Regarding quality...

Michael Edwards, Scantech, Australia, explains the advantages of online coal quality analysers.

Environmental demands for sustainable development have led to the coal industry investing in new technologies to improve efficiency and reduce emissions from coal production and coal burning in power stations and other industries. For many years Solid Energy New Zealand Ltd has been introducing 'clean coal' technologies into the country. With New Zealand's ratification of the Kyoto Protocol in December 2002, there are increasing incentives for further improvements.

In modern coal plants, quality assurance at all stages of production must be defined, measured and audited. All stakeholders are demanding compliance with international standards for quality assurance.

Real-time coal quality analysis during the various phases of coal production can permit adherence to environmental standards and at the same time provide operators with significant opportunities for quality assurance. Therefore, online coal quality analysers have become a standard process control tool in the coal industry.

Overview

As part of their response to these environmental and quality assurance concerns, Solid Energy have installed COALSCAN online ash monitors to assist the coal production at their Rotowaro and Huntly East mines. The three analysers are based on three very different technologies. Solid Energy have chosen the most appropriate and cost effective solution for three very different process control applications.

State Coal was rebranded as Solid Energy, an incorporated private company, in 1996. Since that time it has operated as a commercial company but with only one shareholder, the New Zealand Government. The company produces approximately 3 million tpa from its nine underground and opencast mines around Huntly in the Waikato, Greymouth, Westport and Reefton areas on the West Coast and at Ohai in Southland, with more than half of Solid Energy's annual output sold for export.

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COALSCAN 2800 is the most recent generation of Scantech's DUET analysers.


Close up view of COALSCAN 9500.


View of Solid Energy's blending plant at Rotowaro.

The Rotowaro coalfield, 10 km west of the Huntly township, is historically the most important in the North Island. It was first mined in 1915 after a branch railway to the area, including a bridge over the Waikato River, was completed. In 1942 State Coal mines started production at Kimihia opencast mine. Private owners began abandoning Waikato mines after World War II. Showing remarkable long-term strategic foresight, the Government stepped in and started buying the mines. By 1950 State Coal was the largest coal miner in New Zealand.

Rotowaro and Weavers opencast mines were opened in 1958 and in 1978 State Coal began production at Huntly East and West underground mines. Weavers ceased production in 1993 and Huntly West in 2001. This left Solid Energy with the Rotowaro opencast mine and Huntly East underground mine.

Ash monitoring

Coal production from Huntly East in 2002 was 390,000 t. The majority of its annual production is sold to New Zealand Steel's nearby Glenbrook Mill. A COALSCAN 1500 natural gamma ash monitor is installed to monitor the quality of coal as it is transported out of the mine. The results can be used for feedback to the mine to control their mining practices and feed forward to the operators to control the processing and blending of the mined coal.

The COALSCAN 1500 measures the natural radiation emitted from the coal. The radiation comes from natural decay of potassium, uranium and thorium, all elements found in the ash. For Huntly East, and many other coals, the natural radiation count rate is proportional to the ash content. The accuracy of the ash measurement is between 1% and 2%, which is perfectly suitable for this type of application.

The detector and associated electronics are installed underneath the conveyor belt and lead shielding is placed over the conveyor to screen the detector from other radiation sources, such as cosmic radiation. The analyser is installed after a transfer point and so the coal is well mixed. This natural radiation measured by the detectors comes from the lower layers of the coal close to the belt, and the configuration means a variable belt loading will not affect the results. In fact, the configuration means that the COALSCAN 1500 is equally accurate at all belt loadings.

Coal from the Rotowaro Mine is mainly supplied to the Huntly power plant, which currently burns 1 million tpa of Solid Energy coal. The Glenbrook steel mill consumes 830,000 tpa, approximately half from Huntly East and half from Rotowaro. In the next few years the supply to the power station is expected to increase to 1.7 million tpa, whilst there will be a decrease in the demand from the steel mill for Rotowaro coal, as more coal will be sourced from the Huntly East Mine.

The Rotowaro Mine has two main pits, known as the Township and Awaroa4 pits. The Township pit is the main pit at present, with 7 million t reserve. However, it has only about one year of operation remaining. The first coal from the Awaroa4 pit, with reserves of 11 million t, will be produced in February next year and continue until 2012. It will be the last of the opencast mines in the area.

Rotowaro specifications

There are two major seams and a number of minor seams at Rotowaro. The major seams are known as the Kupakupa and Taupiri seams. The upper Kupakupa seam is typically 3 - 6 m thick. The underlying Taupiri seams are up to 8 m thick, but are often highly split.

The Rotowaro coal is of sub-bituminous rank, with low ash and low sulphur content. The coal is highly reactive, which enhances the reduction of iron ore as the seams have become mixed with other materials. The moisture is fairly high at approximately 21% and the specific energy is approximately 22 MJ/kg. The sulphur content is between 0.25% and 0.35%, which means that it is a very sought after coal.

There has been wide and intensive underground mining of the Rotowaro coal seams. This now results in many problems with coal quality maintenance from the opencast mine. Only approximately 15% of the coal is washed and the coal analysers are relied on to ensure all coal produced, either fed direct to the plant or via the washery, meets the target quality. The ash in the mined coal can range from 3% to 15%, while the target ash is 5% to 6%.

Coal is stacked in the blending plant onto one of four stockpiles, each holding up to 8,000 t. The stockpiles are separated mainly on the basis of the ash measurement from a COALSCAN 2500 online analyser. On occasions the stockpiles are built according to different sulphur qualities, based on sulphur results from the mine's borehole analyses.

The COALSCAN 2500 is one generation in a series of analysers built by Scantech based on dual energy transmission technology (DUET). The principle of this technology is that a pair of gamma ray sources, Americium (Am241) and Ceasium (Cs137), are located in a housing below the belt. Their gamma rays are directed in a collimated beam through the belt and coal, then recorded by a detection system above the belt.

The attenuation of the lower energy Am241 beam is proportional bulk density of the coal and the average mass number of the elements comprising the coal, while the attenuation of the higher energy Cs137 beam is proportional only to the bulk density of the coal. This means that the attenuation of the Am241 beam divided by the attenuation of the Cs137 beam is proportional to the average mass number.

The technology is based on the fact that the elements with the highest mass numbers are the elements in the ash. This ratio is therefore proportional to the ash content of the coal. For coals where the composition of the ash is consistent the technology is a very good predictor of ash.

For instance, iron (Fe) has a very high mass number, so if the Fe_2O_3 content of the ash is consistent, then the Fe_2O_3 in the coal is changing in the same way that the ash is changing. As a very simple example, if the DUET analyser measures that the Fe_2O_3 content of the coal doubles, then this is the result of a doubling in the ash content. This relationship is the basis of how the DUET analyser monitors variations in the coal's ash content.

Coal is directed to one stockpile or another on the basis of the COALSCAN 2500 results. Coals with an ash below a given cut point are sent to one stockpile and coals with ash above the cut point are sent to another stockpile. There are a number of different coal sources feeding coal to the blending plant, and the COALSCAN 2500 results vary with coal type. To overcome this issue, the cut point is changed according to the coal source, thereby ensuring stockpiles are being built of the correct quality.

Reclaiming

Coal is reclaimed from two, sometimes three, stockpiles at once. The quality of the blended coal is monitored using a byline COALSCAN 9500 analyser, to ensure that it meets the customer's specifications. Each day two to three trains are loaded for shipment to New Zealand Steel, each train carrying about 1200 t. Genesis Power is supplied by truck and overland conveyor into the Huntly power plant.

The COALSCAN 9500 is based on prompt gamma neutron activation analysis technology (PGNAA). Neutrons are emitted during the radioactive decay of Californium-252 (Cf^{252}). These neutrons can be directed to interact with bulk materials such as coal, so that the nuclei of the elements in the coal absorb the energy of the neutrons. Soon after the nucleus absorbs this energy it returns to its natural state by emitting the energy as gamma rays.

Each element has its own unique nuclear structure. This means that the gamma ray spectrum that each element emits is unique. An element's gamma ray spectrum usually consists of several features, called peaks, the energy of which is related to the element's nuclear structure. The measured gamma ray spectrum of the coal is a sum of the gamma ray spectra of the elements in the coal.

Analysers can be designed to take advantage of the PGNAA process to measure the concentration of the elements in the bulk material, by detecting the range of gamma rays called the gamma ray spectrum, of the coal. An analyser built to use this technology is often called an elemental analyser because it measures the Si, Al and Fe concentration in the material.

The concentration of oxides is calculated assuming that each element is only found in one chemical form, for example Si is only present as SiO_2 and Al is only present as Al_2O_3. The ash in the coal is derived by summing these oxides and hence the result is independent of coal type. This is important in a blending application where there are many coal types present and the proportion of each is continually changing.

Moisture is another important parameter to measure because it affects the specific energy of the coal, and thus how it will be consumed in the power station and steel mill. The COALSCAN 9500 also includes a microwave moisture monitor. This monitor measures the moisture content of the coal by measuring the microwave signal after it has passed through the coal. The microwaves pass much more easily through dry coal than they do through water, so that the higher the moisture content of the coal, the greater the measured microwave attenuation and phase shift will be.

Conclusion

The Huntly power plant was designed to burn 'typical' Rotowaro coal and the operation of the Glenbrook steel mill is optimised for the Rotowaro coals. Obviously there is a financial incentive for the mine to produce an average coal that meets their customer's specifications. However, a consistent product will ensure that the power station and steel mill are both operating efficiently. Product homogeneity can be ensured by process control using online analysis.

A sampler feeds coal to the COALSCAN 9500 and a conveyor returns the coal to the main belt.

COALSCAN 1500: an analyser is installed under the belt. Above the belt is lead shielding.

In recent years there have been continued improvements in analyser performance. There are fewer restrictions in their application and their accuracy has improved. These advances, combined with concerns for environmental and quality control issues, mean that an online analyser should be an automatic inclusion in any new plant design or upgrade.

However, manufacturers of analysers and their customers must ensure that they use suitable technology for each application on a case by case basis. Each of the three coal analysers Solid Energy installed has perfectly matched the application. The information they provide has the appropriate accuracy for the operator's process control requirements in that application.

Coal producers, coal users and online analyser suppliers can all benefit from a detailed review of each potential application to match the coal characteristics and the process control philosophy with analyser technology. The best online analysis solution does not always have to be the most expensive! ■

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