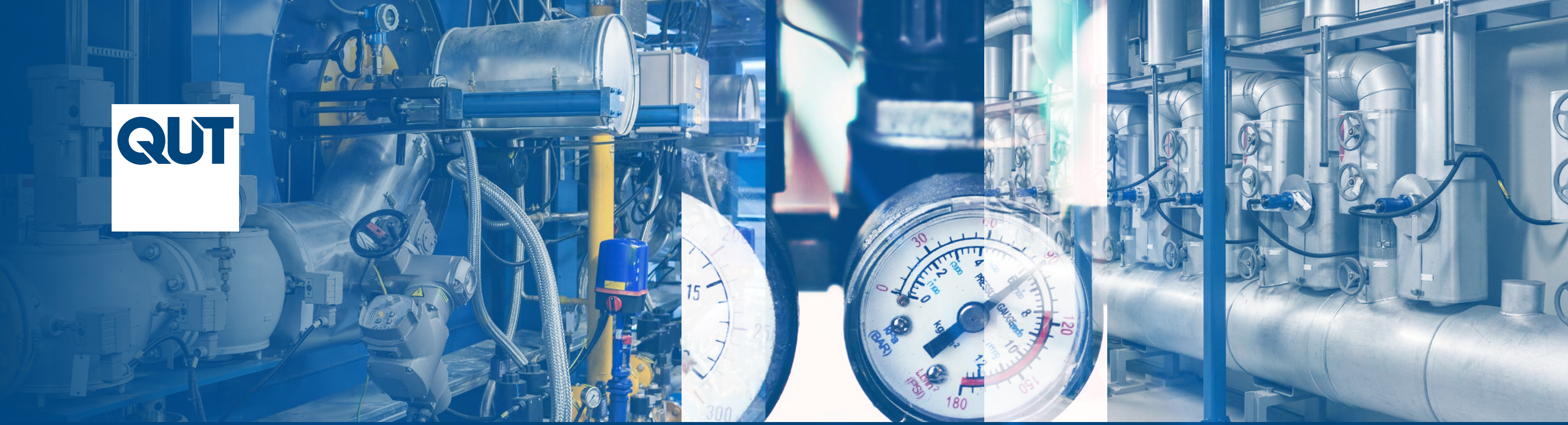


QUT RESEARCHERS IMPROVE BOILER PERFORMANCE THROUGH CFD MODELLING

How QUT staff can assist you

Staff at QUT have extensive experience in undertaking CFD modelling of the boiler gas, particle and air flows. Boilers that have been modelled include both biomass and coal fired boilers from 30 to more than 300 tonnes of steam per hour.

Boilers are a critical part of many industrial processes that require steam and/or power. High costs are associated with boiler replacement plant, boiler maintenance and boiler downtime.

The flow and combustion processes in boilers, particularly solid fuel boilers, are very complex. Consequently most boiler design is based on rules of thumb and past experience. To meet performance guarantees, boilers need to be designed conservatively and this increases capital costs. Even with conservative design, boiler maintenance costs are high and in many industries, fuel costs can be crippling if boilers operate at low efficiency.

Computational fluid dynamics (CFD)

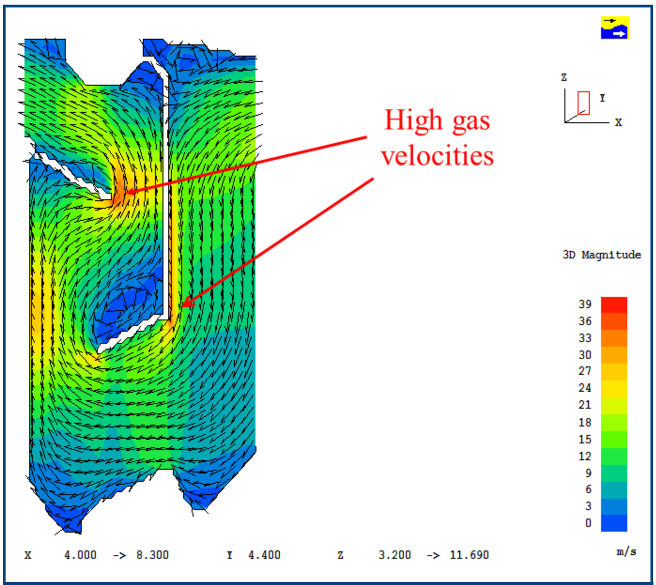
Computational fluid dynamics (CFD) is becoming widely used to predict flow patterns occurring in many industrial processes. When sub-models for combustion (single and multi-phase) and heat transfer (convection, conduction and radiation) are incorporated into CFD codes, the flow and temperature distributions can be predicted with sufficient accuracy to be used as a basis for engineering design decisions. Improvements to boiler efficiency using CFD modelling include:

- Reducing tube wear
- Reduced dew point corrosion
- Improved combustion performance.

Reducing tube wear

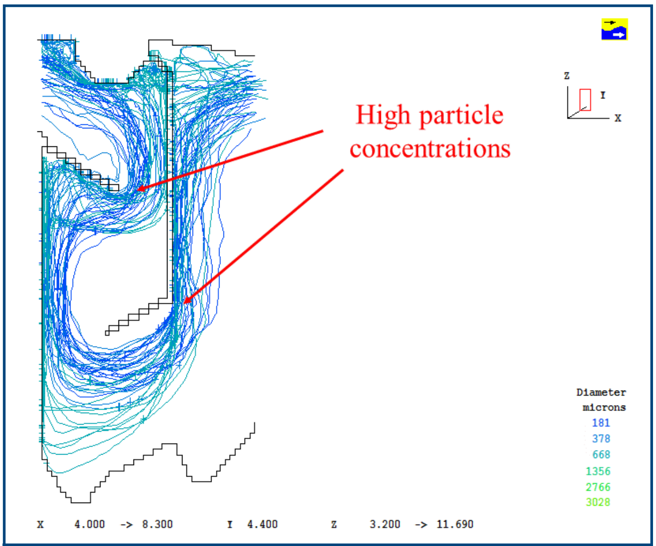
All tube banks and wall tubes in a solid fuel boiler are susceptible to wear by abrasive ash particles. If not addressed tubes leak and the boiler has to be shut down for repairs. Re-tubing a boiler tube bank often costs over one million dollars which is in addition to the costs associated with boiler down time.

The rate of tube wear is very sensitive to particle velocities and the impact angle between the particles and tubes. CFD has been extensively used to modify boiler designs to reduce peak gas velocities while maintaining enough flow across boiler tubes for high heat transfer. An example of the use of CFD for reducing boiler tube wear is shown in the side elevation view of the predicted gas velocity patterns in a boiler with a baffled convection bank. High gas velocities and tube wear rates are predicted to occur near the tip of the convection bank baffle in the upper left of the figure and around the base of the lower baffle.



Gas velocity (m.s[-1]) predictions: Colours show velocity magnitude, arrows show direction.

The locations also correspond to areas of high particle concentrations as seen in the corresponding plot of particle trajectories below.

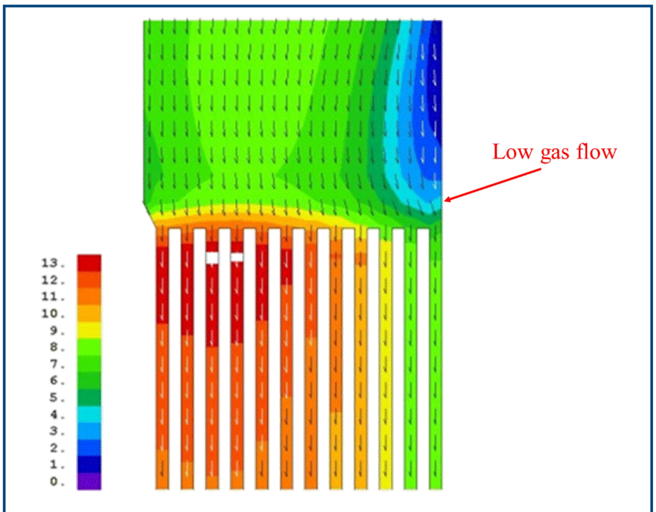


Particle trajectory predictions: Colours show particle size group.

CFD has been used to modify this and many other convection bank designs so that peak velocities are lower and cross flow is increased. Lower peak velocities reduce tube wear and more cross flow increases heat transfer.

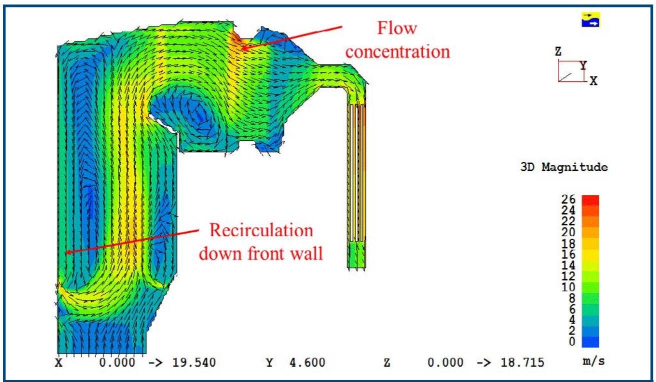
Reduce dew point corrosion

Dew point corrosion is a common problem in tubular air heaters. Air leakage through corroded tubes reduces boiler steam output and boiler efficiency. It often occurs in air heaters with a gas exit temperature well above the dew point of the flue gas because the gas and/or air flow distributions through the boiler are poor. Low gas flow through tubes as seen in the right side of the figure below will increase dew point corrosion.

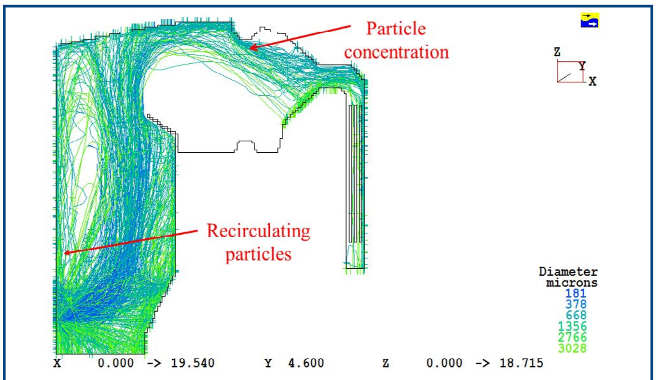


Gas velocity (m.s[-1]) predictions: Colours show velocity magnitude, arrows show direction.

CFD has been used to evaluate boiler design modifications such as the introduction of a furnace exit baffle as seen in the gas velocity and particle trajectory plots below.



Gas velocity (m.s[-1]) predictions: Colours show velocity magnitude, arrows show direction.



Particle trajectory predictions: Colours show particle size group.

A furnace exit baffle helps promote recirculation of gas and particles down the front wall of the furnace which should improve burnout. However it could also cause the gas and particle flows to be concentrated towards the top of the convection bank, affecting heat transfer and tube wear.

Improve combustion performance

High carbon monoxide concentrations in the boiler flue gas indicate poor combustion performance which is usually the consequence of a boiler being operated with too little air flow. However measured carbon monoxide concentrations can also be high when the measured oxygen concentrations indicate the total air flow into the boiler is correct. The problem in this case is often a poor air flow distribution into the boiler. This can be corrected by using CFD to design turning vanes and duct work modifications. With the improved air flow distribution combustion performance will improve and boiler fuel consumption will reduce. Furnace secondary air modifications evaluated with CFD analyses have also been used to improve combustion.

Contact QUT

Please contact QUT staff at the details below to discuss how similar consultations can be carried out for your boiler to reduce the ongoing maintenance costs and improve performance.

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