Sensitive Inline Analyzers Set to Transform the Cement Industry

Portland cement manufacturing is an energy-intensive process that accounts for 6–8% of the world's fuel use and approximately 5% of man-made global CO_2 emissions. A typical plant produces 1 million m.t. of Portland cement annually, which requires accurate mixing of 1.6 million m.t. of heterogeneous raw materials. To achieve this level of accuracy, manufacturers must precisely determine the composition of raw materials.

The industry uses a nuclear radiation-based technology called prompt gamma neutron activation analysis (PGNAA), which offers highly accurate (within 0.1 wt%) inline measurement of the elemental composition of 100% of the raw material input. The PGNAA system bombards the material of interest with neutrons, exciting the atoms in the material and causing them to emit gamma rays, which are collected by a gamma-ray detector and analyzed.

Although PGNAA systems are widely utilized, they are suitable only for heavy, dense materials that produce strong signals, such as cement raw materials. XRSciences — a Carlsbad, CA-based startup funded by the National Science Foundation (NSF) — has overcome the PGNAA signal-strength limitation. Their system enables PGNAA use beyond raw material analysis (in which 80% of the costs are incurred).

Lower-density materials that are added later in the manufacturing process, such as slag and kiln dust, do not produce a strong enough signal for PGNAA to measure, which results in significant process variability. Because of the density limitations of PGNAA technology, plants are forced to use unreliable spot sampling for analyses that affect plant costs, output quality, and emissions.

XRSciences' novel patent-pending analyzer geometry, new advanced analysis algorithms, and high-speed electronics dramatically increase the signal strength from lower-density materials, enabling PGNAA systems capable of performing accurate analyses to be deployed throughout the cement manufacturing process. Table 1 compares the legacy analyzer's performance to that of XRSciences' version.

The broadened application of PGNAA systems could dramatically reduce cement makers' energy consumption, coal use, and toxic emissions. In addition, because the material stream is analyzed in its entirety, the process can accept a wider variety of raw materials (*e.g.*, flyash, blast furnace slag), while still maintaining (and even improving) the quality and consistency of the finished cement.

Table 1. The new PGNAA technology outperforms the legacy analyzer.

Material Type	Form	Legacy PGNAA Performance	New PGNAA Performance
Raw Material	Rock	Satisfactory	Excellent
Raw Meal (kiln input)	Powder	Poor	Excellent
Clinker (kiln output)	Balls	Poor	Excellent
Finished Cement	Powder	Poor	Excellent
Waste Fuel	Shreds	Poor	Excellent
Waste-Fuel Contaminants	Shreds	Poor	Excellent

▲ Cement raw materials are being analyzed on a conveyor using traditional PGNAA analysis. Image courtesy of XRSciences.

The technology will also permit stable and reliable kiln operation with a broader spectrum of fuels and could allow a large fraction (up to approximatly 40%) of conventional fuels (*e.g.*, coal and natural gas) to be replaced by less-expensive, lower-density alternatives (*e.g.*, biomass, municipal solid waste, tires). This could reduce fuel costs by up to 25% and drive down manufacturing costs by up to 20%.

Another opportunity for XRSciences' technology is the analysis of finished raw cement, called clinker. For material composition analysis, operators typically must wait 45–90 min for a spot sample of clinker to cool before adjusting raw materials and fuel composition. The new PGNAA clinker analyzer can immediately measure hot clinker, significantly improving operational control and efficiency.

Tom Gibbons, a former cement plant manager, vice president of operations, and the first user of PGNAA 25 years ago explains, "These new analyzers will mean a whole new era will open up in cement manufacturing that can result in reduced emissions, enhanced productivity, and product quality, while decreasing manufacturing costs — further transforming the Portland cement industry." CEP

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