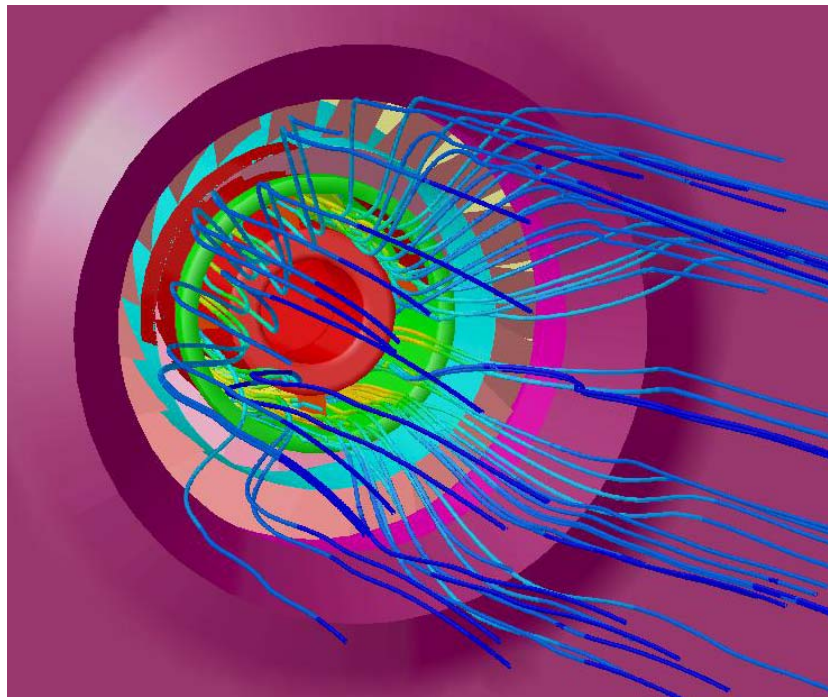
- Power Plant Laboratories (Windsor, CT)
  - 6 Engineers - full time CFD
  - 4 Engineers - part time CFD
  - Mainly use FLUENT
  - Also use CFX, Aiolos
  - Product development / problem solving for the Utility Boiler business
  - Chemical process industry

PPL CFD Examples - Burners

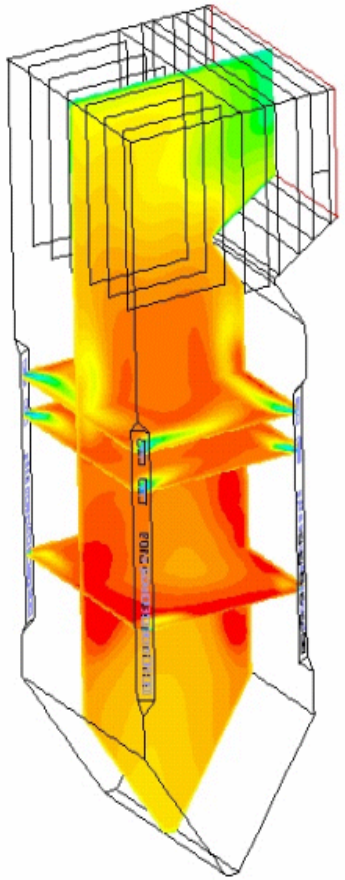


LNCFS - P2™ Coal Nozzle

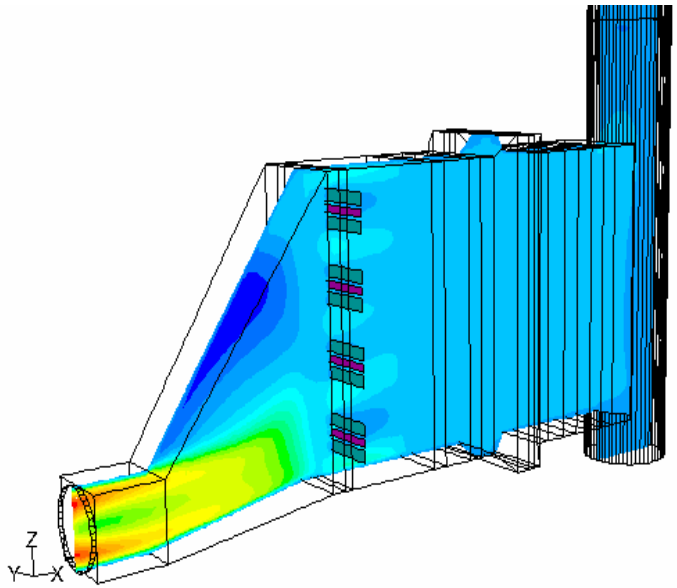
Wall-Fired Coal Burner



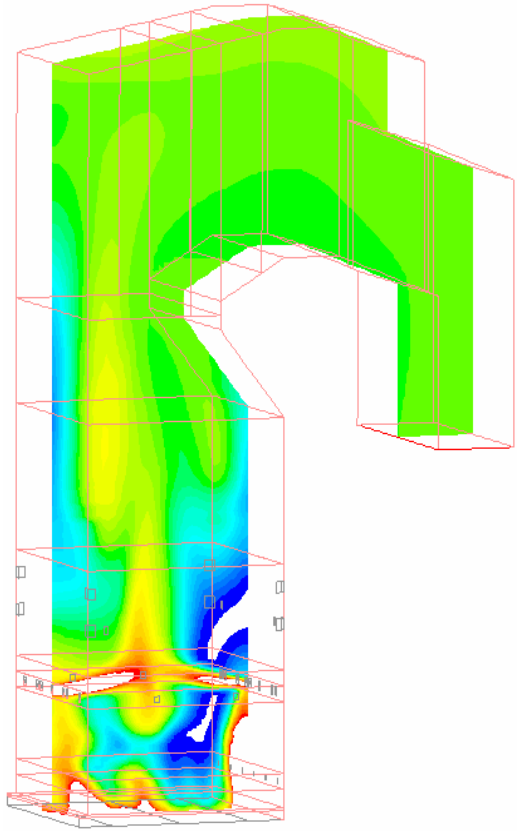
PPL CFD Examples - Boilers



PC Boiler

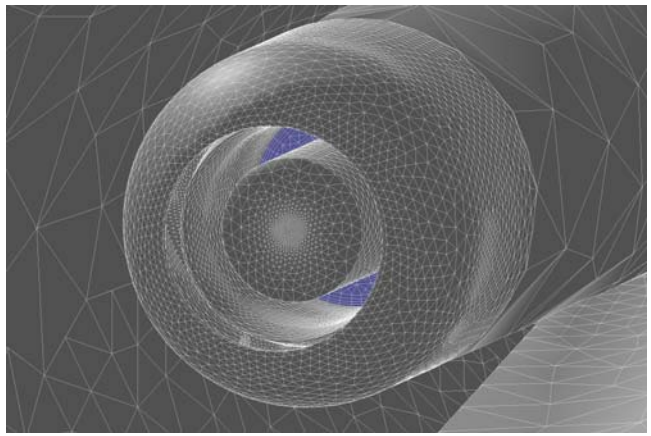


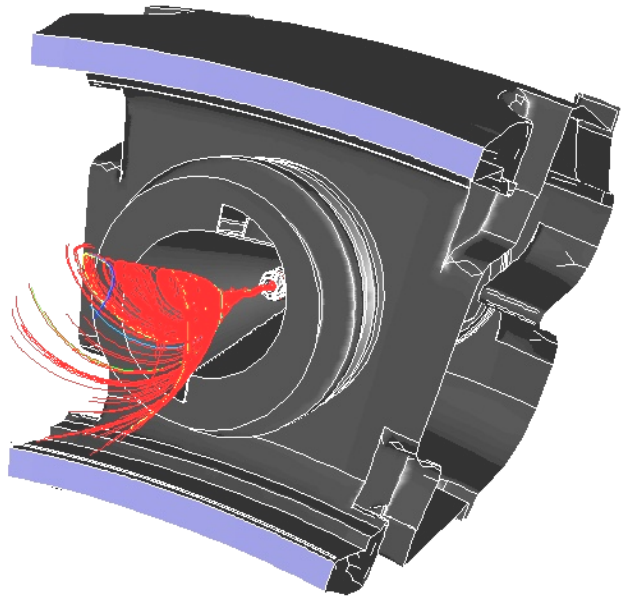
HRSG

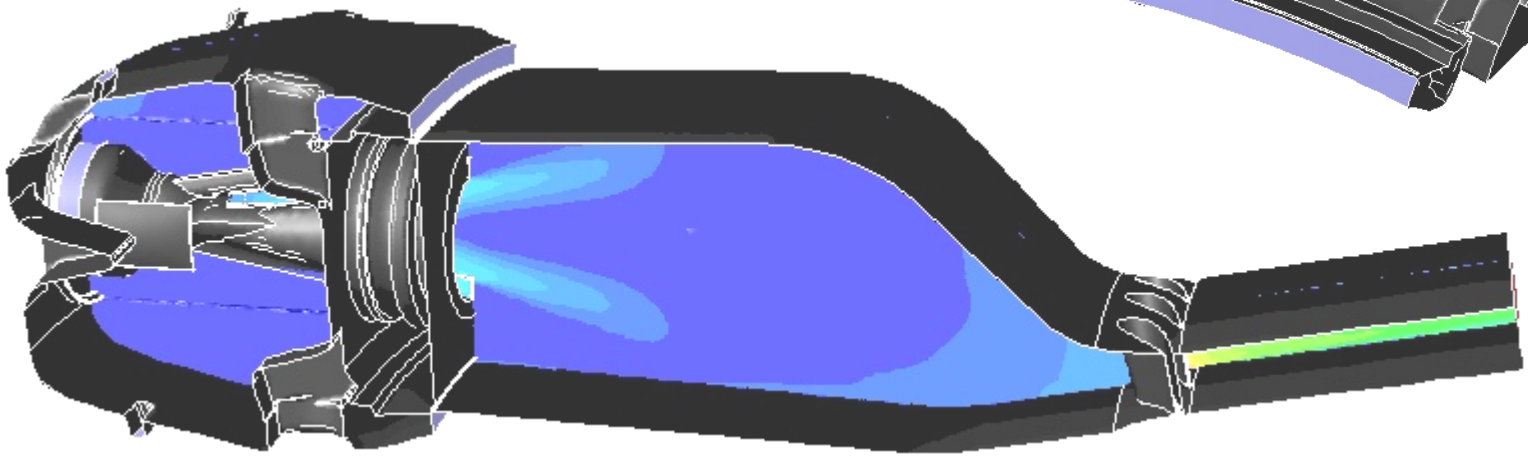


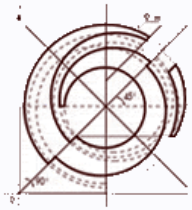
Stoker

PPL CFD Examples - Gas Turbine Combustors



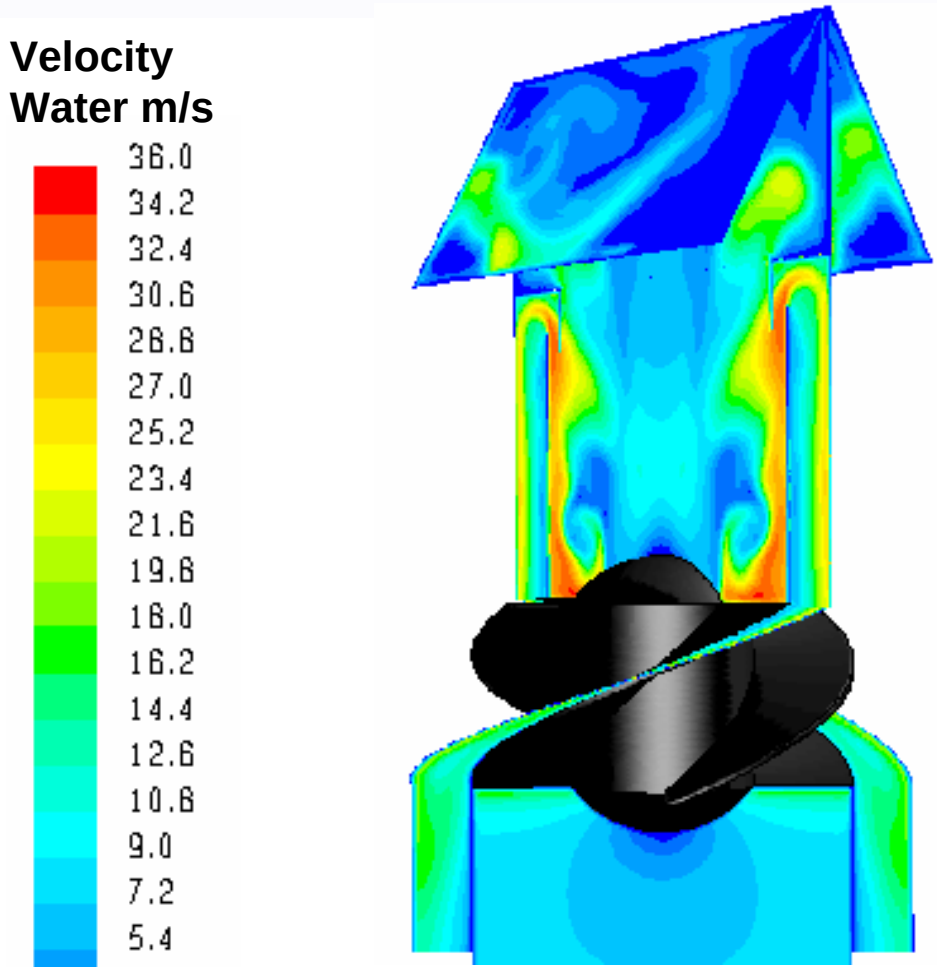




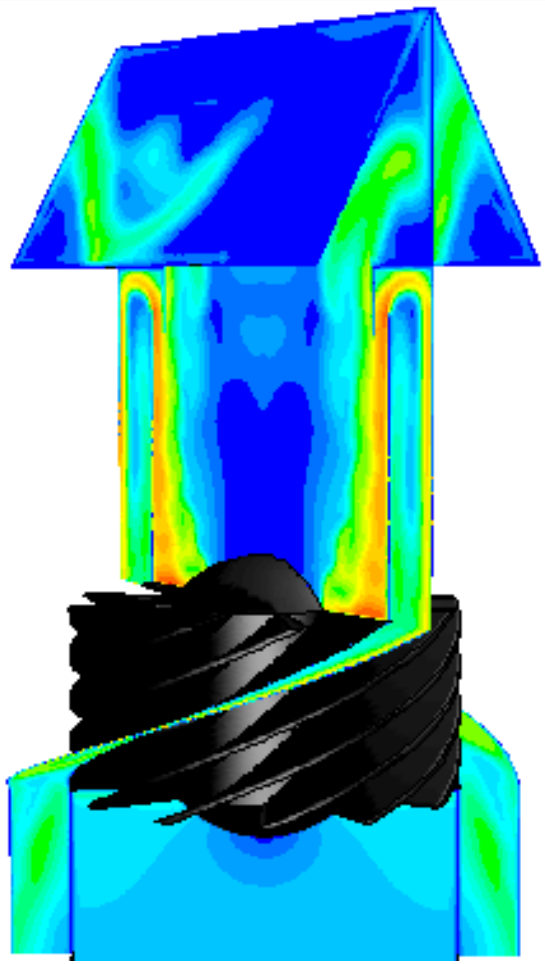


Steam Drum Internals

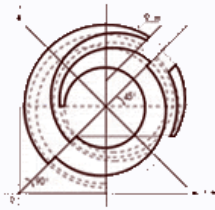
PPL CFD Examples - Steam Drum Internals



4 Vanes

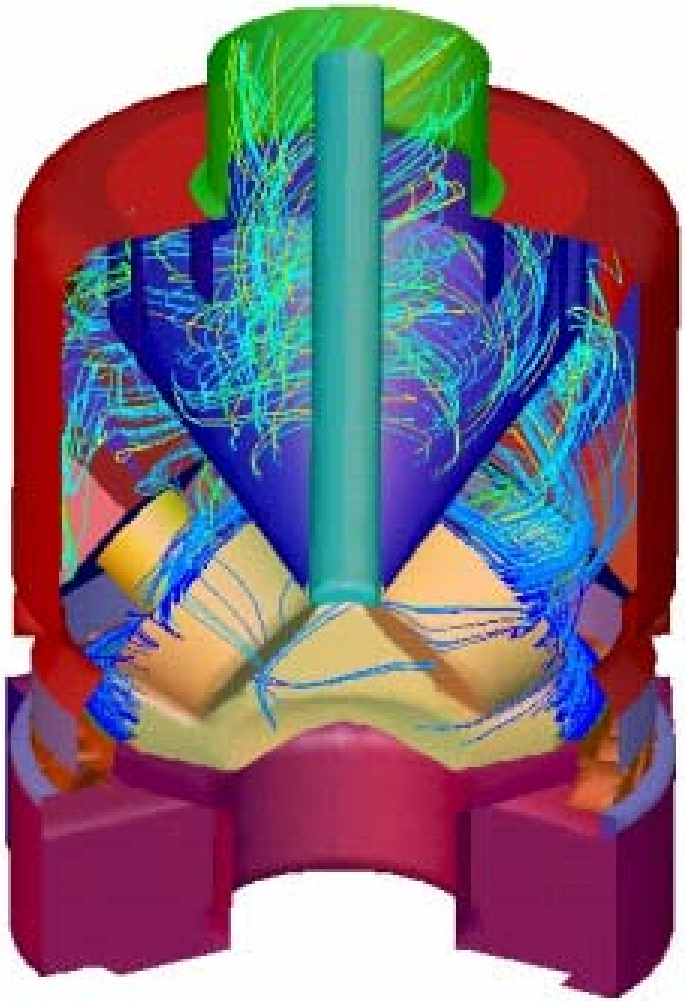


12 Vanes

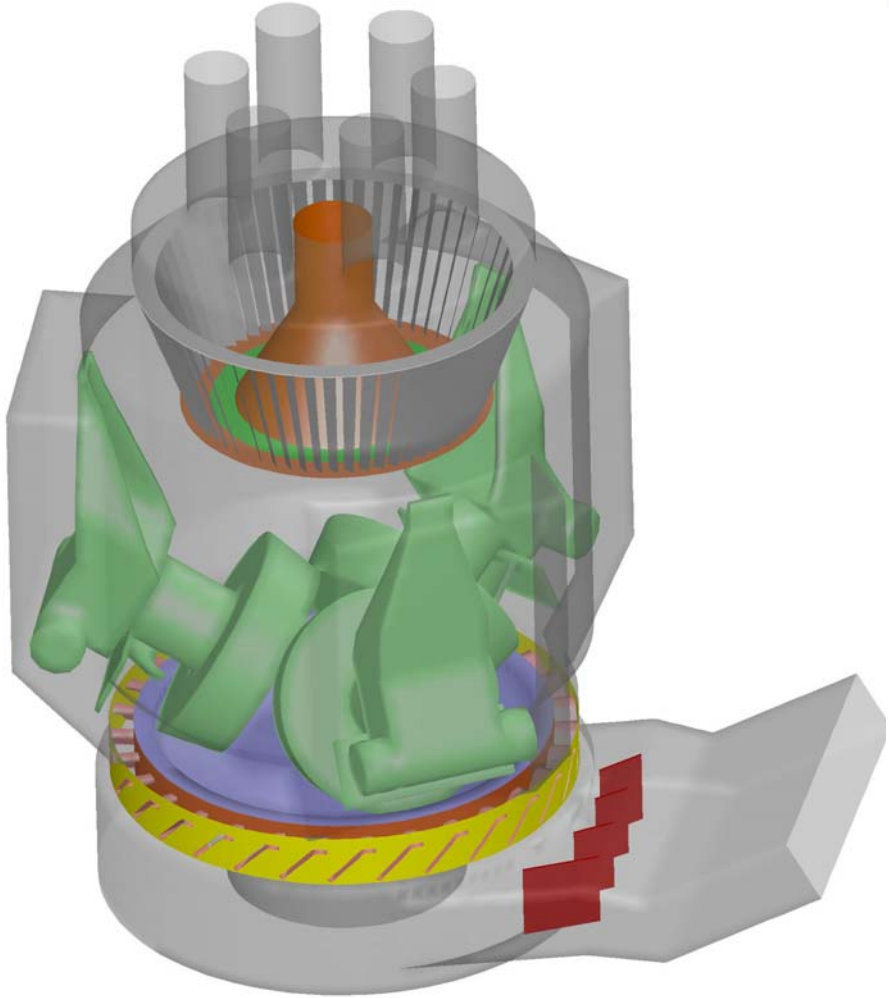


Pulverizers

Pulverizer - Classifier Design

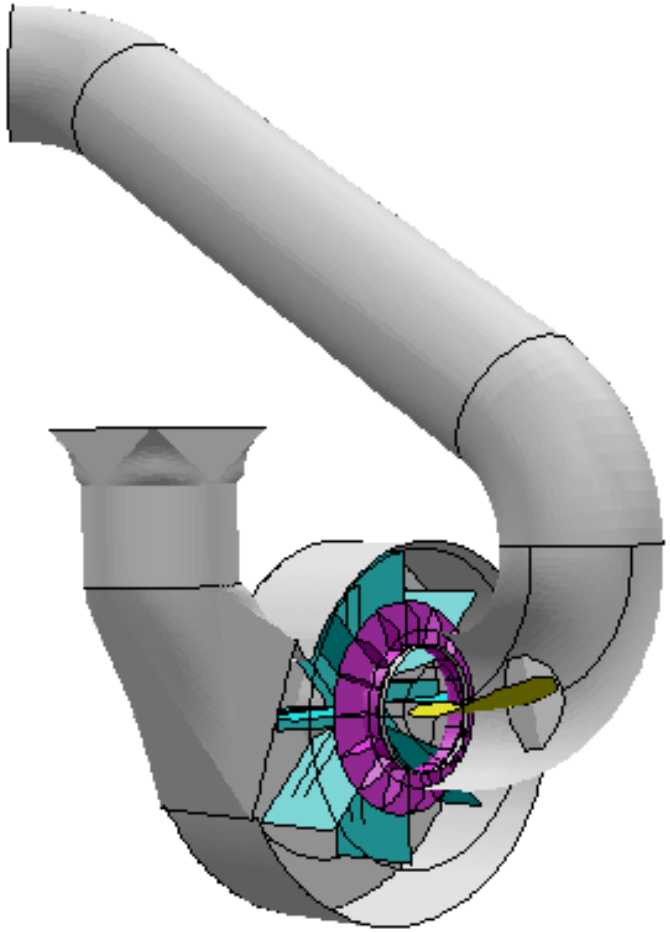


Static Classifiers

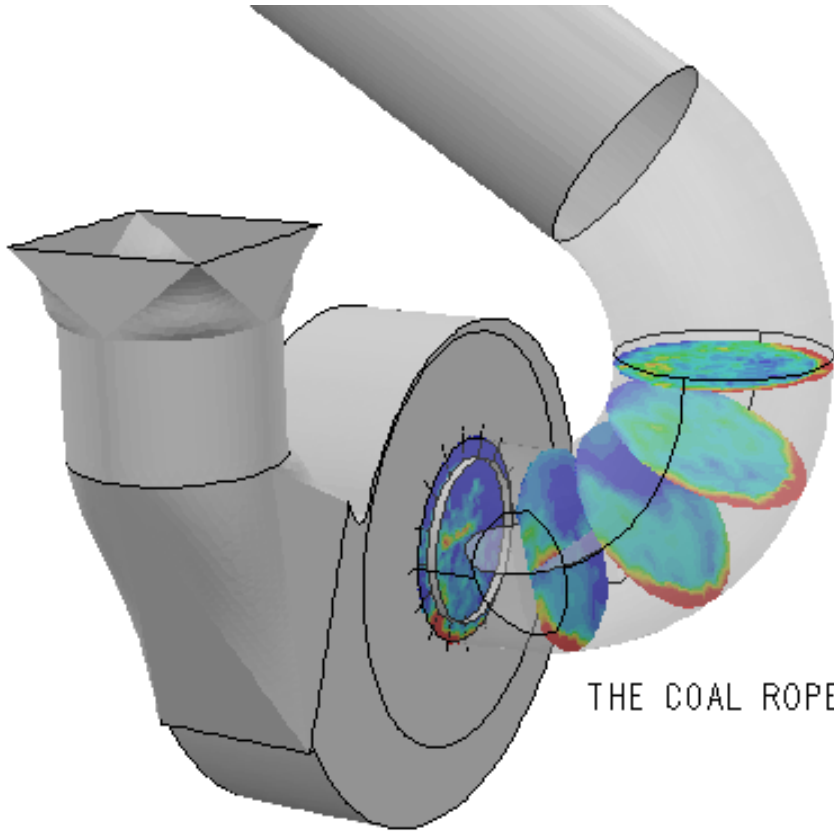


Dynamic Classifiers

Pulverizer - Exhauster Design

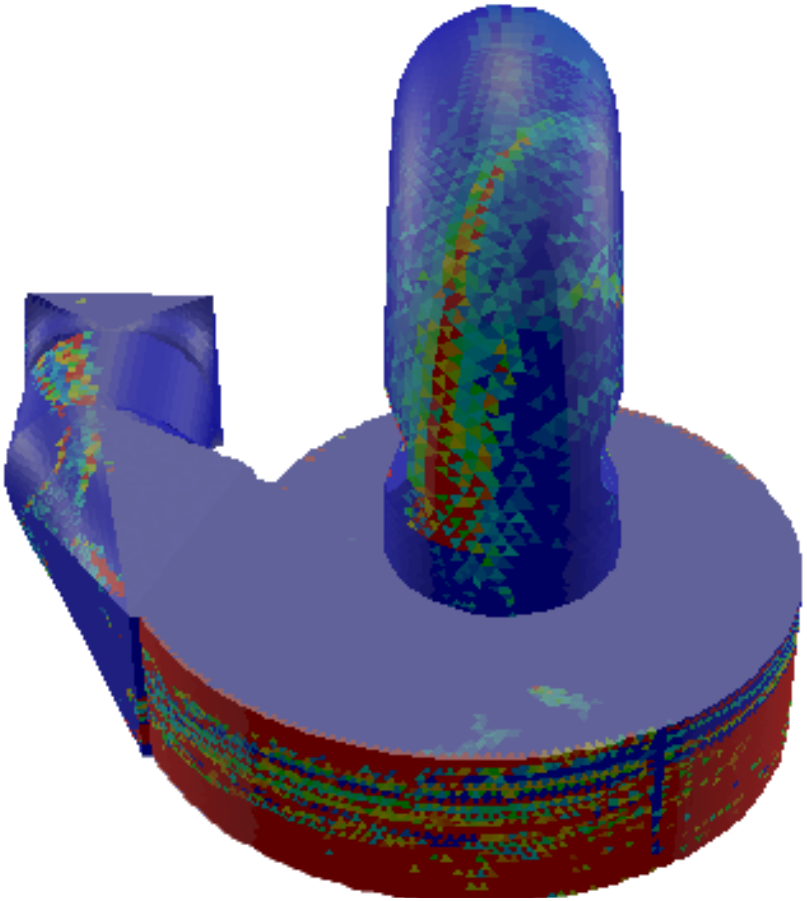


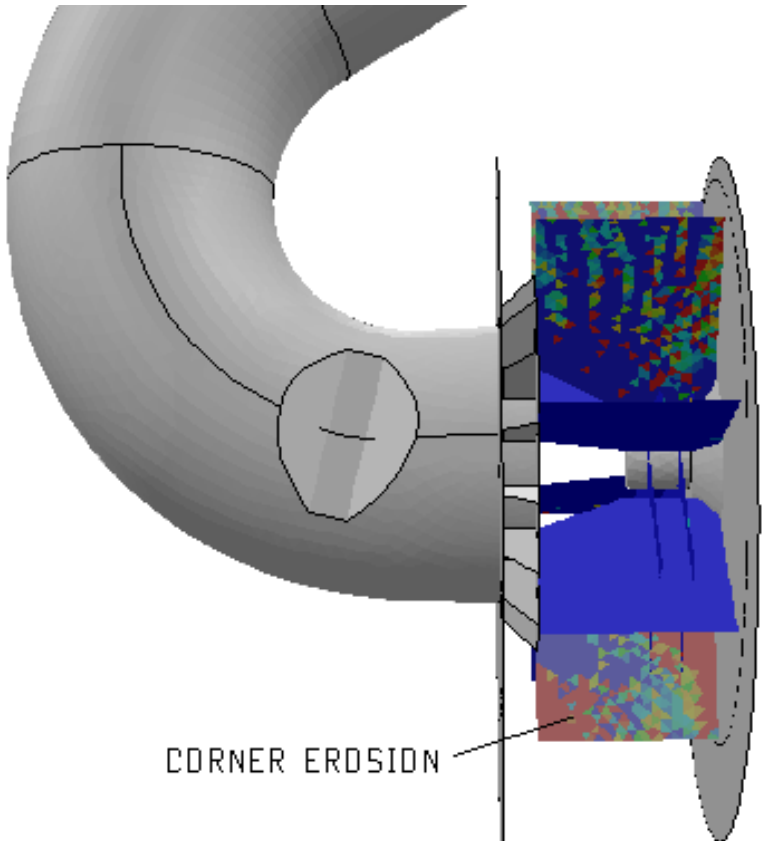
Geometry



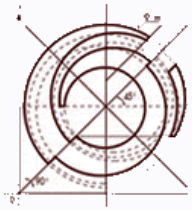
Particle Concentration

Pulverizer - Exhauster Design



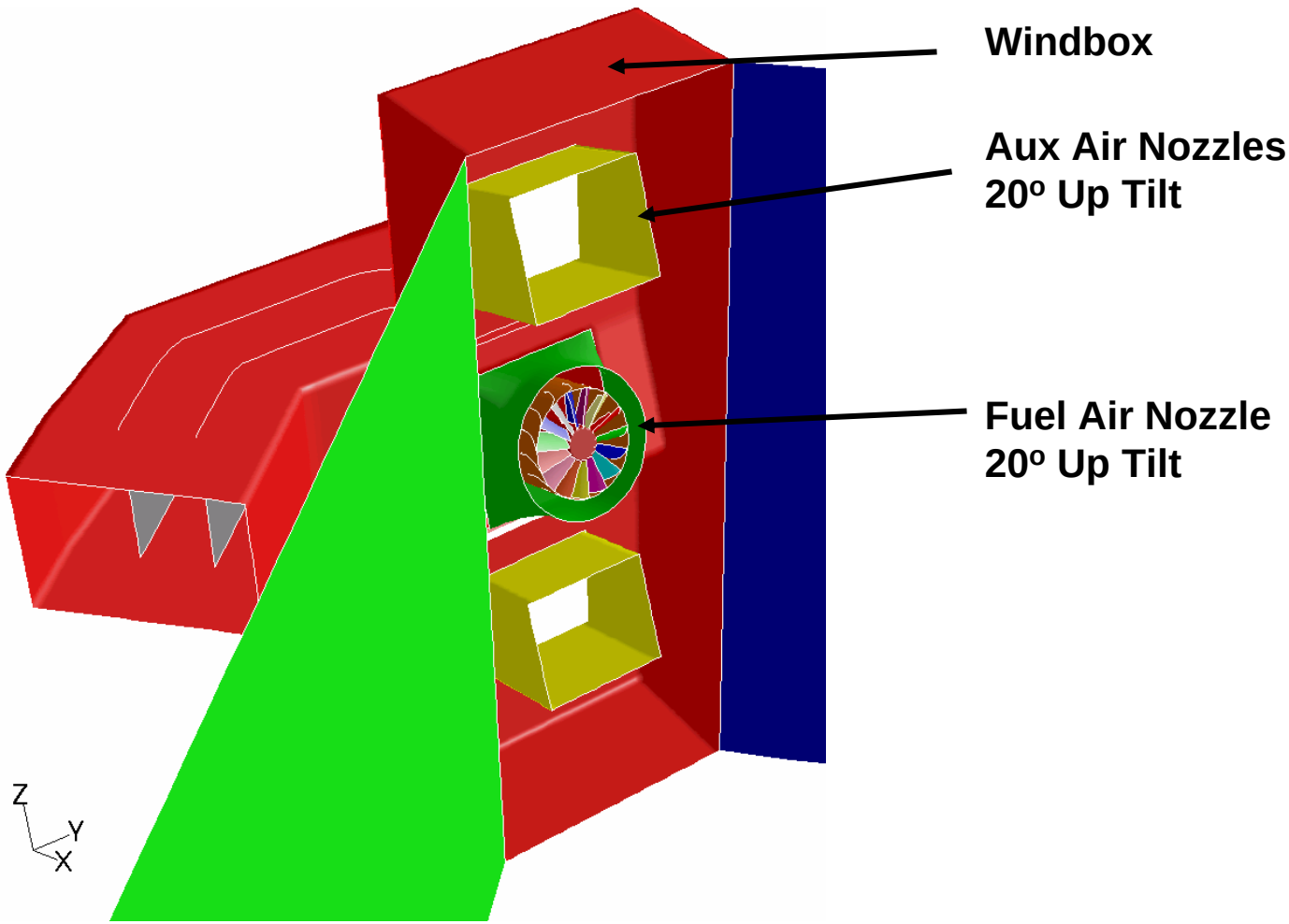


Predicted Errosion Patterns

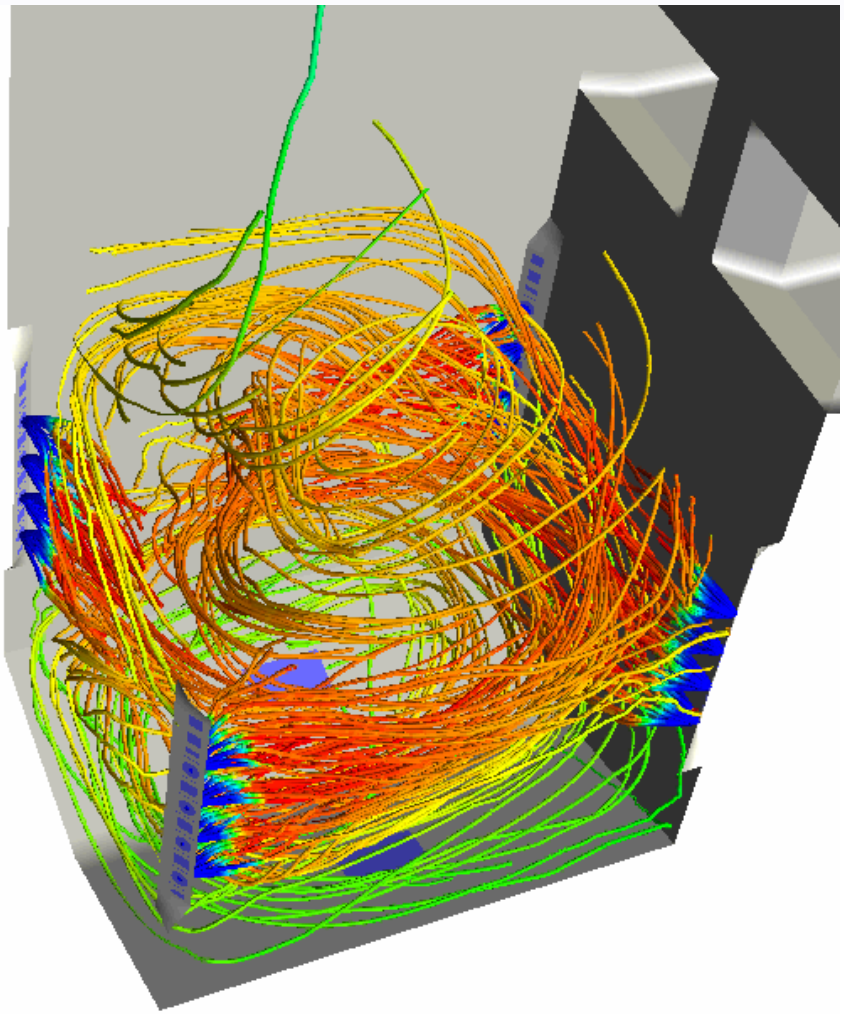


Oil-Fired Utility Boiler

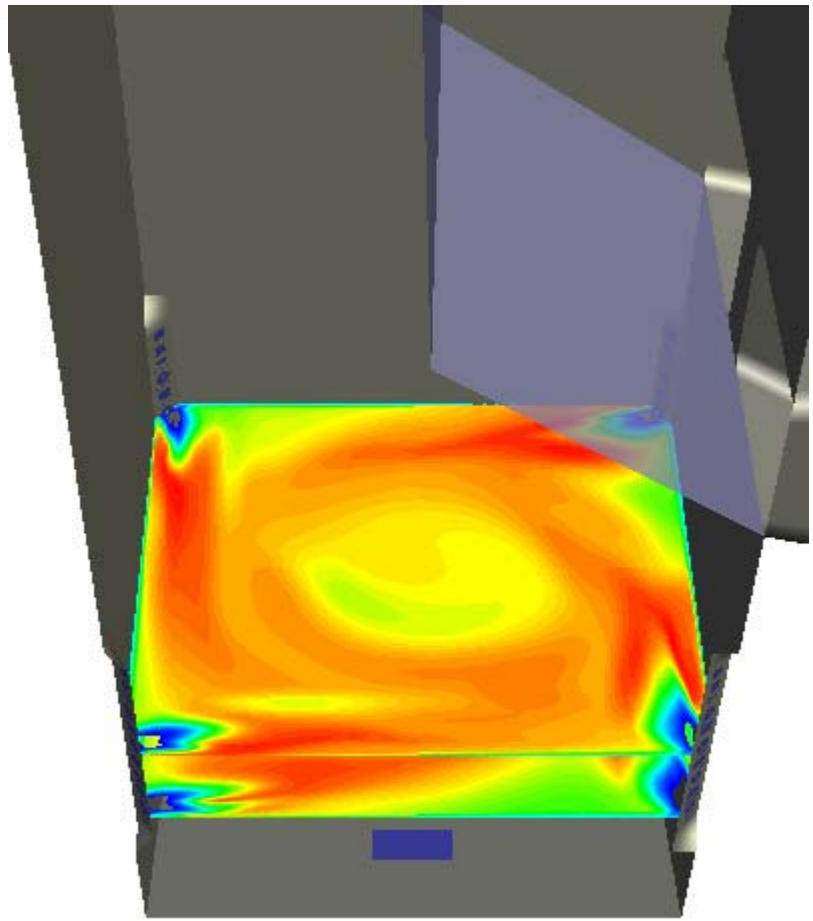
Oil Burner - Impact of Tilt



Oil-Fired Boiler



Particle Trajectories

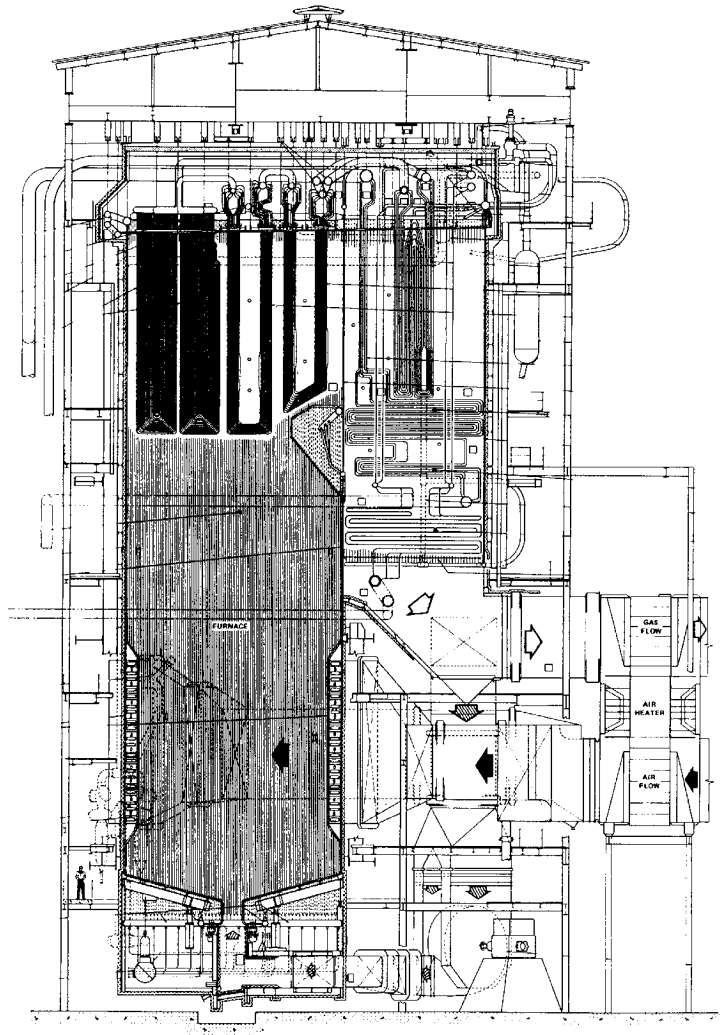


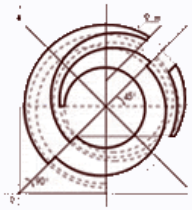
Gas Temperature

Natural Gas-Fired Utility Boiler

Gas-Fired Boiler: Description

- MCR 700 MW
- Natural gas fuel
- Tangential firing system
- 5 burner elevations
- 30% flue gas recirculation (FGR)
- FGR with combustion air
- 12% separated overfire air (SOFA)
- 50 ppm NOx





Gas Fired Boiler

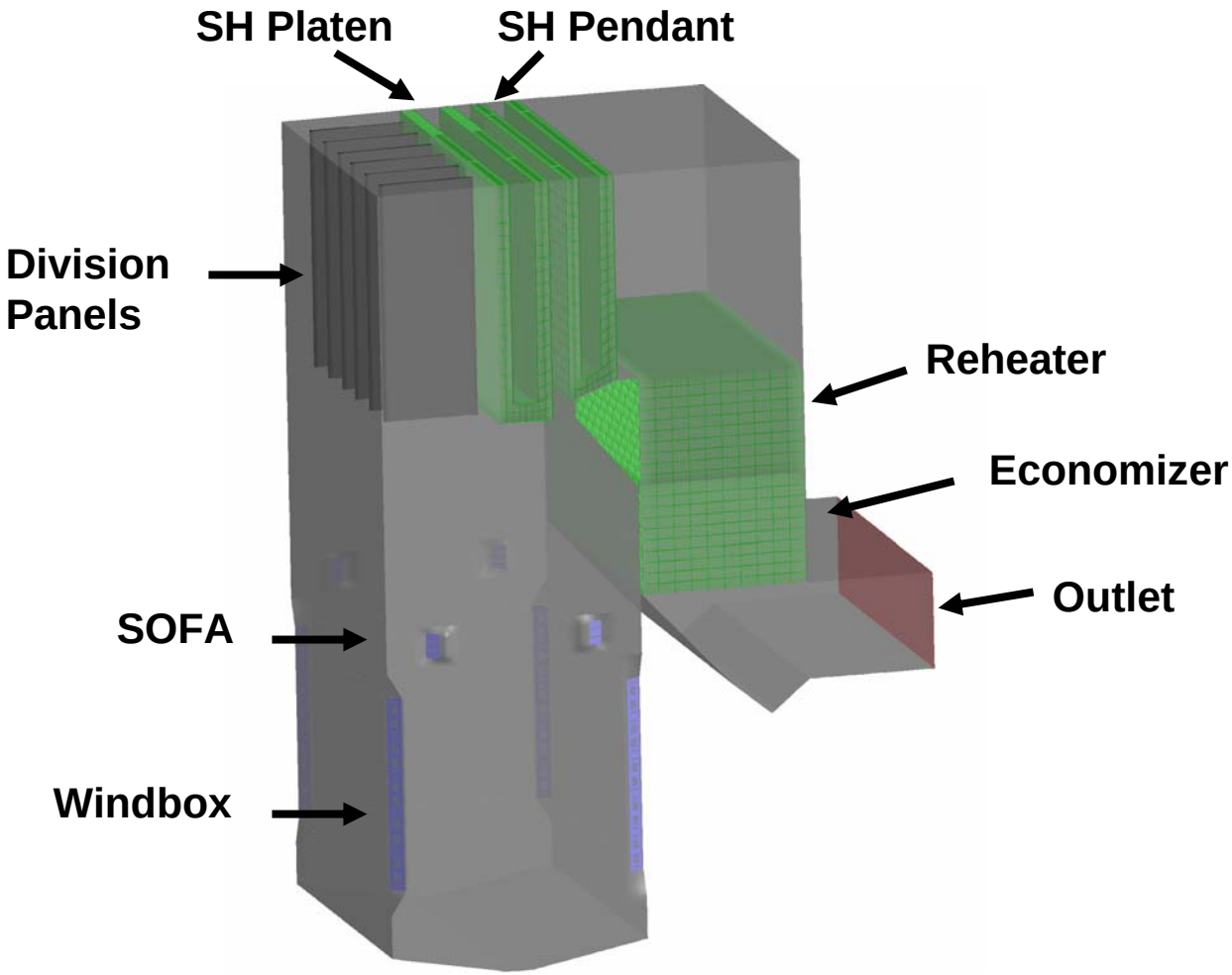
ALSTOM

Objective: Low cost solution for NOx of 15 ppm

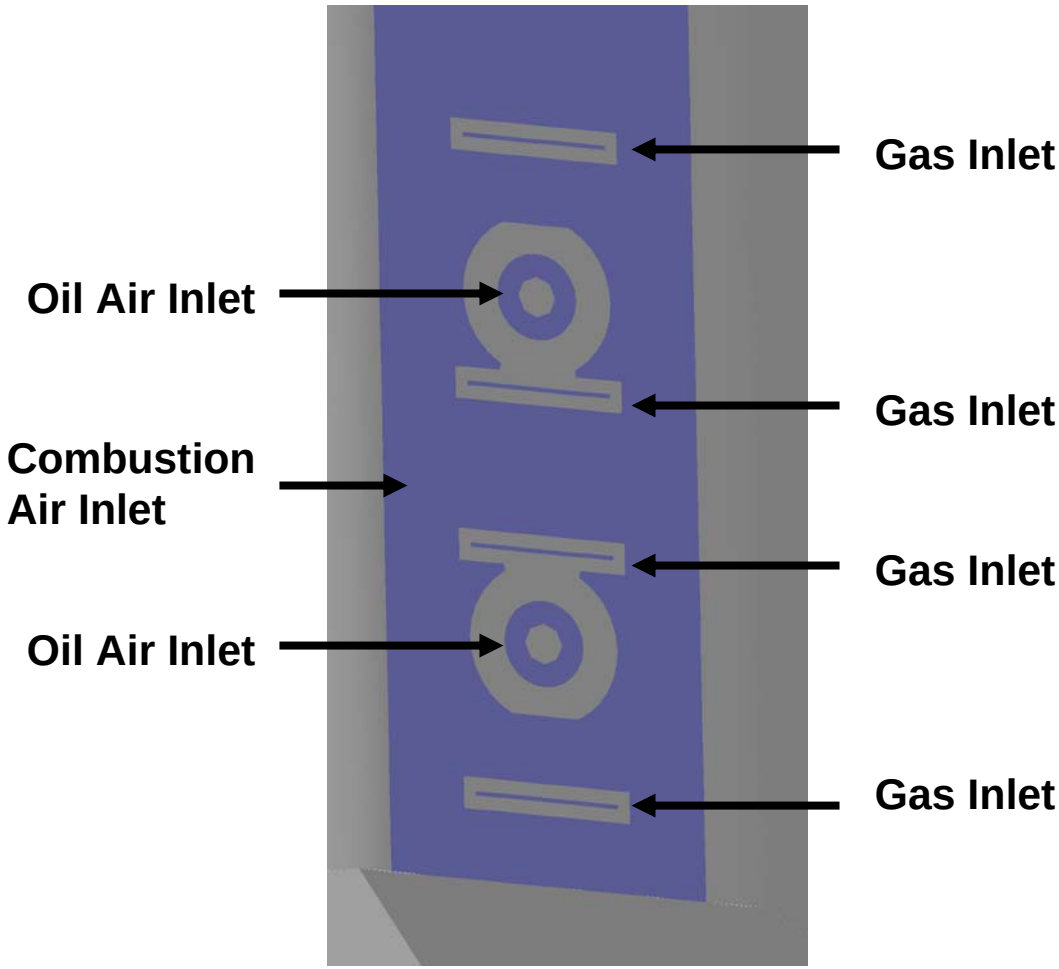
NOx reduction strategies

- Increased FGR
- Steam or water injection
- SOFA quantity and location
- Burners out of service
- Decreased load

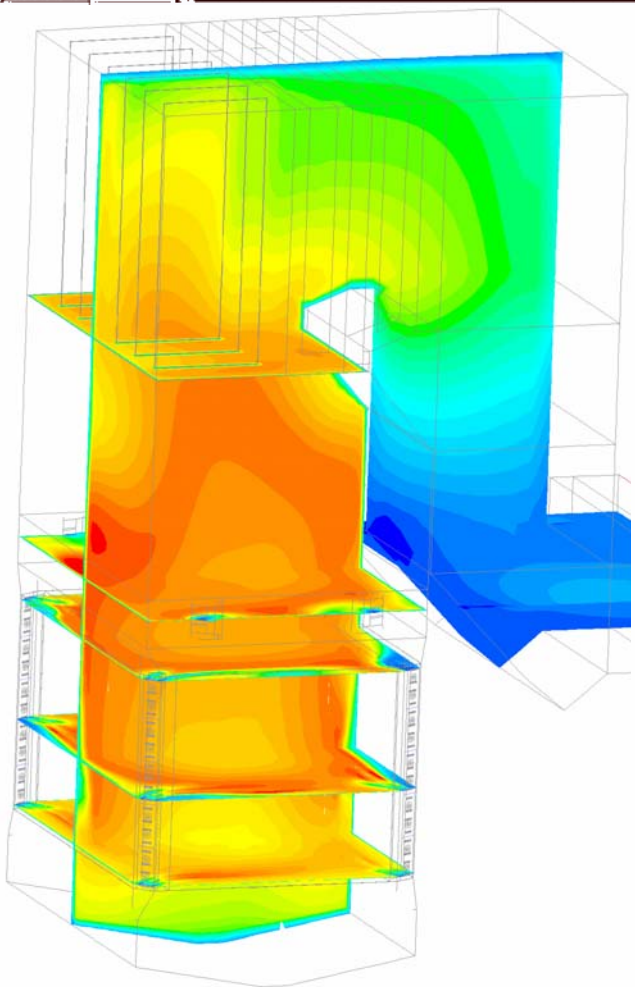
Gas-Fired Boiler: Geometry



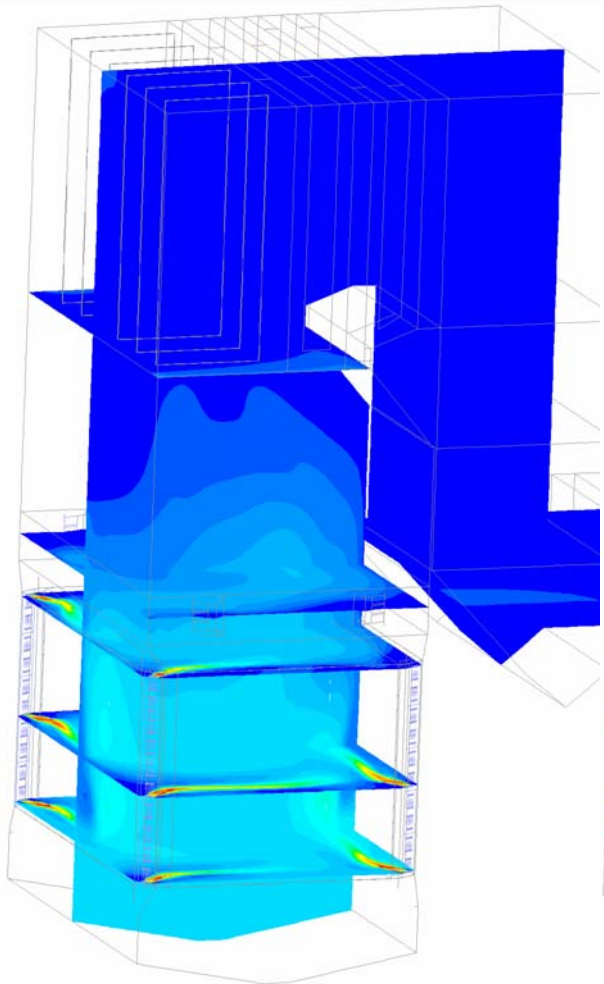
Gas-Fired Boiler: Geometry



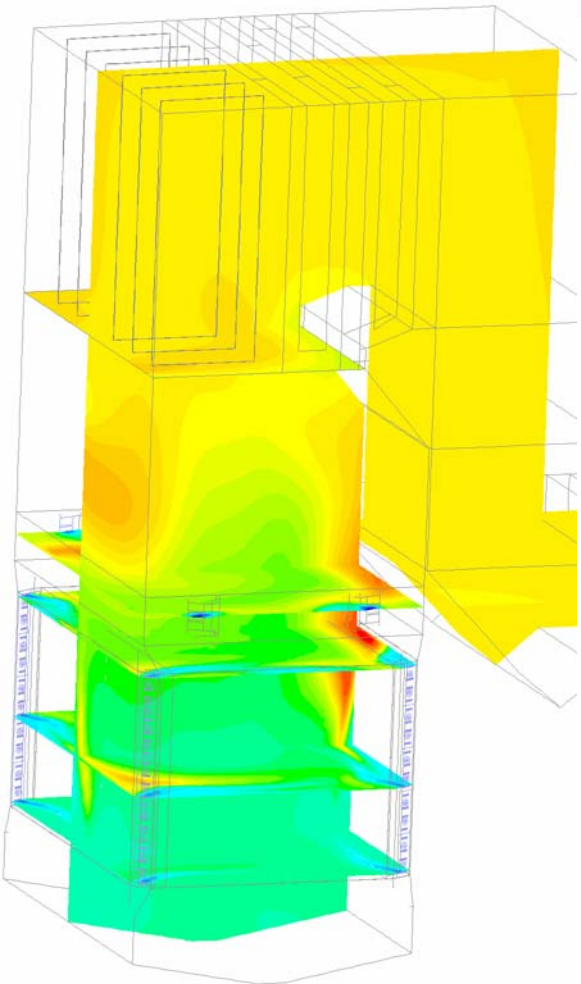
Gas-Fired Boiler: Baseline



Temperature

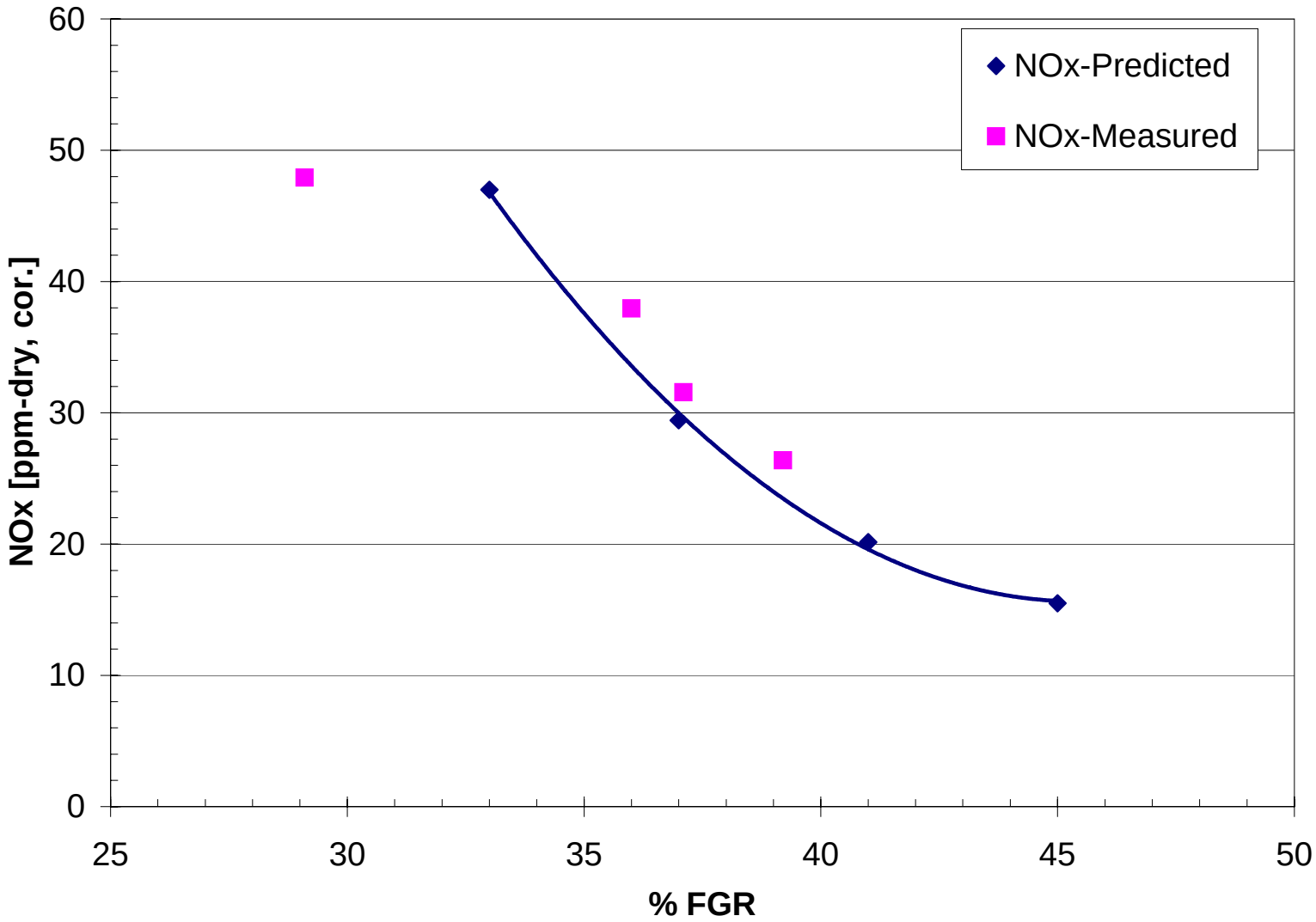


Oxygen



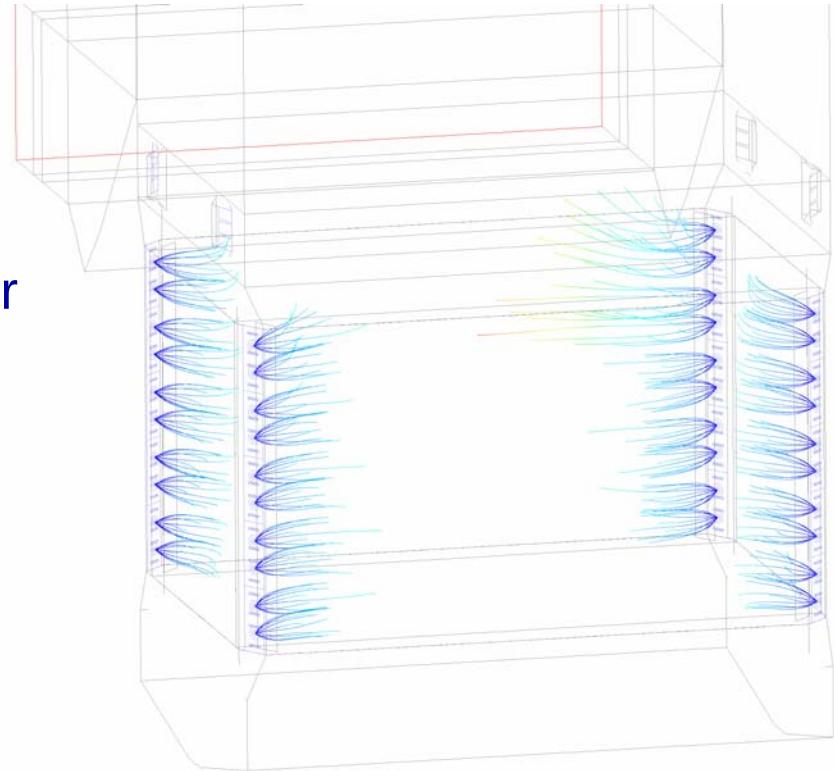
NOx

Gas-Fired Boiler: NOx vs FGR

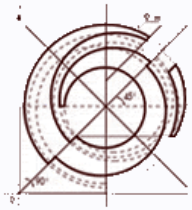


Gas-Fired Boiler: Conclusions

- NOx emissions of 15 ppm achievable
  - Increase FGR to 45%
  - Inject 60,000 lb/hr of steam or water through oil guns
  - or reduction to 950 ºF SH
  - Add independent yaw control on SOFA tips to tune for CO



100 micron water droplets



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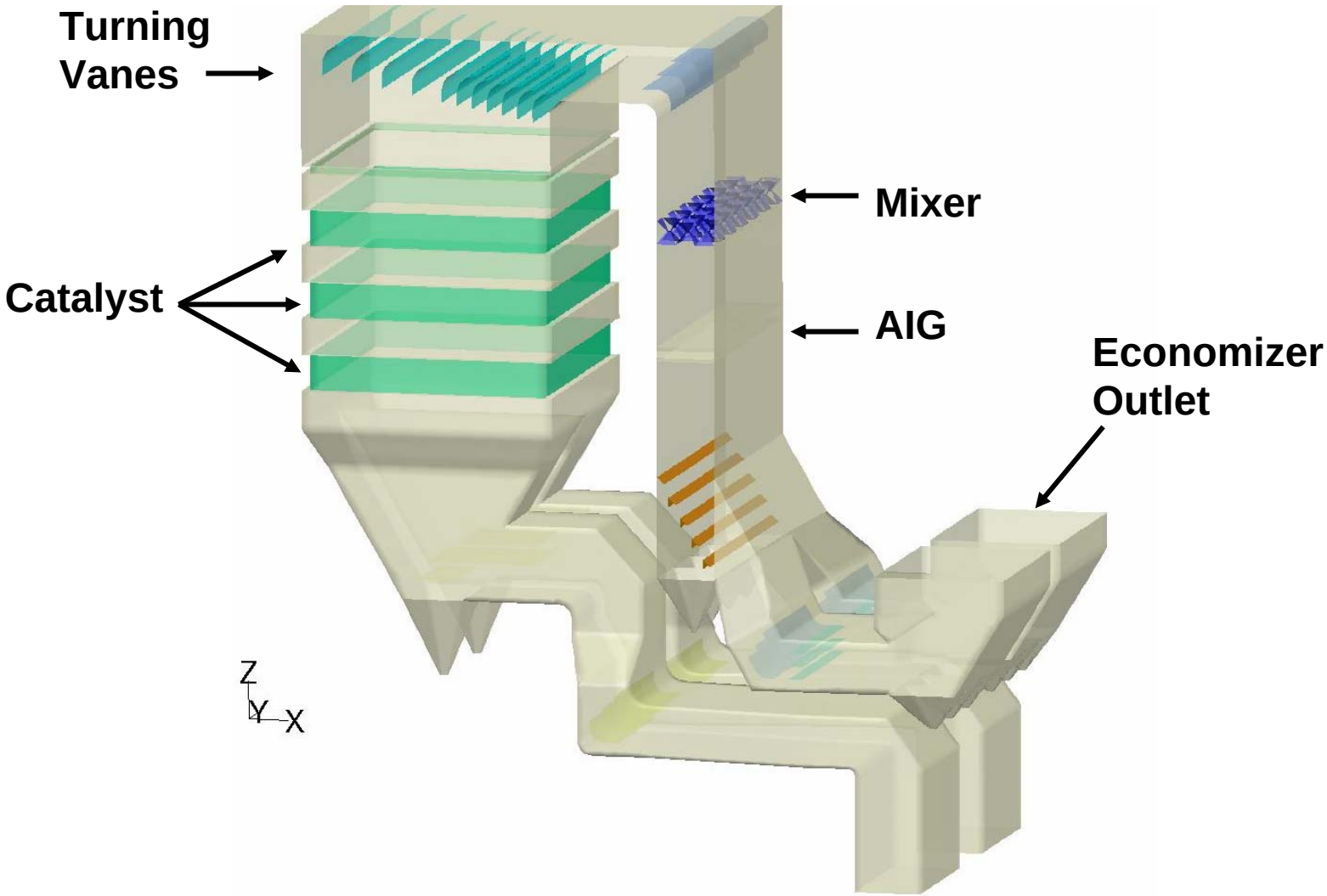
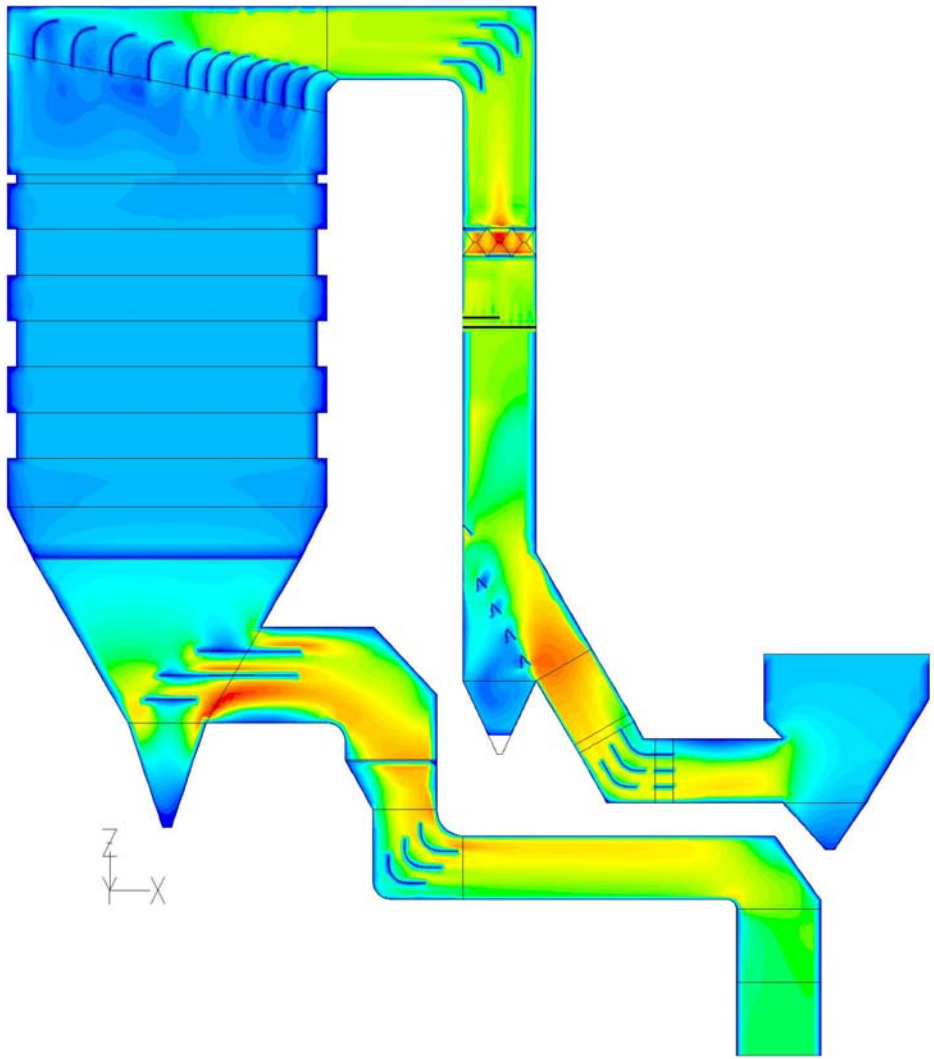
SCR Design Issues

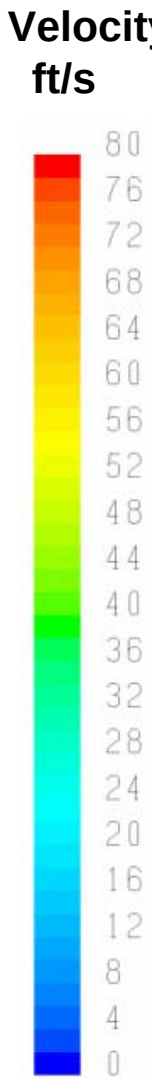
- Flow Distribution
- Temperature Distribution
- System Pressure Drop
- Particle Collection

SCR Design

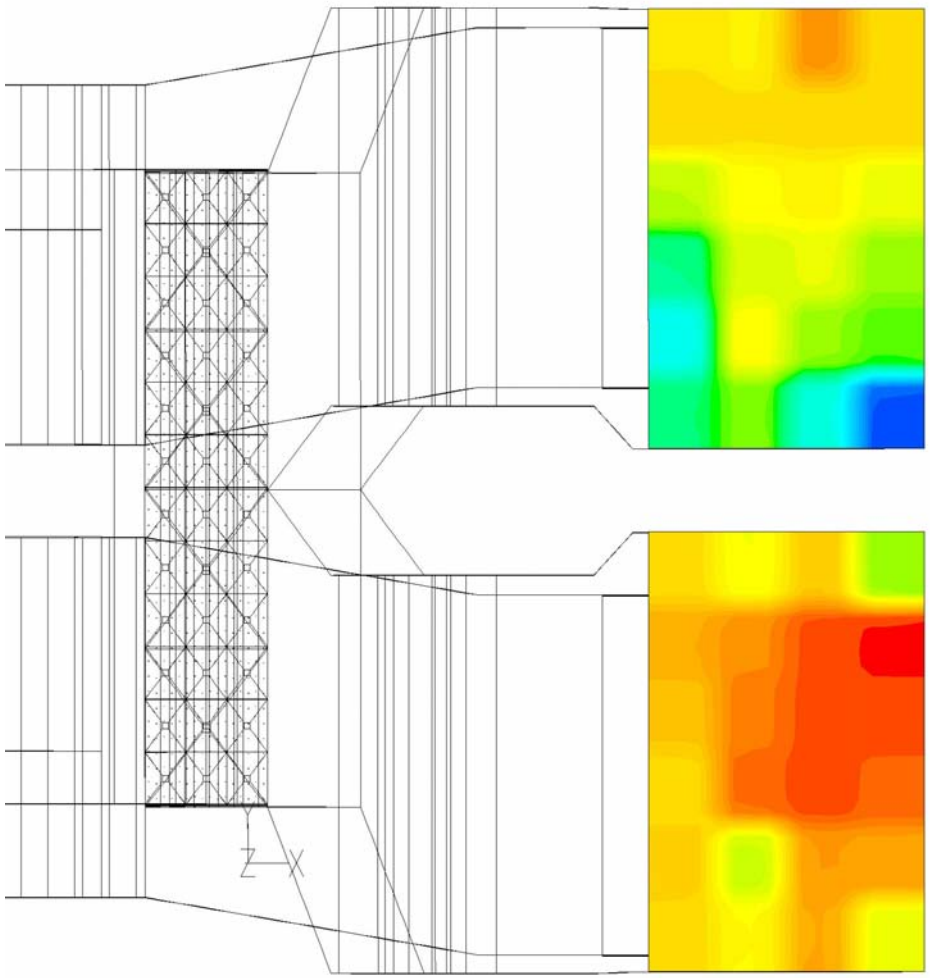


SCR - Velocity Distribution





SCR - Measured NOx Profile



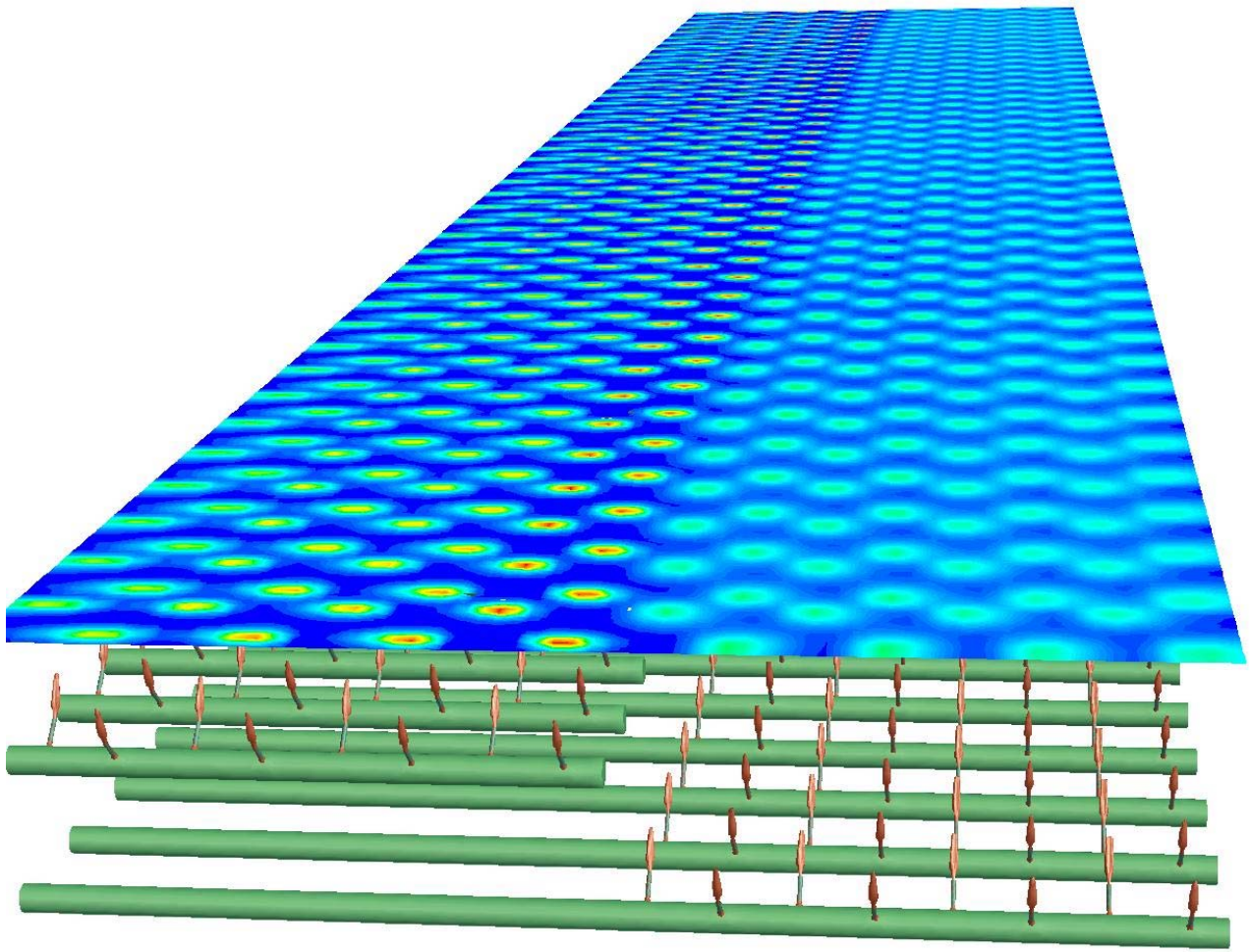
A - Side

B - Side

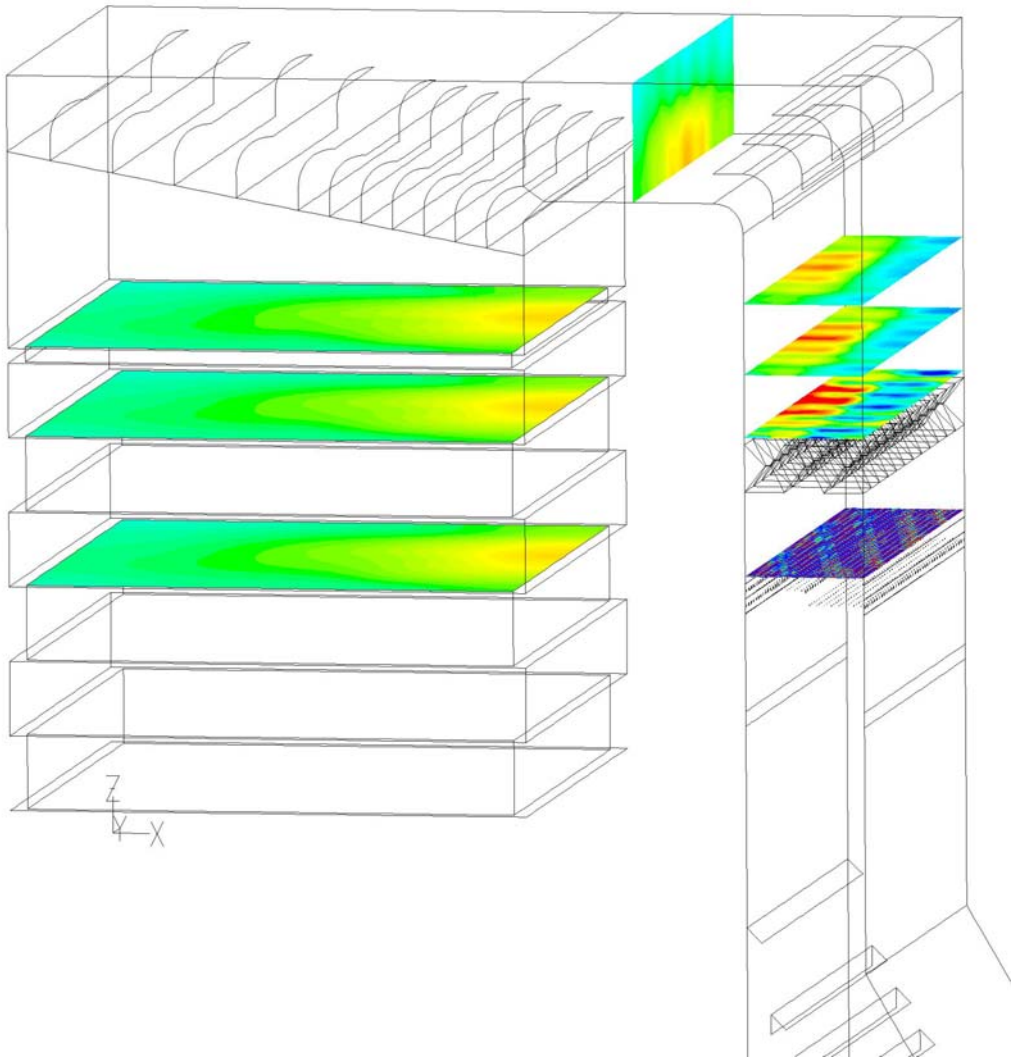
NOx, ppm

265
261
257
252
248
244
240
235
231
227
222
218
214
210
206
201
197
193
189
184
180

SCR - Ammonia Injection Grid

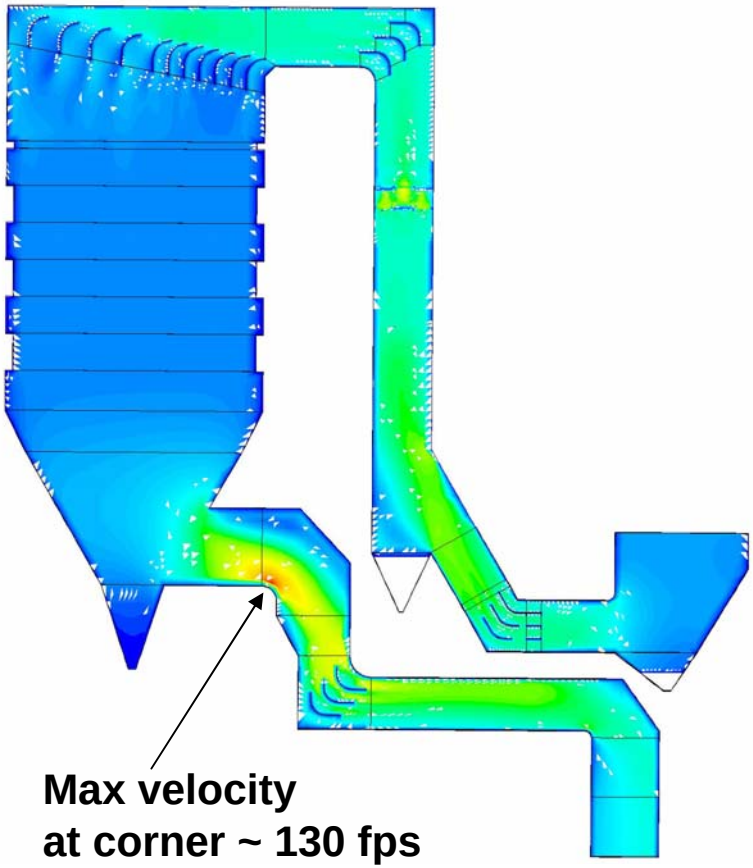


SCR - Ammonia Injection Grid

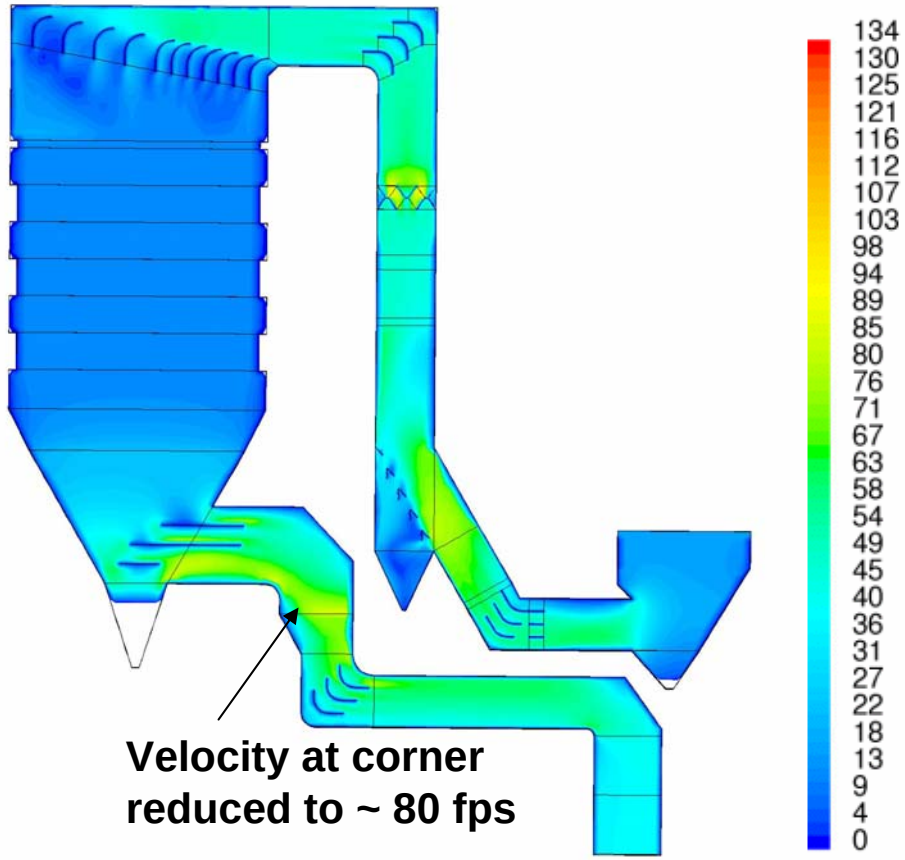


Normalized mole fraction ratio: NH_3/NO

SCR - Vane Design

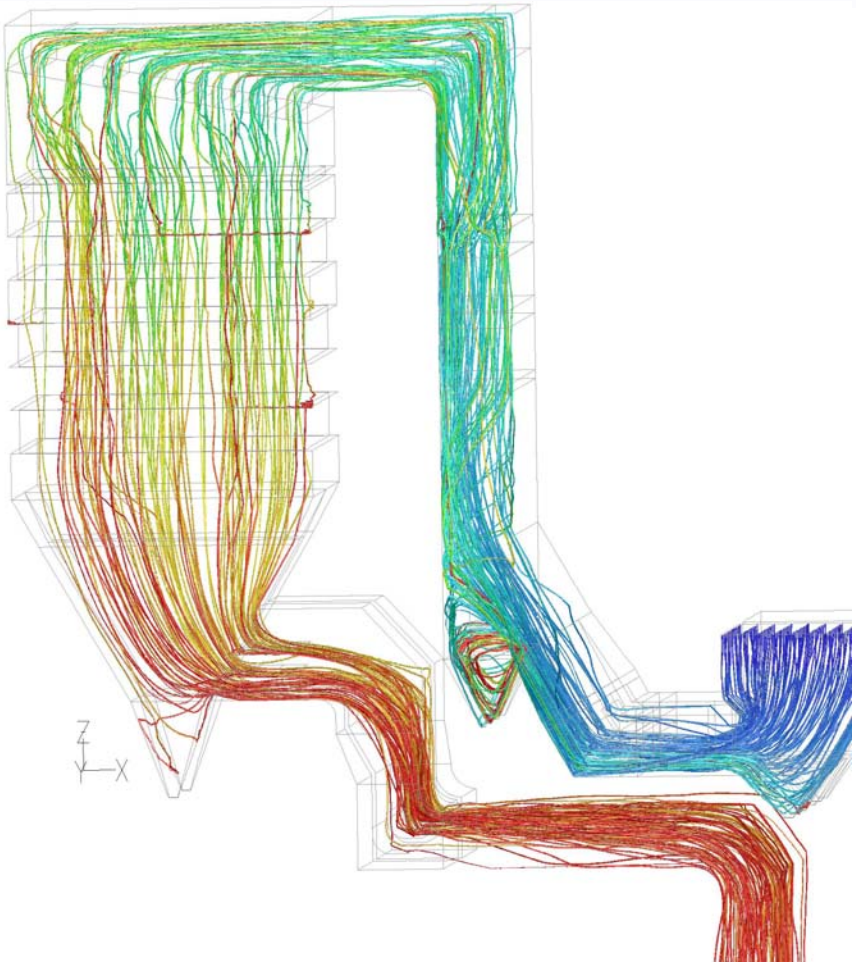


No Vanes in SCR Outlet

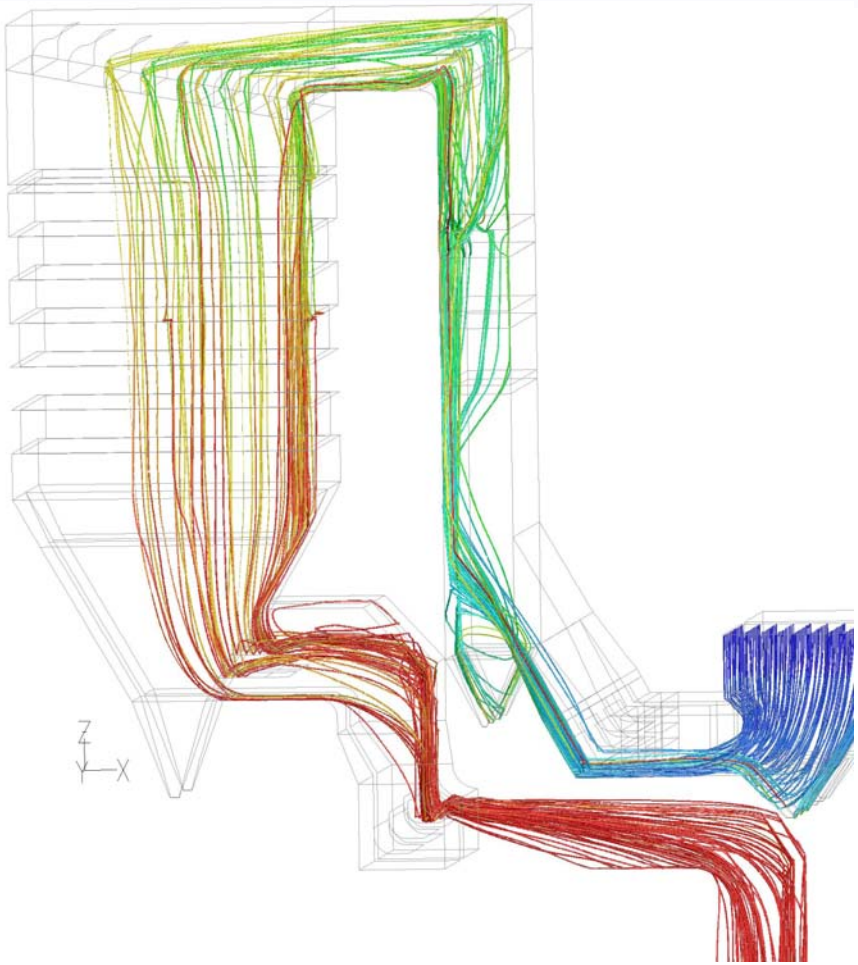


Suggested Vane Installation

SCR - Particle Collection

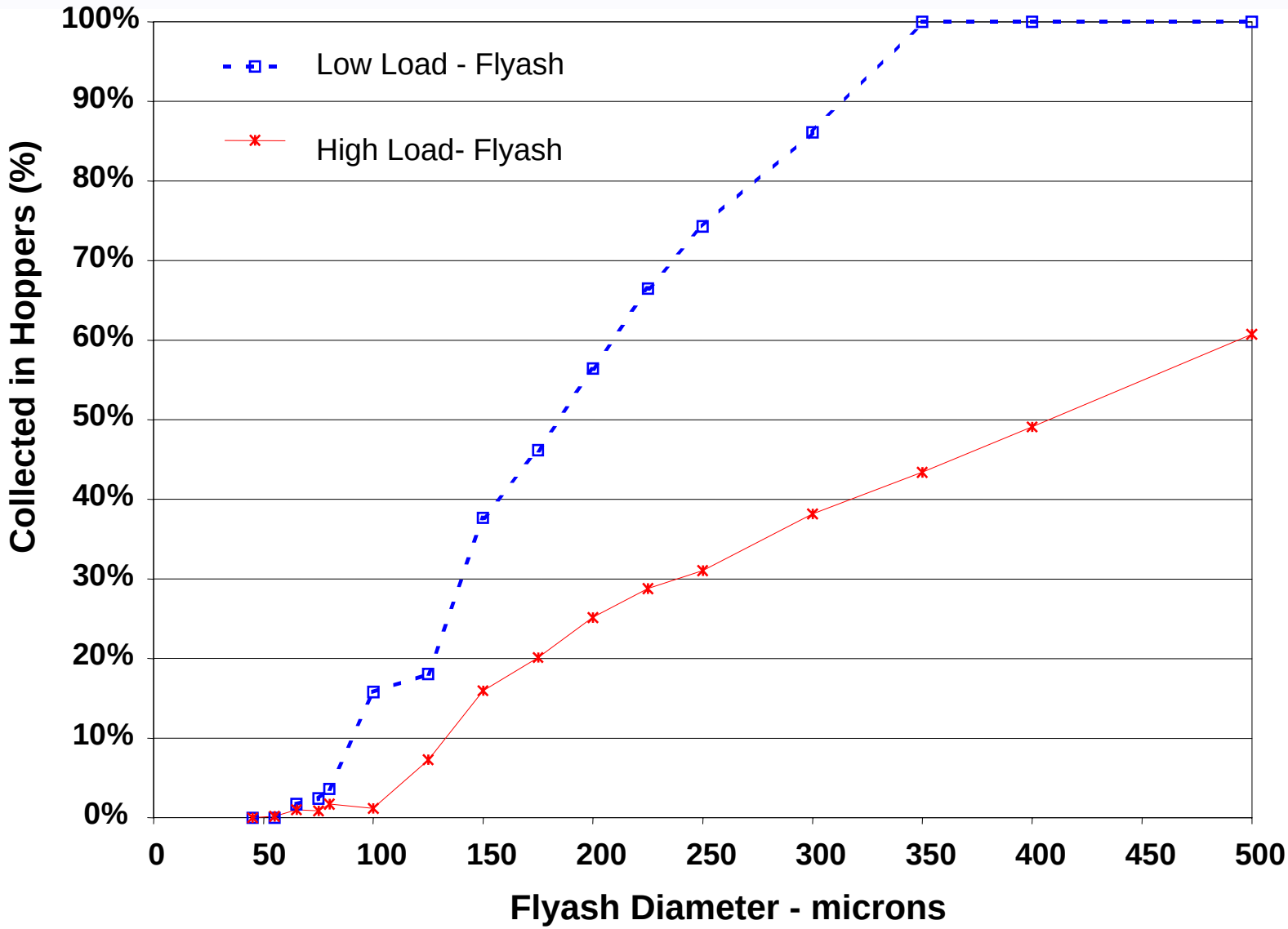


50 microns

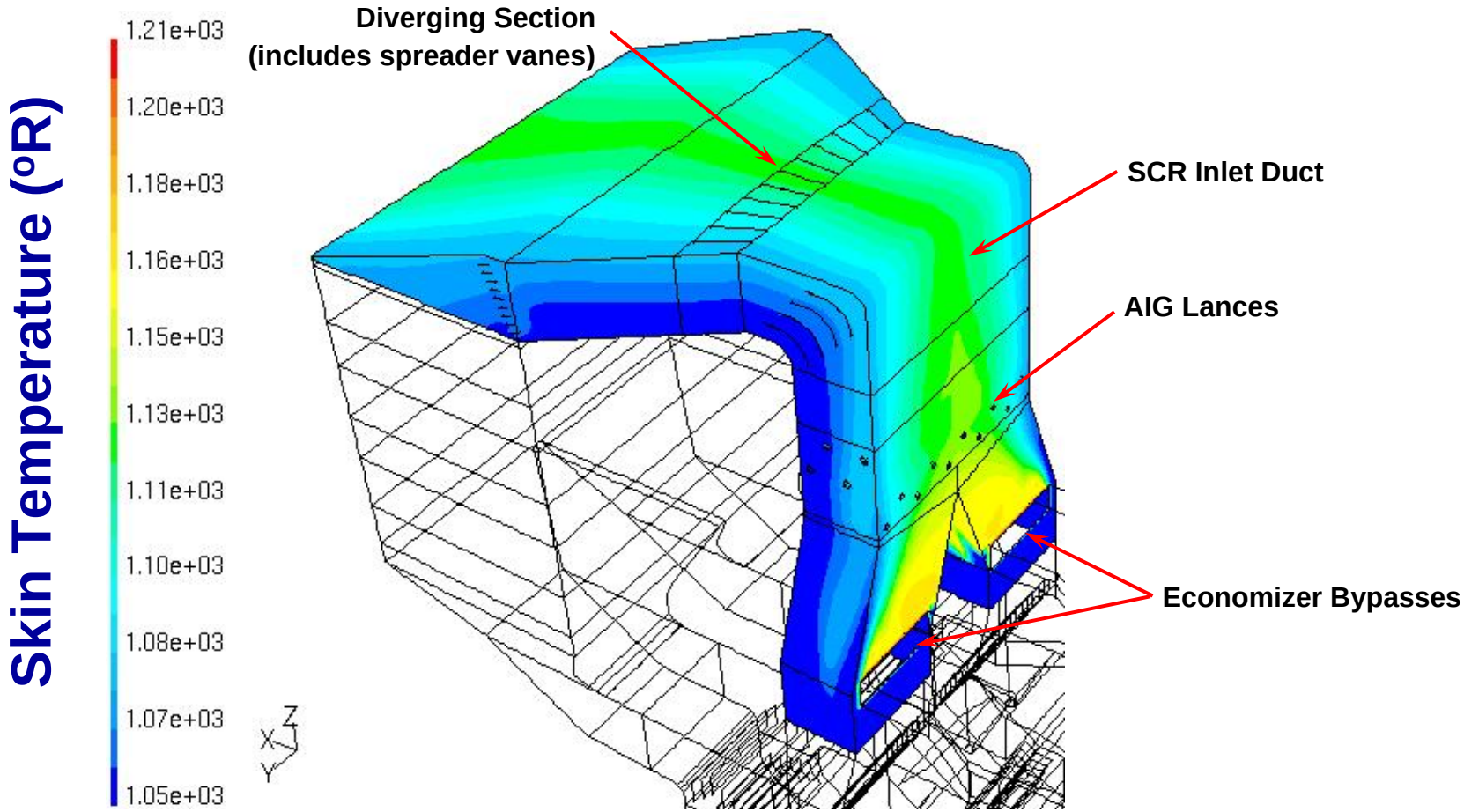


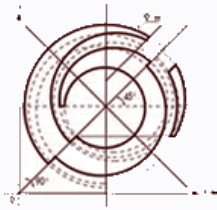
250 microns

SCR - Particle Collection



SCR - Duct Metal Temperature





Conclusions

- CFD is a valuable design tool for a wide range of power generation applications

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