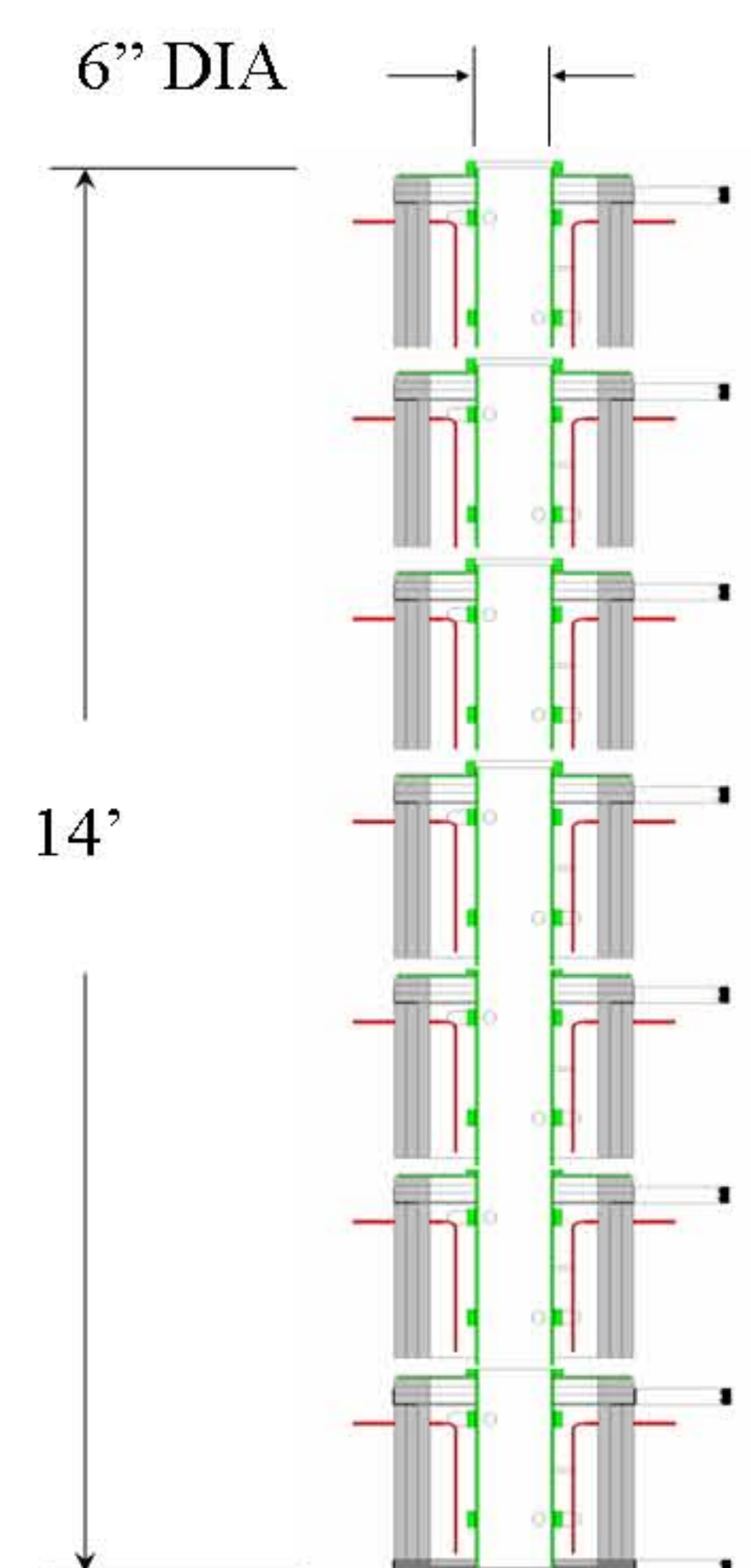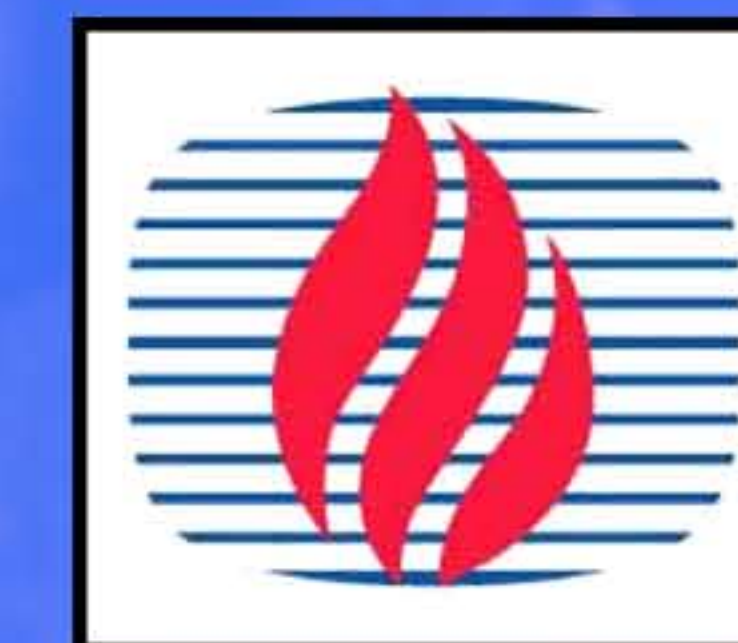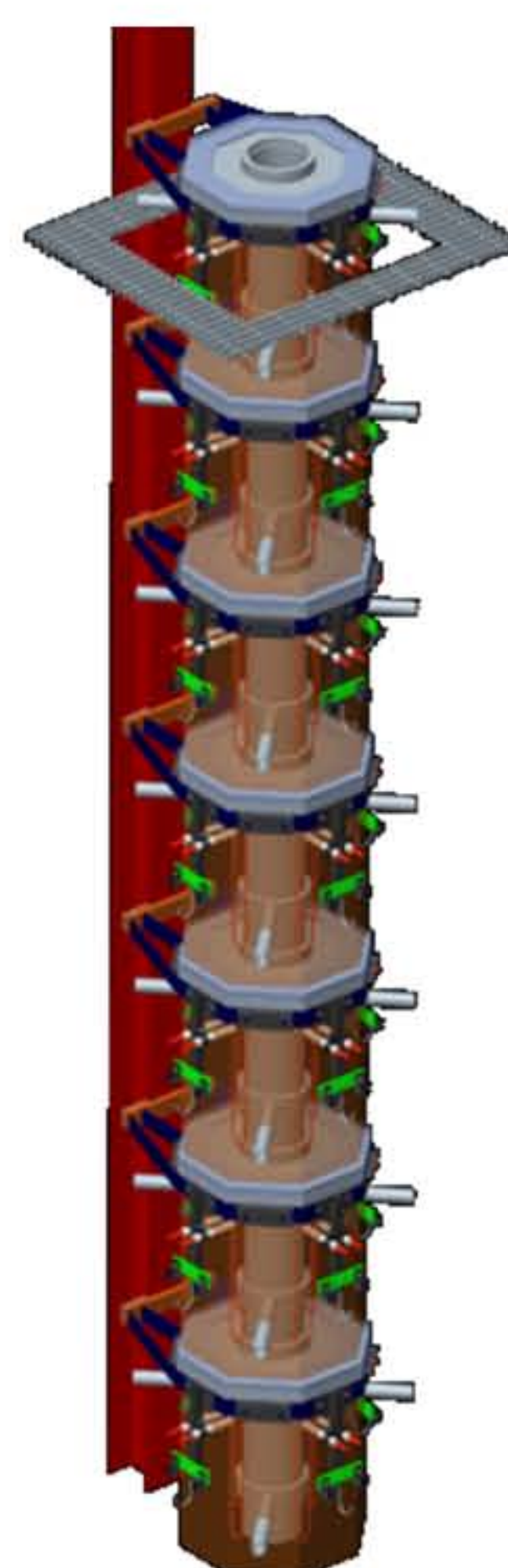# A Comprehensive Combustion Model with Deposition

Ryan Blanchard, Darron Cundick, Dan Maynes, Larry Baxter, Dale Tree

ACERC, Chemical and Mechanical Engineering Departments, Brigham Young University, Provo, Utah

BYU
Mechanical
Engineering

6" DIA

14'

Reactor Cross Section
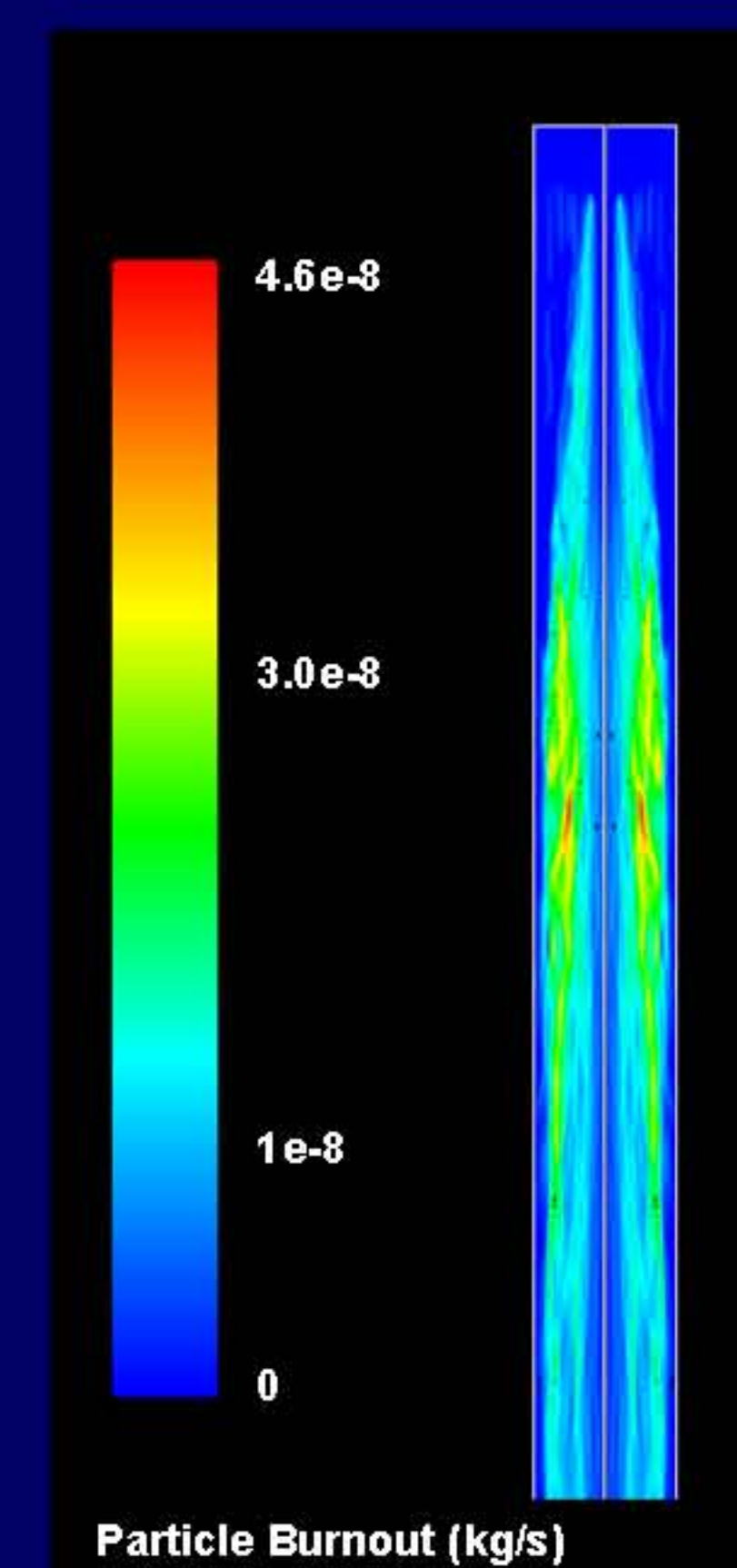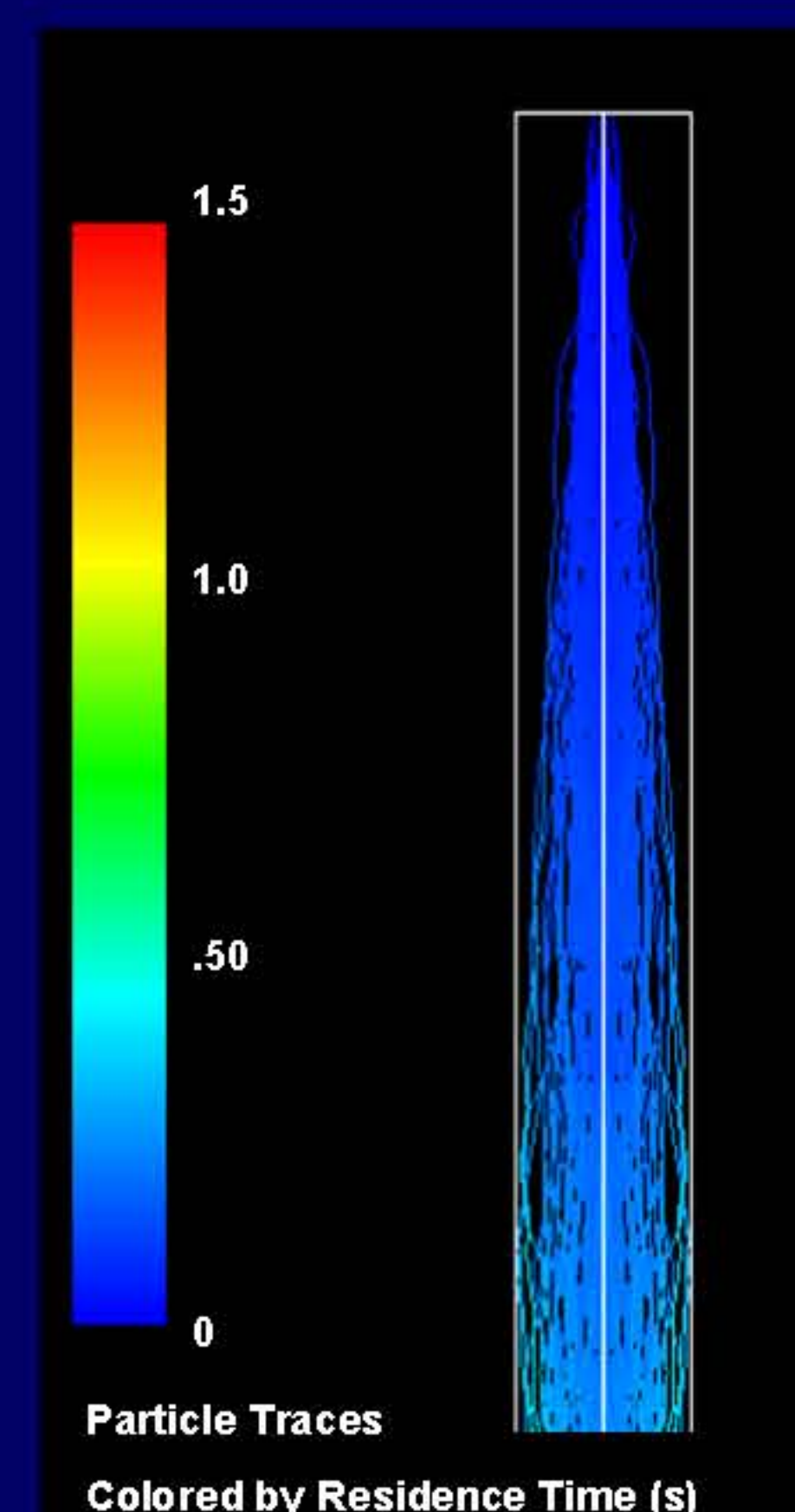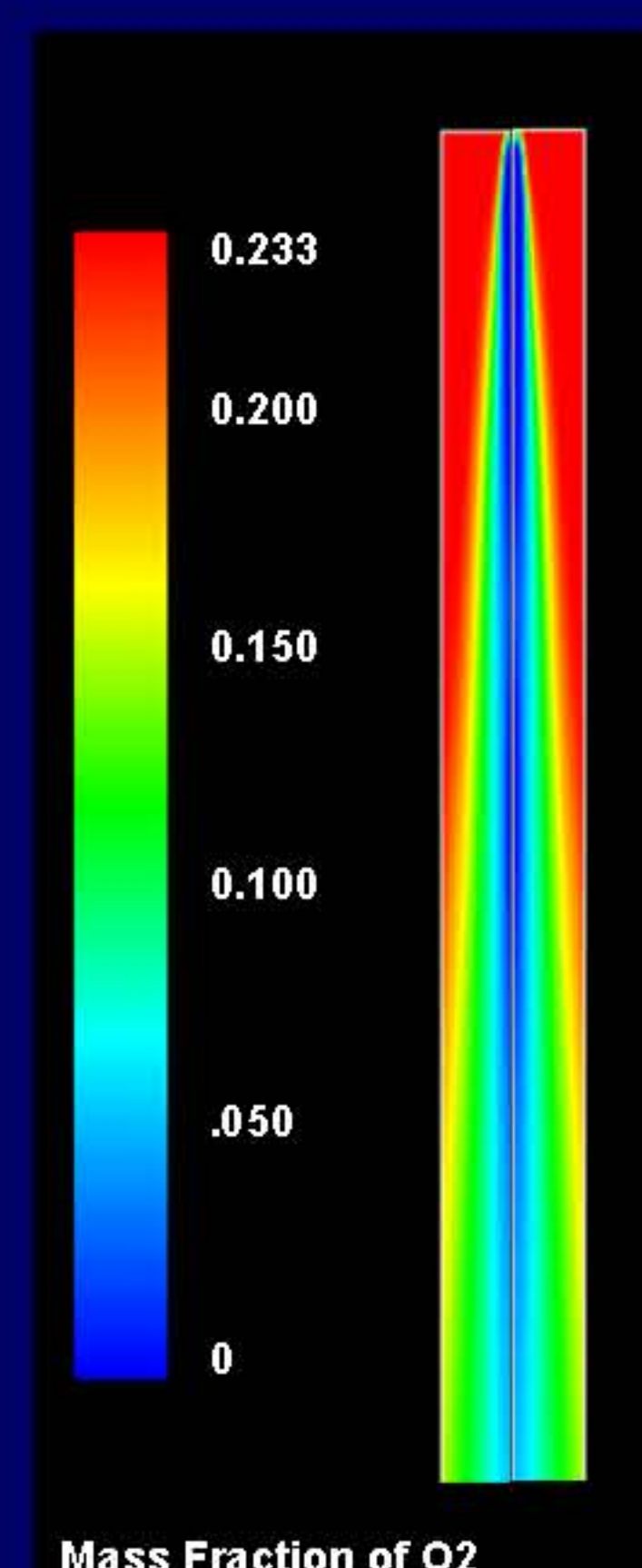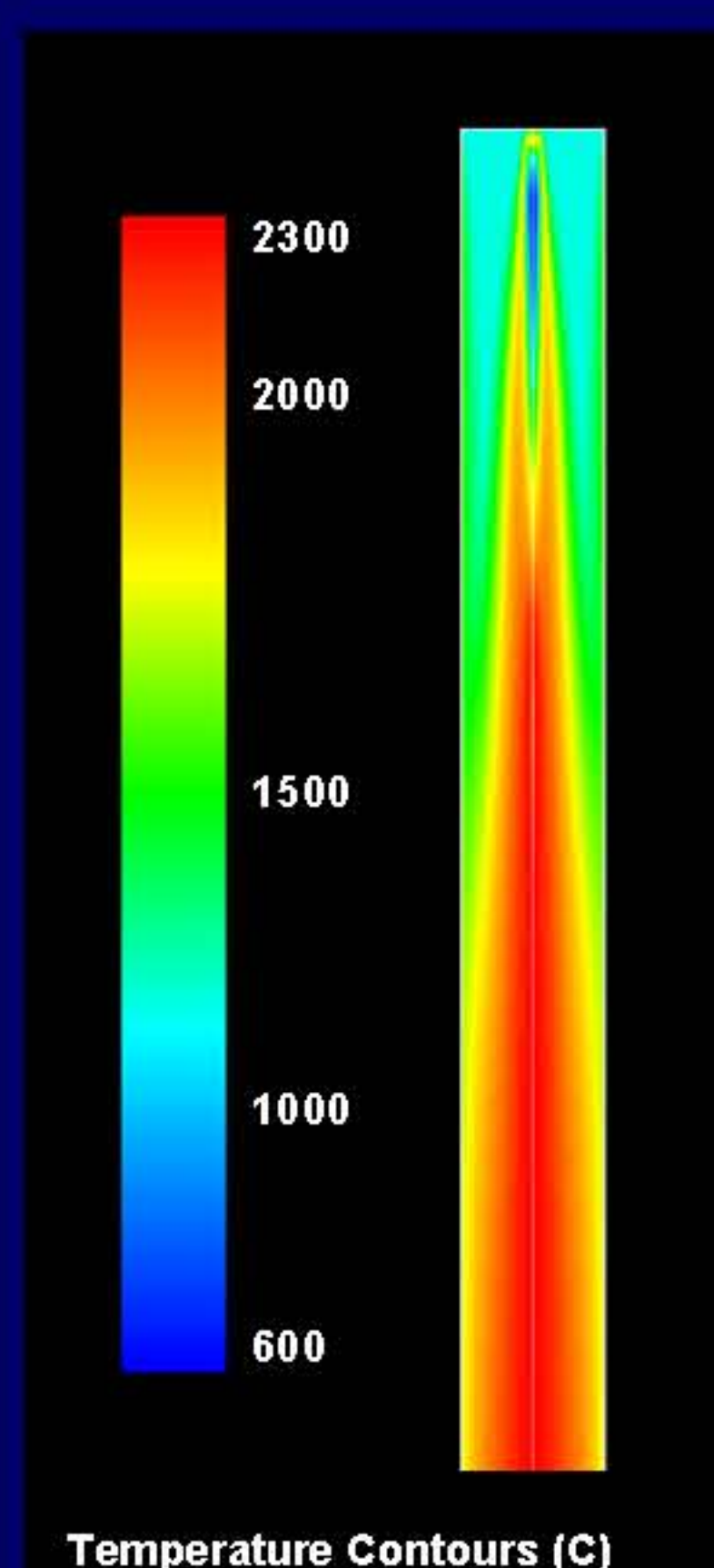
CAD Rendering

Background

The deposition and accumulation of ash on the walls of a coal-fired reactor significantly reduces the overall heat transfer rate through the reactor's walls. CFD codes often include basic deposition models but do not model many of the phenomena important to the behavior of deposit layers in coal-fired reactors.

Objectives

• Build a new Multi-fuel reactor with heated walls.
• Model the reactor's combustion processes.
• Couple the transient deposit layer model to the steady state combustion model.
• The transient model contains deposition rate, deposit layers (particulate, sintered, frozen, slag), conduction and radiation heat transfer models.

Combustion Model

• Dimensions
  – 6" Diameter x 14' Long
• Coal
  – 0.6-1.2 kg/hr
  – 60μm Particles
• Air
  – 10-17 kg/hr
  – 1000 °C
• Wall Models
  – Fixed Temperature Profile
  – Thick Wall with Convection
  – Deposit Layer UDF
  – Emittance UDF

• Grid
  – 2D Axisymmetric
  – Structured
  – 12801 Nodes
• Chemistry / Properties
  – Non-premixed Combustion
  – Equilibrium Look-up Tables
• Particle Tracking
  – Stochastic Random Walk
  – Combusting Coal Particle
  – Deposition UDF
• Other Models
  – Viscous: k-ω
  – Radiation: P1

4'

2300
2000
1500
1000
600

Temperature Contours (C)

0.233
0.200
0.150
0.100
.050
0

Mass Fraction of O2

1.5
1.0
.50
0

Particle Traces
Colored by Residence Time (s)

4.6e-8
3.0e-8
1e-8
0

Particle Burnout (kg/s)

Centerline Temperature Profile

Temperature (Celsius) vs Axial Location (m)

Wall Heat Flux Profile

Total Heat Flux (W/m2) vs Axial Location (m)
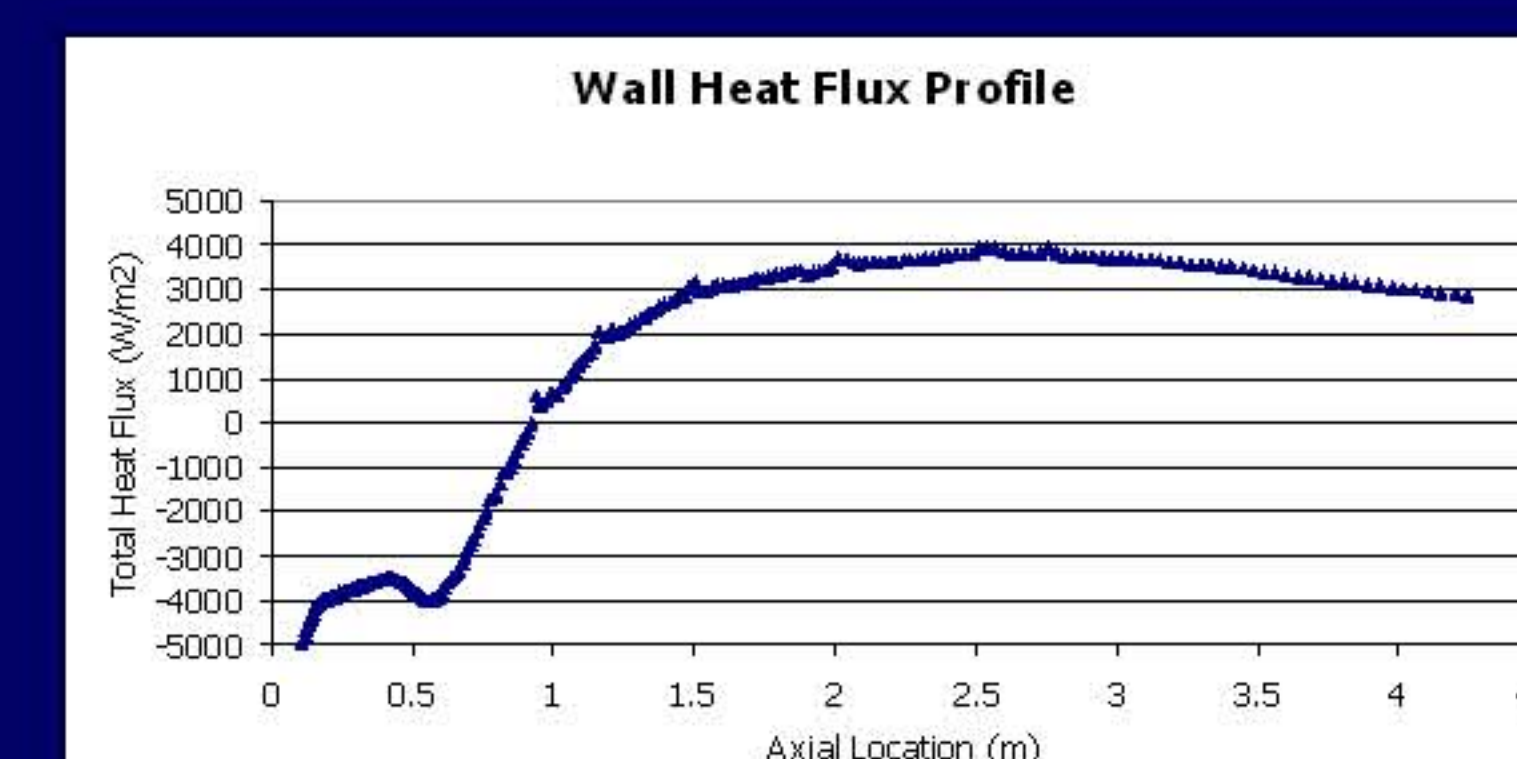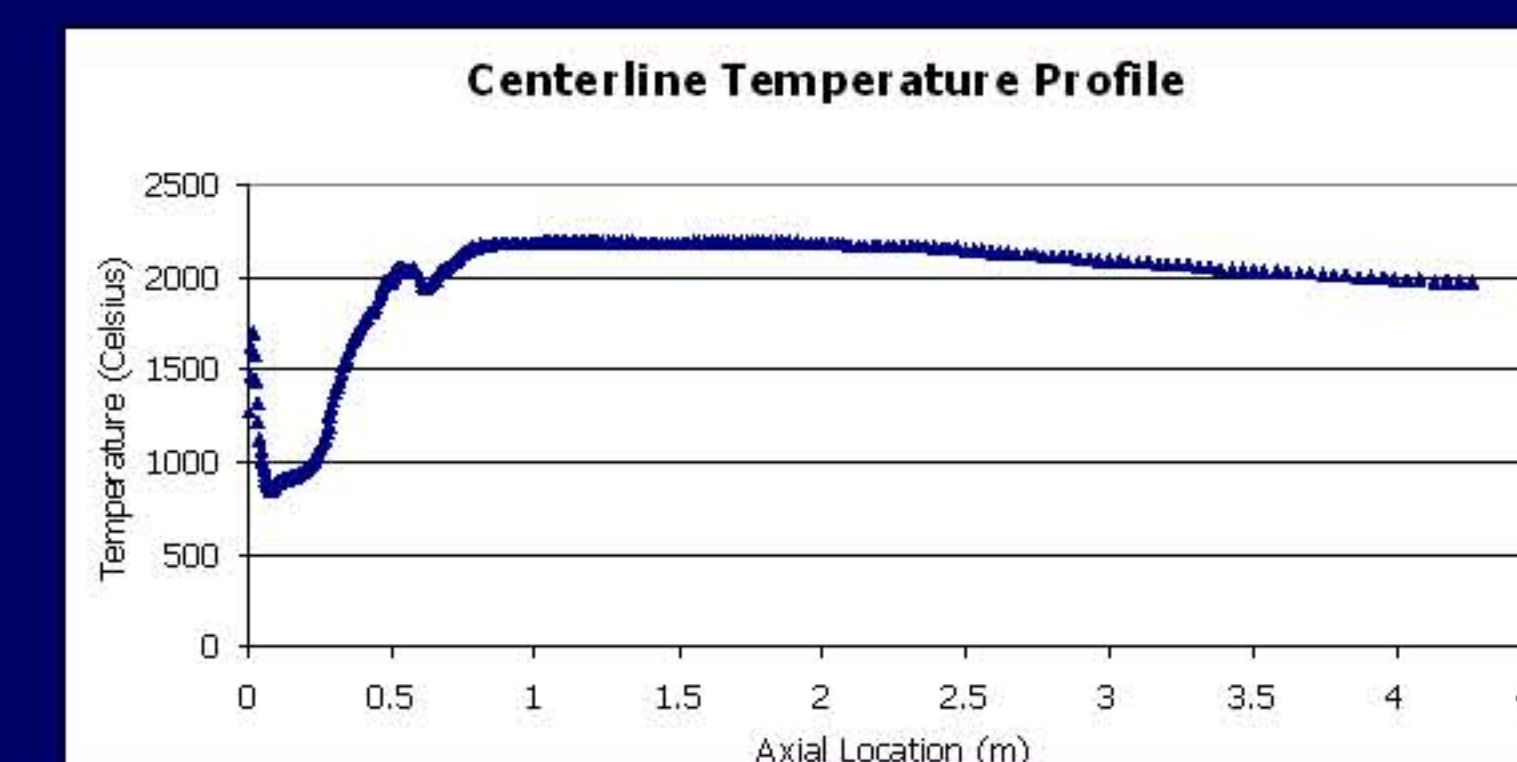
Summary

• Construction of the new multi-fuel reactor is currently in progress.

• Combustion processes in the reactor have been modeled.

• Coupled transient ash-layer model to the steady state reactor.

• Future work will incorporate deposition and emittance models into the combustion model.