Low load operating protocol investigation of a 620MWe power boiler using a fast Eulerian-Eulerian CFD model

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Abstract

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Keywords: CFD, Eulerian-Eulerian, Boiler, Low-load operation

Nomenclature

			Greek letters		
Symbol	*Quantity*	*Unit*	α_p	Particle absorption coefficient	m^{-1}
A	Area	m^2	g	Gravity	m/s^2

1. Introduction

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2. Mathematical model

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3. Numerical modelling setup

In this section the numerical model configuration will be explained covering the boilers geometry, model inputs (e.g. fuel characteristics and boundary conditions) ending with the numerical solution strategy employed.

Table 1: Utility boiler fuel characteristics

Fuel constituent	**Fraction**	**Unit**
Ultimate analysis - (DAF)	-	-
Carbon	0.7753	kg/kg_{fuel}
Hydrogen	0.0415	kg/kg_{fuel}
Nitrogen	0.0181	kg/kg_{fuel}
Oxygen	0.1474	kg/kg_{fuel}
Sulphur	0.0175	kg/kg_{fuel}
Proximate analysis - (AR)	-	-
Fixed carbon	0.340	kg/kg_{fuel}
Volatile matter	0.196	kg/kg_{fuel}
Ash	0.4090	kg/kg_{fuel}
Moisture	0.0550	kg/kg_{fuel}
Energy content - (DAF)	**Value**	
Higher heating value	15070	kJ/kg_{fuel}

3.1. Geometry

3.2. Model inputs

3.3. Numerical solution strategy

Validation separately mention the rates/loadings - give results for 40% case inputs Low Ultra low load inputs

4. Results & discussion

The current section will discuss the results obtained from using the above-mentioned modelling methodologies. The validity of the modelling approach will first be established by comparing the simulation results for MCR load cases (namely 100%, 81% and 60% MCR loads) to that of the experimentally obtained results of the actual plant. Once the model has been shown to demonstrate sufficient accuracy in determining the overall heat loads and combustion characteristics in the boiler furnace at varying loads, the results of the various low-load burner firing configurations are shown and discussed.

4.1. Model validation

The validation of the proposed model was conducted for three steady-state MCR loads of 100%, 80% and 60%. The model inputs and boundary conditions can be obtained from the study conducted by Laubscher and Rousseau (REFERENCE), where they used an EL reference frame and DO radiation model.

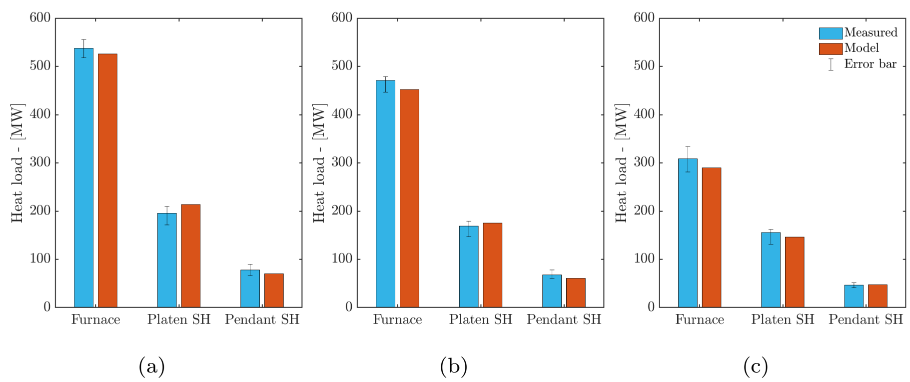
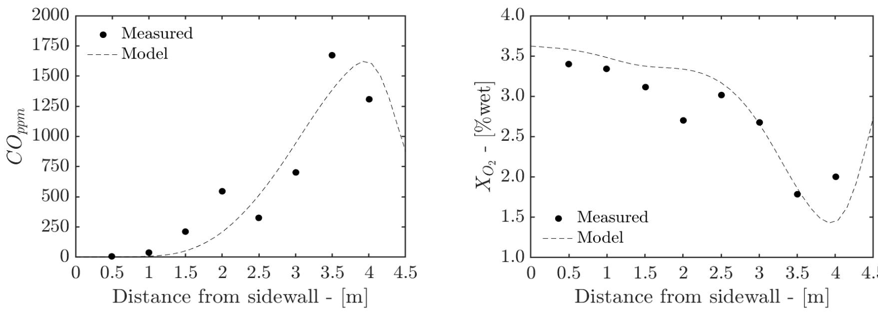


Figure 1: Comparison of experimentally calculated and model heat loads for the furnace, platen SH and pendant SH at (a) 100% MCR, (b) 80% MCR and (c) 60% MCR

In figure 4.1 it is shown that the overall heat loads are in good agreement with the measured results. For the simulated validation loads the proposed model results are within the associated error band, the general trend is an under prediction on the furnace heat loads and an over prediction on the platen super-heater. The pendant super heater illustrate the best comparable results for all load cases.

The CFD model was further validated by comparing the CO_{ppm} and X_{O_2} measurements against the CFD results. The probe measurements were taken at a furnace height of 37.5 $[m]$ near the center of the boiler during a full load (100% MCR) operating conditions. The probe is inserted from the side walls to a depth of 4.5 $[m]$, measurements were taken every 0.5 $[m]$ increment.



(a) (b)

Figure 2: Experimentally calculated CO and O_2 concentration predictions

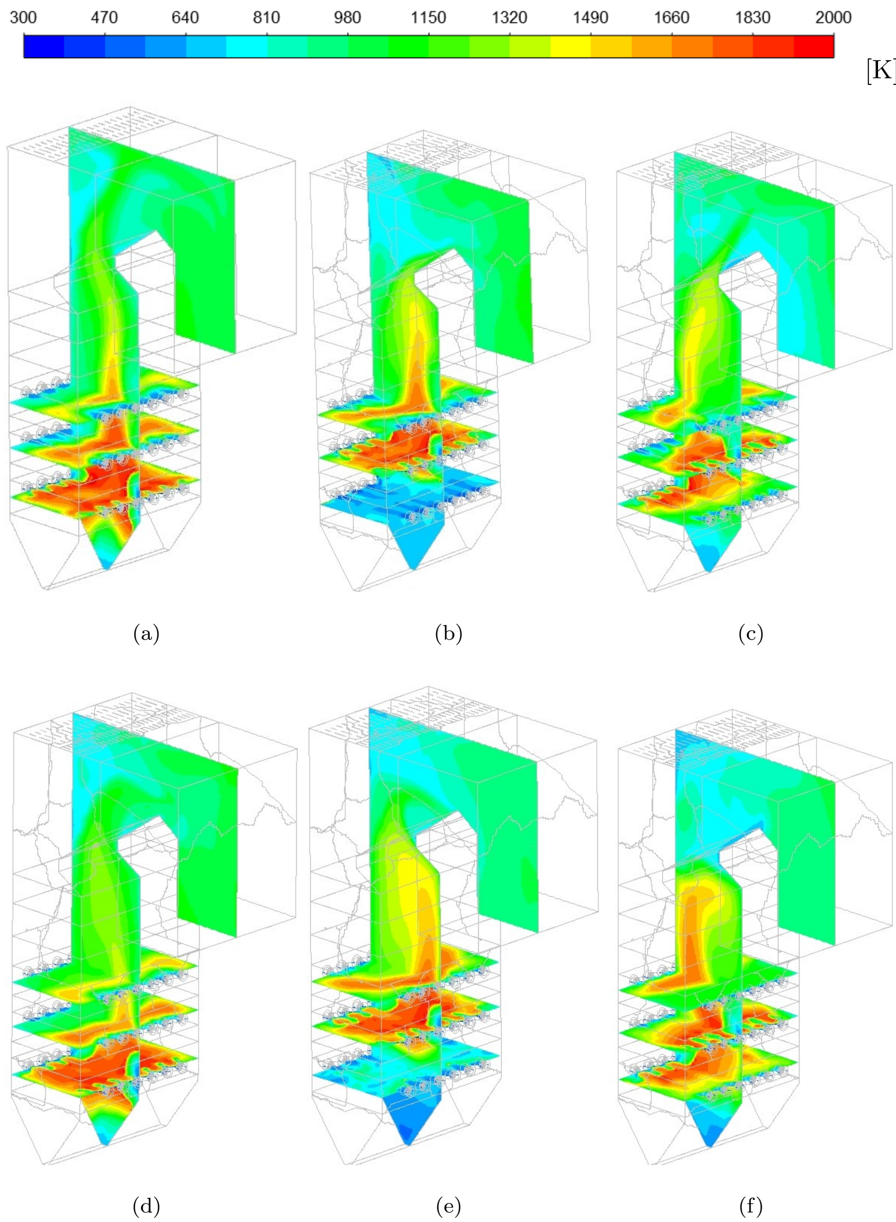
Figure 4.1 shows the averaged measurement values to that of the CFD predictions. It can be seen that the CFD model can sufficiently resolve the CO_{ppm} and X_{O_2} concentrations at the given probe location. For further information regarding the validation of the model the interested reader is directed to the works of Rawlins et al [REFERENCE]

4.2. Simulation results for various burner firing arrangements at 32% MCR

Explain the investigation table with case descriptions Need flownex model and process modelling description

Table 2: Utility boiler fuel characteristics

Value	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**
Platen max temp						
Pendant max temp						



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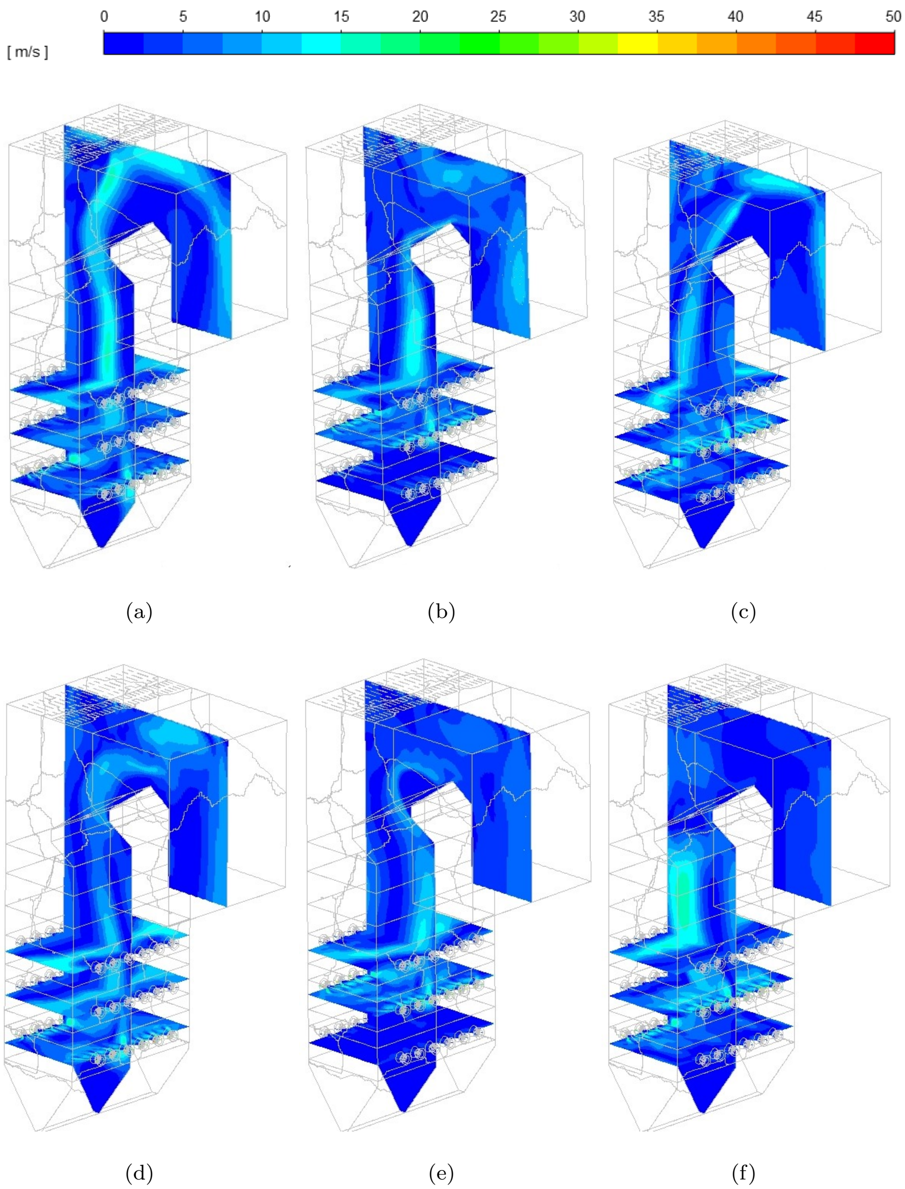

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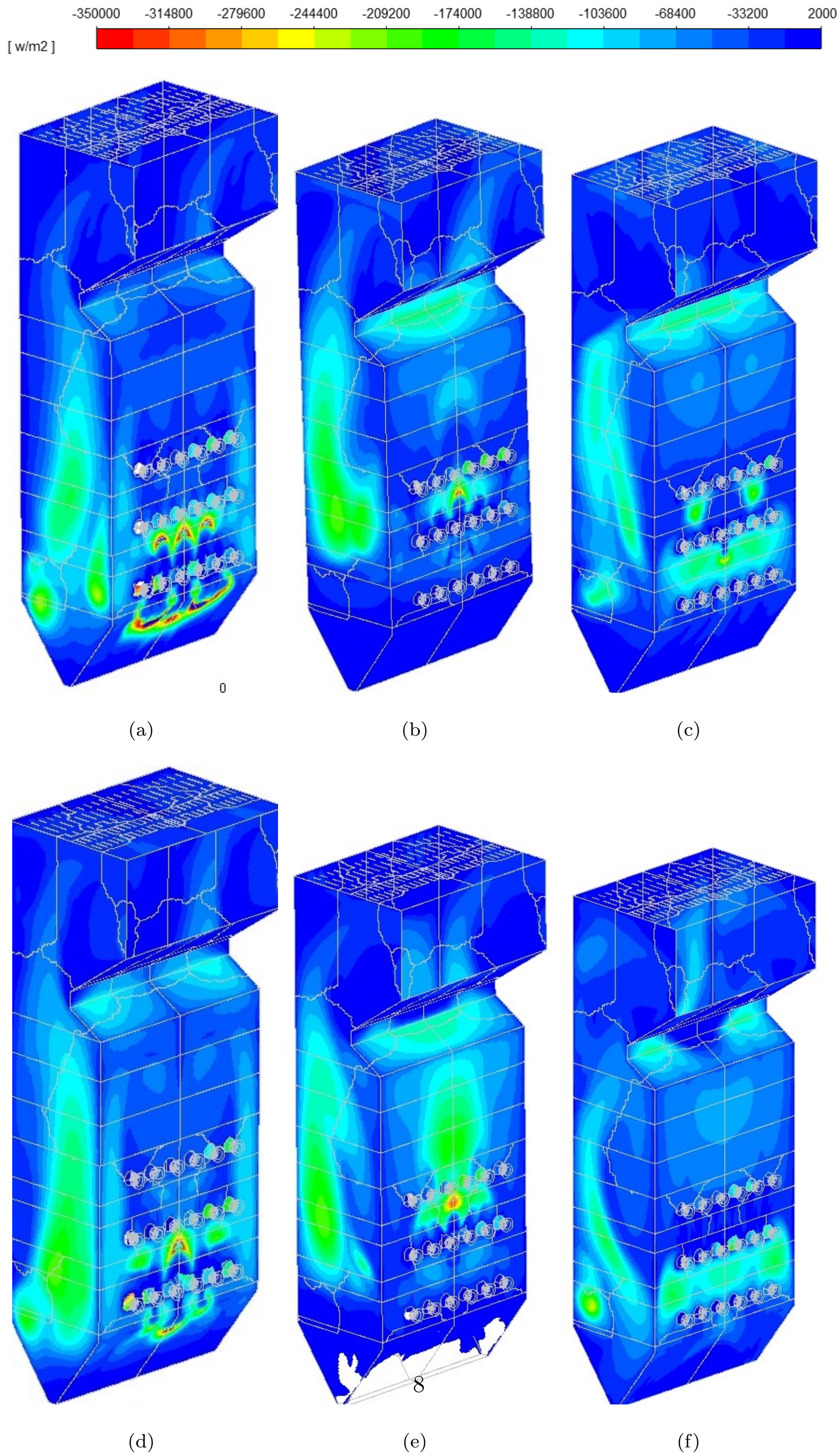
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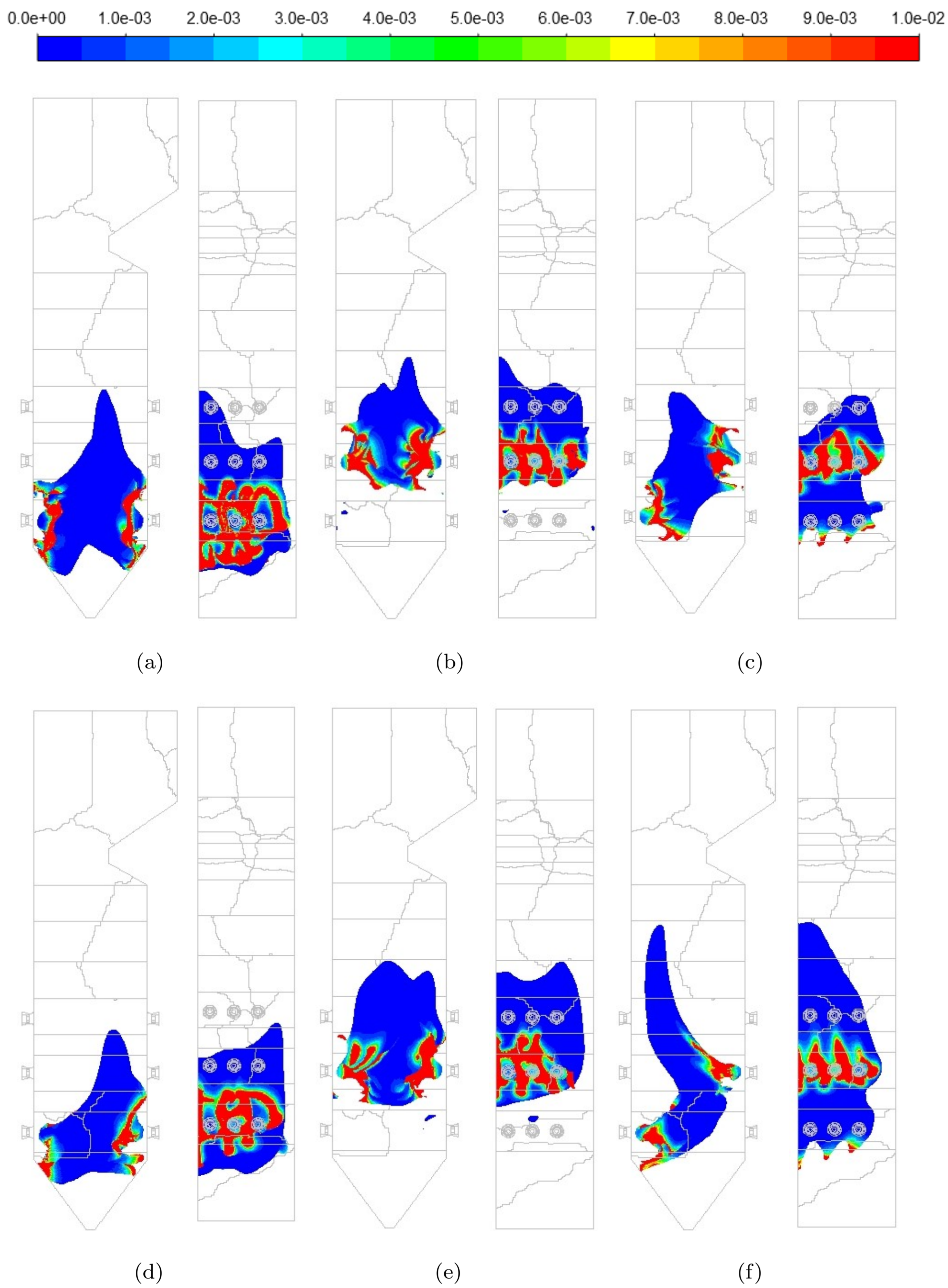
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5. Conclusions

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References