An Integrated Sensor System for the Optimisation of Pulverised Fuel Fired Power Plant

Y. Yan(1), R. M. Carter(1), J. Krabicka(1), S. Cornwell(2)
(1)*Department of Electronics, University of Kent, Canterbury, Kent CT2 7NT, UK*
(2)*RWE npower, Windmill Hill Business Park, Whitehill Way, Swindon SN5 6PB,UK*

The use of renewable and low quality fuels in the power generation industry is becoming increasingly widespread. This presentation summarises the recent development of an advanced sensor system for combustion efficiency optimisation and consequent CO2 reductions through the use of new and emerging sensor technologies. Sensor technologies for flame stability monitoring, on-line fuel tracking, fuel flow metering and particle sizing have been combined to establish an integrated, cost-effective sensor system. Following the design and implementation of a prototype system, extensive experimental evaluation has been undertaken on industrial-scale combustion test facilities by firing a range of biomass fuels, low quality coals and fuel blends. Demonstration trials are being undertaken on full scale power stations.

Introduction

Coal-fired power stations are burning an increasingly varied range of fuels, including biomass and coals of varying composition, under tight economic and environmental constraints. To achieve more efficient operation of power plants using these fuels it is imperative to monitor and measure concurrently a number of parameters on an on-line continuous basis. It is well known that the optimization of plant operating conditions leads to significant reductions in both harmful environmental emissions and operating costs [1]. The present research has been undertaken in order to explore the capability of a suitable combination of current cutting-edge new and emerging sensor technologies [2]. This work should not only prove useful in optimizing existing plants but also provide the quantified operational knowledge required when specifying and designing efficient new build installations.

Methodology

Flame Stability Monitoring

Power plants monitor the intensity of flames in the interests of safety through the use of photo sensors built into ‘flame eyes’. Existing systems use this information to indicate flame presence or out, allowing automatic shutdown of fuel feed mechanisms in an absence of flame. For the present research flame stability monitoring is achieved by ‘tapping’ the signals from existing flame-eyes and processing the resulting data using a dedicated signal processing system. The information gives plant engineers immediate information regarding the stability of combustion.

Fuel Tracking

Power plants often store fuels on large stock piles which come from many sources and are of varying type and quality. On-line fuel identification (tracking) of the type of fuel being burnt is highly desirable in order to use plant optimization software packages to obtain the best possible plant configuration for improved efficiency and reduced harmful emissions. In the present research fuel tracking is achieved through advanced flame monitoring. Three different wavelengths of light generated by the flame are received and various parameters in both the frequency and time domains are extracted. These parameters are then used as inputs to a trained neural network for on-line fuel identification [3, 4].

Fuel Flow Monitoring and Particle Sizing

Fuel particle velocity and particle size distribution are important parameters when optimizing the fuel flow aspects of power plant operation. The fuel particle velocity is measured using electrostatic sensors [5]. For particle size measurement a digital imaging technique is applied. By illuminating the flow with a pulsed laser sheet it has been possible to acquire clear images of particles and by image processing to establish particle size distribution [6]. It should be noted that in the present system both measurement devices are integrated into the same sensor housing for easy installation.

System Integration

Fig.1 shows the installation of the integrated instrumentation system at a coal fired power plant in the UK. Only is one row of burners shown here, there being more such rows in reality. Flame-eyes were installed on all burners, but for fuel tracking, flow metering and particle sizing sensors, these sensors were on one of the burners on each row.

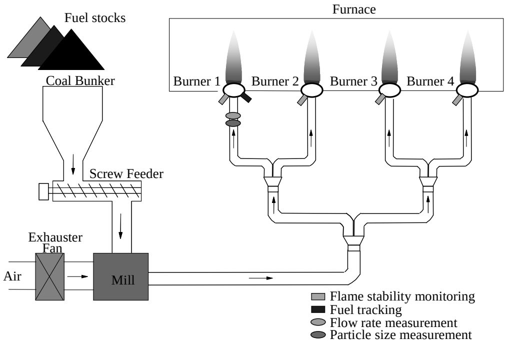

Fig.1.Installation of the integrated instrumentation system

On-Plant Trials

Demonstration trials of the integrated system are being undertaking. The performance of each sub-system is also being assessed. The flame stability monitoring system as installed at the plant is seen in Fig.2. Flame stability data have been used to diagnose the conditions of the burners and their configurations for combustion optimization.

Fig.2 Flame stability monitoring system in operation

A fuel tracking head is outwardly similar to standard flame-eye design and its installation at the burner is shown in Fig.3. Four different types of coal were tested under routine operational conditions.

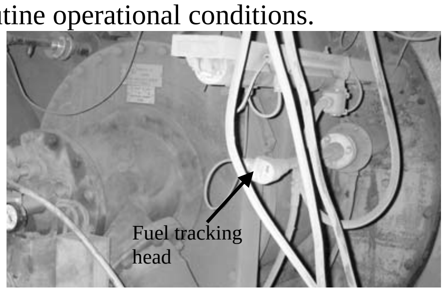

Fig.3 Fuel tracking head installed at the burner

Fig.4 shows the combined imaging and electrostatic flow metering sensor with the housing removed. The sensor is fitted in a 4” cylindrical BSP port to maintain compatibility with existing duct access points.

Fig.4 Combined particle sizing and flow metering sensor

Concluding Remarks

The present research has brought together a number of modern and novel instrumentation technologies to create an integrated measurement system. Initial data from the plant trials have demonstrated the functionality and operability of the system under full scale industrial conditions. It is envisioned that such a system will be deployed throughout the chain of power plant operations from fuel delivery to burner front with effectiveness spanning from fuel stock piles to ultimate exhaust emissions. It is anticipated that the availability of the data provided will allow both existing and new-build plant to be optimized in terms of plant efficiency, economic viability and environmental emissions.

References

[1] CRF/BCURA, Coal Research Needs in the UK, 2004.
[2] Malmgren A., Oluwande G. and Riley G., Multiphase flow in coal-fired power plant, DTI/Pub URN 03/1635, 2003.
[3] DTI Cleaner Coal Technology R&D Programme, On-Line Fuel Tracking by Advanced Flame Monitoring, Project Number 327, 2006.
[4] Xu L., Yan Y., Cornwell S and Riley G, On-line fuel identification using digital signal processing and fuzzy inference techniques, IEEE Transactions on Instrumentation and Measurement, 2004, 53:1316-1320.
[5] Ma J. and Yan Y., Design and evaluation of electrostatic sensors for the mass flow measurement of pneumatically conveyed solids, Flow Measurement and Instrumentation, 2000, 11:195-204.
[6] Carter R.M., Yan Y., Cameron S.D., On-line measurement of particle size distribution and mass flow rate of particles in a pneumatic suspension using combined imaging and electrostatic sensors, Flow Measurement and Instrumentation, 2005, 16:309–314.