CFD ANALYSIS OF RADIATIVE HEAT TRANSFER IN BOILER FIRST PASS

Objective

To assess the radiative heat transfer phenomenon and resulting temperature distribution within various sections of first pass in a pulverized coal fired boiler.

Challenges

- Geometry clean-up and discretization.
- Meshing the domain with appropriate quality so that small volumes are captured.
- Appropriate radiation model to predict radiative heat transfer process.

CFD Model

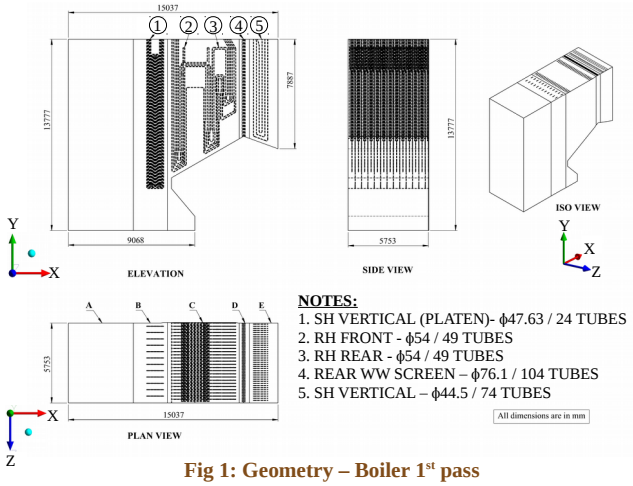


Fig 1: Geometry – Boiler 1st pass

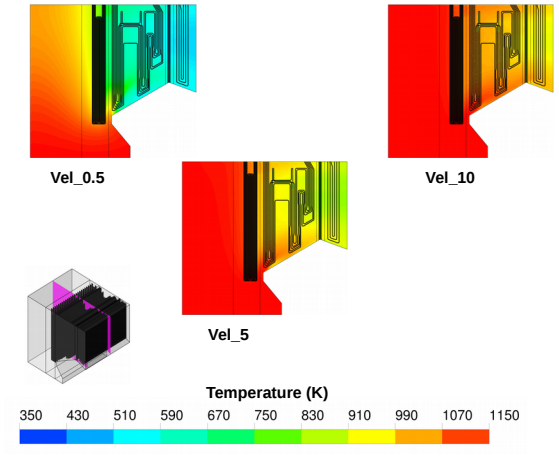
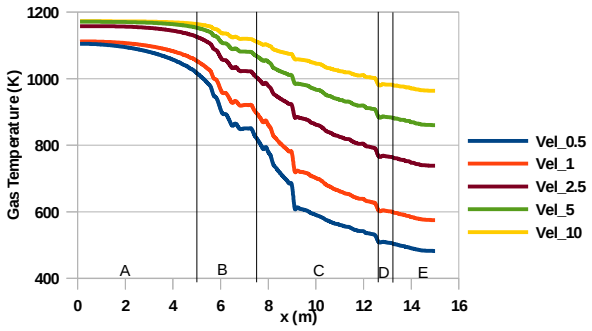
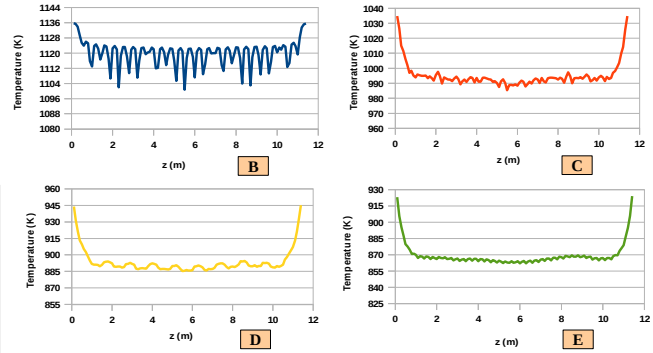


Fig 2: Temperature Contours



Graph 1: Temperature of Flue gas along the flow direction



Graph 2: Temperature of flue gas in the direction perpendicular to flow

Approach

Radiative heat transfer in first pass of tangentially fired PC Boiler is mainly through flame and hot gas radiation. In this study,an attempt has been made to model the phenomenon of radiation and predict the temperature distribution among the various sections within the first pass and its variation w.r.t to change in Boiler load conditions. The turbulent flow field of flue gas was resolved using RANS based Standard k-ϵ model and the radiative heat transfer phenomenon from hot flue gas was modelled using Discrete Ordinate (DO) method, with non reflecting internal walls. The domain was split into multiple zones (A,B,C,D&E) as shown in Fig 1 to facilitate quality meshing at critical regions. Flue gas at 900°C was set to be entering the domain inlet with varying velocity; temperature and radiative heat flux in each of the first pass zones were predicted and compared. For model validation, radiative heat transfer coefficient in the platen super heater area, predicted via the CFD model was compared with analytically results discussed by Dawid et. al.[1].

Conclusion

The process of radiative heat transfer, from flue gas to steam generating tubes in the Boiler first pass, predicted using DO Radiation model was in close agreement with the analytical value discussed by Dawid et. al.[1]. The effect of flue gas flow rate on temperature and heat flux distribution were also studied with the same approach and results were compared. CFD predicted values for temperature and heat transfer coefficient within various sections of Boiler first pass were found to be in good agreement with analytically calculated values.

Benefits

- Design of pressure part tube sections and positioning inside the boiler can be eased to achieve better and efficient heat transfer
- Optimization of size and numbers of heat transfer elements to meet the required load conditions.

Applications

- Design of boiler 1st pass pressure part components
- Boiler Furnace design.

1) DAWID TALER and JAN TALER, *Simplified Analysis of Radiation Heat Exchange in Boiler Superheaters*, Heat Transfer Engineering, 30(8):661–669, 2009)

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