Extending the Life of Your Legacy PGNA Cement Analyzer through a 3rd Party Retrofit

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Abstract

PGNA Nuclear Elemental Analyzers are now widely used around the world in the cement industry. They add significant value in controlling the quality of the raw materials prior to firing in the kiln. The two main applications are pile building after the quarry and raw mix control using crushed quarry rock and material additives such as iron, silica, calcium, and aluminum. In almost all cases the ultimate goal is reduced C3S or LSF variability and in many cases the variability is reduced by greater than 50%. It has been documented that this can result in a plant savings of as much as $1M per year for a 1M TPY plant. The useful life of a typical PGNA Analyzer is somewhere from 10 to 15 years. At that point most customers can either buy a new analyzer or get an upgrade from the OEM, which historically has been a fairly expensive option. Third party upgrades of existing legacy machines are now available, making it possible to have up-to-date technology at competitive prices. This paper will examine the uses of analyzers, the economics for cement plants, and take a quick look at the third party upgrade option now available to the cement market.

Introduction

PGNA Nuclear Analyzer History

True Nuclear Elemental Analyzer

True Nuclear Elemental Analyzers using Prompt Gamma Neutron Activation Analysis (PGNAA) first became commercially available in the early 1980’s in the coal industry, primarily at coal mines. Then in 1985 they were made available for cement production. All the early versions of the technology were chute-based with vertical flow through the analyzer. It was the site’s responsibility to get the material into and out of the analyzer. Then in the early 1990’s on-belt type models of the technology were introduced. This version of the technology as implemented for cement production has been very successful, with at least 600 units installed around the world. The primary uses for the technology in cement production have been pile building and raw mix control. It has been documented that in some raw mix control applications the reduction in C3S or LSF variability has been 50% or greater. It has also been shown to provide cost savings in many cases of at least $1 per ton of clinker produced. A list of the highest potential areas for cost savings at a cement plant are shown in table 1.

Area of Savings	Nature of Savings	Annual Savings $$	Comment
Conserve additives	Material cost	$50K to $100K	Additives such as iron slag, sand, and bauxite are costly
One sample per shift	Labor cost for lab (assumes 1 lead and 4 techs reduces to 1 lead and 1 tech)	$50K to $100K	At many sites quality = a lot of people sampling and analyzing samples
No kiln outages	Maintenance cost	$100K to $200K	Unplanned kiln outages = big labor and parts expenses
Kiln fuel savings**	Energy cost	$50K to $100K	A compelling factor, especially with escalating fuel costs
Extend refractory life	Material cost	$100K to $200K	A 10 day re-brick cycle = $200K per day. Unplanned kiln outages can be eliminated
	TOTAL	$250K to $1000K	
**Note: Additional energy savings can be achieved with the elimination of material recirculation in the silos. There can also be a one-time capital cost savings if silos are eliminated and surge hoppers used instead.			

Table 1. Cost Savings at a Cement Plant

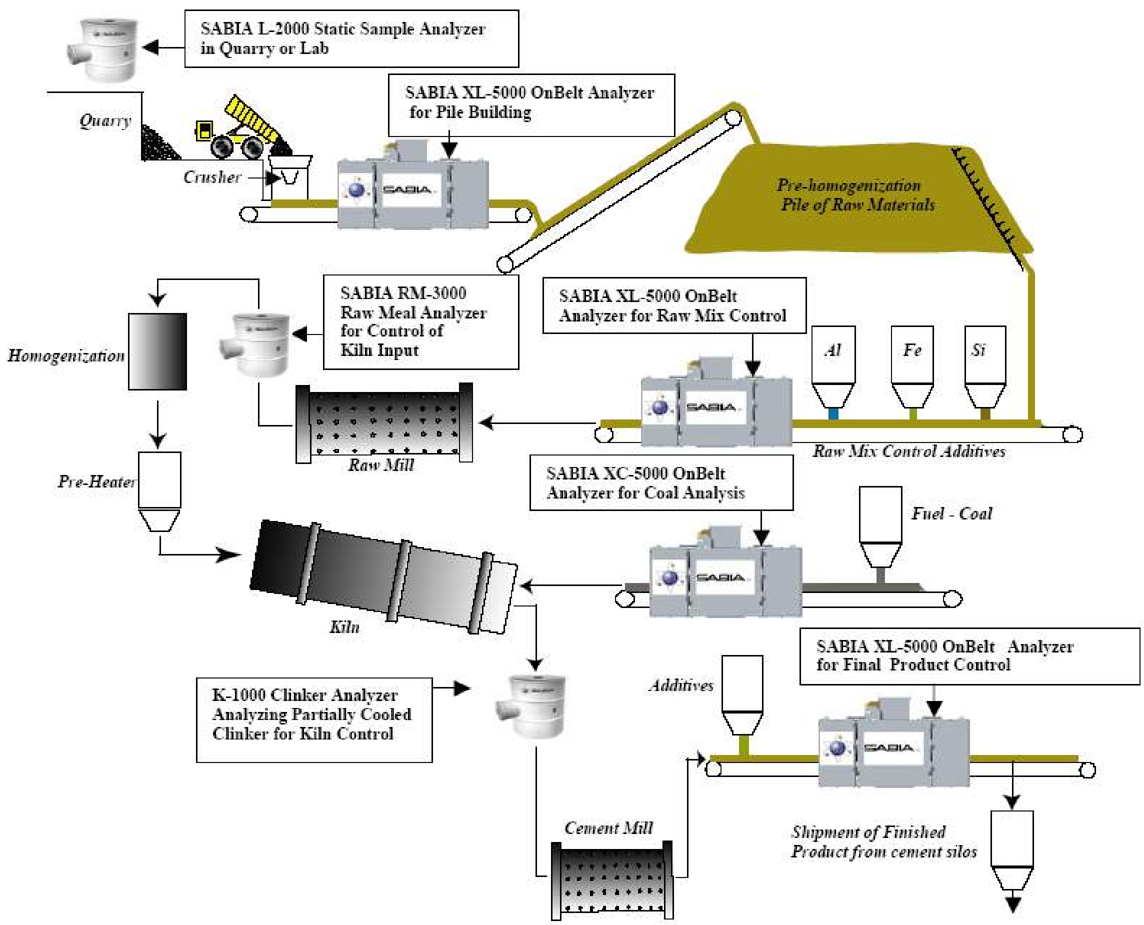

Figure 1. Potential PGNAA applications at a cement plant

Basic Principles

When a bulk material such as limestone is bombarded with thermal neutrons, (<1 electron volt neutron energy), from a Californium 252 nuclear source, many of the neutrons are captured by elemental atoms within the limestone. When this happens, the atom becomes temporarily unstable. In order to re-stabilize, the atom sheds a spectrum of high-energy gamma rays. The specific energies of gamma rays given off are a unique set for each of the elements within the periodic table. This principle makes it possible to create a signal to enable the on-line elemental analysis of limestone possible with PGNAA.

Obtaining and Processing the Signal

In order to create an electronic signal used for the determination of the weight percent of the elements of interest within the limestone the unique elemental signature gamma rays resulting from the capture of neutrons by elemental atoms are detected by a scintillating crystal such as Sodium Iodide (NaI). As the gamma rays penetrate the detector they deposit their energy as high-speed electrons within the crystal. These electrons create ionization, which can be detected as UV light pulses. The light pulses are in turn detected by photo-multiplier tubes (a vacuum tube electronic component operating at a high voltage, typically 500 to 1000 VDC) and turned into electrical pulses which are immediately amplified, shaped and then converted into digital signals, and collected into a spectrum over some predetermined period of time (typically one minute) which can then be processed by a computer at very high speeds.

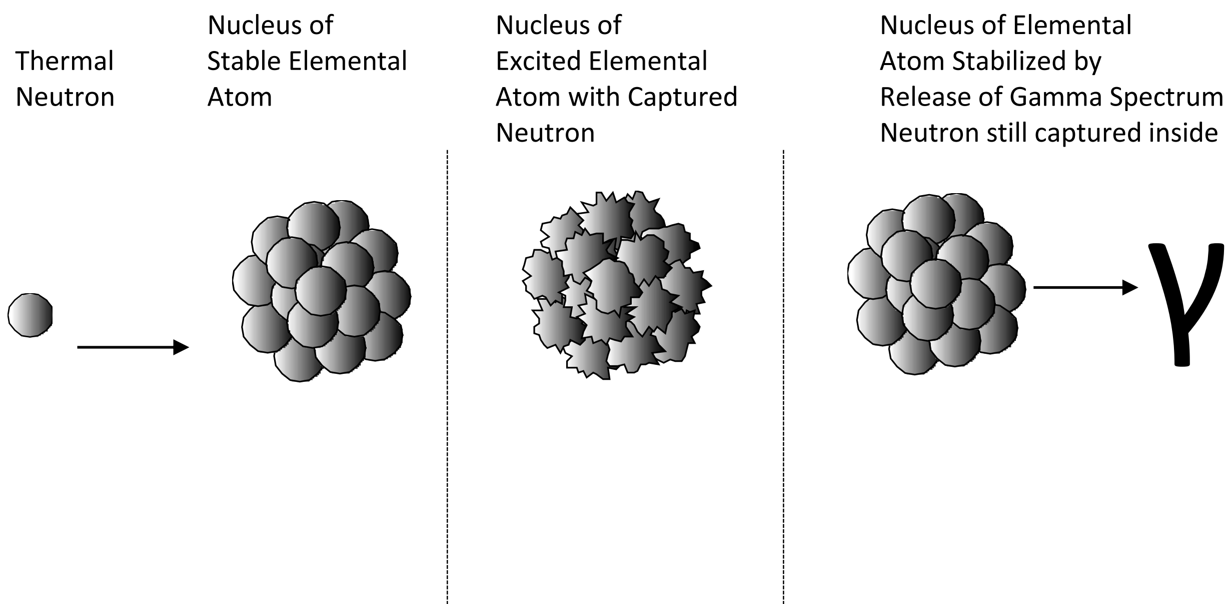

Figure 2. The Nuclear Physics of PGNAA

Processing the Spectrum

The resulting gamma-ray spectrum collected over a one-minute period is actually a histogram of all the incoming gamma-ray energy levels ranging from zero to ten MeV (Million electron volts). A typical spectrum is shown in figures 3 and 4, which shows several million pulses collected in one minute.

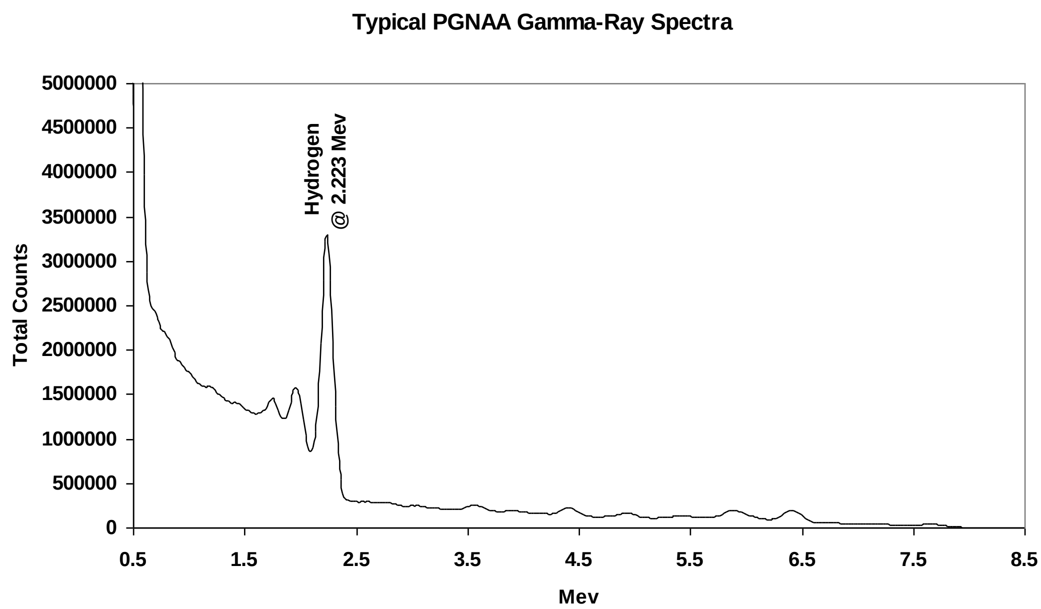

Figure 3. A Typical Gamma Ray Spectrum – High and Low Energies

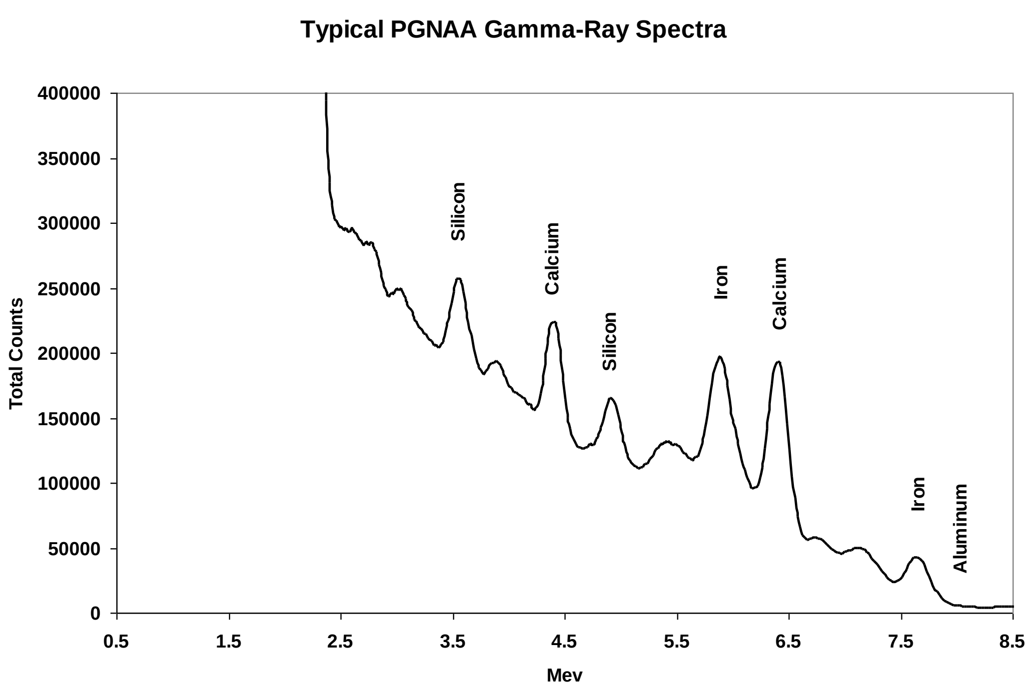

Figure 4. A Typical Gamma Ray High Energy Spectrum

Intuition says that arriving at the weight percent of each element could be accomplished with a simple evaluation of the size of each of the peaks, which is not the case. Optimum use of the information in the gamma-ray spectrum requires a full spectrum analysis such as Library Least Squares that utilizes the instrument response to pure elements used as a library against which the incoming spectral data can be compared on a minute-by-minute basis. Typically a multiple linear regression technique is used which solves a linear matrix equation with matrix inverse math. With the high speed and data capacity of computers available today the time required for this mathematical treatment (de-convolution of the spectra) of the data takes only seconds and becomes transparent to the end user. Prior to presentation of the final answers to the customer the results of the multiple linear regression are normalized with respect to each other. The technology has made significant strides and now offers the marketplace impressive precisions and accuracies.

Why a Retrofit?

The first commercially successful on-belt PGNA analyzers were installed in the 1990's. These units and many of those placed in the first decade of this century are all now past the OEM's projected useful life. Since there are very few or no moving parts in these analyzers the failure mechanism is the sodium iodide crystal/photo multiplier combination, the proprietary electronics or the analyzer computers. In most cases the OEM reaches a point with these legacy units where parts are no longer available and they have to inform the customer the original unit as shipped can no longer be supported without a changeout of detector, electronics, and/or computer. In some cases the OEM retrofit can be expensive. A third party retrofit option now gives the cement producer the potential for a more price competitive option as well as the potential for a new service experience.

What is Involved in a Retrofit

Once a site has determined that it is time for a retrofit, a site assessment and audit must occur to verify the status of the existing unit and the potential for improvement via a retrofit. This will include assessments of the effectives of current utilization (unit placement), current nuclear source strength, health of detectors, health of electronics, etc.

After the visit, a full quotation is prepared which includes a brief report on the site assessment. A proper approach of the retrofit will be explained to gain the most use out of the original analyzer, as well as optimizing the abilities of the analyzer with new components. In every case, communication with the plant DCS is covered.

The Retrofit at Large Alpena

The cement plant in Alpena, MI was originally opened in 1908 and was acquired by Lafarge North America in 1986. It currently produces 2.5 million tons of Portland Cement per year with its 5 operating kilns. The plant is continuously making changes to increase productivity and improve environmentally. They were awarded by the Portland Cement Association with an award in Overall Environmental Excellence in April of 2004.

The operation at Alpena included two model 1812HL chute type raw meal analyzers originally supplied by Thermo Gamma Metrics in the early 1990's. These two chute analyzers were utilized to characterize material being fed into two different silo groups for either the kiln group 5 or the kiln group 6 with an overall objective of reducing the C3S variability. These analyzers had proven to be effective tools for Lafarge until about 2005 when every four to six weeks the analyzers would go down, many times during the middle of the night. It was at this time that Lafarge Alpena approached SABIA for a third party upgrade to the systems.   The existing detectors, electronics and computers were replaced. Earl Kingsbury, who was in charge of the analyzers at the time was very satisfied with the result. Not only was the regular down time eliminated but the C3S variability was greatly reduced.

Figure 5. Alpena Cement Plant

Conclusion

Early PGNA on-belt analyzers are beginning to get past their expected lifetime. This may require the electronics, components or the entire analyzer to be replaced. A third-party upgrade can be an efficient way to allow a site to continue to reap the benefits of an on-line analyzer without the cost of a whole new system.

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