

Online Stockpile Analysis

Darrell Leetham, Thermo Fisher Scientific, USA, discusses the use of the company's new CB Omni analyser at Mitsubishi Cement's Lucerne Valley plant.



Introduction

Mitsubishi's Lucerne Valley plant is located at the base of the San Bernadino Mountains, near the Mojave Desert, and supplies the southern California market (Figure 1). The original plant was constructed in 1957 as a wet process line and has gone through multiple modernisations, including a conversion to the dry process in the early 1980s. Using a 3-stage crushing system, circular preblending stockpile and a four-stage, dual-string preheater tower, the plant can produce approximately 1.7 million tpa.

As the cement market becomes increasingly competitive, producers continually seek means to increase production efficiency, reduce costs and optimise product quality. This is the case at the Lucerne Valley plant, and management there has, over the years, actively implemented the use of updated technology and improved beneficial processes. Most recently, the stockpile preblend process was upgraded with an online analysis system that makes use of high-frequency analysis and quality control software to automatically blend quarried raw materials into the circular preblending storage pile.

The preblending process

The quarry at the Lucerne Valley plant delivers two grades of limestone to a primary and secondary crushing circuit. The two grades of limestone are crushed independently and are subsequently stored in two separate cone piles, based on material quality as determined by drill cutting analysis. The piles are divided into a high-grade limestone and a low-grade limestone. Weigh feeders below the two-cone storage piles deliver a blend of the two raw materials to a conveyor system that transports the raw material to a tertiary crusher and onto a 50 000 t circular preblending storage pile (Figures 2 - 4). At any given time, the blend proportion of the high-grade and low-grade limestone is determined based on the chemistry of the blending tail of the circular storage and the target chemistry for the preblend. The preblend is then reclaimed and placed into a bin at the next stage in the process: the raw mix proportioning circuit. In the past, material analyses for the preblend pile were generated by sending samples obtained from a transfer tower to the onsite laboratory for evaluation. The frequency of analysis was once every two hours. While this process was able to meet the goals of the plant's quality requirements, a better,

more efficient and less costly method of preblend control was desired.

In 2006, the plant decided to pursue the installation and implementation of an online analyser. Benefits of such a system are as follows:

- Eliminates the use of the sample tower.
 - ♦ Sample errors eliminated.
 - ♦ Maintenance costs associated with sample tower eliminated.
 - ♦ Analysis interruptions from sample tower failures reduced or eliminated.
- High frequency analysis and control capability (once per minute versus once every two hours).
- Reduces variation in material quality due to high frequency analysis and control.
- Reduces burden on laboratory by removing preblend analysis tasks.

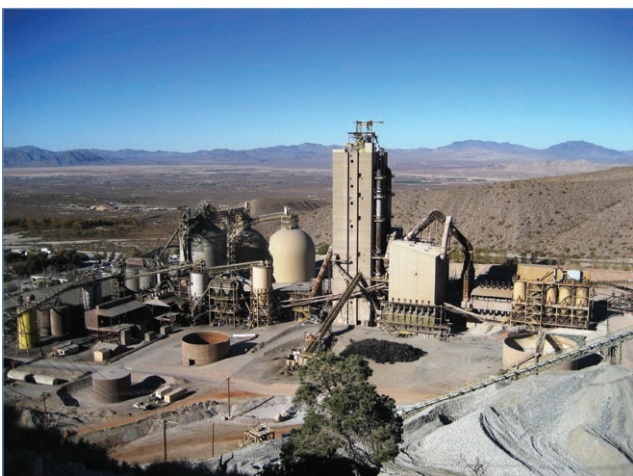


Figure 1. Mitsubishi's Lucerne Valley Plant in California.

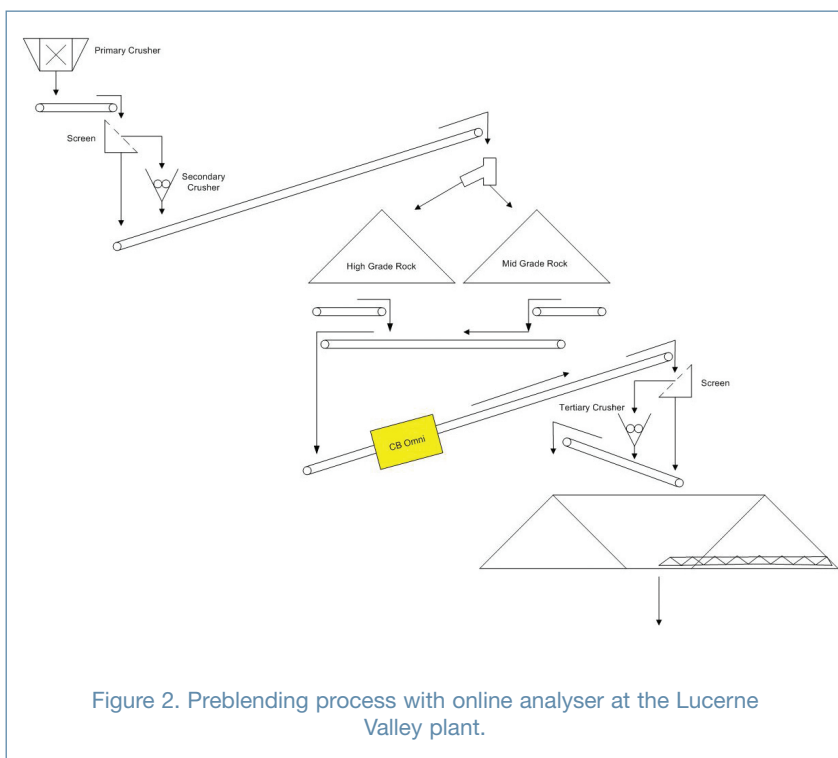


Figure 2. Preblending process with online analyser at the Lucerne Valley plant.

The new online analyser generates an analysis of the full material stream in transit to the preblending pile once per minute. The analyses are collected by FLSmidth Automation's QCX system, and blend proportions are automatically sent back to the weigh feeders beneath the high- and low-grade cone stockpiles.

Technology utilised

Mitsubishi Cement selected Thermo Fisher Scientific's newest model of online analyser, the CB Omni, and this is the first of its kind to be installed. The CB Omni uses Prompt Gamma Neutron Activation Analysis (PGNAA), which allows 100% of the raw materials to be analysed while in continuous motion on a conveyor.

PGNAA-based online analysis for the cement industry was first introduced by Gamma-Metrics, now Thermo Fisher Scientific, back in the mid-1980s. Neutrons, generally from a radio isotope, are used to interrogate materials and interact with the nuclei of the materials. In doing so, gamma rays are emitted. Each gamma ray generated comes from the nucleus of an element such as calcium (Ca), silicon (Si) or aluminum (Al), and has a unique energy associated with the element from which it was generated. The gamma rays are counted and their energies sorted by a detection mechanism. A spectrum of energies is created and is analysed by software algorithms and gives the concentrations of the different elements. The elemental composition is used to adjust the quality control process (Figures 5 and 6).

The first analysers using PGNAA were "chute style" systems where material flowed vertically through the analyser. PGNAA online analysis leapt forward in 1993 with the introduction of the first CrossBelt Analyser (CBA) by Thermo Fisher Scientific. This unique system did not require the costly installation of the vertical style analysers and could be directly integrated into a new or existing conveyor line. The CBA was quite popular, with many models introduced and significant advancements made over

several years. Advancements included digital electronics and signal processing capability, and better methods of integration into the conveyor line, providing installation cost savings and flexibility.

In late 2006, the two leading PGNAA online analyser suppliers became one when Thermo Fisher Scientific acquired Analyser Systems Inc. The technology advancements from both organisations were evaluated and a new generation of analyser was introduced in mid-2007: the CB Omni (Figure 7).

The Thermo Scientific CB Omni

The CB Omni is a product of combined technologies from the two organisations previously mentioned, and builds on prior generation systems from each company by incorporating technological advancements on multiple levels: a new, highly efficient detector design, new state-of-the-art digital signal processing electronics, new concepts in system shielding and increased levels



Figure 3. First and second stage crushing circuit with preblending dome in the background.



Figure 4. High-grade and low-grade limestone storage piles.

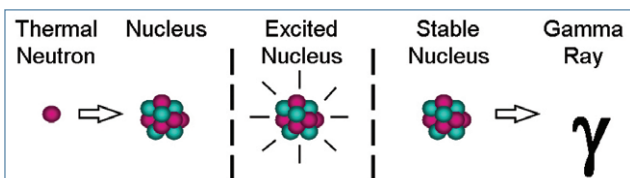


Figure 5. Prompt Gamma Neutron Activation Analysis.

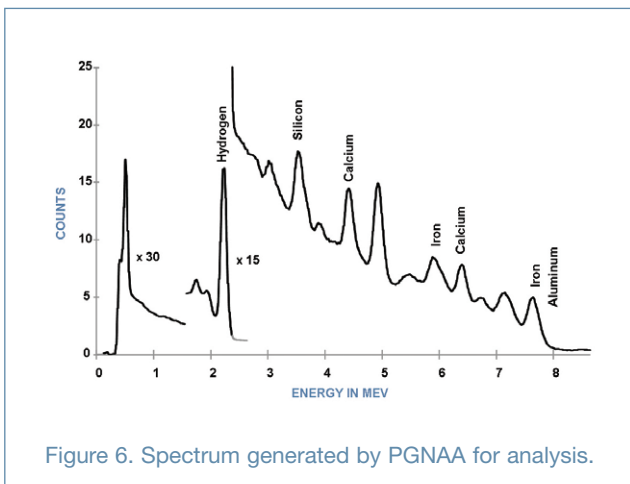


Figure 6. Spectrum generated by PGNA for analysis.

of performance flexibility. These new advancements are coupled with a previously unavailable option for wireless data communications between analyser and operator console and between operator console and remote terminals, both stationary and mobile.

Similar to other CrossBelt analysers, the CB Omni consists of multiple components that comprise the system as a whole: analyser assembly, electronics unit, operator console and reference standards (Figure 8).

Unique modular analyser assembly and shielding

When the CB Omni was in the design phase, one target feature was a method by which the shielding could be moved and manipulated during installation, without the use of, or limited use of, equipment. With this goal in mind, it was also a requirement to maintain the installation flexibility afforded by previous generation analyser systems. The CB Omni accomplished these goals and has taken ease of installation one step further by designing an assembly consisting of a frame and shield modules that are easily placed directly onto the existing conveyor stringers without having to cut into the conveyor structure. The existing structure is braced from below with added support to carry the weight of the system. Once the frame is in place, a series of standardised shield modules are set into the framework. The use of a combination of the similarly shaped modules, along with a source and detector module, allows the CB Omni to be assembled in a multitude of ways, creating different sized analyser systems for use in various applications. All the standardised shield modules are light enough to be manipulated and moved by one or two people, making assembly of the system quite easy (Figure 9).

The design of the analyser allows the unit width to remain proportional to the dimension of the conveyor line and access walkways (catwalks). This helps minimise installation costs by avoiding the need to widen catwalks and, in many cases, also avoids the need to re-route existing electrical and signal conduit. In addition, the overall system size and weight have been reduced over previous generation systems. The changes allow the CB Omni to be installed in locations with limited space or constrained areas where previous generation systems had difficulty fitting.

The dimensions of the tunnel opening are fully flexible and are defined by evaluating the plant's production rate, production variability, conveyor belt speed and material particle size. Based on the nominal height of the material and the variation in height, appropriate dimensions are determined such that the raw materials will not impact the system (Figure 10).

The safety of the system is of utmost importance, and the new shielding materials used within the modules allow access and ensure personnel safety around the system. The unit is inherently safe and does not require isolation and fencing to keep plant personnel away from the system. Measured radiation levels around the sides of the system are significantly below regulation limits and are comparable to many day-to-day activities (Table 1). Additionally, as with all previous generation systems from Thermo Fisher Scientific, this series of analyser has been manufactured with rugged composite materials, which are suited for any external environment without the need for protection from the elements.

New efficiencies from detectors and electronics

Design changes and improvements on the CB Omni were not limited to the mechanical aspects of the system. The leading scientists working on the project devised a unique new scintillation detection mechanism that has resulted in significant gains in performance. The entire detector package was redesigned and new, state-of-the-art, digital signal processing components back up the high performance detectors. The package provides an astounding 40% more pulses for analysis than previous generations systems. This means better statistics and better repeatability of the analyser.

Furthermore, the CB Omni design now also allows a very high degree of flexibility with respect to the levels of system performance available. The end-user has the freedom to select the level of performance most appropriate to the application of the analyser. The redesigned detectors and detector housing allow the use of one, two or four detectors per system. This flexibility has not been available before and previous generation systems only offered a standard two detectors per system. Since the new detectors are 40% more efficient in the number of counts produced, high levels of repeatability can be achieved with less source strength, or significant increases in performance can be achieved by the use of additional detectors. For example, one user may want to minimise the amount of isotope used to save on long-term replenishment costs, while another may want to increase performance by adding additional source, additional detectors, or both. The CB Omni has three levels of source and three configurations of detectors to choose from, making a total of nine distinct combinations and levels of performance.

Detectors in a PGNAA system are crystals that function by producing photons when a gamma-ray enters. There are a few different types of crystals that do this. Two used in commercially available PGNAA online analyser systems are Bismuth Germanate (BGO) and Sodium Iodide (NaI). The CB Omni uses NaI crystals, as previous generation systems from Thermo Fisher Scientific did, but in a unique way. NaI is used by the CB Omni for a number of reasons. One of the main reasons is that light output from a NaI crystal is approximately five times greater than from a BGO crystal, meaning the spectral resolution on NaI is better. NaI is also less sensitive to changes in output due to temperature fluctuations. In addition, NaI is less expensive than BGO overall, making the choice for NaI detectors on the CB Omni obvious.

Uniformity of measurement

Neutron based online analysis systems have the ability to provide a volumetric measurement of materials as opposed to other spectral analysis technologies such as X-ray fluorescence, X-ray diffraction, near infrared or visible light. Such techniques are surface measurements and have limited depths of penetration and only a limited amount of surface area, such as the spot size of the measurement beam. If the surface material is not representative of the entire volume on the belt, incorrect information on the current condition of the process can be indicated and inappropriately acted upon. Examples of such cases are segregated (layered) materials on the belt, materials covered in dust, materials on the belt placed side by side, and in



Figure 7. Thermo Scientific CB Omni at Mitsubishi's Lucerne Valley plant.

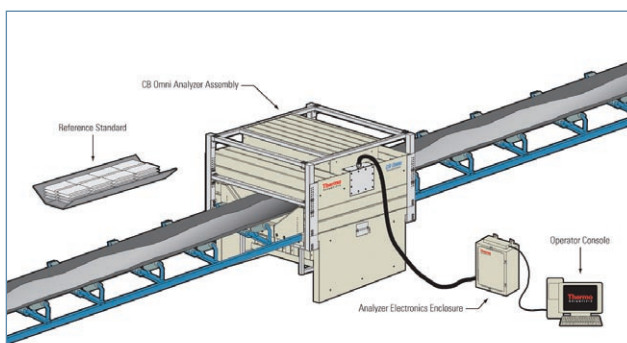


Figure 8. CB Omni analyser components.

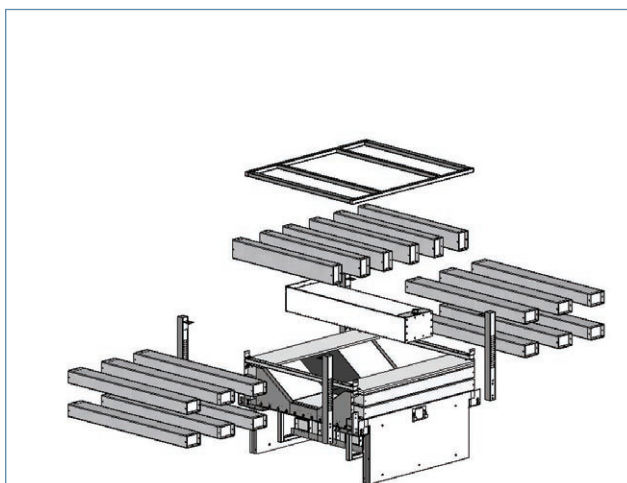
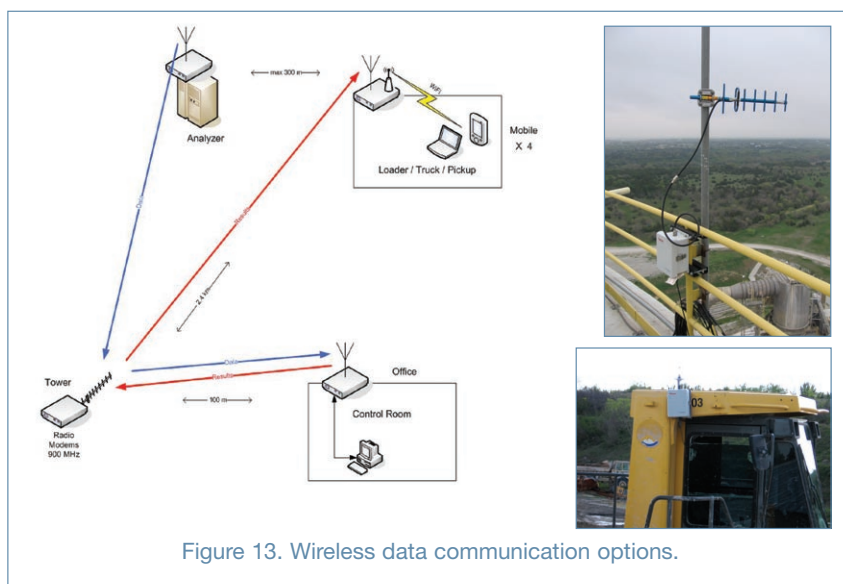
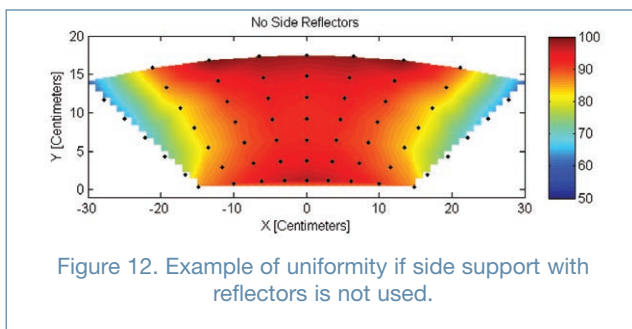
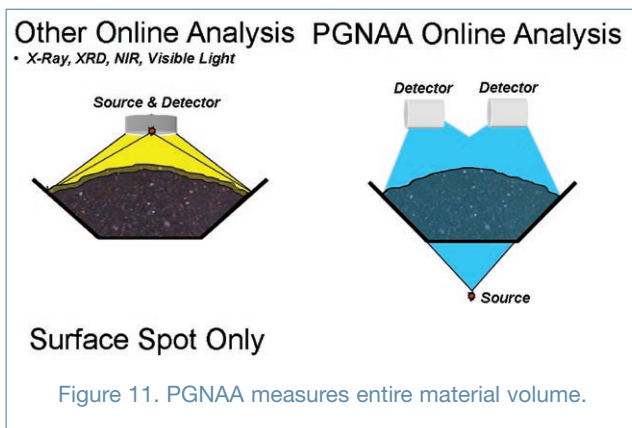
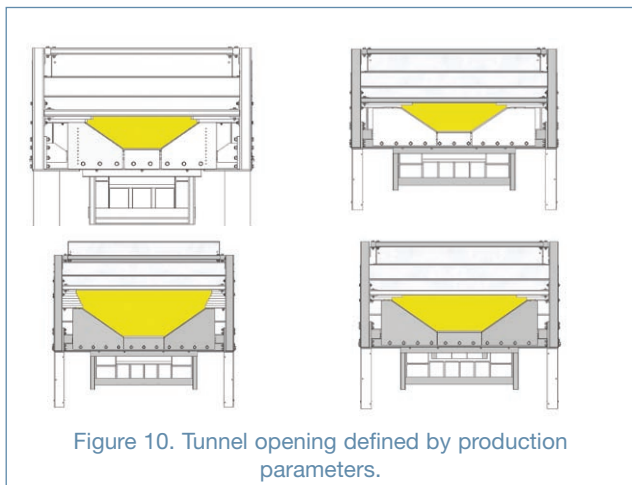


Figure 9. Modular shielding components for CB Omni.

Table 1. Radiation levels of various activities

	Radiation levels	
Flying across the Atlantic	6 mR	0.06 mSv
Chest X-ray	10 mR	0.1 mSv
Living in a brick house	75 mR/yr	0.75 mSv/yr
Living in Colorado (elev. 1600 m)	120 mR/yr	1.2 mSv/yr
Worker exposure limit	5000 mR/yr	50 mSv
Public exposure limit	100 mR/yr	1 mSv
10 min/day every work day at Omni	<10 mR/yr	0.1 mSv



homogenous materials with fines on the bottom of the belt (Figure 11).

PGNAA and other neutron interrogation techniques are not susceptible to this limitation; however, these systems must be designed so that the measurement volume is equally represented. This can be a challenging task and is not always achievable. The signal throughout the measurement volume can be different due to neutron propagation, reflectance, neutron moderation and material self-shielding. Neutron analyser designers go to great lengths to make the analysis volume equally represented. An indication of how well this is achieved is described by the uniformity of the measurement volume. Various methods are used to create a measurement volume that is uniform. Some examples of techniques used are: source position, detector position, detector geometry, the use and placement of neutron moderating materials, and the use and placement of neutron reflecting and scattering materials.

The designers of the CB Omni have taken these concepts into consideration and have optimised the measurement volume for uniformity of analysis. Neutron reflectors and moderators are used in the side support structure of the system, as well as the bottom and top of the tunnel, to help provide a uniform analysis volume. If such a system did not have side conveyor supports in which to place these materials, the type of analysis uniformity seen with the CB Omni could not be achieved (Figure 12).

Wireless communications

A feature not previously offered for online analysis is the ability to optionally communicate with the operator console, remote terminals and mobile equipment without the use of cables, if desired. This new online analysis feature designed for the CB Omni is called the Thermo Scientific Wireless Xpert (WX) product, and it simplifies instrument connectivity and communication while broadening installation flexibility and data availability. The different nodes of the instrument are connected using radio modems to transmit and receive data. One of the most intriguing features of the option is its ability to communicate with mobile terminals in vehicles. The WX option for the CB Omni transmits product quality information through its web-based server to remote and mobile terminals such as PCs, Personal Digital Assistants and Portable PCs. Feedback to the process is enhanced by

providing information to quarry operators and field operations, where control actions can be made based on information from the online analyser (Figure 13).

Conclusion

The CB Omni analyser has brought a new level of performance and installation efficiency to the industry. It has the ability to install directly onto the conveyor stringers, with only additional support structure needed, and its unparalleled installation ease and flexibility provides minimal impact to the existing operation and installed cost savings. The wireless communication options with the system have given online analysis new methods to provide information easily and where it is needed most.