

Imaging Based Quantitative Characterisation of an Oxy-Coal Flame on a 500 kW_{th} Combustion Test Facility

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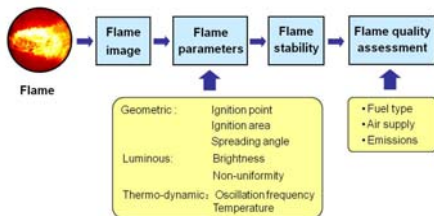
Background

Oxy-coal combustion with CO₂ capture from flue gas is a near-zero emission technology that can be adapted to both new and existing coal-fired power stations. However, switching to oxy-coal brings a number of uncertainties to the combustion process thus affecting furnace control. Quantitative monitoring and characterisation of flames in such a combustion process are therefore required to investigate the impact of the oxy-coal on the combustion characteristics of the furnace.

Methods

Digital imaging and image processing techniques were applied for the on-line monitoring and characterisation of an oxy-coal flame. A set of flame parameters were measured using a vision-based flame monitoring system.

- **Flame temperature**- computed based on the two-colour pyrometry.
- **Flame oscillation frequency**- the weighted-average frequency of the reconstructed signal obtained from the flame images.

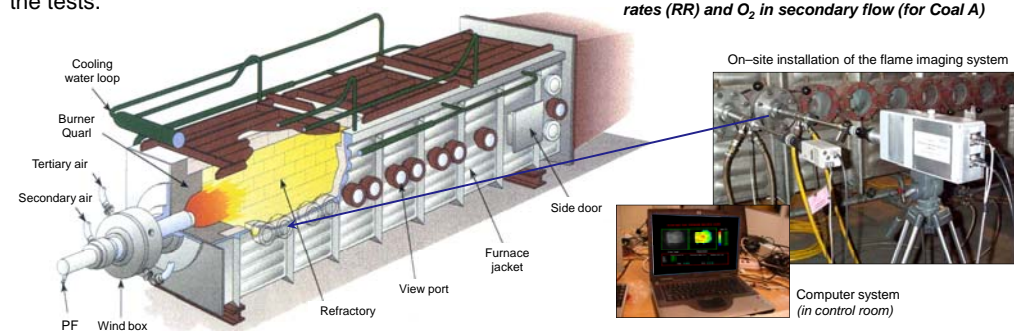


Vision based flame monitoring technique

Experimental Conditions

Experiments were conducted on the 500kW_{th} Combustion Test Facility run by RWE npower plc. Different simulated flue gas recycle rates (RR), i.e., 75%, 72%, 68%, 65% & 62%, were established for two coals (Coal A & Coal B).

For all test conditions, the primary flow (CO₂+O₂) was fixed at 155kg/h with the 16.2%O₂ (by mass). The secondary flow (Sec.f, CO₂+O₂) and the percentage of O₂ were set as variables for the tests.



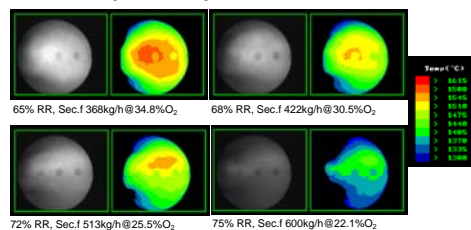
500kW_{th} Combustion Test Facility and the flame imaging system

Properties of coals tested

Content	Coal A	Coal B
Moisture (%)	total:4.74, inherent: 4.73	total: 3.71, inherent: 3.71
Ash (%)	14.29 (ar), 14.29 (aa), 15.00 (db)	14.67 (ar), 14.67 (aa), 15.24 (db)
VM (%)	29.60 (ar), 29.60 (aa), 36.56 (daf)	23.66 (ar), 23.66 (aa), 29.01 (daf)
Carbon (%)	62.64 (ar), 62.64 (aa), 65.75 (db), 77.36 (daf)	68.05 (ar), 62.64 (aa), 70.67 (db), 83.37 (daf)
GCV (kj/kg)	26717.3 (ar), 26717.3 (aa), 28045.3 (db), 32994.5 (daf)	26760.3 (ar), 26760.3 (aa), 27791.4 (db), 32786.5 (daf)

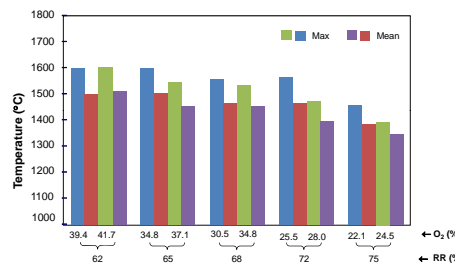
Results

Flame temperature profile

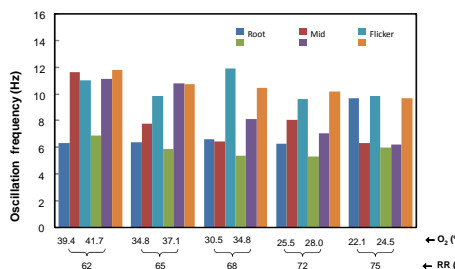


Flame temperature profile for different flue gas recycle rates (for Coal A)

Flame temperature and oscillation frequency

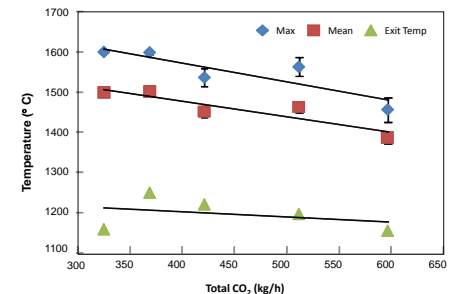


Flame temperature for different flue gas recycle rates (RR) and O₂ in secondary flow (for Coal A)

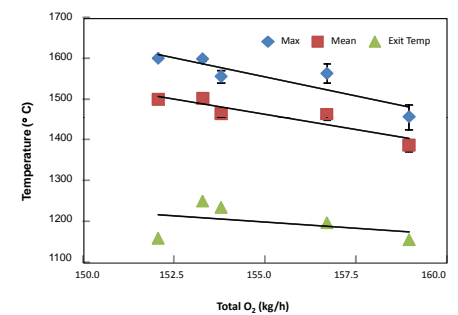


Flame oscillation frequency for different flue gas recycle rates (RR) and O₂ in secondary flow (for Coal A)

Flame temperature for total CO₂ and O₂



Flame temperature for different total CO₂ (for Coal A)



Flame temperature for different total O₂ (for Coal A)

Note: The data points are average values of 10 instantaneous readings. The "error bar" indicates the standard variation of the data.

Concluding Remarks

The digital imaging and image processing techniques have been applied for characterising oxy-coal flames on an industrial-scale test furnace for a variety of operation conditions. It has been found that the oxy-coal firing has a significant impact on the flame characteristics.

- The flame temperature and oscillation frequency decrease with the flue gas recycle rate, so as with the total CO₂ and O₂, indicating a decreased flame stability.
- In most cases, the oscillation frequency is lower in the flame root region than that in the middle region, indicating some ignition stability problem under the oxy-coal firing operation.

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