Emission Prediction of a Combustion Process through Flame Radical Imaging- A Feasibility Study

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Dr Gang Lu, Mr Duo Sun, and Dr Xinli Li*

Following the award of the Faculty Fund, the investigation into the feasibility of predicting pollutant emissions in combustion flue gas through flame radical imaging and soft computing techniques has been carried out. The objectives of the project were (1) to conduct extensive experiments to investigate the characteristics of flame radicals (OH*, CN*, CH* and C2*) and their relationship to the emissions (NOx, CO2) in flue gas; and (2) to determine suitable computing algorithms for predicting the emissions (NOx, CO2) in flue gas using characteristics of flame radicals (radiation intensity, spectral distribution, etc).

Under the fund, a part-time Research Associate (Mr Duo Sun) was appointed from February to March 2012. The project started with a literature survey following by extensive experiments on a laboratory-scale gas-fired combustion rig in the EDA Instrumentation Lab. The intensified imaging system which was built under a previous EPSRC funded project [1] was employed for the investigation. Propane gas was used as the primary fuel, and three types of biomass materials, i.e., wood chips, willow and palm, were used as biomass additions. Algorithms for predicting NOx emission from a combustion process have been investigated based on flame radical characteristics. The intensity contours and ratios of flame radicals (OH*, CH*, CN*, and C2*) were extracted as flame characteristic values, together with averaged temperature and NOx emission, were used to train the Neural Networks (NN) and Support vector Machine (SVM) models for the prediction of NOx emission. Experimental results have shown that the predicted NOx emissions are in good agreement with the reference values (taken using a gas analyser) with the maximum relative error of 8.29%. These are very promising results, proving the feasibility of predicting pollutant emissions in combustion flue gas using flame radical data. The results have led to three technical papers presented in international conferences [2-4].

The research fund has also allowed Dr G Lu to attend the IEEE International Conference on Imaging Systems and Techniques 2012 (IST2012) in Manchester in July 2012, and gave a keynote lecture at the event, in addition to present two technical papers. The attendance to the IST2012 also guaranteed the team to submit the full version of the paper to the Measurement Science and Technology Special Issue for the IEEE IST2012 [6], which should be a REFable publication if accepted.

The preliminary results of the investigation have been received a great interest from RWE npower, one of our long-term industrial partners, leading to the research proposal- Biomass Flame Monitoring at Tilbury Power Station, £9,874, submitted to RWE npower in July 2012 (pending).

In a review of the outcomes of the research, it is evident that the measurable outputs set in the proposal have been fully met. Future work will focus on evaluating the proposed algorithm for different biomass fuels in large scale furnaces, and the predicting of other pollutants in the flue gas (e.g., SO2, CO2) using the similar strategy.

References


4. D. Sun, G. Lu, and Y. Yan, ‘Monitoring and characterisation of biomass and coal fired flames on a full-scale power station,’ the 9th European Conference on Coal Research and Its Applications, 10th-12th Sept 2012, Nottingham, UK.


Dr Gang Lu (EDA)

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* Dr Xinli Li is a visiting researcher from North China Electric Power University.