Radiometry: advancing cement process control

In the challenging conditions of a cement plant, traditional process control methods are not always suitable. Radiometric process control provides a non-contact and non-intrusive technique to carry out continuous level measurement, detect cyclone blockages in the preheater, measure bulk flow on the conveyor and moisture measurement.

■ *by* ***Berthold Technologies****, Germany*

Radiometric process control is the perfect solution when conventional measurement techniques fail, eg due to extreme heat or challenging process conditions. For several decades radiometry has been successfully established in all industrial sectors and for a wide range of applications. The non-contact and non-intrusive technique offers measurement solutions for level, level switch, density, concentration and mass flow determinations as well as moisture measurement in vessels, pipes and conveyor belts. Therefore, this technology is particularly helpful when dealing with the harsh process conditions in cement production.

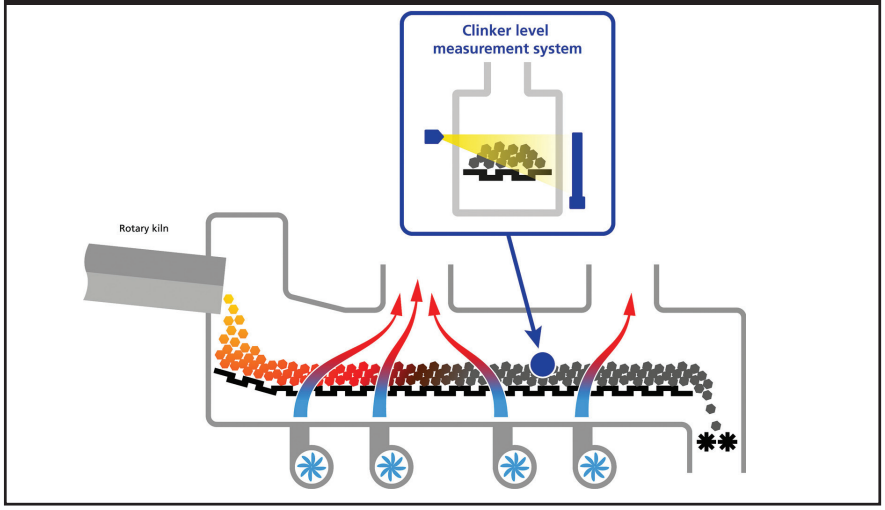
Many steps are required to produce cement out of raw materials, which are mainly limestone and small quantities of other components such as sand, clay and iron ore. Since optimal mixing ratios and cooling times are essential for the final product, the individual steps must be monitored continuously. Despite the challenging conditions, this high demand for accuracy and repeatability is accomplished using radiometry.

How radiometry functions

Every radiometric measurement, except neutron moisture measurement, is based on one principle: attenuation of radiation. For a radiometric measurement, a radioactive source and a detector, capable of detecting gamma radiation, are necessary. The source and detector are typically installed outside of the process, in one line with the vessel, pipe or conveyor to be irradiated in between.

Caesium-137 (^{137}Cs, with a half-life of 30.2 years) or cobalt-60 (^{60}Co, with a half-life of 5.3 years) are used as radioactive sources. With the help of a tight capsule, the radioactive material is always sealed safely, even under extreme and rough conditions. Only a small opening in the surrounding shield serves as a narrow exit and collimation point for the gamma radiation beam used in the measurement.

Figure 1: level measurement at a clinker cooler in a cement plant (blue point shows measurement location)



Modern detectors, mostly scintillation detectors, are highly sensitive to gamma radiation, which allows very small source activities. This ensures that the requirements of radiation protection are entirely fulfilled.

The initial radiation is attenuated

Figure 2: cyclone blockage detection with different source and detector options – profile and location of the measurement (left) and cross-sections through cyclone (right)

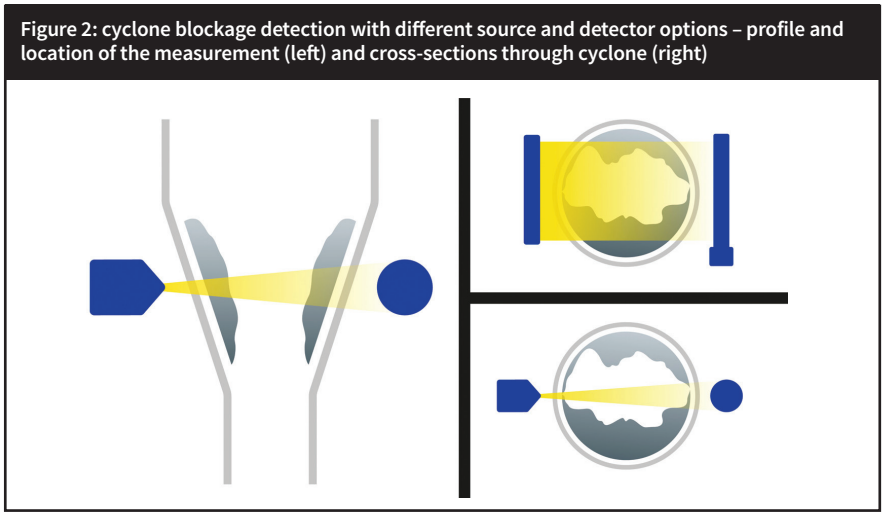
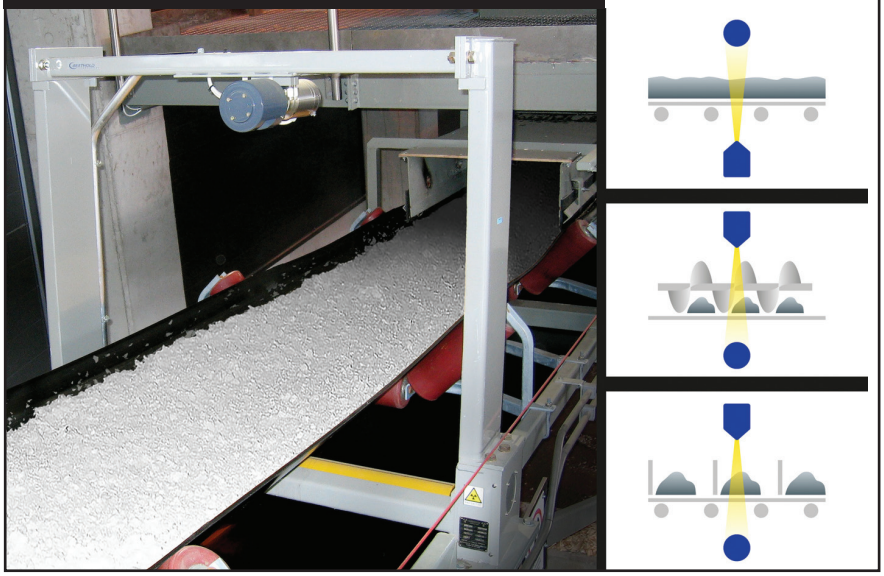


Figure 3: bulk flow measurement at crushed cement with point detector over belt and rod source beneath the belt (left) and different installation options (right)



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by the media to be monitored in the respective vessel, pipe or transported by the conveyor. This attenuated radiation is then detected by the detector. By means of a calibration, the resulting signal is assigned to a respective process value. In general, the higher the product density, level or load, the less radiation reaches the detector. In this way, level, density, concentration, solid content, mass flow and bulk flow can be reliably determined.

Since both the detector and the source are available as point or rod versions, the measurement set-up can be adjusted to the conditions on site and the application task. For instance, in a level switch application, which only monitors one specific level value, a point detector – point source set-up is plausible, whereas for bulk flow measurements, which need to cover the full conveyor width, rod sources with point detectors are the perfect combination.

The radiometric principle for measuring the moisture of products is based on the deceleration of fast neutrons. Neutron moisture measurement combines a source of fast neutrons with a detector for slow neutrons in one device. When a fast neutron hits several hydrogen nuclei in the media to be measured, it progressively slows down in speed. The number of slow neutrons is then detected by the detector, which represents the amount of hydrogen, and thus, water within the product defined by a calibration.

Advantages of radiometric process control

Radiometry has the advantage that the number of influencing variables on the measurement and thus, disturbance variables, is much smaller than with non-radiometric measurement methods. Since both the source and the detector are mounted outside of the process, they do not come into direct contact with the process media and harsh process conditions. Therefore, the non-contacting and non-intrusive measurement is unaffected by temperature, dust, conductivity, or chemical properties of the measured material. Due to rugged materials, the lack of moving parts and the outside mounting, the components do not experience any wear-and-tear, and can be operated for a very long period without the need of additional maintenance and recalibration. Hence, costly downtime can be practically avoided. The measurement systems are easy to install and retrofit installations on existing systems are no problem.

Applications in cement production that benefit from the use of radiometry

There are several applications where radiometric process control is of advantage.

Continuous level measurement for cement clinker coolers

The efficient operation of the rotary kiln and the following cooling is critical to maintain efficiency and profitability in the cement manufacturing process. Since the operating temperatures exceed 1300˚C, the measurement of the clinker level on the cooling grates is fraught with issues. Traditional techniques for measuring the level cannot withstand such a harsh environment. However, the quality of the clinker is directly affected by the cooling rate. To be cost efficient, it is important to regulate the introduced air flow so that it fits the mass of the clinker on the cooling grates. Therefore, an accurate measurement of the clinker level is crucial.

Radiometric process control allows non-contact and non-intrusive level measurement with accurate and reliable results while mounted outside of this extremely-high temperature environment. For this application, a point source and a rod detector with a sensitive length adjusted to the maximum level are very common (see Figure 1).

Cyclone blockage detection

The cement plant's preheater with a series of cyclones is located upstream of the rotary kiln. Therefore, hot exhaust gases from the rotary kiln can intrude these cyclones to preheat the raw material, which enters the rotary kiln in the next step. The undesirable side effect of this process is that vaporised compounds of the fuel (containing alkalis, sulphur and carbon) that fires the kiln, condense preferably in the lower part of the cyclone preheater and form wall build-ups.

These wall build-ups disturb and/or block the process downward flow of hot kiln feed and the upward flow of hot kiln exhaust gases. This can result in severe accidents and process shutdowns until the blockage is removed. A radiometric measurement, which delivers a continuous current output signal, can monitor these wall build-ups in real-time to avoid the blockage of the cyclone. The measurement is installed at the most critical location: at the outlet of the cyclone, directly in front

of the rotary kiln (see Figure 2). A point detector – point source arrangement is, owing to the low cost, often preferred. However, since the build-ups are mostly not symmetrical, the superior solution is a rod source – rod detector arrangement.

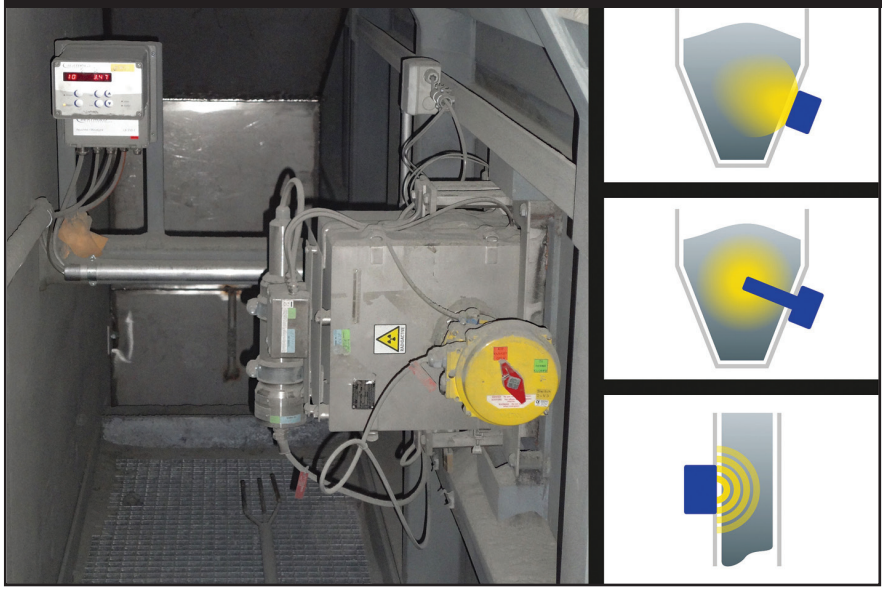
Measurement of bulk flow on conveyors

In cement production conveyors are indispensable. Knowing the actual throughput is crucial for the final product. Bulk flow measurement at conveyors can be very challenging using non-radiometric techniques. Due to various types of conveyors, products and environmental influences, mechanical belt scales are very prone to errors or cannot be used at all.

Radiometric belt scales measure the area weight of a product. With an external input for speed (or constant speed) these systems provide an online mass flow reading. They can be easily used for all kinds of conveyors, making them the system of choice for reliable and reproducible results. They are perfectly suited for monitoring loading and unloading procedures, material mixing, or dosing applications. Environmental influences such as dust, wind, vibration or fluctuation in conveyor belt tension do not affect the measurement at all. In contrast to mechanical solutions the radiometric system does not need maintenance or frequent recalibration. Radiometric belt scales can be easily retrofitted without costly modifications to any existing conveying systems (eg, conveyor belt, screw conveyor or box conveyor).

Different radiometric set-ups are possible (see Figure 3): a cost-effective solution is represented by a ^{137}Cs point source and a rod detector. This solution is ideal for materials with low bulk density and small loading height. For chain conveyors or conveyors with a wide belt width, two ^{137}Cs point sources in combination with a rod detector are favoured. However, the best accuracy and best measurement stability are provided by the arrangement of a ^{60}Co rod source in combination with a point detector. Due to the higher gamma energy, ^{60}Co delivers a higher penetration depth, which makes this arrangement the superior solution for higher bulk loads and very dense materials. For each of the options addressed, detector(s) and source(s) are mounted to a measuring frame, which is adjusted in size and orientation to the conveyor.

Figure 4: moisture measurement at silo (left) and different installation options (right)



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Moisture measurement of solids in bunkers

The measurement of moisture in the raw material, such as sand and clay, is crucial to achieve a high-quality clinker. Neutron moisture measurement at bunkers and silos is the superior solution to determine the moisture. The sensor is directly located in the product stream and captures a large volume (ϕ1m) and as a result, representative moisture contents are achieved (see Figure 4).

Conclusion

Where non-radiometric solutions fail, with the help of radiometric process control important process stages in cement production can be monitored in real-time to optimise process flows and improve operational safety. The non-contacting and non-intrusive measuring technology provides highly-accurate and reproducible results, while resisting the harsh process conditions prevailing. Therefore, radiometric process control is the superior solution without requiring further maintenance and recalibration. ■

About Berthold Technologies

As a world technology leader in the field of radiometric measuring systems, Berthold products convince with outstanding measuring performance and reliability. The production of high-quality measuring systems for industry and research began more than 70 years ago in Bad Wildbad in the Black Forest.

The main fields of application are in chemical and polymers (ie, fertiliser industry), steel and power plants, mining and mineral processing, waste and recycling, refineries, paper, glass as well as in the food industry (ie, sugar beets).

In addition, microwave measuring systems for the determination of moisture and concentration are also part of the company's extensive portfolio.