M.J.Hennessy, Andrew Pain and Michael Edwards, Scantech, Australia, look at online analysis of coal for the control of parameters at an Australian power plant.

Looking online

Liddell power plant was commissioned in 1973 and is situated approximately 10 km south of Muswellbrook off the New England Highway, in the Hunter Valley region of New South Wales, Australia. The plant has four 500 MW generators. Liddell and Bayswater (which is also set in the Hunter Valley) power plants are a part of Macquarie Generation, a state owned corporation, which supplies the state of NSW with approximately 40% of the state's electricity demand.

Liddell buys coal from nine local mines. Variations in the quality of the coal impact on the running costs associated with the operation of the power plant in a number of ways. In a direct manner, poor quality control of the processed coal will increase waste disposal costs, maintenance costs and will require the use of a larger amount of coal to provide the same net energy to the electricity grid. Poor quality control also means increased risk of exceeding the limits of emissions into the atmosphere.

Recently Liddell power plant has installed and commissioned two 9500X Coalscan online analysers to achieve these process control requirements.

Benefits of online analysis

Liddell produces electricity from four steam driven turbo-generators. Each turbo-generator is connected to a boiler which uses finely pulverised coal to produce the steam needed. Coal for the four boilers is supplied from the nearby privately-owned mines. Most coal is delivered to the plant by overland conveyors. It is directed either to the plant bunkers for immediate use or to an adjacent storage area that can hold up to 2 million t. Thus, on the basis of the results from online analysers monitoring the quality of these coal supplies, the operators have the opportunity to blend coals being delivered with that stockpiled.

Liddell is 'licensed to co-fire plant biomass coal to produce electricity', which essentially means it can use sawdust and wood shavings from the nearby timber industry as a portion of its fuel, replacing up to 5% of its coal requirements. In practice, however, biomass accounts for only about 0.5% of Liddell's output. The online analysers also monitor the impact of this biomass on the plant processes.

Additionally, Liddell as a business wants to ensure it keeps maintenance costs to a minimum, while still achieving limited downtime. It also wants to keep running costs to a minimum, that is, it wants to ensure the energy efficiency is maximised by maintaining a consistent feed to the boilers. Keeping a consistent quality feed to the boilers will help attain all these goals, and is best achieved by real-time process control using online analysers.

Driver for reducing emissions

Studies in the 1970s first warned of the problem of acidification, or acid rain. Several studies confirmed the hypothesis that air pollutants could travel several thousand kilometres before deposition and damage occurred. This damage includes effects on crops and forests. Most acid rain is caused by airborne deposits of sulphur dioxides (SOx) and nitrogen oxides (NOx). Coal and oil-burning power plants are the biggest source of SOx.

In response to these concerns, the NSW Environmental Protection Agency currently requires the maximum SOx emission from any site to be 600 ppm over a one hour rolling average, and the emission of dust to be 100 mg/m^3 over a one hour rolling average. The site is not automatically fined for exceedences. The penalty is in accordance with the number of exceedences, how long the exceedence lasted, was it dust or SOx and the actual emission level(s). There has never been a problem limiting the NOx to less than the mandated limit of 700 ppm/rolling hourly average. The EPA uses a non-

9500X Coalscan online analyser.

dispersive IR analyser in the hut adjacent to the stacks to monitor SOx and NOx emissions.

Liddell has long-term contracts with its coal suppliers and what it gets is what it burns. The justification for the purchase of the Coalscans was to address this SOx problem by suitable blending of coal from the various suppliers.

Use of online coal analysers at Liddell

Liddell's two main conveyor belts lead directly to the bunkers which supply coal to the boilers, both have a Scantech online 9500X Coalscan. Placing the analysers on the direct lines to the boiler bunkers, allows the operator to blend in real-time by selecting the coal's origin.

The Coalscan's results are available to the plant's display system, which are then displayed onto Liddell's Citect screens that can be viewed in the trends pages. Operators monitor the Coalscans' output on the screens; showing projected the ash, sulphur, moisture, specific energy and SOx. The operators then manually switch over coal type to ensure that the average emitted SOx is below the 600 ppm/rolling hour.

Before the installation of the Coalscans, if the operators were about to use a traditionally high sulphur coal, they would blend it with a traditionally low sulphur coal. Once the coal has been conveyed out of their holding bins they are locked into using this coal in their burners. The non-dispersive IR monitor would only allow them to tell them sometime afterwards whether the blending was done correctly.

Coal from each supplier is stockpiled according to its expected quality. Macquarie Generation purchases the coal on the basis of that expected, average quality. However, there is often found to be significant variation in the coal quality within a stockpile and between stockpiles from each supplier. Online analysis of the coal permits the operators to account for this variation by making appropriate changes in the blending program. An SOx alarm is set to 550 ppm/rolling hourly average. A loud siren is set off which sets the operators into corrective actions.

How it works

Since the early 1980s the use of online analysis using Prompt Gamma-ray Neutron Activation Analysis (PGNAA) technique has become prevalent for elemental analysis for the measurement and subsequent control of critical parameters of the coal, for example, being injected into the boilers at power plants.

A PGNAA analyser uses a neutron emitting source, the neutrons which are absorbed by the nucleus of an element in the coal which causes the nucleus to become unstable, with the resultant emission of several gamma-rays restoring the elements' nucleus to a stable state.

When coal is irradiated with thermalised neutrons from an isotope source (Californium-252, Cf252) the neutrons may be captured by nuclei in the coal. The likelihood of capture by any particular element depends on the concentration of that element in the coal and on the thermal neutron capture cross-section for that element. When capture occurs, characteristic gamma rays for that element are promptly emitted, with energies typically in the range 1 to 10 MeV. The Coalscan measures the gamma rays and then identifies the elemental composition of the coal in real-time. The elemental concentrations are then used to calculate derived parameters such as ash, specific energy and SOx.

The earliest of Scantech's PGNAA analysers was the Coalscan 9500 model, where a sample of the material on the main conveyor belt would be directed using a sampler to a secondary belt that supplied a steady stream of sampled material to the analyser - denoted as a by-line analyser.

The modern designed analysers, such as the Coalscan 9500X, are now installed directly around the primary belt, and so measure all the material of interest. Direct on-belt analysis of the material of interest has numerous advantages, the most important being that all of the material of interest is 'seen' by the analyser, so that there can be no errors from sampling, both by the by-line sampling technique and that used by laboratories for analysis.

All the PGNAA analysers can measure the moisture of the coal with the addition of the microwave hardware, which can be easily configured during manufacture.

Analysers that employ PGNAA technology have the capability to measure the concentration of a number of key elements. With the measurement of the sulphur, and with the use of blending software, the end user can control SOx output levels from the stack by adding a low concentration sulphur coal with a higher concentration coal to produce a resultant product that will ensure that emission levels are within the EPA.

The future

The EPA is regularly reducing the permissible SOx emission levels and thus it is likely that in the near future there will be even greater importance in the Coalscans for process control in order to ensure that the power plant does not exceed even more stringent limits.

The operators do not currently blend the coal to a target ash or specific energy. It is recognised that such process control will improve plant efficiency as the burners were designed for a particular range of coal qualities. They deliberately buy coal that is most economical in terms of dollars per megajoule and then just burn it, albeit ensuring that there are no SOx exceedences. It is recognised though, that these short-term cost savings need to be balanced with long-term efficiencies in plant operations.