Boiler performance evaluation using CFD

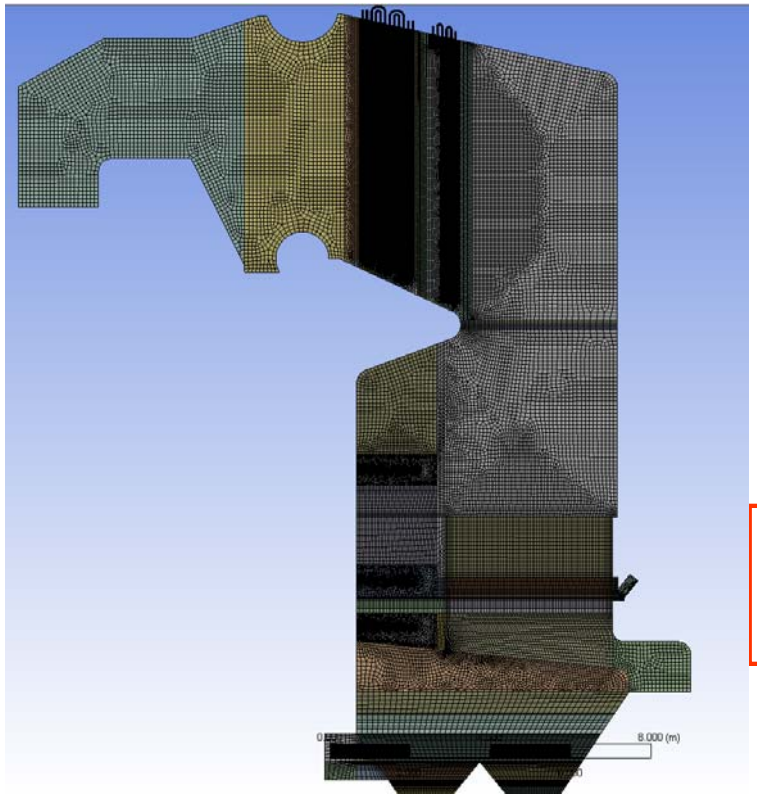
25 August 2014

Boiler and Environmental Solutions

Overview

- Why CFD?
- What is Computational Fluid Dynamics (CFD)?
- Industrial Applications
- Case Study – Industrial Watertube Boiler Erosion Modelling
- Other Example Case Studies
  - Combustion modelling
  - Heat transfer
- Conclusion

What is Computational Fluid Dynamics (CFD)?



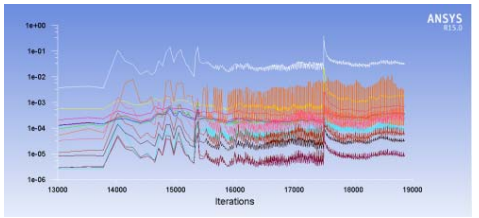
1. *User defines the problem*

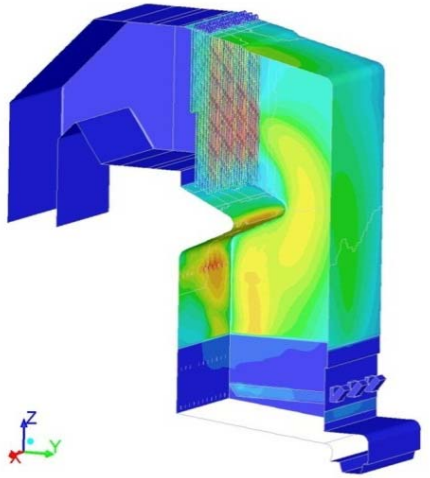
2. *Construct geometry and mesh*

3. *Define boundary conditions and physical models*

4. *Solve the equations*

5. *Interpret and validate the results*





Dell T7610 workstations

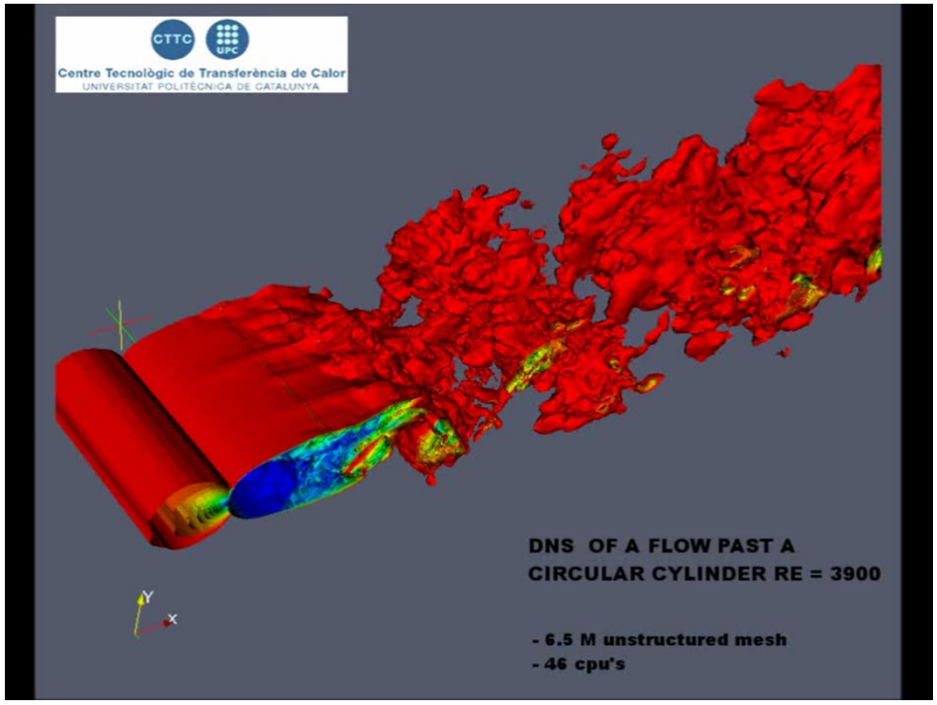


Why CFD?

- **Traditional methods**
  Global combustion reactions
  Lumped parameter heat transfer calculations – empirical simplification

- **Not ideal for NEW developments**
- **Modern standards require a higher level of detail**
- **Computer test platform**





Industrial Applications

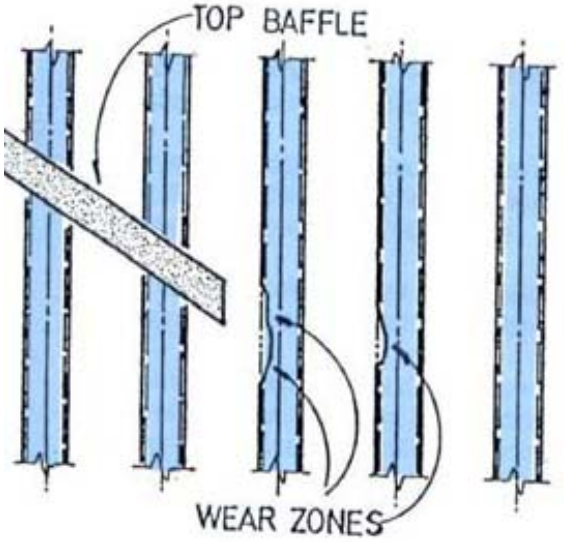
- Improve heat exchanger performance – 3D
- Temperature distribution on walls –stresses
- Flue gas recycling, reduce excess air, control furnace gas temperatures,

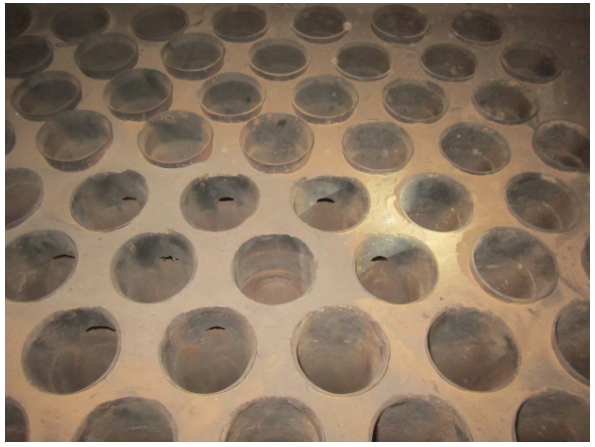
reduce NO_X, improve boiler efficiency

- New secondary air systems - increased furnace capacity
- Lower emissions
- Diagnostic tests
- New fuels
- Erosion, fouling, corrosion
- Control

Case Study – Industrial Watertube Boiler Erosion Modelling

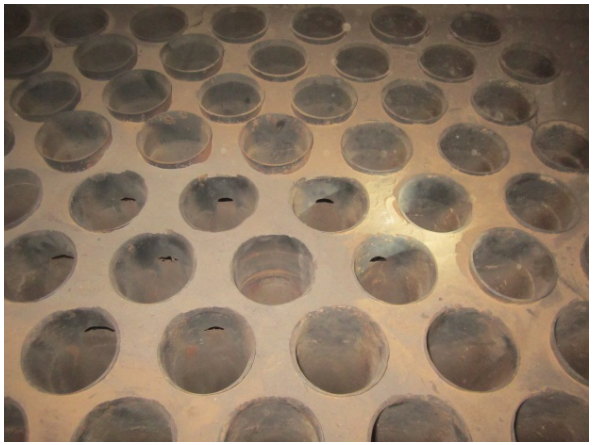
- Common erosion problematic areas
  - Three pass boilers (mainbank tubes)
  - Air heaters
  - Economisers
  - Grit collectors
  - Superheaters

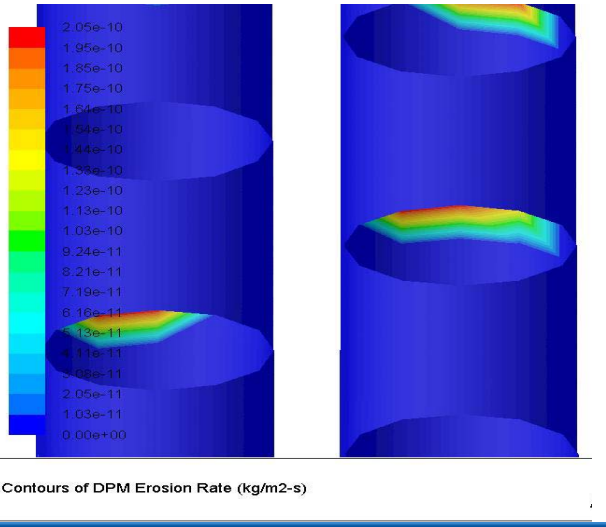




Case Study – Industrial Watertube Boiler Erosion Modelling

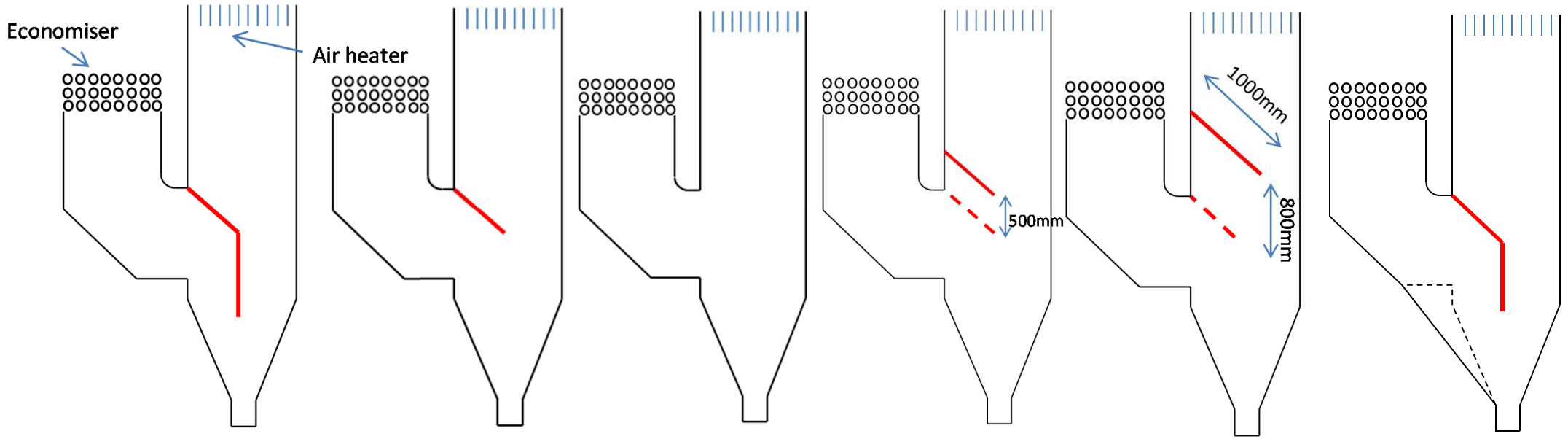
- Solutions to erosion problems
  - Shrouding
  - Ceramic cladding
  - Tube rearrangement – at the cost of heat transfer
  - Grit collectors
  - Throughout hoppers
  - Decrease velocity – at the cost of heat transfer
  - Design tool to aid the placement and layout - CFD





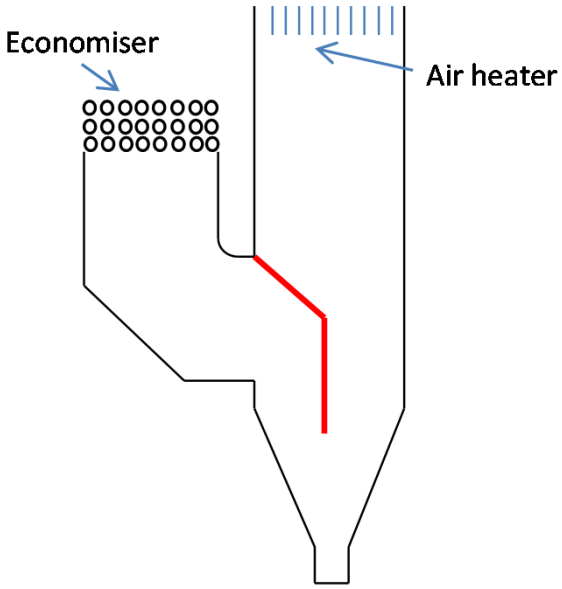
Case Study – Industrial Watertube Boiler
Erosion Modelling

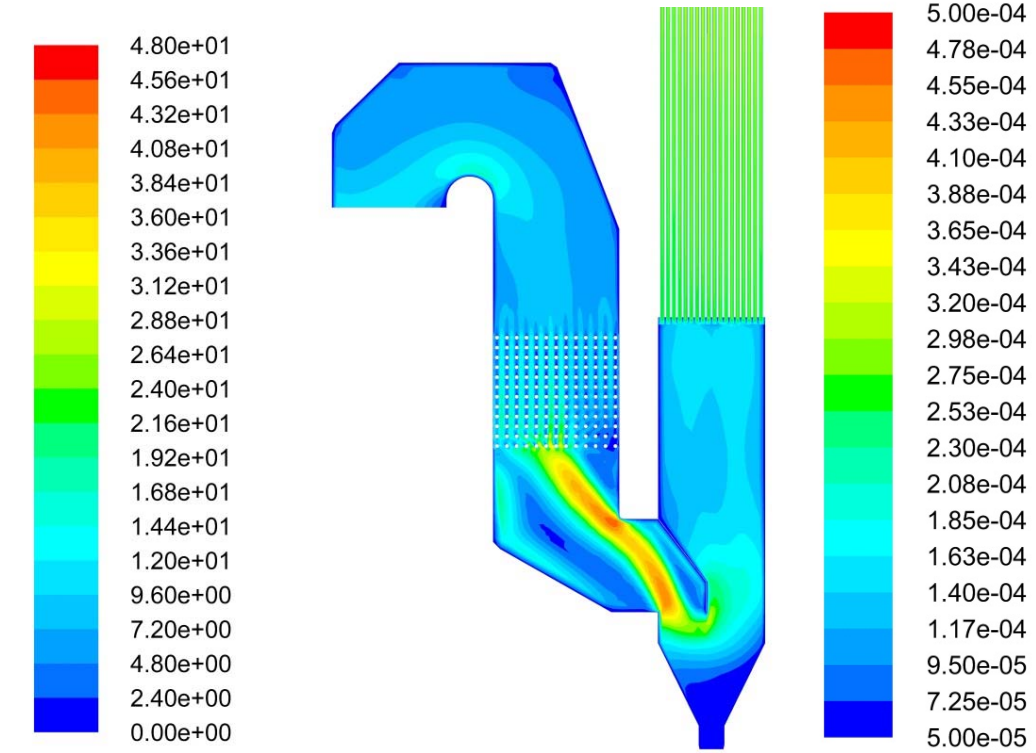
- This case study:
  - Erosion on economiser
  - CFD to determine a better solution



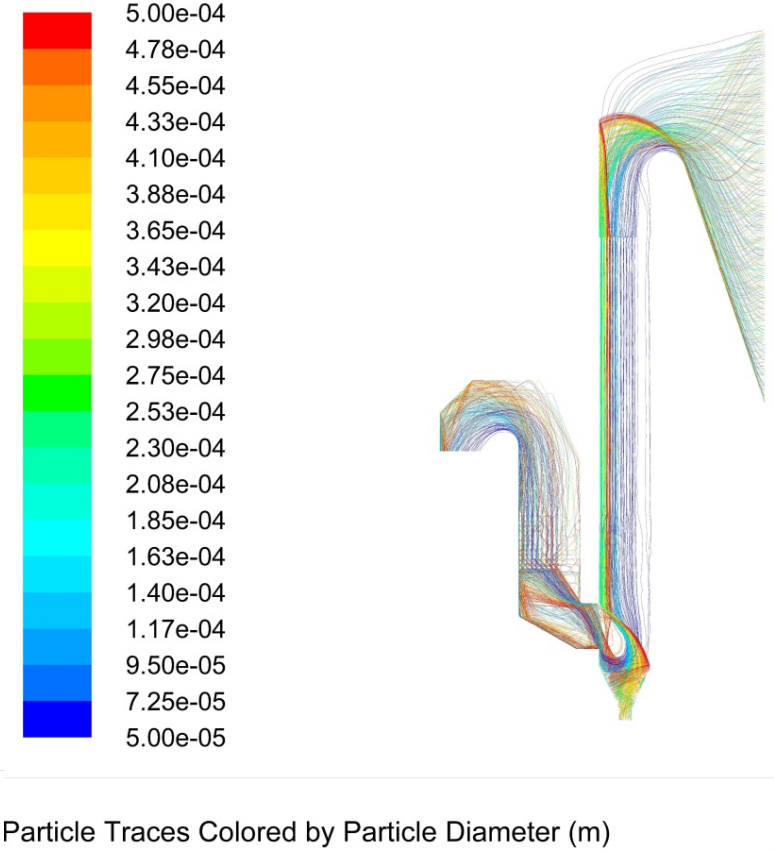
Case Study – Industrial Watertube Boiler Erosion Modelling

- Setup of the CFD for the baseline case





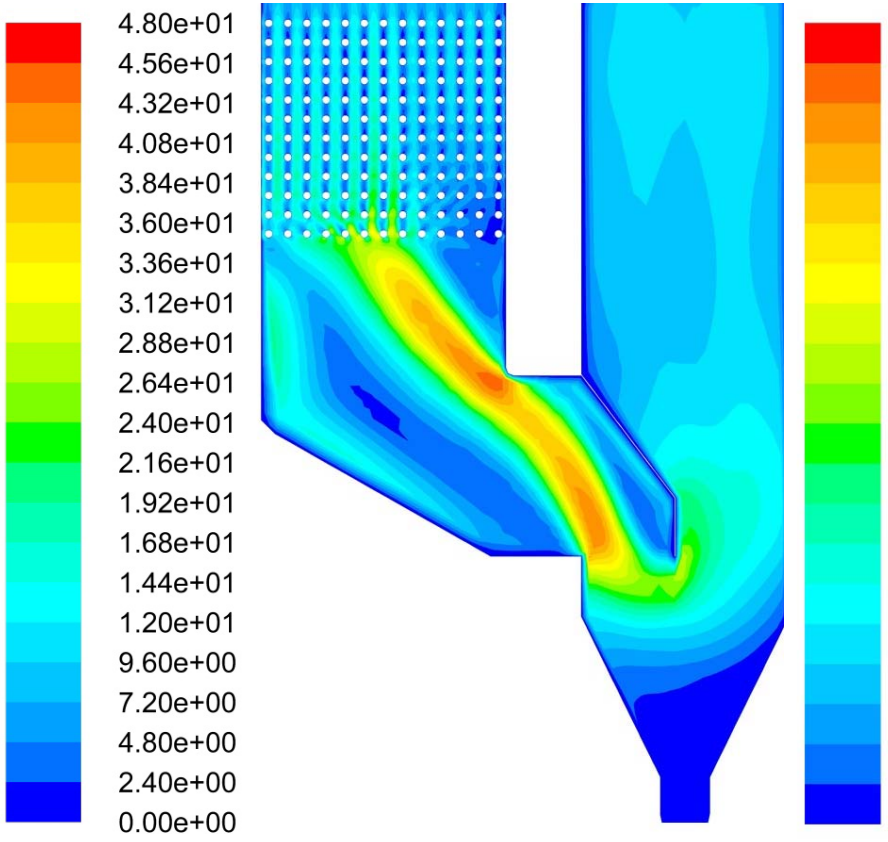
Contours of Velocity Magnitude (m/s)



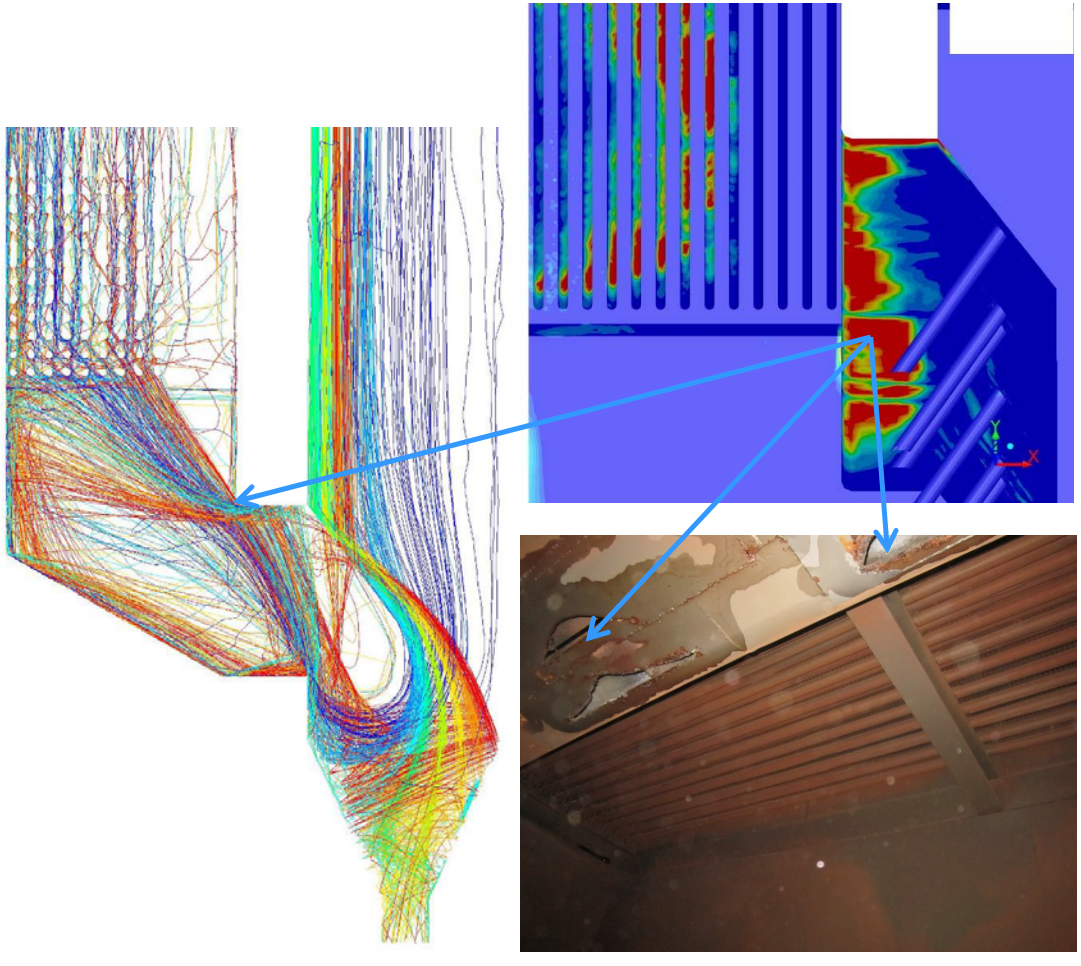
Particle Traces Colored by Particle Diameter (m)

Case Study – Industrial Watertube Boiler Erosion Modelling

- Validating the baseline case



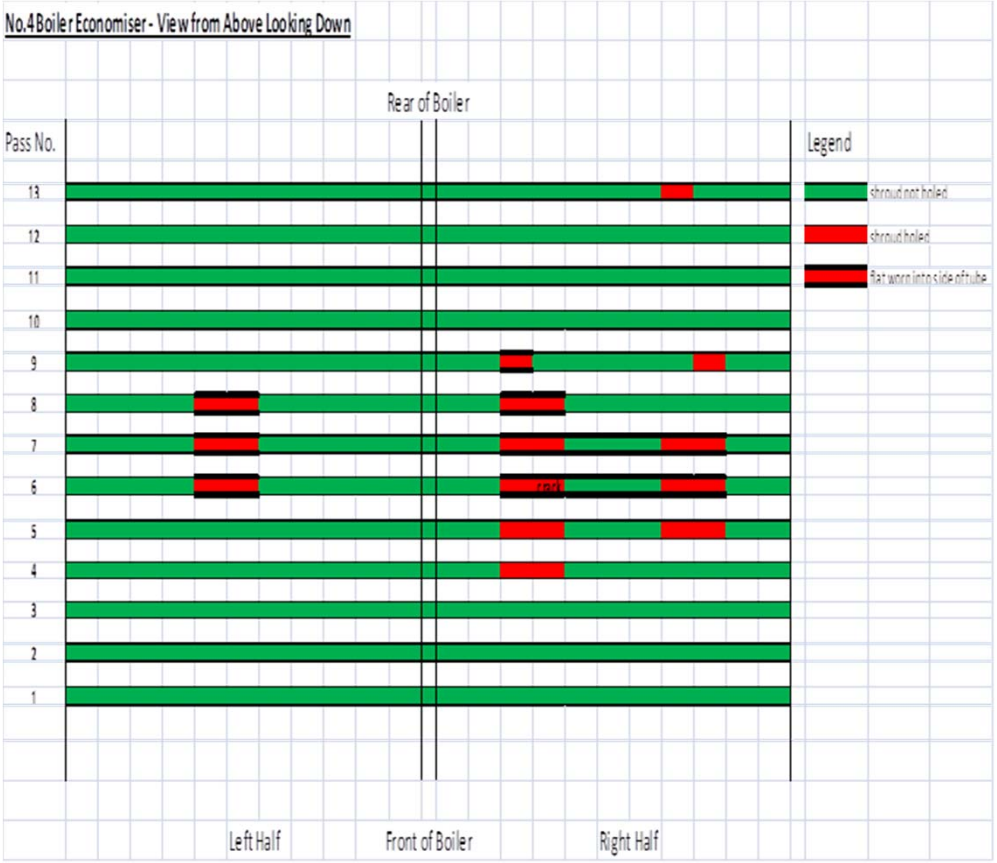
Contours of Velocity Magnitude (m/s)

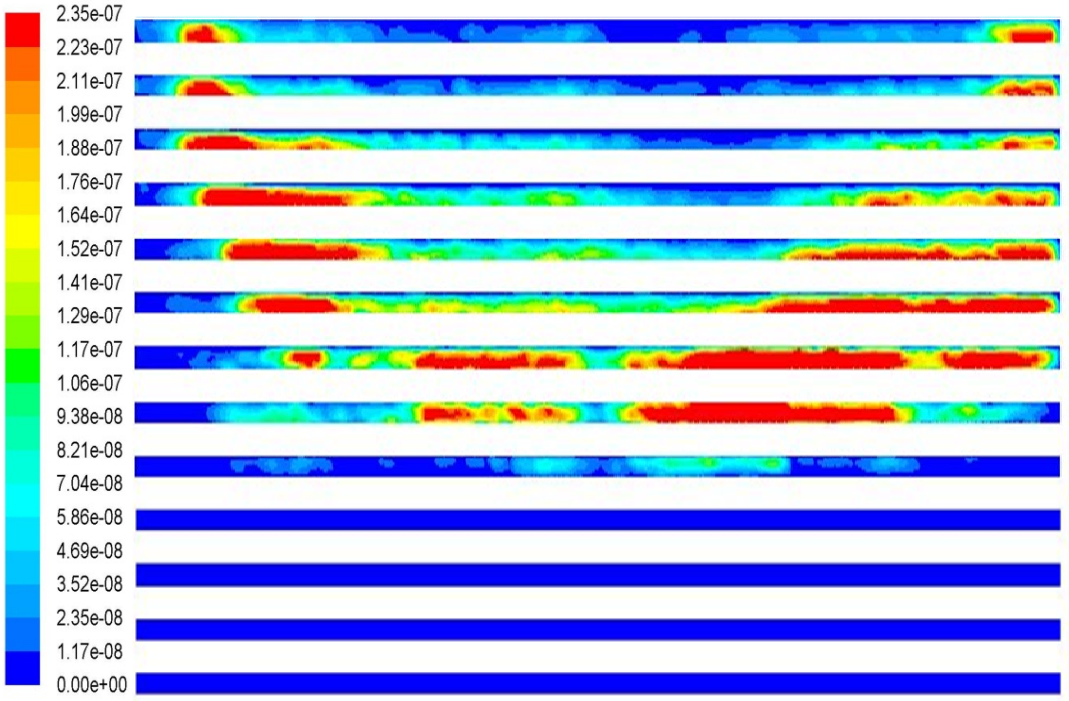


Particle Traces Colored by Particle Diameter (m)

Case Study – Industrial Watertube Boiler Erosion Modelling

- Validating the baseline case

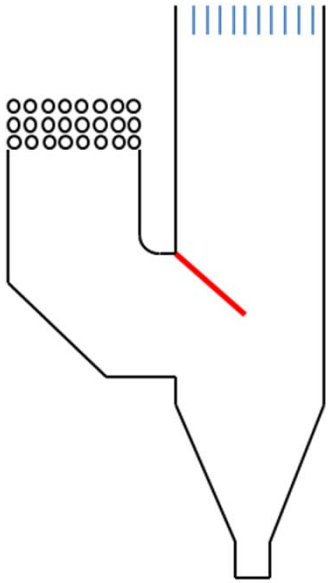


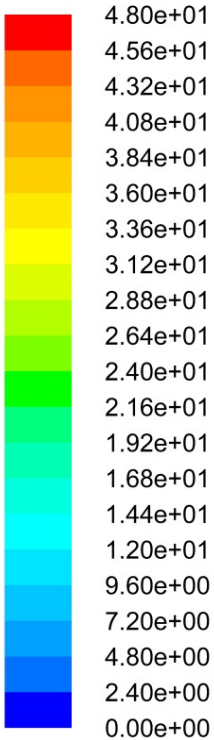


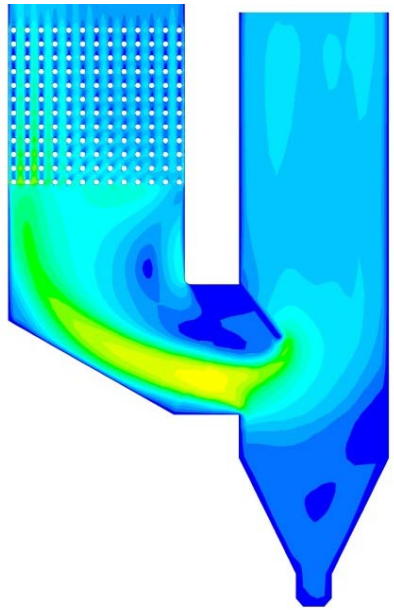
Contours of DPM Erosion Rate (kg/m2-s)

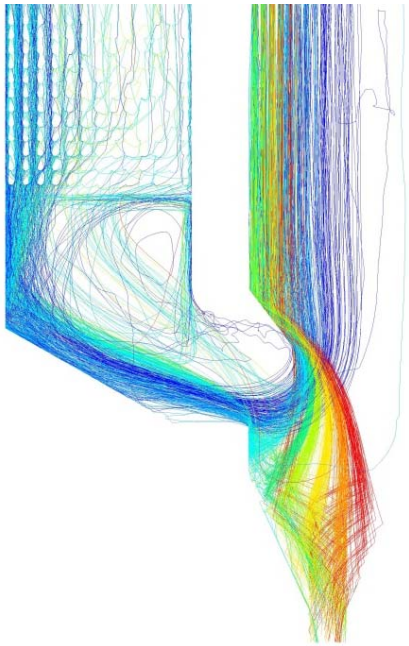
Case Study – Industrial Watertube Boiler Erosion Modelling

- Alternate arrangement – baffle cut back





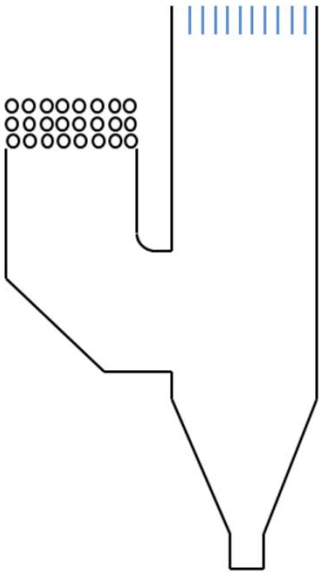


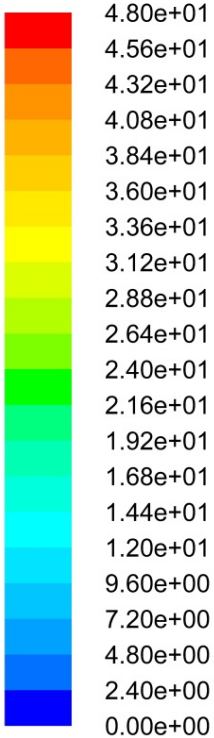


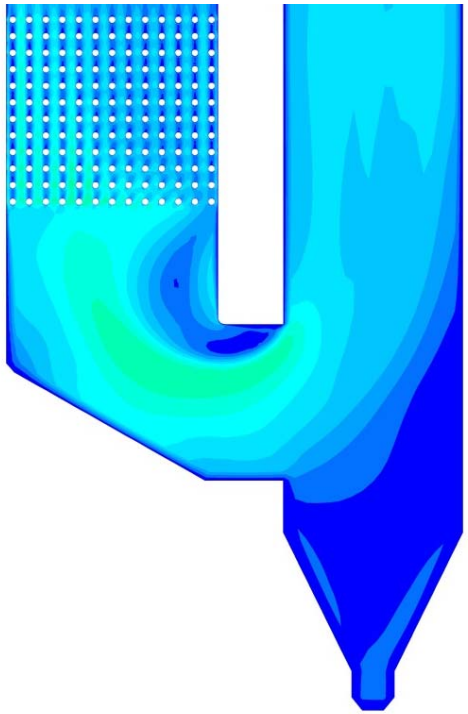
Contours of Velocity Magnitude

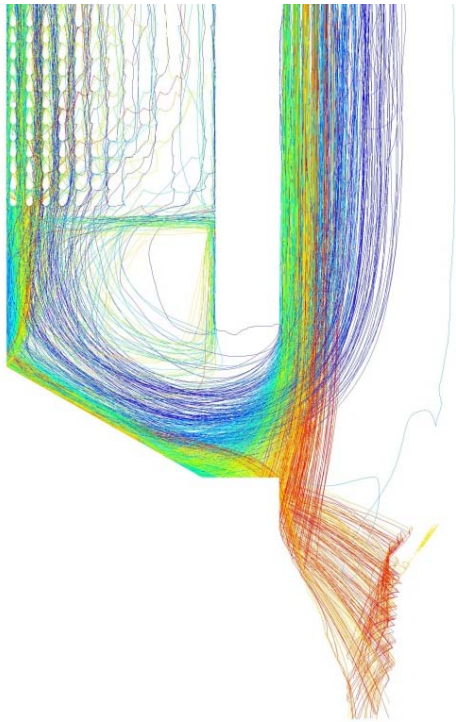
Case Study – Industrial Watertube Boiler Erosion Modelling

- Alternate arrangement – baffle taken out





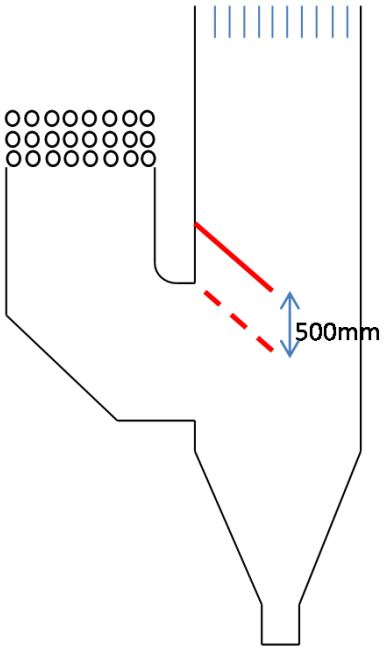


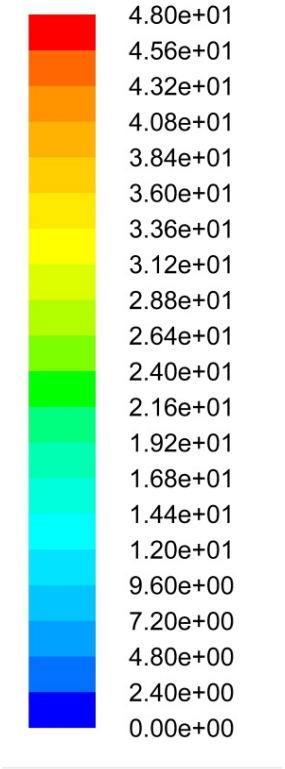


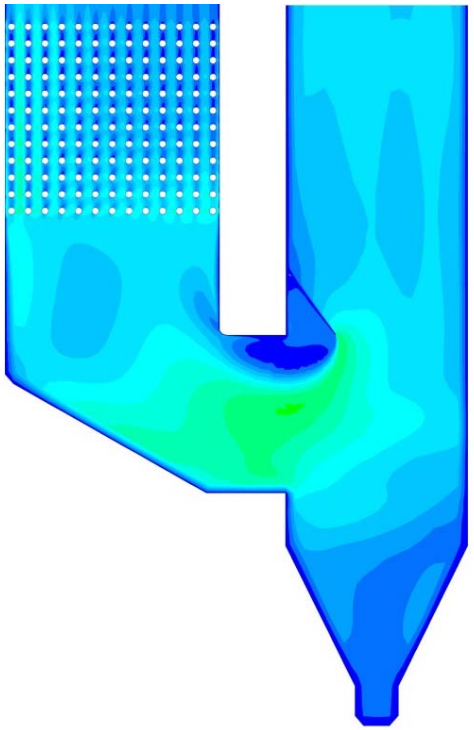
Contours of Velocity Magnitude

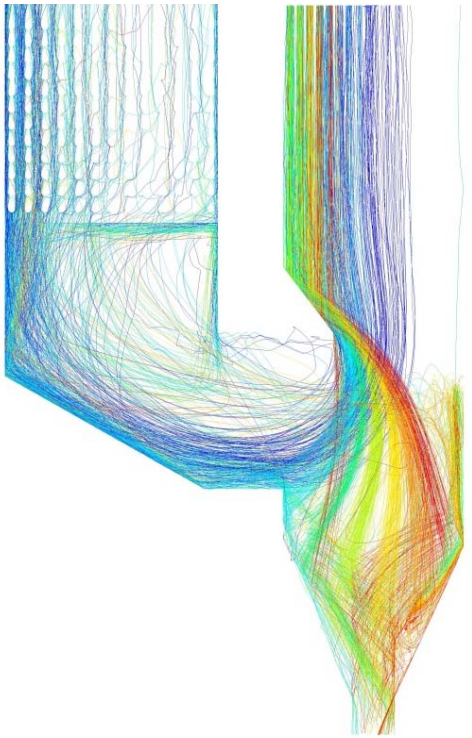
Case Study – Industrial Watertube Boiler
Erosion Modelling

- Alternate arrangement – baffle cut back and raised





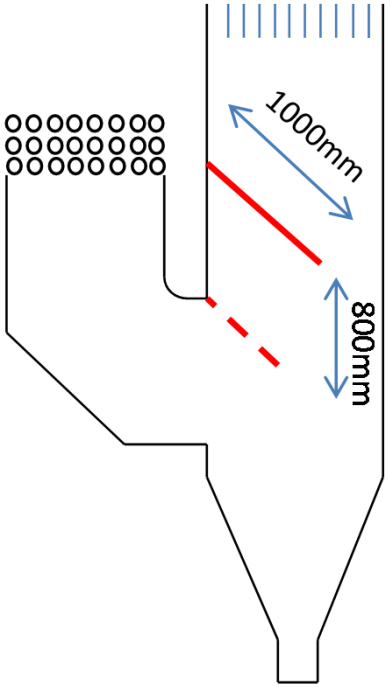


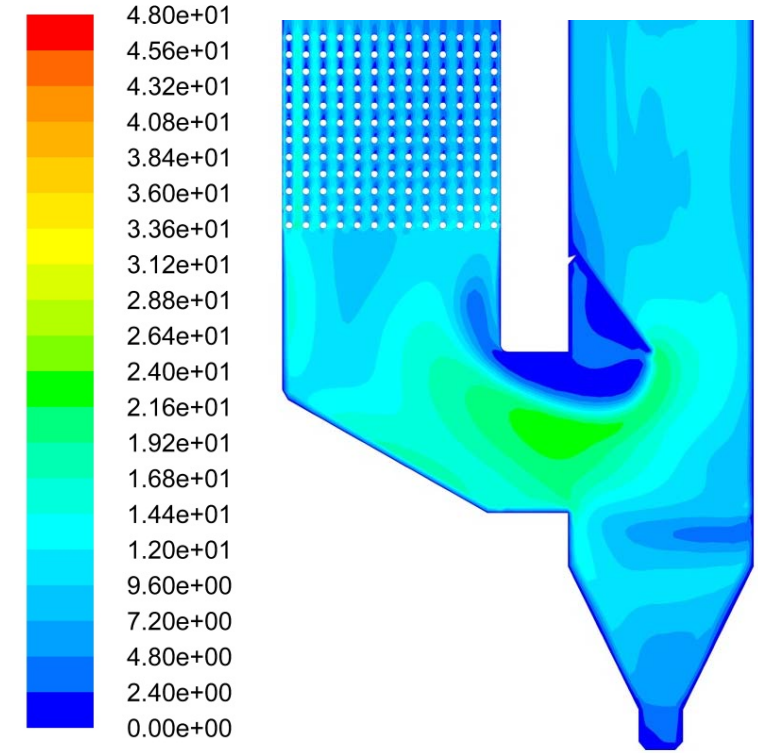


Contours of Velocity Magnitude

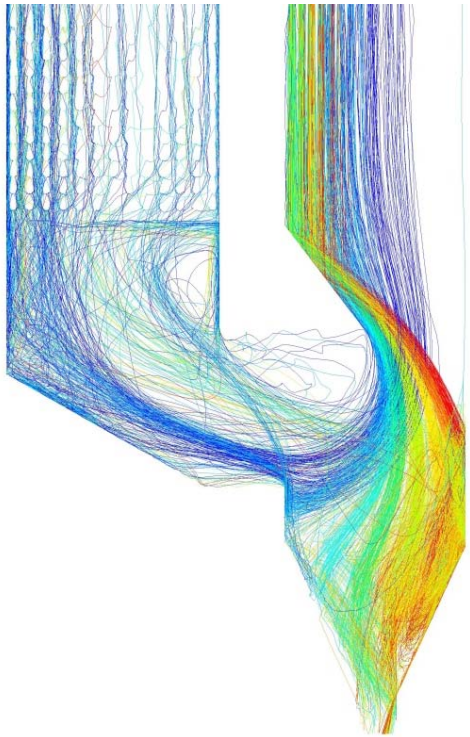
Case Study – Industrial Watertube Boiler Erosion Modelling

- Alternate arrangement – baffle cut back and raised



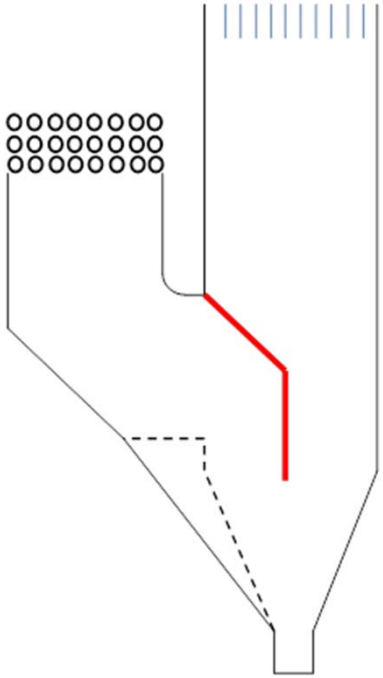


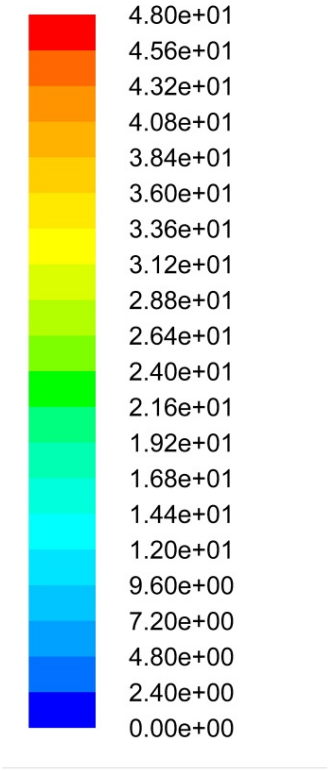
Contours of Velocity Magnitude



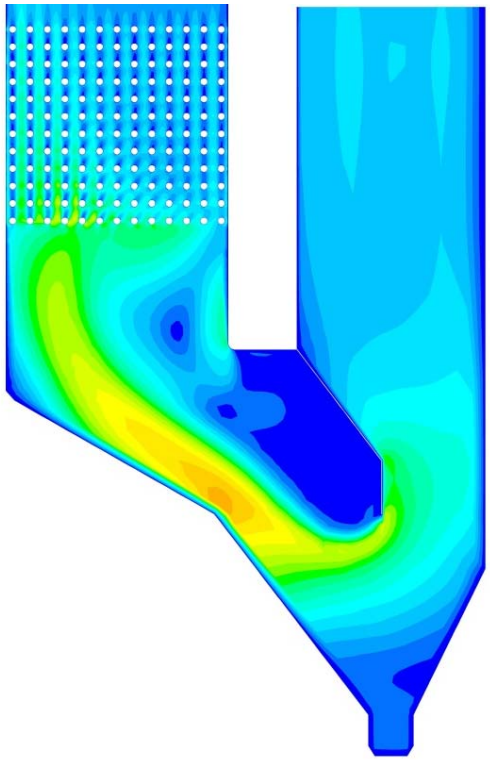
Case Study – Industrial Watertube Boiler Erosion Modelling

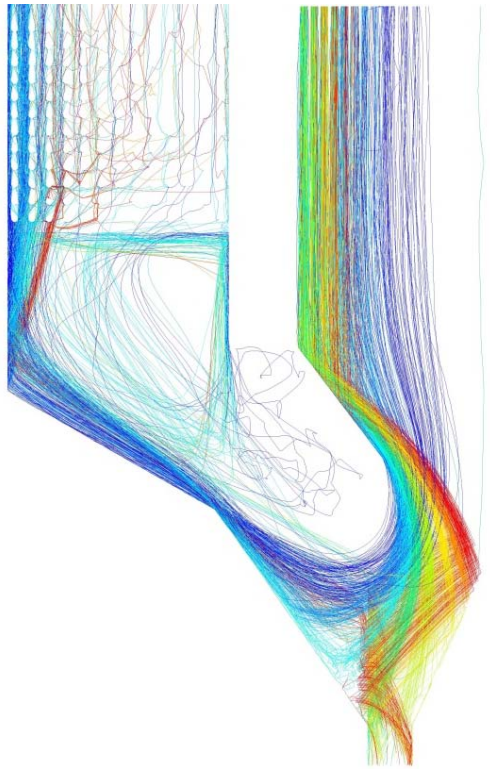
- Alternate arrangement – baffle as is and hopper modified





Contours of Velocity Magnitude





Case Study – Industrial Watertube Boiler Erosion Modelling

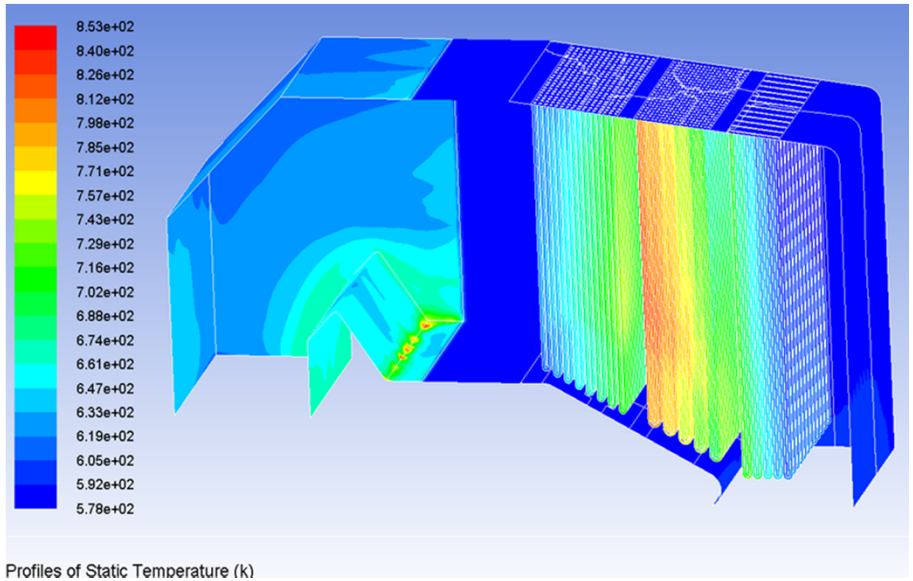
- Alternate arrangement – results

Table 1 Difference in erosion rate

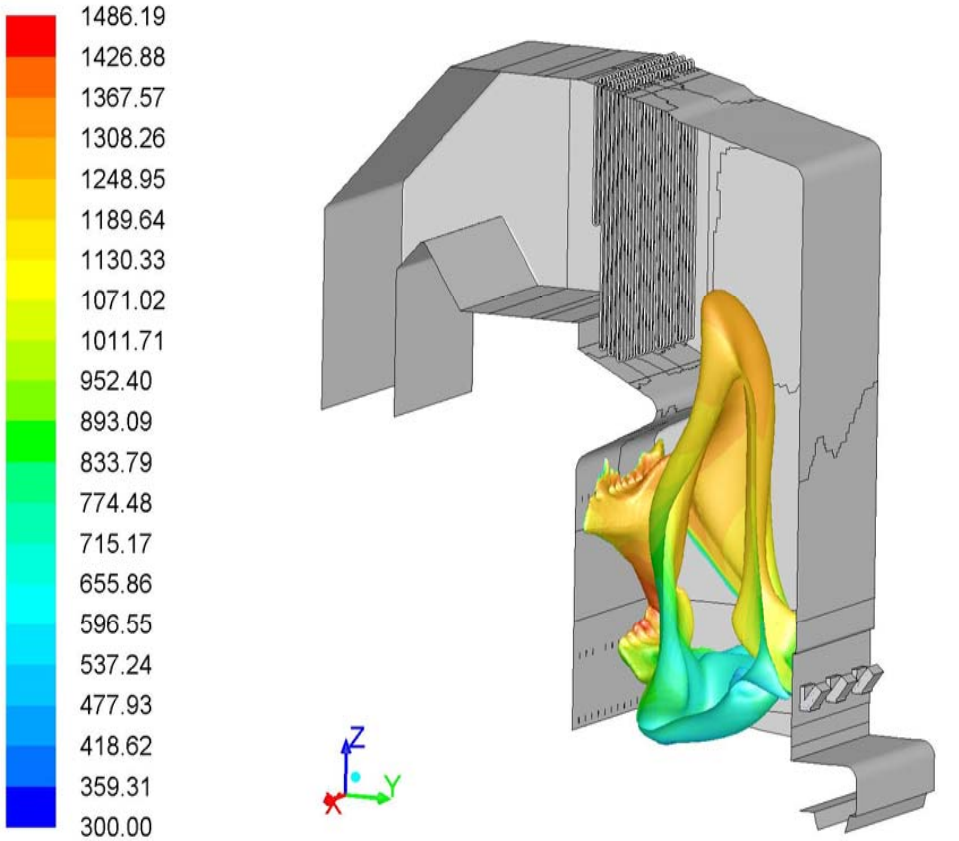
Case	Ave erosion on economiser [kg/m2-s]	Max erosion on economiser [kg/m2-s]	Mass flow into throw-out hopper [% of total]
As is	7.80e-9	20.6e-7	45.6
Baffle cut back	3.46e-9	5.10e-7	26.3
No baffle	3.27e-9	5.50e-7	3.4
Lifted baffle	1.89e-9	4.20e-7	34.5
Lifted & extended baffle	1.17e-9	2.77e-7	51.3
Corner cut back and baffle as is	4.91e-9	8.78e-7	44.3

Other Applications

- Combustion
- Heat transfer
- More detailed modelling required



Profiles of Static Temperature (k)



Contours of Static Temperature (k)

Conclusion

- CFD is the current state of the art method
- Applied successfully to reduce the wear on critical components
- Demonstrated the ability to accurately predict erosion patterns
- Advances in computers - accuracy feasible
- Validation = KEY

THANK YOU