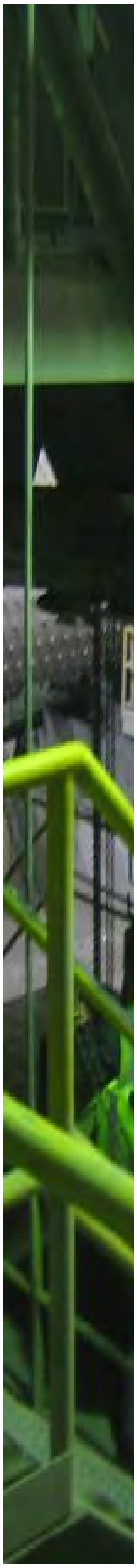
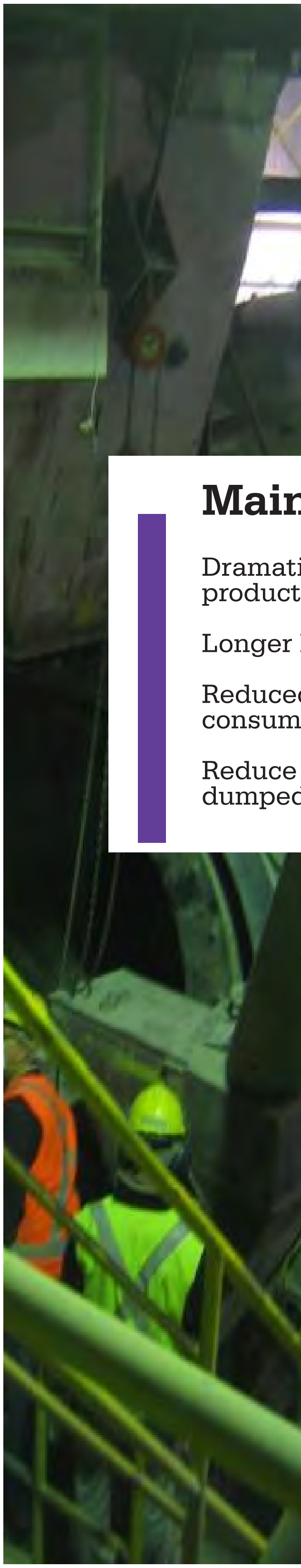
Using On-line Nuclear Elemental Analyzers (PGNA) to Control Cement Production





Main Benefits

- Dramatically improved product homogeniety
- Longer kiln refactory life
- Reduced energy consumption
- Reduce kiln purges and dumped clinker

STOCKPILE AND RAW MIX

Controlling C3S or LSF

Unequaled Homogeniety Now Possible

A Brief History of Cement Production

Even in ancient times the use of cement played a vital role in the advance of civilization. Egyptians used calcined gypsum as a cement and the Greeks and Romans used lime made by heating limestone and added sand to make mortar, with coarser stones for concrete. At some point the Romans discovered that by adding crushed volcanic ash to lime that a cement could be made which set under water and this was used for the construction of harbors. This was later called a 'pozzolanic' cement, named after the village of Pozzuoli near Vesuvius.

After the fall of the Roman Empire in Europe there was a general loss of building skills, which included the loss of cement making. Pozzolana cement was not rediscovered until the late Middle Ages. In eighteenth century Britain the need to prevent the constant loss of ships created the need to build lighthouses that could be built on rocks exposed to the constant onslaught of the sea. This served as a driving force, pushing cement technology forward once again. Smeaton, while building the third Eddystone lighthouse (1759) in England discovered by using lime, clay and crushed slag from the iron-making process he could create a mortar which could harden under water. In 1824 Joseph Aspdin received a patent for "Portland Cement", which he produced by firing ground clay and limestone until the mix was calcined. He called it Portland Cement because the end product looked like Portland Stone, a widely used building stone in England. While Aspdin is usually regarded as the inventor of Portland Cement, it wasn't until 1845 that Isaac Johnson made the first modern Portland Cement by subjecting a mix of chalk and clay to the high temperatures used in production today.

Three major developments since 1845, the development of rotary kilns, the addition of gypsum to control setting, and the use of ball mills to grind clinker and raw materials, have brought us to the modern era of cement production.

Today's Portland cement is made by first mixing calcium carbonate material such as limestone with silica-, alumina-, and iron oxide-containing materials. These materials are dry ground into a very fine powder, mixed together in predetermined proportions, preheated, and calcined (heated to a high temperature that will burn off impurities without fusing the ingredients). Next the material is burned in a large rotary kiln at 2,550 degrees Fahrenheit (1,400 degrees Celsius). At this temperature, the material partially fuses into a substance known as clinker. A modern kiln can produce over 6,000 tons of clinker a day. The clinker is then cooled and ground to a fine powder in a tube or ball mill. A ball mill is a rotating drum filled with steel balls of different sizes (depending on the desired fineness of the cement) that crush and grind the clinker. Gypsum is added during the grinding process. The final product is Portland cement, the material that makes our modern day infrastructures possible.

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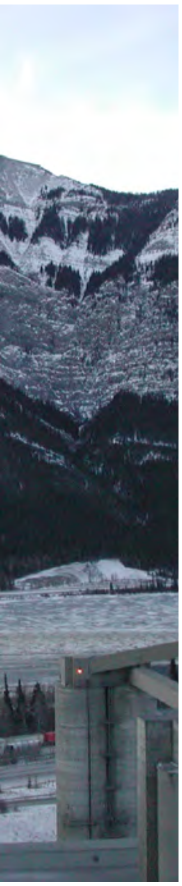
The Challenges of Modern Large-scale Cement Production

Large Variability Equals Greater Production Costs

σ = Production Costs ($$$)

Controlling the Cement Production Process



Production Challenges

- Meet stringent product quality demands
- Begin process with variable raw material
- Control Energy consumption
- Minimize Waste
- Stay Friendly to Environment

In our modern era Portland Cement must be manufactured to increasingly stringent specifications for strength, setting time, with demanding restrictions on the presence of such things as alkalies while at the same time dealing with the constant pressure for low prices. The typical cement production facility begins this demanding process with the basic materials as provided by mother nature in the quarry, materials they have no control over. This usually proves to be the main challenge for the production of cement because very few qarries deliver ideal raw ingredients and few quarries deliver a consistent raw material quality over time. For some time producers of cement have realized that homogeneity of raw mix could provide reduced production costs, which meant higher profitability and also competitive advantage. Producers realized that the homogeneity of kiln feed chemical composition had a strong bearing on fuel consumption, uninterrupted kiln operation, and the end performance of the product. They knew that reacting to non-homogeneous feed materials by burning harder resulted in increased fuel consumption, costly buildups on kiln refactory due to increased alkali and sulfates (this meant increased kiln shutdown frequency), clinker with lower porosity, large alite, poor nodulization and variable alkali sulfate content. In addition, cement produced by harder burning could result in cement that required more water to set correctly and that had less early strength and other inconsistencies in behavior during the setting process. Producers knew that consistent feed to the kiln avoided all of these problems, thus significantly reducing production costs and ensuring a consistently performing product for their customers. Modern producers of cement are also often surprised to find themselves involved in litigation over products that contribute to problems in buildings and structures around the world.

In the past producers of cement gained visibility of their processes using strategically chosen physical samples from their processes and analyzed them in laboratories using wet chemistry , or more recently, X-ray flouresence technology (XRF). Over the years XRF has proven itself to be a reliable method for precisely determining the chemistry of small physical samples in the lab. The problem in using this approach to control processes is the delay time between the sample acquisition and the lab results as well as the challenge of having a small sample represent the entire process stream.

This all began to change in 1985 when the first Prompt Gamma Neutron Activation (PGNA) On-Line Nuclear Elemental Analyzer was introduced to the cement industry at the Phoenix Cement Plant in Cottonwood, Arizona. PGNA analyzers are nuclear analyzers that utilize a neutron source directed at the material on the process belt to dertermine precisely and accurately the elemental composition of the material. With this real-time visibility of the process, cement producers were able, for the first time, to control and reduce the variability of their processes.

Using On-line Nuclear Elemental Analyzers (PGNA) to Control Cement Production

Using Real Time Visibility of Raw Materials to Reduce Variability

Cement Producers Now Have Capability to Control Processes Dynamically

Using Process Elemental/Quality Information for Real-time Control

Pile Building and Raw Mix Control

Contol C3S in Stockpile or in Raw Mix

Dramatic Reduction in C3S variability

Extend Refractory Life

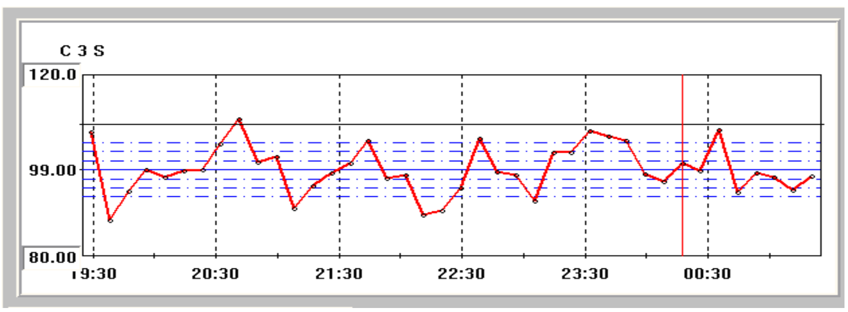
Reduce Energy Costs

Maximize Profitability

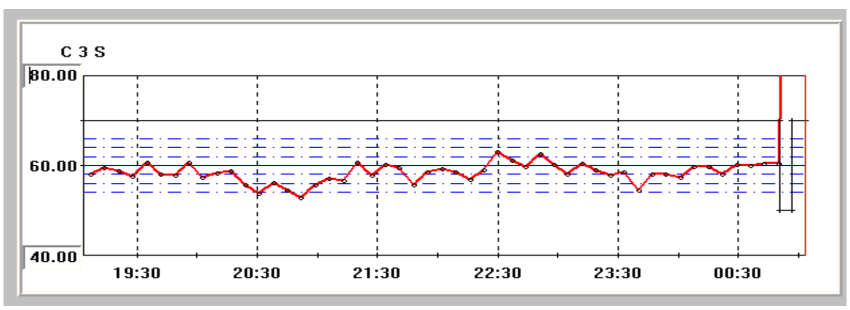
Controlling the Cement Production Process

Applications

Since shipment of the first PGNA analyzer to the Cement Industry in 1985, over 450 nuclear on-line analyzers have been delivered around the world. In some cases, payback was within weeks, with most less than one year. Nuclear on-line elemental analyzers today are designed for maximum convenience of installation and minimum interruption to the operation. Physical mounting can be done in less than eight hours, with full commissioning completed in less than five working days. The units mount on existing conveyors with no changes to the conveyor structure. The analyzer looks at all the material on a moving conveyor and delivers to the customer a real-time weight percent elemental and cement quality parameter analysis. This information is used to build a mound to a specific C3S target or to blend raw mix with additives to achieve a desired C3S. This is done with a PID (Proportional, Integral, and Derivative) process control loop using the input from the analyzer to drive additive feeders. The PID software can be provided by the analyzer vendor, a third party, or by the customer himself. The SABIA Model XL-5000 OnBelt Analyzer for Cement is web browser based, which means that the analyzer computer acts as a web server and with its own IP address it can be accessed from anywhere in the world via the internet. A PGNA analyzer controlling the C3S target on raw mix in a closed PID control loop can achieve dramatic improvement in the control of kiln feed. A recent example shows C3S control with an older PGNA analyzer upgraded to the latest SABIA hardware. With the new system the control loop was able to reduce C3S variability form +/- 10 C3S to +/- 5 C3S, as shown in the graphs.



Before PGNA - C3S Variability of +/- 10



With PGNA - C3S Variability of +/- 5

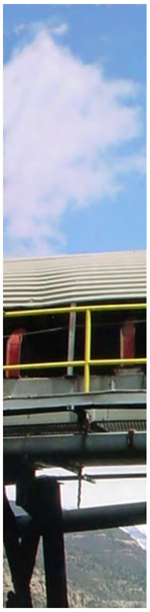
Cutting Costs

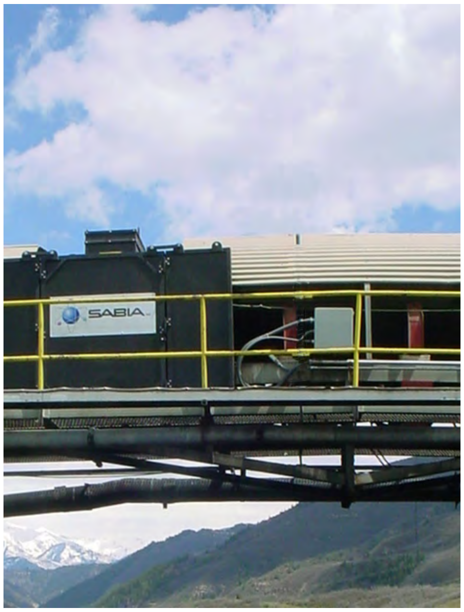
Pre-blending Stockpiles, Raw Mix and Silos

Examples of Putting $$ on the Bottom Line

Pre-blending Stockpiles

About twenty percent of cement producers using PGNA analyzers use them to continuously blend raw materials from the quarry to build stockpiles that are close in chemistry to the desired final C3S for desired product quality. Building stockpiles that are close to the desired end target means the entire plant at every step in the process is subjected to fewer extremes. This consistent quality material flowing through the plant saves money and time during the reclamation process. A consistent source material means less of the expensive additives are needed. Material can be rejected before it becomes a problem. For example, dolomitic material with high MgO or high alkali material can be diverted to a road aggregate application prior to going into the stockpile.





Raw Mix and Silos

The other eighty percent of cement producers using PGNA analyzers use a raw mix application which positions a PGNA analyzer in the cement process downstream of the additive feeders. In this way, the analyzer can provide closed loop control feedback to the plant for the correct addition of materials to achieve desired quality targets. This dynamically achieved target can eliminate the need to recirculate material in the silos. At some sites this can save as much as $50,000 US per month in energy costs for the recirculation silos. The lab can move away from hourly samples to one per shift. Some forward thinking plants have even eliminated the shift samples. Silos can be designed smaller and used as surge hoppers vs. storage hoppers, requiring less storage of material and easier maintenance. By making the kiln feed more uniform there is direct savings in fuel consumption. The temperature of the kiln is directly proportional to free lime. As the deviation increases the amount of CaO will increase, requiring higher temperatures and more fuel. Up to 20% savings in fuel costs have been achieved by many plants. This consistency of the kiln feed relates directly to the temperature fluctuations in the kiln. This changes the kiln flux which in turn affects the refractory coating, stripping the insulator away. Minimizing temperature changes saves maintenance and allows for longer times between re-bricking. A 10 day down cycle to rebrick costs approximately $200,000 US per day, or $2,000,000 US total. A reasonable summary of all these production cost savings in aggregate is $400,000 US per year. With the price of a high performance PGNA analyzer now less than $300,000 US it has become straightforward to justify the purchase of an analyzer.

Annual Cost Savings

$50K to $100K Reduction in Energy Consumption

$50K to $100K Reduction in additives expenses

$100K to $200K savings in reduced kiln outtages

$100K to $200K savings in reduced waste and elimination of kiln purges