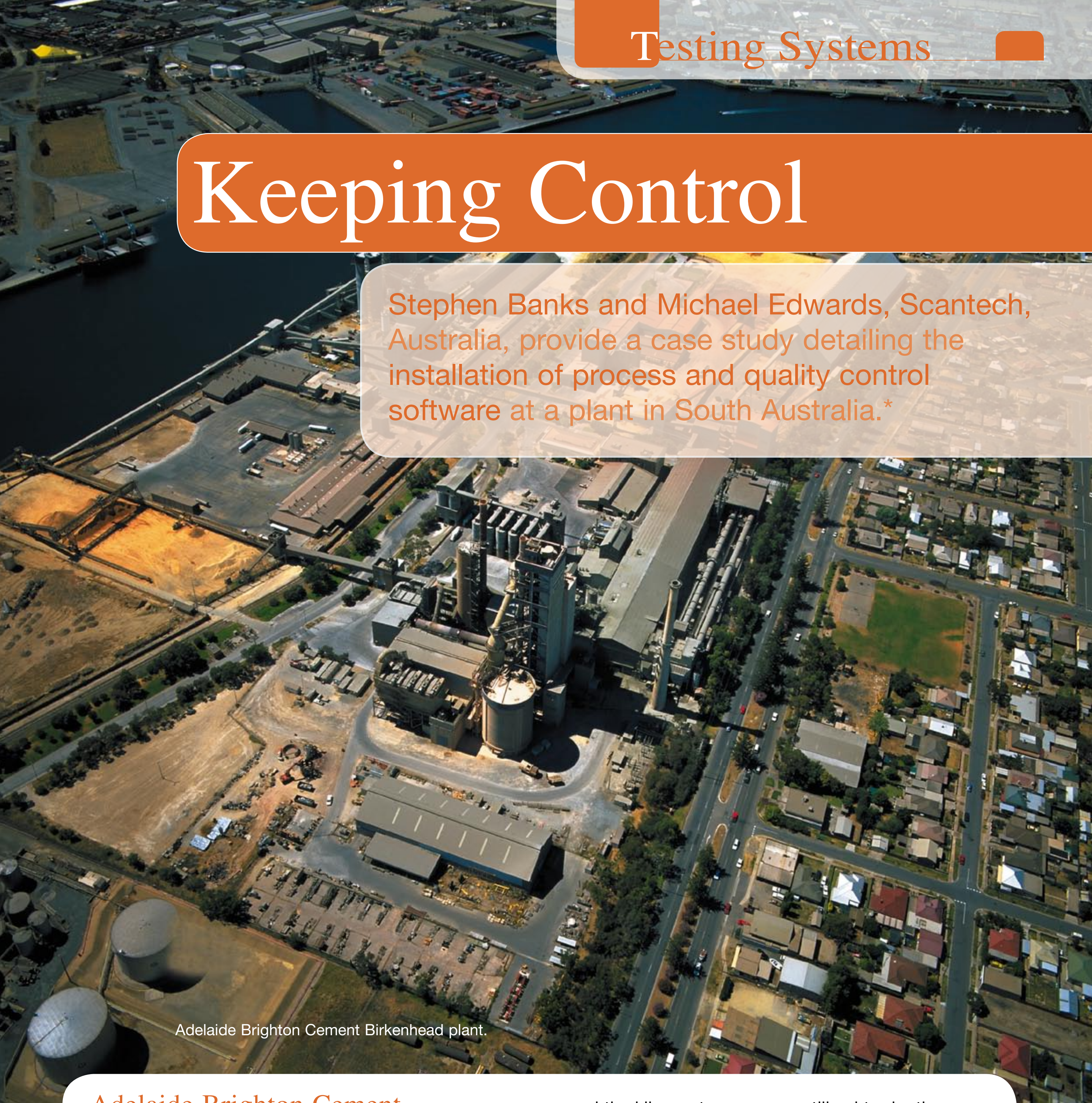
Keeping Control

Stephen Banks and Michael Edwards, Scantech, Australia, provide a case study detailing the installation of process and quality control software at a plant in South Australia.*



Adelaide Brighton Cement Birkenhead plant.

Adelaide Brighton Cement

With origins dating back to 1882, Adelaide Brighton Cement Ltd is a subsidiary of S&P/ASX 200 Company Adelaide Brighton Ltd (ABC), a leading Australian construction materials company. Adelaide Brighton has operations in all mainland states and territories of Australia, with a market capitalisation of over AU$1.2 billion and approximately 1300 employees nationally.

The company's largest clinker production plant is located in Birkenhead, South Australia. The plant has an annual production capacity of 1.2 million t of clinker and 1.1 million t of cement. The plant produces clinker in a separate string precalciner kiln, and the kiln waste gases are utilised to dry the raw materials that are milled in two vertical spindle roller mills. The clinker and cement that the plant produces are directed to the local market and also exported to Melbourne and Brisbane.

Adelaide Brighton Cement Ltd is focused on cost reduction by process and quality control improvements. As part of that focus, the latest model Scantech Geoscan and QCX BlendExpert software have recently been commissioned to reduce the chemical variation in the raw mix stream at Birkenhead.

The raw materials used at Birkenhead for clinker manufacture are limestone, clay, shale and iron ore. The limestone is delivered from the company's

*Based on a paper presented at the 14th Arab International Cement Conference and Exhibition, 21 – 23 November 2006, Cairo, Egypt.

Klein Point mine by its ship, which is powered mainly by natural gas and makes one voyage per day. The limestone is discharged into linear preblending heaps and typically forms about 90% of the raw mix. However, due to the heterogeneous nature of the Klein Point deposit, there may be significant variation in the average grade from heap to heap. Also, there are segregation effects which cause a higher than average grade to be reclaimed at the end of each heap.

The shale, clay and iron ore are delivered pre-crushed and stored in bins equipped with separate weigh feeders. These are used, together with reclaimed limestone, to produce one raw mix stream, which is fed alternately to the feed bins of the two raw mills. Consequently, only one raw mix control system is required.

Quality control

Cement manufacturers and their customers realise that, as well as the average quality being on specification, for optimal concrete manufacture, cement must be produced from a consistent clinker. This, in turn, can only be achieved if the raw mix chemistry is consistent. If the incoming materials are variable, control of the process requires on-line or rapid off-line analysis in order to adjust the composition of material fed to the raw mills, thus minimising variation[1].

Preheater and calciner tower.

On-line analysis allows the monitoring of raw materials to ensure contractual compliance, as well as the determination and adjustment of raw material proportions, to produce the optimal mix design with minimal variation.

Typically, two methods of analysis are used: X-ray fluorescence (XRF) for off-line analysis and Prompt Gamma Neutron Activation Analysis (PGNAA) for online analysis. Scantech's Geoscan uses the PGNAA technique. Both techniques must be calibrated from standard samples, although the features of the two methods are quite different. The use of XRF requires a sampling system to produce a very small, supposedly representative sample.

Therefore, while the XRF method has excellent precision, there is potential for incurring a large sampling error. Also, there is an inevitable delay in producing a result. Conversely, online PGNAA analyses the total material stream, thus avoiding a sampling error while providing real time analysis. PGNAA also avoids the capital and maintenance requirements for a sampling system.

Modern cement plant operators have accepted that to meet the requirements of rapid analysis and adjustments for efficient control of a continuous operation, automated control systems, which include on-line analysis such as the Geoscan, must be used.

The PGNAA technique

Neutrons are generated during the fission decay of a Californium source located in the analyser in close proximity to the raw materials. As neutrons are uncharged, they easily pass through the bulk of the material under analysis, compared to other analysis methods that only analyse the surface of the material.

When a neutron interacts with an element, part of the neutron's energy is absorbed by the nucleus of the element. The nucleus is left in an excited state and promptly de-excites through the emission of gamma rays. The energy of the emitted gamma rays is unique to each element and hence measurements of the gamma ray spectrum reveal the amount of that element present.

On the basis of stoichiometric conversion factors, the elemental composition can then be used to determine the concentration of oxides in the raw material. The accuracy and precision of a single measurement now approaches that of XRF.

Basis for implementation

For simplicity, cement chemists assume that Portland clinker is comprised of four major compounds: C_3S, C_2S, C_3A, and C_4AF; the concentration of which may be predicted from the major oxides using Bogue equations. The variation in quality of Portland cement from plant to plant is due to, among other things, the mineralogy of raw materials. Generally, a mix is sought that reduces the heat input required for clinkering and also reduces the cost of raw materials, while producing a cement of acceptable performance.

To avoid kiln instability and minimise fuel costs, material composition should be consistent. For

The Geoscan at ABC.

consistency in material composition, a standard deviation of less than 3% C_3S or 1.2% LSF should be maintained[2]. It is now generally recognised that online PGNAA analysers are the best way to achieve this.

Since the commissioning of the new Scantech Geoscan and the associated BlendExpert software system, a standard deviation of clinker LSF of less than 1.1% can be achieved at Adelaide Brighton Cement.

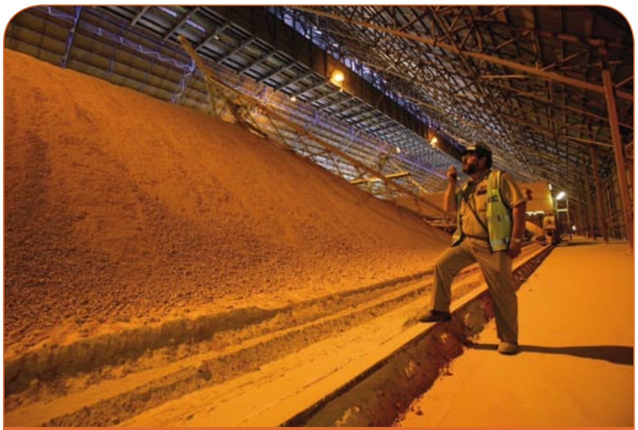
The need for precise control of the raw mix has increased at Birkenhead due to the effects of alternate fuels including waste wood, the effect of which is typically observed through a reduction in C_3S due to the associated ash. Also, the limestone at the Birkenhead plant contains a significant amount of chlorine resulting in the need for the kiln to be equipped with a chloride bypass. The Geoscan offers the most convenient check of chloride content for the raw materials, as the PGNAA technique is extremely sensitive to chlorine. In general, these issues are likely to be more significant as plants increasingly use alternate fuels.

Geoscan

Scantech's Geoscan is an elemental analyser employing the PGNAA technique. Using this technique, it is able to report the percentage composition of a number of elements (Si, Al, Fe, Ca, Mg, Na, Ti, K, Cl, S, Mn) for the bulk material currently under analysis. From these, quality control factors such as the Bogue compounds and/or LSF, SR and AR, may be calculated.

The installation of the Geoscan itself is a relatively simple task. It has a side shield that can be removed to enable the analyser to be placed around the conveyor belt. Its width along the belt axis of only 1 m also ensures that minimal modification of the conveyor support and idler system is needed, as the Geoscan is able to fit between idlers set at standard spacings.

An early model Geoscan was first installed at ABC in 1996. To maintain the most accurate process control possible, the latest model, known



Limestone preblend and bridge reclaimer.

as the UCG1400, has recently replaced the older model. This was installed in July 2006 in the same location as the previous one, downstream from the raw mix blending system and a subsequent transfer point that ensures some homogenisation of the raw material before analysis.

Two of the main reasons for the improved accuracy are the advances in digital electronics and newly developed spectral analysis routines. Other advantages of the new model include the need for very little standardisation, the conveyor belt not making contact with the analyser, as well as improved temperature stability. These improvements have also helped to increase the analyser accuracy, and at the same time have reduced maintenance requirements.

The use of new Bismuth Germinate detectors has significantly reduced the required amount of standardisation to two hours every six months. This means that the plant may operate continuously with very little downtime due to the analyser being unavailable.

Sliders are no longer required as the conveyor belt no longer makes contact with the analyser tunnel. In other on-line analysers, sliders are an ongoing cost as they wear down and require replacement after approximately two to three years of use. There is also potential for damage to occur due to the conveyor belt making contact with the analyser.

The new Geoscan model has solid state air conditioners that result in near perfect stability of results despite changing ambient temperature. Conventional on-line analysers use condenser air conditioners that require ongoing maintenance and are inherently less stable. Temperature stability is important, as variations in temperature affect the efficiency and resolution of the detectors located within the analyser, which will affect results.

Integration of the Geoscan into the automated process control system at Birkenhead is via a SuperSCAN system, Scantech's graphical display interface. The SuperSCAN system allows access to a wide variety of information regarding both the material under analysis and the status of the Geoscan, such as trending charts, results on an as-received basis, loss free basis and dry basis. Quality control factors, material flow rates and statistical data for any period of time are all standard features of this system. A selection of these results is then sent to both the BlendExpert system, for automated process control, and to the plant PLC, for access from any terminal connected to the plant PLC network.

Installation

At Birkenhead, the quality parameters used and controlled are C_3A, C_3S, and C_4AF, which are calculated using the Geoscan reported composition. The BlendExpert system then acts by modifying the flow rate of the raw material feeders to achieve the target values.

The BlendExpert system manages process control by observing the current composition, as reported by the Geoscan, making a prediction of the future composition based on previous results, and also adjusting feeder flow rates every 15 minutes in an effort to minimise the variation in the pseudo silo. The pseudo silo is a 500 t rolling average of the composition, which is used as an estimate of the composition of the two raw mill feed bins.

Two "control loops" are used to determine the current composition of the material exiting the feeders and are referred to as the outer and inner control loops.

The outer loop compares the XRF raw meal sample results and Geoscan results to determine the bias between the two. The inner loop uses Geoscan 5 minute results, applies the calculated bias, then adjusts the proportions of limestone, shale or iron ore feeders to achieve target chemistry so that variation in the composition entering the raw mills is minimised. The inner loop uses the average of 3 x 5 minute Geoscan results to make a change every 15 minutes

When the Geoscan requires downtime for certain maintenance tasks, the inner loop can be turned off so only the outer loop applies the changes to the proportions of the material feeders based on XRF analysis alone.

Outcomes/expectations

The automatic control of the composition of kiln feed results in far faster control of compositional changes than a laboratory can provide, thus minimising the effects of variability in the quality of raw materials. This will also result in much more consistent kiln operation, clinker quality and extended kiln refractory life. By achieving stability in the quality parameters using Scantech's Geoscan, a known and consistent quality of cement can be produced.

References

1. ALSOP, Philip A, *The Cement Plant Operations Handbook 4th Edition*, January 2005.
2. HALBLEIB, A., 'Innovative Silo Technology for Reliable Raw Meal Homogenization and Uniform Clinker Quality - In Spite of Using Difficult Raw Materials' *ZKG*, 10/2003, p 44.