CFD Simulations of Biomass-Coal Cofiring at Commercial Scale

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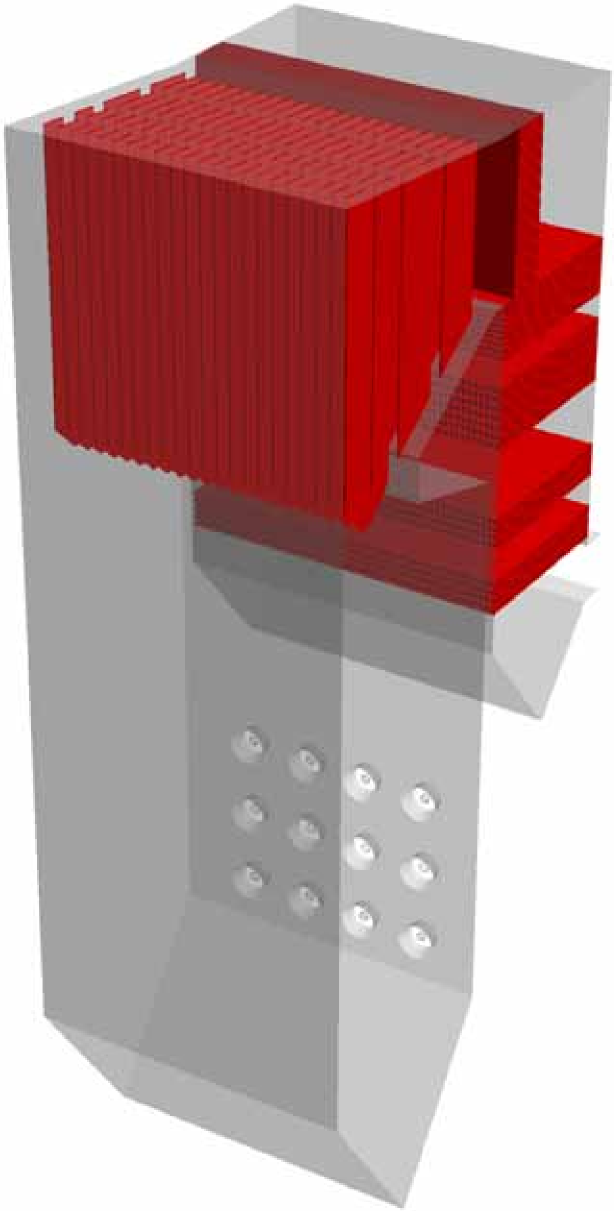
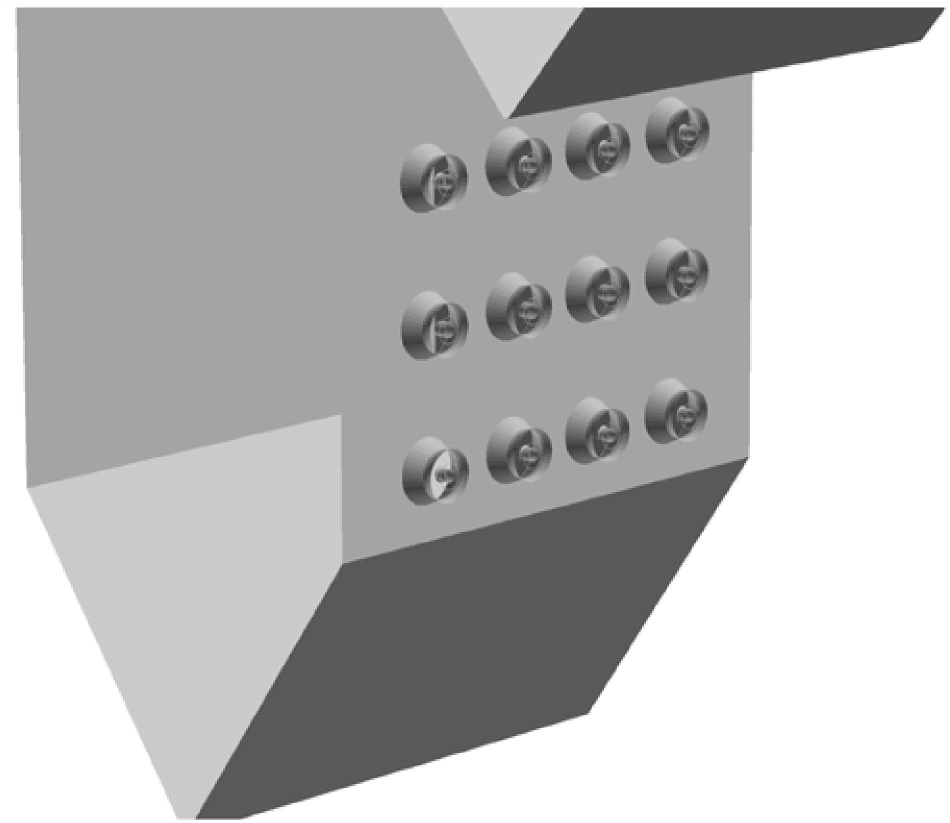
Presentation Outline

- Cofiring of Biomass and Coal in a Suspension Fired Power Plant
  - Model background
  - Measurement trends
  - Comparison of gas temperatures and compositions
- Biomass Firing in a Grate Based Boiler
  - Technology overview
  - Model background
  - Comparison of gas phase temperatures and compositions
- Concluding Remarks

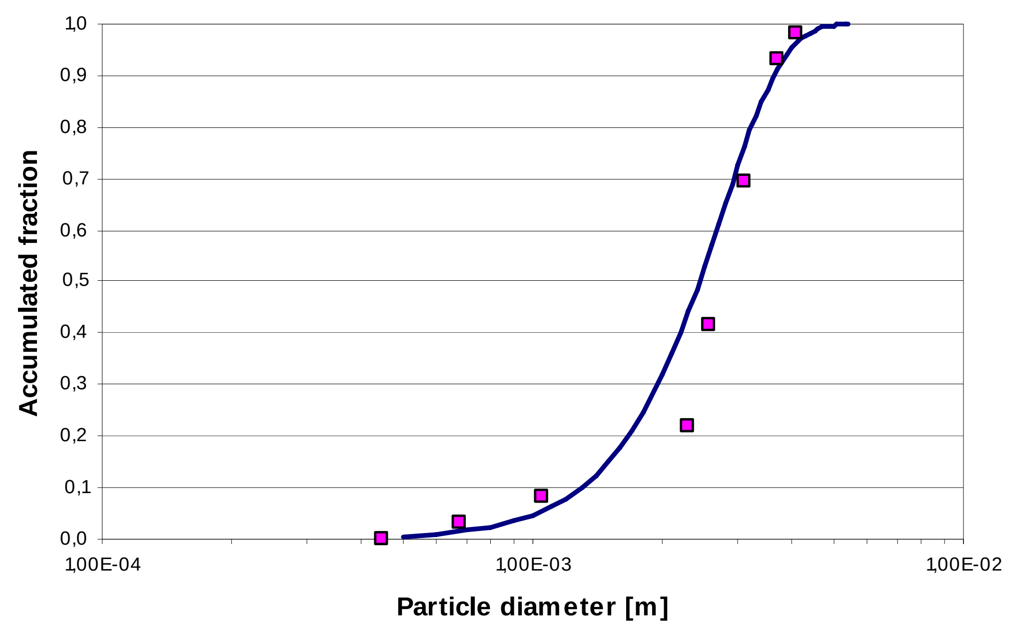
Geometry Outline





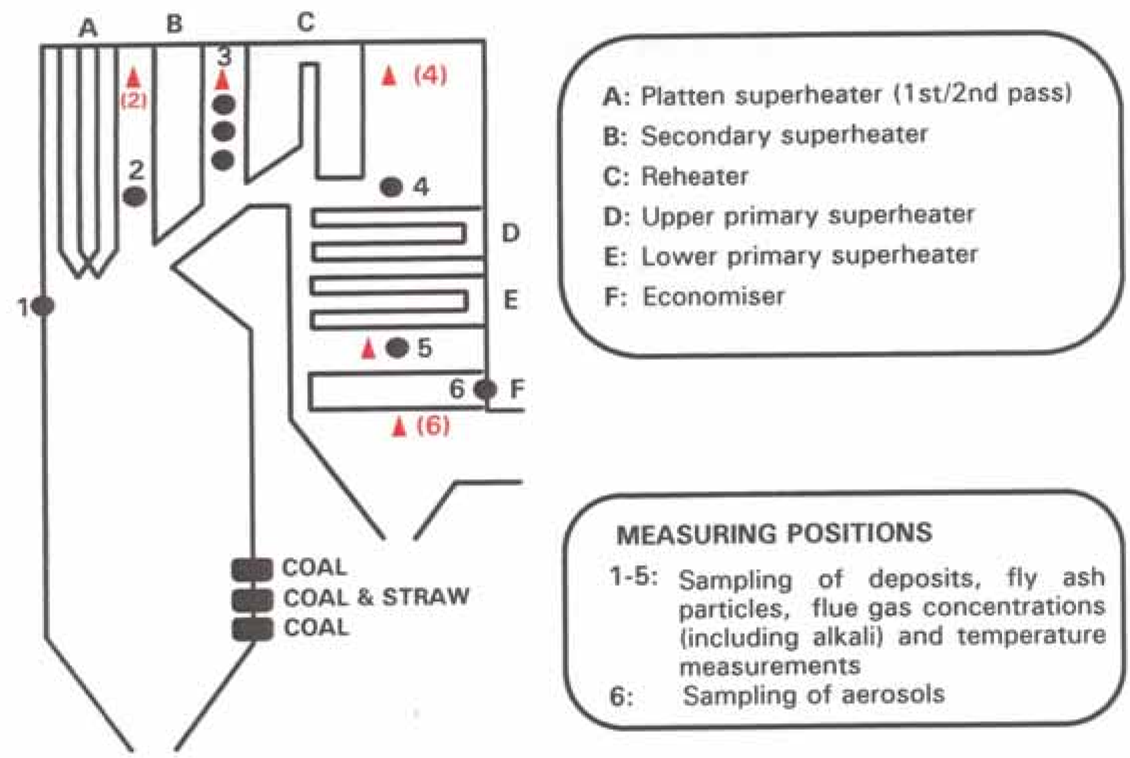
Model Background

- Boundary conditions based on boiler log data
  - Fuel and air flow rates and temperatures
- Fuel composition from ultimate and proximate analyses
  - Volatile gases: CH_4, CO, H_2, CO_2 and H_2O
  - Gas phase reaction mechanism based on Jones and Lindstedt
- Measured fuel size distributions approximated by Rosin Rammler

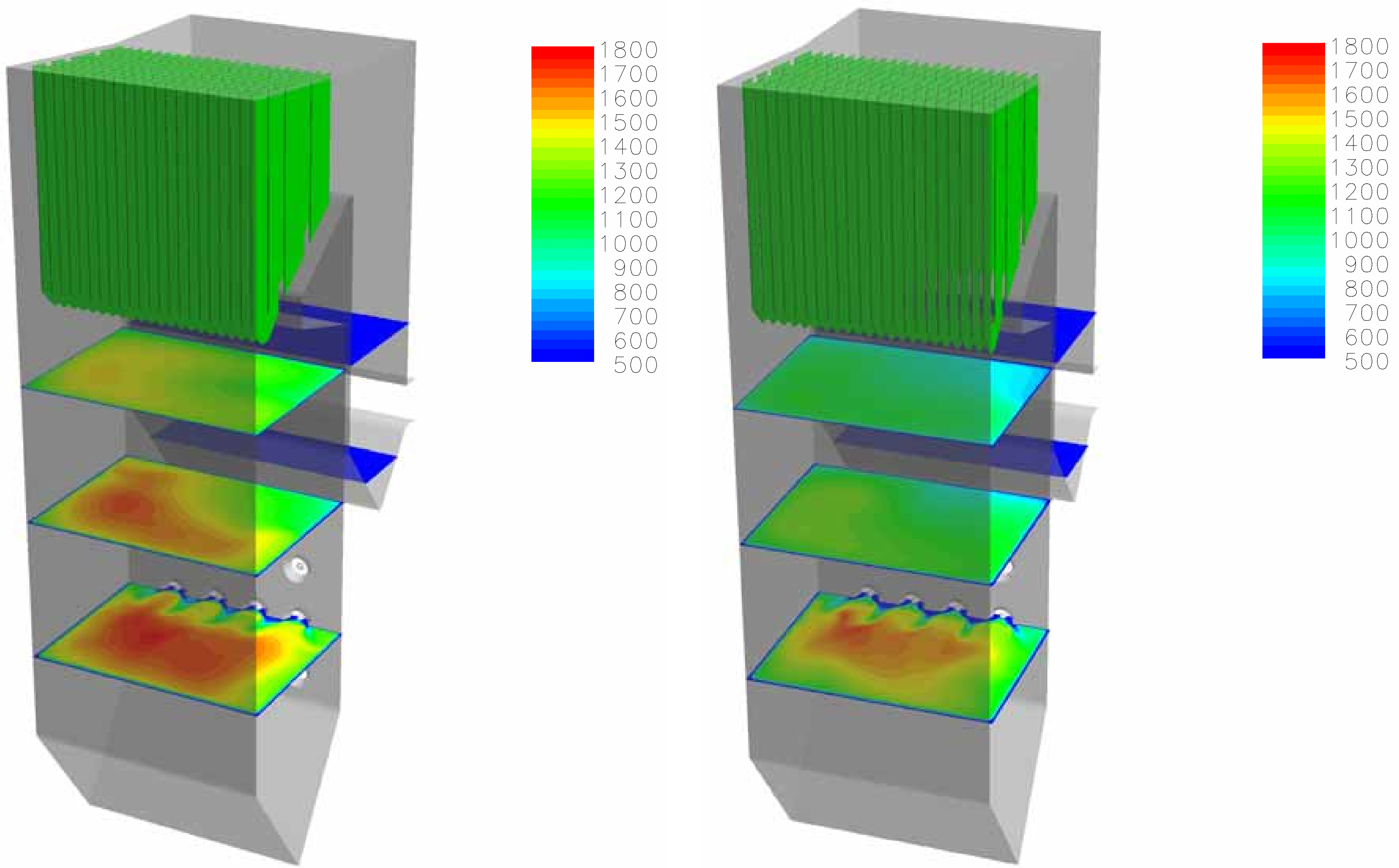


MKS1 Model Demonstration/Validation

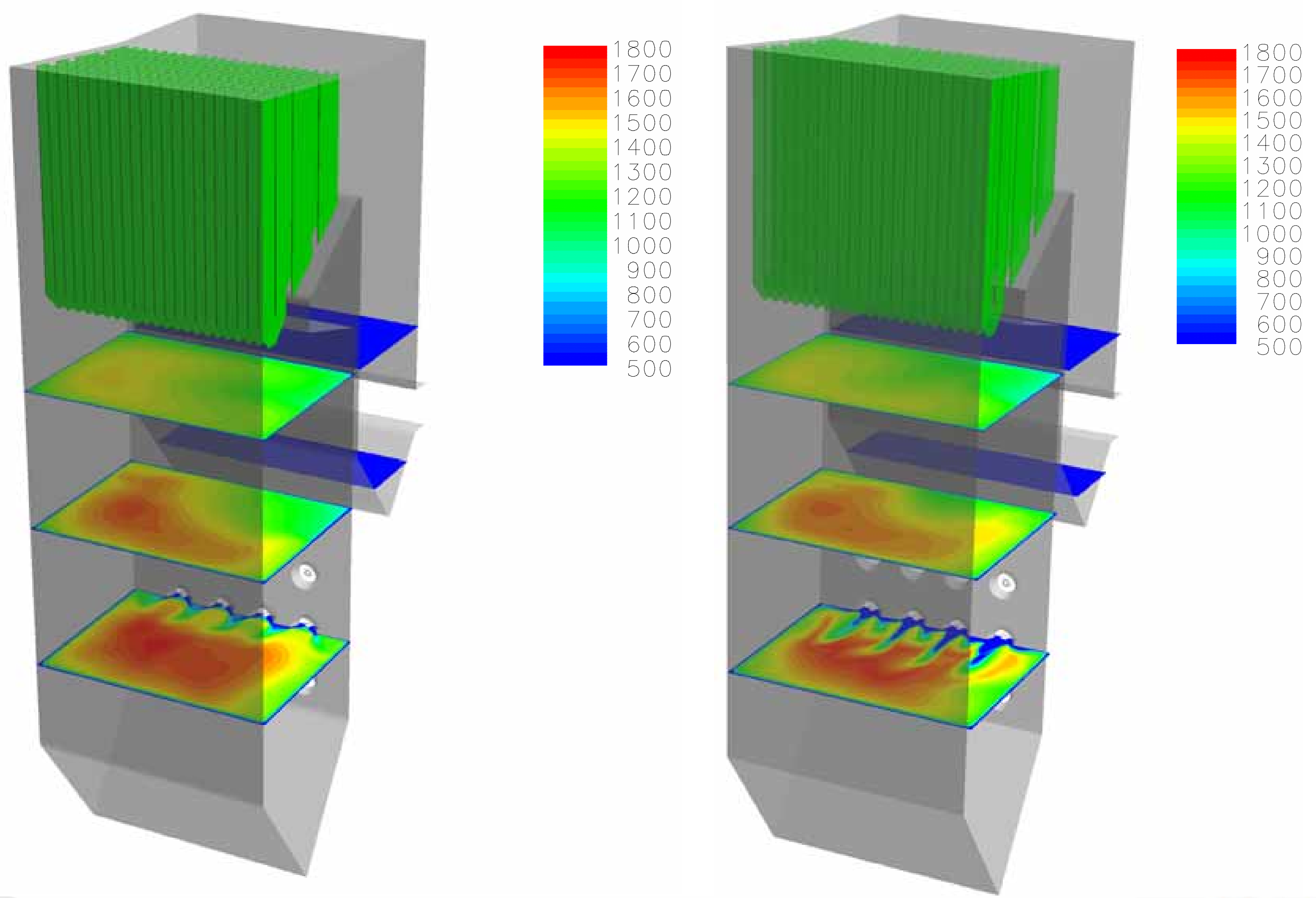
- Simulated operating conditions
  - Full load pure coal firing
  - 50% load pure coal firing
  - Full load 20% cofiring (thermal)
- The measurement locations



Full Load vs 50% Load Coal Firing



Full Load Pure Coal vs. Cofiring (20% thermal)



Temperature Profiles

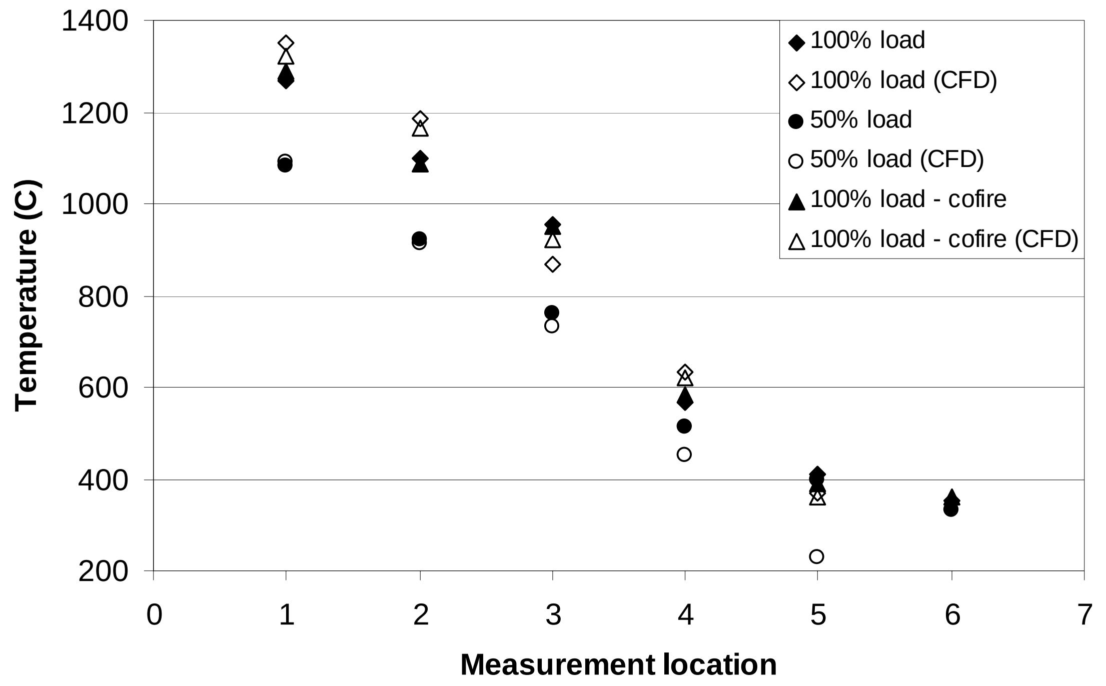
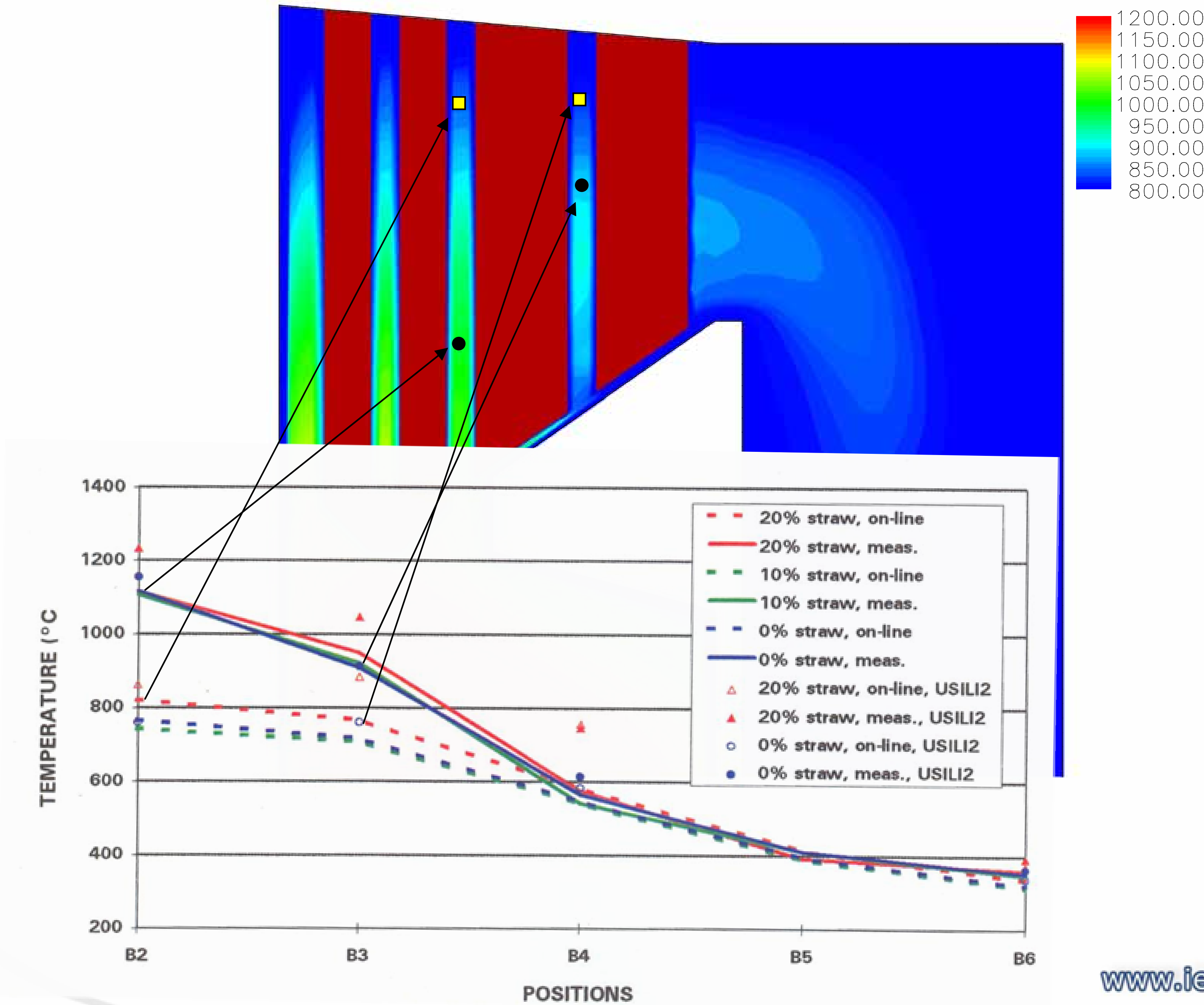


Table 2 Comparison of heat fluxes calculated from steam data and CFD predictions

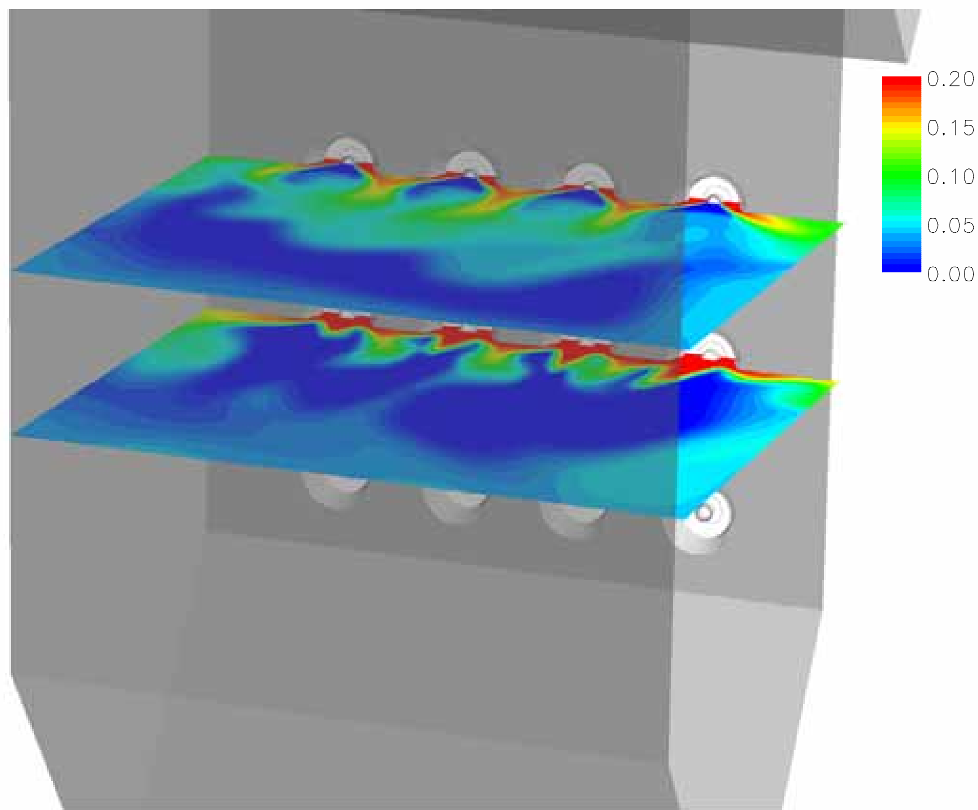
	Boiler data	CFD – coal firing	CFD – cofiring
Platen super heater	58 MW	57 MW	56 MW
Secondary super heater	27 MW	20 MW	19 MW

Gas Temperature



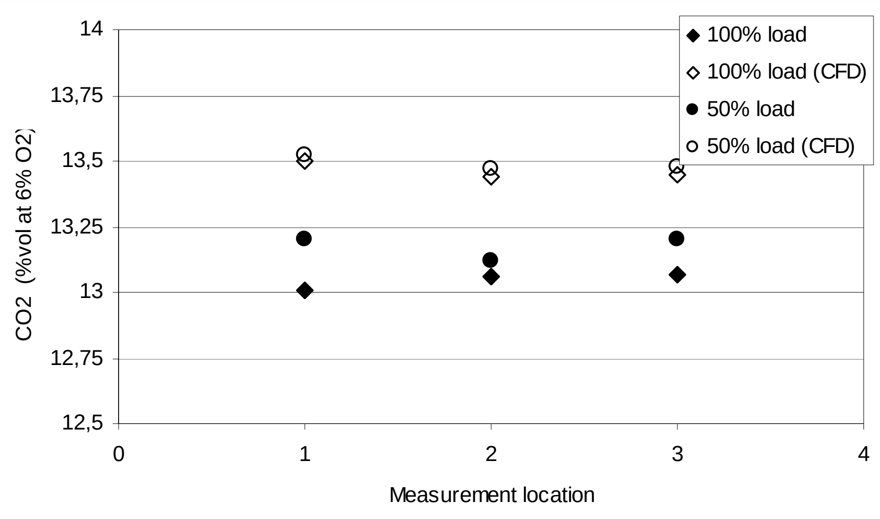
Coal versus Cofired Burner

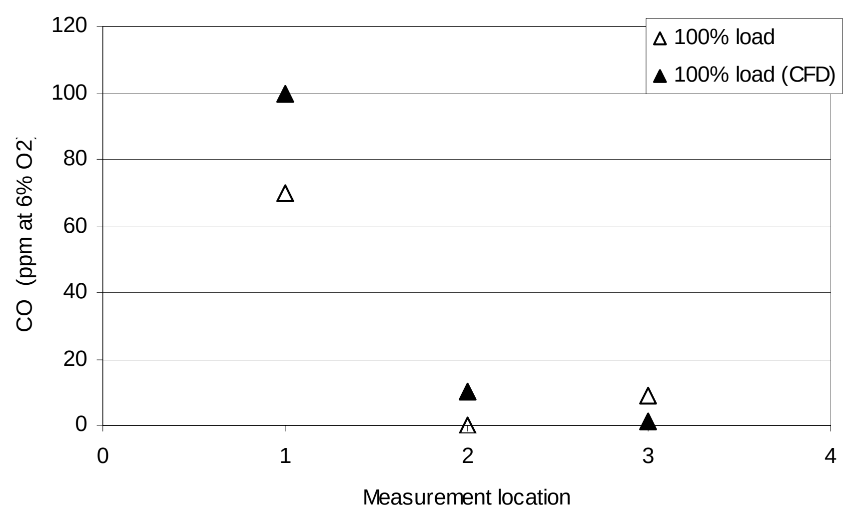
- Oxygen concentration patterns differ between pure coal and co-fired burners
  - Coal burners (top level) show trends similar to pure coal firing
  - Co-fired burners show high O2 concentrations in the near burner region due to IRZ deformation on slower fuel conversion



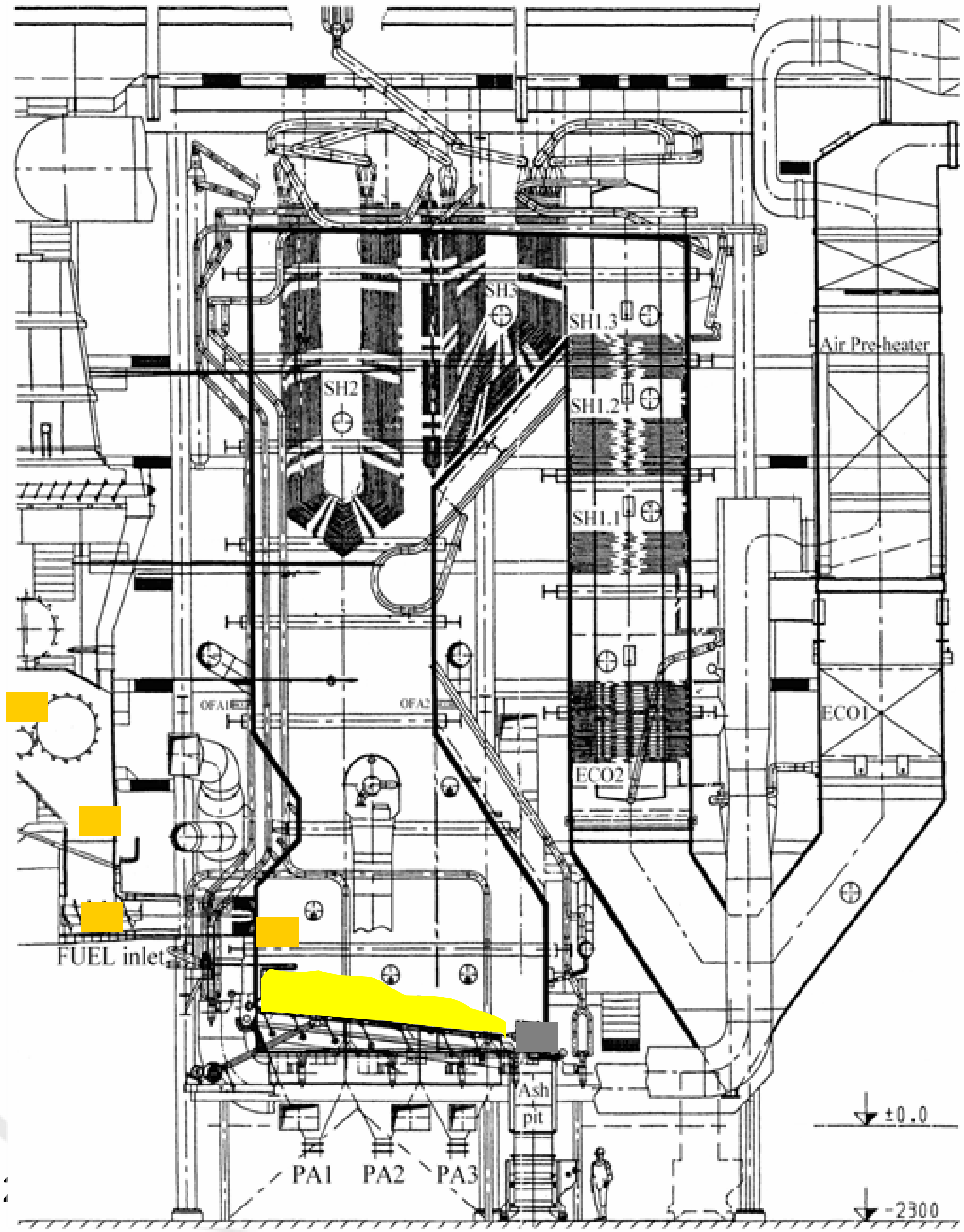
Flue Gas Compositions

- The variation with load is well captured in terms of predicted CO2 concentrations
- The CO concentrations are surprisingly good agreement with measurements



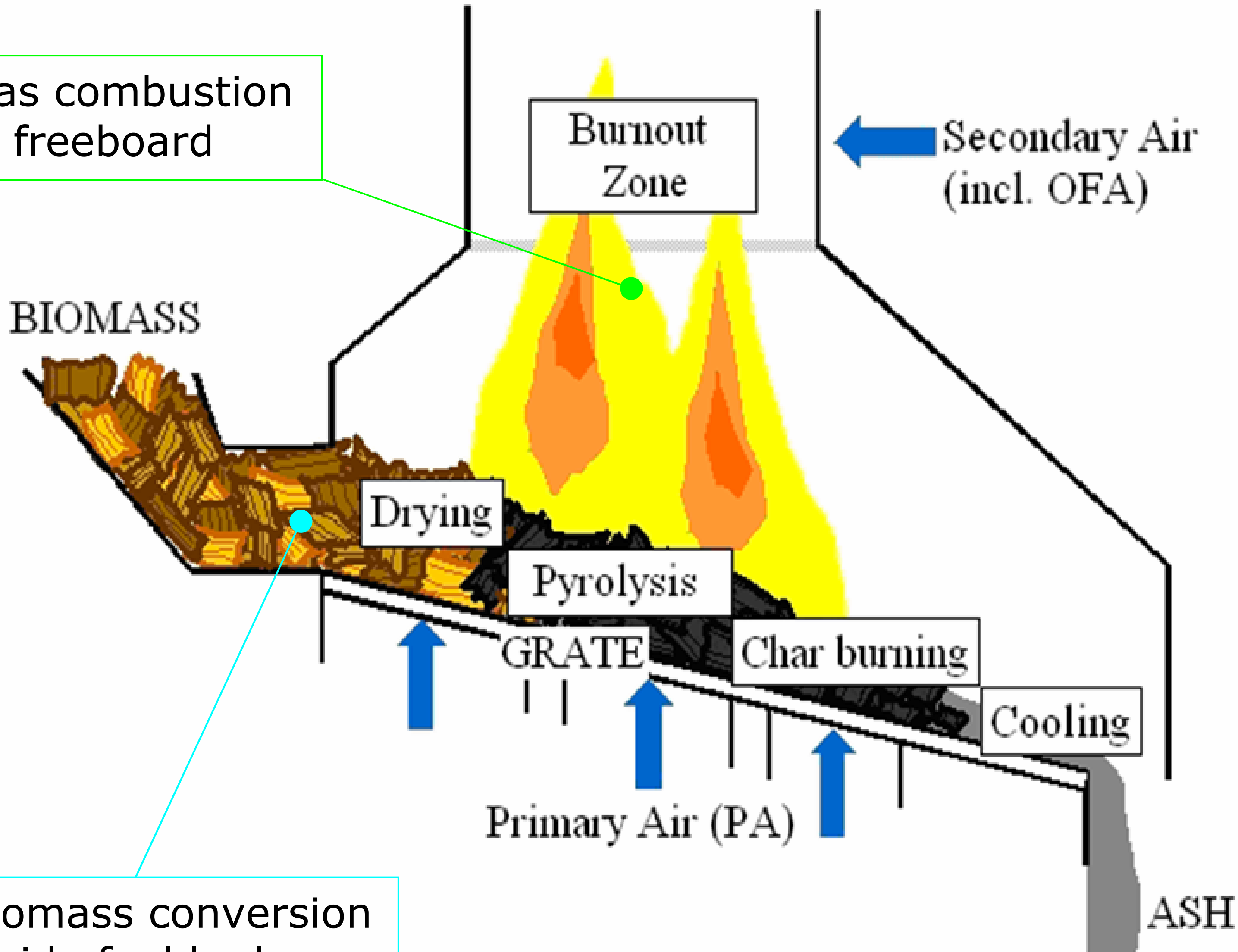


The Grate Boiler



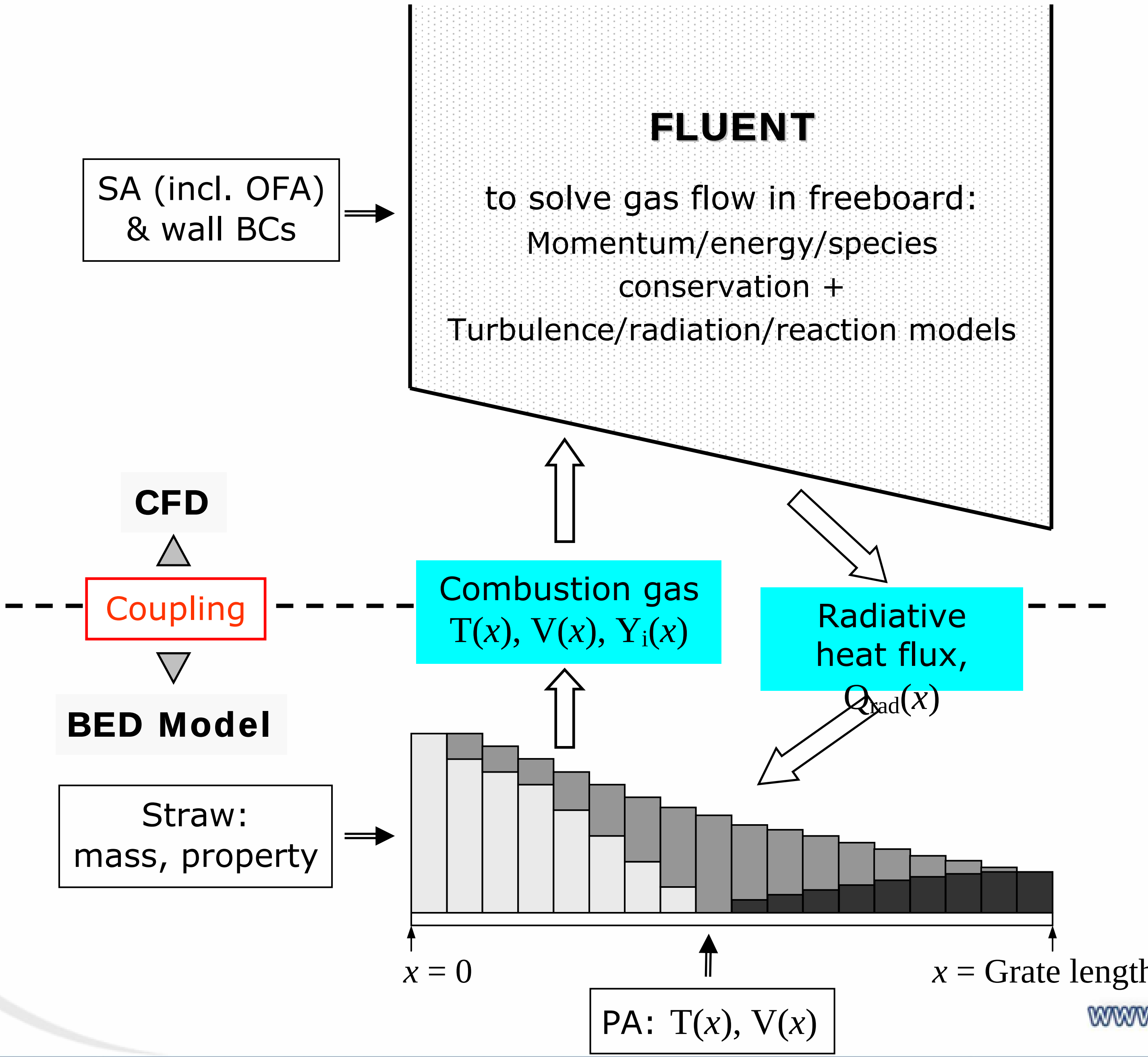
Fuel Conversion Processes

- Gas combustion in freeboard

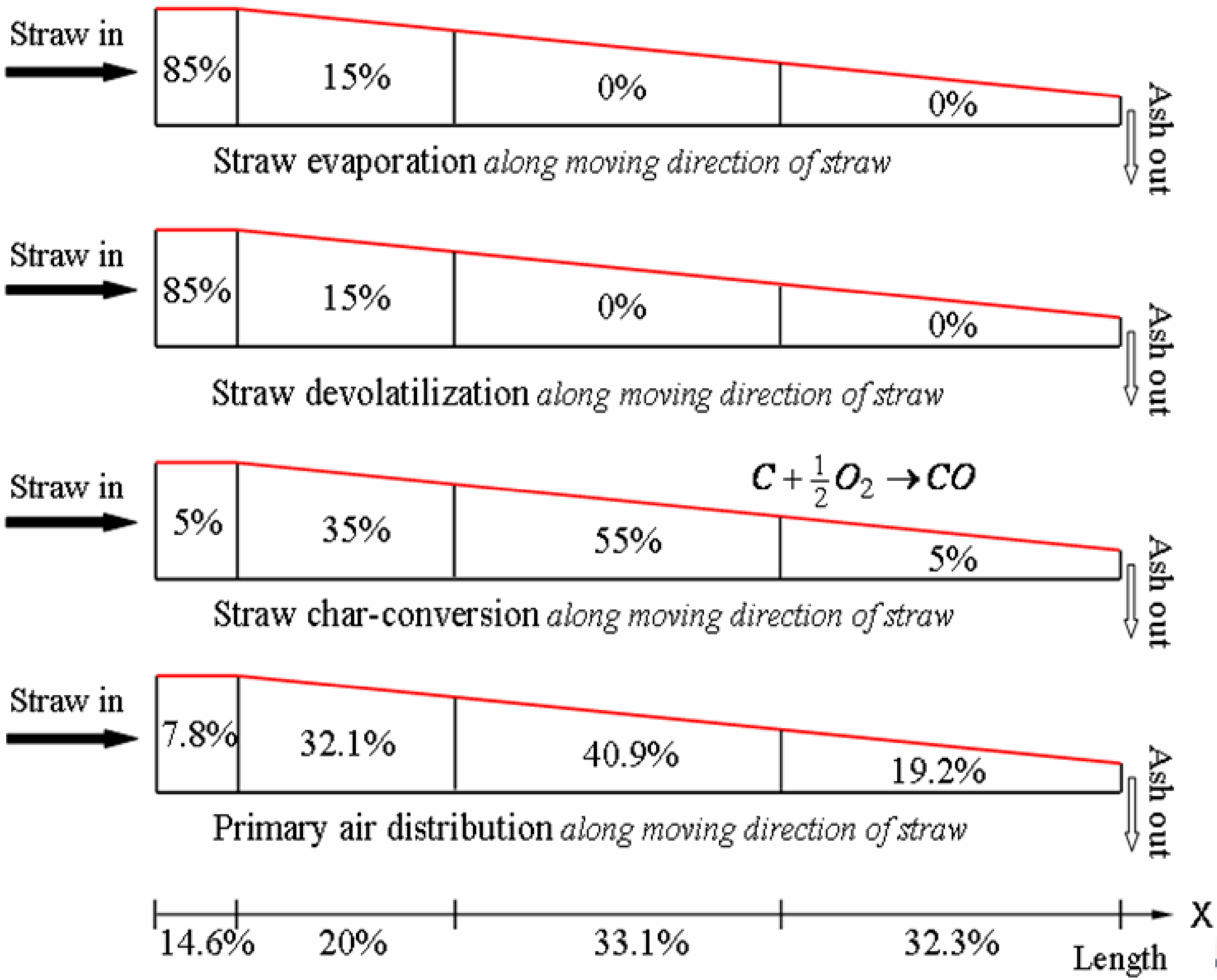


- Biomass conversion inside fuel bed

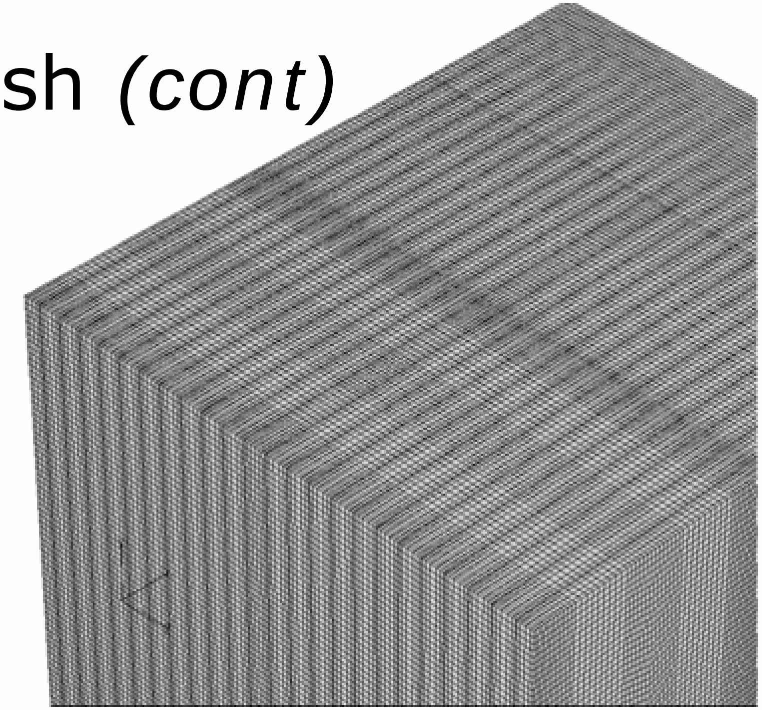
The Modeling Methodology

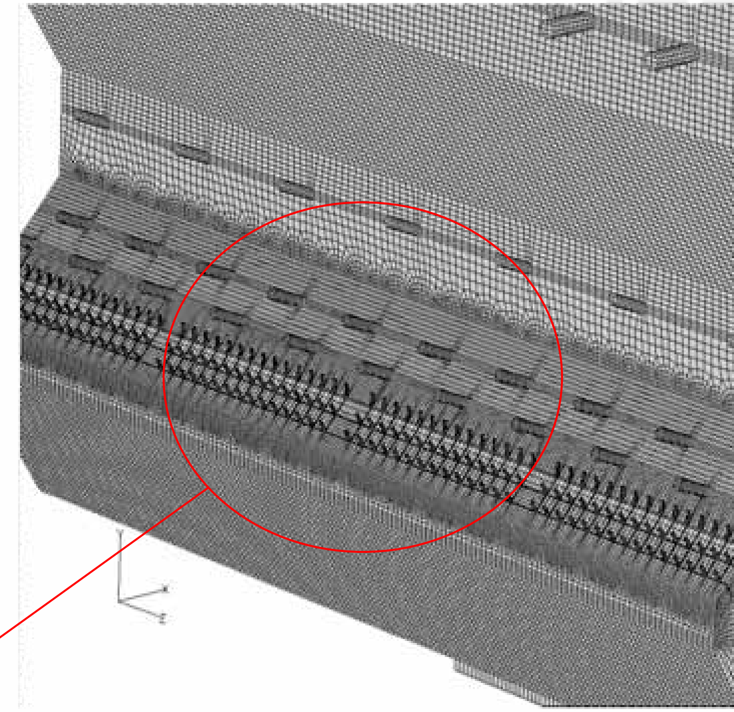


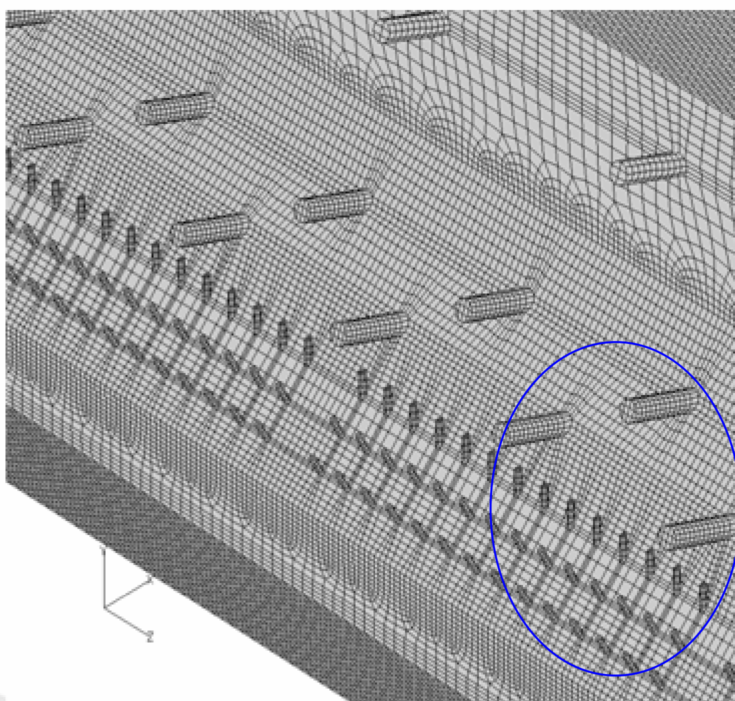
Bed Model: using experience-based conversion rate along the grate

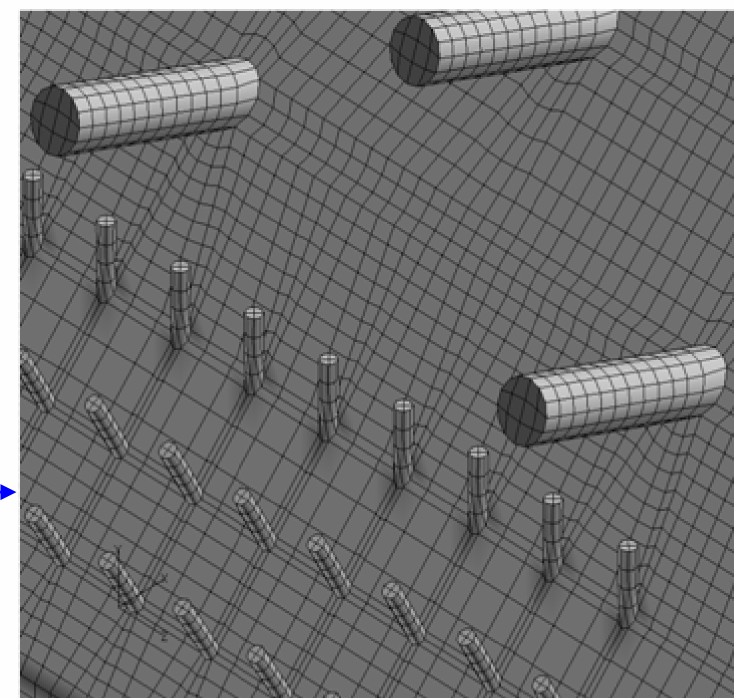


Mesh *(cont)*

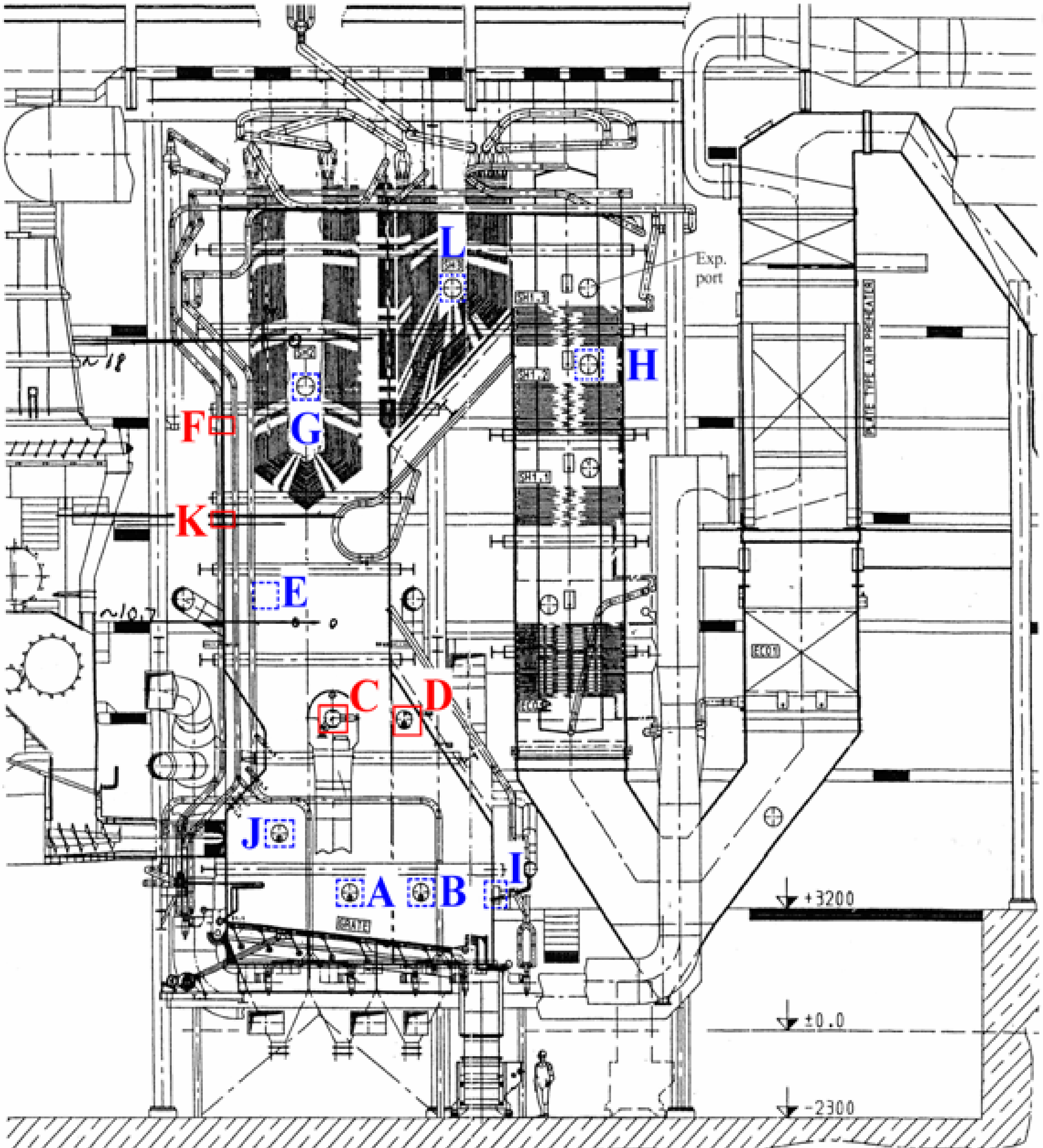








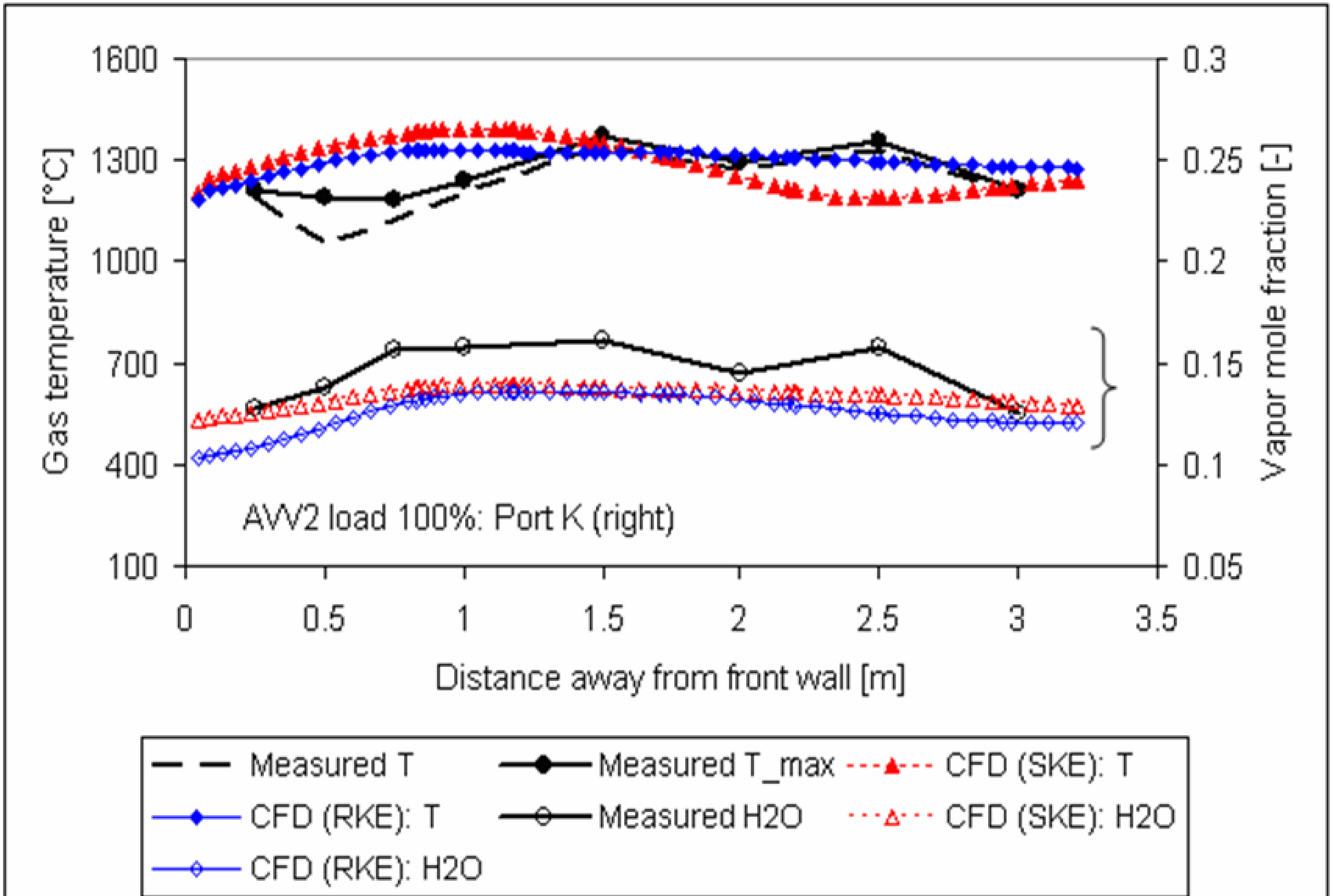
The Measuring Ports



Exit (100% load):

- T (wet): 165 ºC
- NOx (dry): 110 ppm
- SO2 (dry): 34 ppm
- CO (dry): 150 ppm
- O2 (dry): 6.5 %vol
- Boiler η: 91.7%

Validation: CFD vs. Measurements

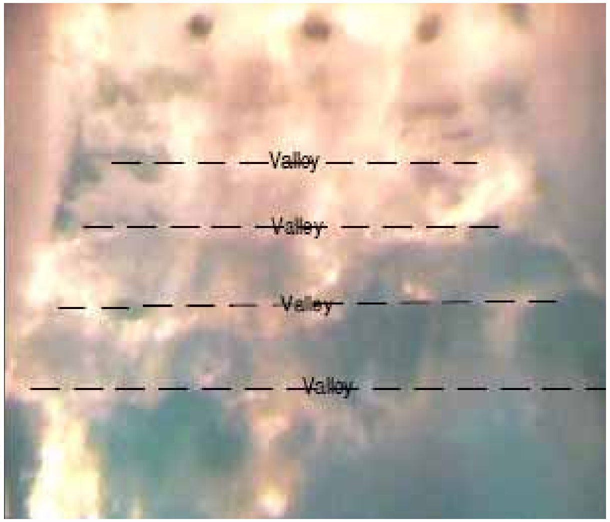


Modeling Challenges

- Three kinds of common combustion disturbances in fuel beds

(1) Local burnouts

(2) Wall-bounded channelling flow

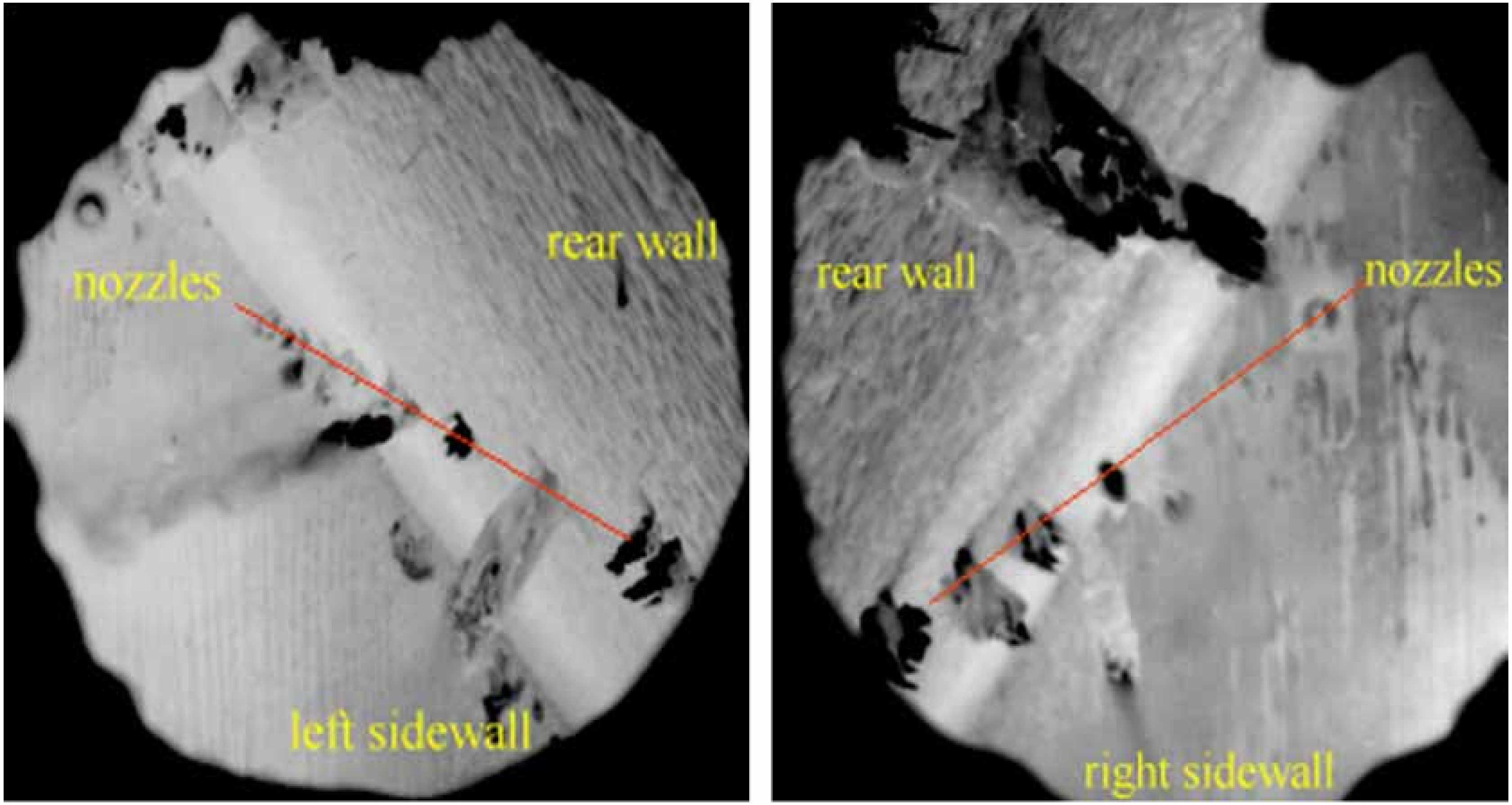


(3) Bed-level instabilities

- Discontinuous features (feeding, grate movement, …)

Modeling Challenges cont'd

- Deposits formed on furnace walls & air nozzles



- Uncertainties related to SA distribution
- …………

Concluding Remarks

- CFD is reaching a state where it becomes a reliable and very useful tool although is is still not predictive in all aspects

- Grate firing:
  - The fuel bed conversion is highly complex and requires substantial development to reach predictive modeling capabilities
  - If the main focus is free-board processes a simplified bed model can be used without substantial error

- Cofiring is suspension fired power plants:
  - Accurate description of biomass particle conversion (large, non-spherical particles) is needed
  - Further validation of near burner processes is needed

- It is important to remember
  - The computational grid along with the large number of standard modeling assumptions associated with CFD are still very important
  - The use of correct boundary conditions is critical