Portland cement is an essential ingredient for the construction industry, used to make concrete and mortar. There are more than 2,000 active cement plants around the world producing over 3.5 billion tonnes per year. They produce cement by heating crushed limestone and other ingredients in a rotary kiln to produce clinker which is milled to a fine powder to produce the finished product.

Temperature monitoring in and around the kiln is essential to an efficient process, and to produce cement of consistent quality. It also enables early detection of kiln refractory issues or insufficiently quenched clinker, which could lead to production stoppages if left unchecked.
The rotary kiln is the key component in a cement plant. It is a long steel cylinder, lined with refractory brickwork to protect the outer shell from the very high temperatures of the interior. The kiln is very large, up to 4 m (12 ft) in diameter and up to 50 m (160 ft) long. It typically rotates three to five times per minute.

As it rotates, the cement material works its way down towards the burning zone, heating up as it does so. This arrangement means that temperatures may vary considerably within the kiln, making monitoring more difficult.

Cement is created by heating crushed limestone with clay, slate, blast furnace slag and other materials, then cooling and grinding the resultant clinker to create a fine powder.

Most modern cement plants use a dry process which is more thermally-efficient than the older wet process. The process consists of the following stages:

1. Quarried limestone is crushed along with clay, slate, blast furnace slag and other components, to a size of 75 mm (3 inches) or less.
2. The raw materials are heated in the multi-stage pre-heater and then fed into a rotary kiln which raises their temperature to approximately 1370 °C (about 2500 °F).
3. As they progress along the rotary kiln towards the firing zone, the raw materials lose moisture and other components and form a rock-like substance called clinker, mineral lumps roughly 25 mm (1 inch) in diameter.
4. Upon leaving the kiln, the hot clinker is cooled, and the heat is recycled to the pre-heater. This improves efficiency, saves money and reduces the environmental impact of the process.
5. The cool clinker is milled to form a fine powder, and any additional cement components – for example, calcium sulphate to control the setting time – are added.
6. The finished cement is bagged and shipped.

Accurate temperature measurements are critical for product quality, environmental performance and kiln lifetime.
The inside of a cement kiln is an extremely challenging environment for making any kind of measurement. Temperatures are very high, there is a lot of dust, and tumbling clinker can damage in situ measuring instruments.

Traditionally, single-point measurements have been made here using a ratio pyrometer with a peak picker algorithm, such as the SPOT R100. This measurement technique allows the device to measure the hottest material visible through the dust, even with up to 95% obscuration. It provides an effective measurement for general monitoring but does not supply much information about the kiln operation.

A superior method, providing more detailed process information about the kiln, uses AMETEK Land’s NIR-B infrared borescope thermal imager. Because the kiln rotates continuously, the clinker collects on one side. This means that, for best effect, the NIR-B can be installed under the burner towards the other side, sighting onto the clinker.

The NIR-B produces a detailed, live radiometric image, with accurate temperature information that allows the operator to measure any subset of 324,000 live data points. This enables measurement of the flame temperature in the burner zone, clinker temperature and refractory wall temperature. The live image provides the operator with a lot of information that can’t be obtained from a single spot measurement, such as identifying ash rings inside the kiln. It is also superior to a standard video camera as it is less prone to being affected by heavy dust levels in the kiln.

HOW IT WORKS | FIRING ZONE TEMPERATURE MEASUREMENT

A short-wavelength, radiometric infrared borescope camera, the NIR-B is specifically designed to measure temperature profiles in furnace interiors. Producing a detailed, live 656x494 thermal image, the NIR-B allows the operator to select from thousands of live data points for highly specific optimisation. In the high-particulate environment of the rotary kiln, it provides a clear image of the kiln interior.

With a choice of 90° or 44° viewing angles, the NIR-B requires only a narrow hole through the firing hood. High-performance water-cooling allows it to operate in hot environments, while an auto-retraction system can be used to remove the camera from the kiln if the cooling fails.

Features:
- High measurement accuracy
- Short-wavelength sensor
- High-performance water-cooling
- Integrated air purge

Benefits:
- Optimum process control
- Simple installation and ease of use
- 24/7 monitoring
- Two-year warranty

Recommending Product:
- NIR-B

Should a single-spot measurement be preferred, the SPOT R100 pyrometer can be used. This is a ratio pyrometer with peak picking, allowing measurements in dusty environments with up to 95% obscuration.

Designed for easy, one-person installation, the SPOT range provides an accurate standalone solution, with no separate signal processor required. Ethernet, Modbus TCP, 4-20 mA analogue outputs, alarm outputs and image streaming are all available.

With models using a variety of operating wavelengths and temperature ranges for different process requirements, the SPOT range includes remotely-accessible motorized focusing. This enables it to deliver accurate stable measurements quickly, reducing maintenance time and enabling faster process adjustments.

Features:
- Self-contained single-sensor solution
- Range of digital and analogue communications
- Local and remote motorised focus control
- Easy plug-and-play installation

Benefits:
- Peak picker mode able to measure in high dust
- No separate processor required
- Scratch-resistant sapphire protection window
- Faster, more accurate measurements

Recommending Product:
- SPOT R100
KILN SHELL MONITORING

Monitoring the exterior kiln shell temperature is critical. The steel kiln shell is protected from the extremely high process temperature by one or two layers of refractory brickwork. If this brickwork fails, either by erosion or physical loss of bricks, the metal shell can be severely damaged, putting the kiln out of action.

Detecting hot spots indicative of refractory damage helps to avoid costly maintenance or unplanned shutdowns. Continuous monitoring along the length of the kiln provides early detection of problems, allowing for repairs to be made before serious damage occurs.

A much more effective technique is to use a linescanner to map the temperature of the outer shell of the kiln. AMETEK Land’s solution for this application is the LSP-HD 62, a compact, high-accuracy linescanner specifically designed to produce thermal images of moving processes.

Installed to view the rotating kiln with an 80° scan angle, it samples 1,000 points along a single line, with an industry-leading scan speed of 150 Hz. This helps build up a picture of the complete shell temperature, identifying any aberrations. For long kilns, multiple scanners can be used – AMETEK Land’s proprietary Landscan WCA software will unify the data from these scanners to form one overall picture of the kiln temperature.

LSP-HD 62

Designed to operate in harsh environments, the LSP-HD uses high-quality optics to produce high-definition thermal images at unrivalled scan speeds, for outstanding process control.

All LSP-HD scanners feature rugged sapphire protection windows that resist scratches, acids and solvents. They also have a robust scanner assembly with only one moving part, and a die-cast housing water cooling and air purging.

The LSP-HD 62 is optimised for cement manufacturing applications, with a temperature range from 100 to 600 °C (212 to 1112 °F). A plug-and-play industrial Ethernet connection provides real-time processed data, enabling refractory problems to be identified and analysed quickly.

HOW IT WORKS | TEMPERATURE SOLUTIONS IN THE KILN SHELL

Traditionally, thermocouples have been used extensively to take temperature measurements along the moving kiln. However, these give poor coverage and are unreliable.

A better measurement is provided by non-contact technologies, and a common method is to use a handheld, portable pyrometer to measure repeatedly along the rotating kiln. However, this method is very labour-intensive, and is not very effective, as it does not provide full coverage of the kiln shell. The measurement also depends on the operator’s skill and judgement, so repeatability is poor when different people make the measurement.

It is also possible to measure the temperature inside the kiln, away from the burning zone, using a SPOT M160 pyrometer and a thermowell. A thermowell is a closed-ended tube that goes through the wall of the kiln and the refractory. The SPOT pyrometer is set up to sight onto the end of the tube. Each time the kiln rotates, the SPOT M160 is able to take a measurement of the temperature at the end of the thermowell. Because the thermowell is a closed-ended tube, it acts in a similar way to a theoretically ideal cavity radiation source. This means that emissivity is not an issue for the thermowell material and provides an accurate determination of the temperature inside the kiln at that point.

USING A THERMOWELL

A linescanner installed to monitor the kiln shell exterior.

RECOMMENDED PRODUCT:

LSP-HD 62

High-resolution optical system
Operates in hot, dusty industrial environments
Easy installation with single Ethernet cable
Range of data output formats

FEATURES

Real-time thermal displays for accurate results
Industry-leading scan speeds
Detects even the smallest temperature differences
Installation costs significantly reduced

BENEFITS

HOW IT WORKS | TEMPERATURE SOLUTIONS IN THE KILN SHELL

Traditionally, thermocouples have been used extensively to take temperature measurements along the moving kiln. However, these give poor coverage and are unreliable.

A better measurement is provided by non-contact technologies, and a common method is to use a handheld, portable pyrometer to measure repeatedly along the rotating kiln. However, this method is very labour-intensive, and is not very effective, as it does not provide full coverage of the kiln shell. The measurement also depends on the operator’s skill and judgement, so repeatability is poor when different people make the measurement.

It is also possible to measure the temperature inside the kiln, away from the burning zone, using a SPOT M160 pyrometer and a thermowell. A thermowell is a closed-ended tube that goes through the wall of the kiln and the refractory. The SPOT pyrometer is set up to sight onto the end of the tube. Each time the kiln rotates, the SPOT M160 is able to take a measurement of the temperature at the end of the thermowell. Because the thermowell is a closed-ended tube, it acts in a similar way to a theoretically ideal cavity radiation source. This means that emissivity is not an issue for the thermowell material and provides an accurate determination of the temperature inside the kiln at that point.

USING A THERMOWELL

A linescanner installed to monitor the kiln shell exterior.

RECOMMENDED PRODUCT:

LSP-HD 62

High-resolution optical system
Operates in hot, dusty industrial environments
Easy installation with single Ethernet cable
Range of data output formats

FEATURES

Real-time thermal displays for accurate results
Industry-leading scan speeds
Detects even the smallest temperature differences
Installation costs significantly reduced

BENEFITS
Even very small clinker fragments can cause serious problems if they are too hot. They can damage the conveyor belt and shut down the entire manufacturing process.

Single-spot pyrometers won’t detect these small hot spots, as they average the temperature over the whole field of view. Instead, a high-resolution solution is required that can detect a small hot spot with a rapid response. AMETEK Land’s HotSpotIR scans the belt at 100 scans per second, detecting 1,000 small temperature spots each time. This allows detection of any uncooled clinker fragments that pass by, activating a high-speed alarm to alert the operator. Preventative action can then be taken, safeguarding the equipment and avoiding a lengthy shutdown and costly loss of production.

**RECOMMENDED PRODUCT:**

**HotSpotIR**

A compact, fixed-focus, high-speed scanning system, the HotSpotIR is specifically developed to detect hot inclusions on a moving conveyor. Designed for industrial environments, it rapidly identifies hot particles, preventing damage and avoiding costly shutdowns.

With high-resolution monitoring across 1,000 temperature spots, user-adjustable scanning speed up to 100 Hz, and repeatability of ±0.5 °C (±0.9 °F), the HotSpotIR can detect hot spots as small as 25 mm (1 inch).

Easy to install, it uses non-contact infrared scanning to measure across a range from 20 to 250 °C (68 to 482 °F). The HotSpotIR connects to a dedicated processor and measures the entire belt surface, activating an alarm which can be set to trigger a fire suppression system or divert the material to a safe location. The continuous monitoring means hot spots can be detected and the alarm triggered in a hundredth of a second, allowing the operator to respond quickly.

**FEATURES**

- Wide scan angle of 80°
- Built-in laser targeting system
- Fast, 100 Hz scanning speed
- Withstands high ambient temperatures

**BENEFITS**

- Increases confidence in safety
- Rapid-response alarm system
- Helps reduce insurance costs
- Prevents damage and downtime
OTHER SOLUTIONS FOR CEMENT MANUFACTURING

AMETEK Land also supplies industry-leading solutions for other applications in the cement manufacturing process. These include:

• Emissions monitoring throughout the process
• Material build-up monitoring at the feed chute and spray tower
• Hot spot and CO detection during the storage, conveying and milling of the coal used for heating
• Flue gas analysis throughout the plant

DOWNLOAD THE CEMENT AND LIME BROCHURE: WWW.AMETEK-LAND.COM

AMETEK LAND COMBUSTION & EMISSIONS MONITORING

MILLWATCH
Advance warning of the onset of combustion through the early detection of carbon monoxide in silos, enclosed storage vessels and coal grinding mills.

4500 MkIII
Industry-leading opacity monitor for PS-1 and ASTM D6216 compliance measurements. Installed on the stack or ducts leading to the stack.

4650-PM
Continuous measurement of the concentration of low-range particulate matter in stacks and ducts. Can be used as a PM-CEMS or PM-CPMS.

MODEL 9100
Cross-stack, in-situ carbon monoxide monitor for direct continuous measurement, to provide efficient combustion control of any boiler system.

LANCOM 4
A portable flue gas analyser featuring up to nine sensors for emissions measurement and combustion optimisation, used for stack emission monitoring.

WDG-1200/1210
Stack-mounted, in-situ oxygen probe for combustion optimisation, featuring integrated control and display electronics.

AMETEK LAND NON-CONTACT MEASUREMENT SOLUTIONS

FTI-E
A high-resolution, fast thermal imager designed to provide detailed temperature information in harsh industrial environments.

CYCLOPS L
Portable, handheld, non-contact spot pyrometers enabling easy and accurate point-and-measure temperature readings.

ARC IMAGER
24-hour infrared thermal monitoring of storage piles in open or semi-enclosed spaces, with alarms triggering when a hotspot is detected.

SERVICES
Our in-house service centres provide after-sales services to ensure you get the best performance from your system. This includes technical support, certification, calibration, commissioning, repairs, servicing, preventative maintenance and training. Our highly trained technicians can also attend your site to cover planned maintenance schedules and repair emergency breakdowns.

AMETEK PROCESS INSTRUMENTS ANALYSERS

WDG-HPIIC
A direct-mounted convection driven combustion analyser providing a continuous measurement of oxygen and combustibles in applications with high particulate levels in the gas stream.

WDG-VRM
Rack-mounted oxygen analyser that can be used alone or an integrated part of a continuous emissions monitoring system.

WDG-VCM w/blowback
Flue gas analyser using zirconium oxide and dual hot-wire catalytic detectors to measure oxygen, combustibles and hydrocarbons in applications up to 1648°C (3000°F).

CEM/O₂ HUMOX
Designed to measure net oxygen and moisture content in flue gas and process applications, to correct emissions, ensure product quality or minimise stack corrosion.

DOWNLOAD THE CEMENT AND LIME BROCHURE: WWW.AMETEK-LAND.COM
SUMMARY

Temperature measurements are critical to the cement manufacturing process, to ensure consistent cement quality and to prolong the lifespan of the equipment.

Monitoring is focused on the rotary kiln, and there are a number of measurement techniques that are applicable. While single-spot measurements from a ratio pyrometer are effective, the most comprehensive information is obtained from thermal imaging using an infrared borescope.

This provides an overall picture of kiln activity at the burner end, allowing the operator to see a live view of operations in the firing zone and beyond.

A linescanner can help safeguard the kiln shell against damage by detecting compromised refractory brickwork at an early stage. In addition, there are many other points where analysis is effective, including hot spot detection and emissions monitoring.

AMETEK LAND SOLUTIONS FOR TEMPERATURE MEASUREMENTS IN CEMENT MANUFACTURE:

NIR-B
Short wavelength borescope thermal imager providing high-resolution images with a wide, 90° view, in a through-the-wall design.

LSP-HD
Ethernet-controlled compact infrared linescanner, designed to produce advanced thermal imaging in moving processes.

SPOT PYROMETERS
Fully-featured, high-performance pyrometers for fixed, non-contact infrared spot temperature measurements and a range of process requirements.

HotSpotIR
Continuous infrared thermal line scanning detects small, hot inclusions on the conveyor, with alarms set to operate an inerting or diverting system to prevent expensive belt or downstream fires.

DOWNLOAD THE BROCHURES NOW AT: WWW.AMETEK-LAND.COM