Improving combustion efficiency in utility boilers - a UK perspective

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Unburnt carbon is a major problem with ageing plant. Carbon-in-ash in a new plant will be about 3%, but for ageing plant employing low NOx technology it can be as high as 15-20% or higher!

The carbon residual in fly ash results from several factors:

- Coal quality,
- Plant condition: in-leakage, problems with mills, burners, dampers etc. on day to day basis,
- Plant operation: control issue, excess air.

The impacts of high carbon-in-ash are:

- Reduced efficiency, hence higher CO_2 emissions,
- Reduced efficiency of electrostatic precipitators leading to high dust emissions,
- Ash utilisation problems.

New emissions legislation increases the pressure to use technologies that result in an increase carbon-in-ash. Deregulation forces utilities to look for cheaper coal supplies, which are often of poorer quality or significantly different from the station's design coal. The question with ageing plant is where to invest limited resources to give the best returns. Innogy plc own and operate 3.5GW of coal fired plant and provide technical support to 6.3GW of coal-fired plant in the UK (which includes AES Drax power). The boilers & combustion team provides expertise in fuels and boiler plant engineering for Innogy's operations and development activities. While the Team provides day to day support to its own and third party plant, it also undertakes more fundamental work. This is often funded by the UK government's Clean Coal Programmes. Projects such as this form part of the continual improvement of Innogy's business.

This presentation will describe two such projects:

1) Improvement in Combustion Efficiency in Utility Boilers (Status on-going)

Innogy are managing a major project part funded by the UK government. The project is a collaborative project involving four UK power generators, boiler and burner manufacturers as well as leading Universities in the field. Cost £1,470,000, £440,000 from UK DTI (30%).

The aim of the project is to optimise operational performance through benchmarking and more informed coal purchasing. This will be achieved by developing new tools for the reliable and rapid prediction of combustion efficiency of coals in pf-fired utility boilers. This will give the ability to improve fuel selection and chose the most appropriate burner/boiler design for a given fuel.

The objectives are to:

- review previous work to predict combustion efficiency;
- identify how prediction can be made quick and more reliable than in existing methods;
- develop the ability to predict how a coal will perform on a given boiler. This will include the ability to allow for specific plant problems, eg, mills, air ingress etc;
- provide a predictive tool which can be used to quantify combustion improvement from proposed plant modifications.

2) The effect of coal blending on combustion performance (status complete)

Objectives

- To identify the accuracy and benefits of small-scale tests for the characterisation of the burnout behaviour of coal blend in full-scale utility boilers
- To generate a comprehensive burnout data set on a suite of coals and coal blends, by carrying out controlled experiments using laboratory-scale or full-scale utility boilers.
- To critically assess and compare the relative effectiveness of current computational fluid dynamics (CFD) modelling techniques to predict blend burnout behaviour.
- To derive, describe and test a methodology that quantifies the relative contribution of component coals to the overall burnout of a blend.

In this project, a small-scale mill was set up to reproduce a pf size distribution similar to that produced in power station mills. It was also used for studying milling properties of individual coal components and their blends. The combustion behaviour of the various coal blends was investigated on a 500kW_t pilot-scale combustion test furnace (CTF) and in a laboratory-scale drop tube furnace (DTF). To demonstrate the applicability of these to full-scale, a series of tests were carried out on a full-scale boiler. CFD modelling was also used to predict the performance of coal blends in the CTF.

The small-scale milling system was successfully modified to enable it to produce aerodynamically classified pf with similar chemical composition to that from a power station mill. A comprehensive data set was obtained for a number of coals of different types and for blends prepared from them. The effects of coal type and particle size were demonstrated at both laboratory- and pilot-scale, however, pilot-scale rigs were confirmed to be the only accurate method for quantitatively determining the cost benefits of blending coals at full-scale.

A methodology for assessing coal blends was devised and improved testing and data processing procedures were developed for making good assessments of carbon in ash levels from laboratory-scale data. The possible error from using “average” blend properties was demonstrated. Mathematical modelling was shown not to have developed sufficiently for it to be used as a tool in assessing coal blends for power station use at this time. There are still significant difficulties that

must be overcome before it can be used as a fuel assessment technique. However, the possibility of incorporating test data for different blend components was demonstrated.

The presentation will also include a brief discuss of other work that is being carried out by Innogy plc in areas relevant to unburnt carbon, for example: novel leakage detection, ash re-firing, and ash beneficiation.