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Non-contact Infrared Thermometry

Scott R. Williams, International Marketing Specialist, Raytek Corp., Berlin, Germany, describes the advantages of such measurements, which include reliable 24-hour temperature monitoring of cement kilns, early hot spot detection, increased refractory life, as well as reduced maintenance costs and downtime.

Introduction
Industrial IR sensors and systems for non-contact measurement are vital to the cement industry and can be employed throughout a plant for process monitoring and predictive maintenance. Sensors for non-contact thermometry, including fixed-mount temperature sensors, hand-held thermometers and thermal imagers, detect the energy radiated from any object and measure its temperature with high accuracy within a temperature range of -50 to 3000 °C. The early detection of hot or cold spots is essential to avoid costly maintenance or an unplanned shutdown. Continuous monitoring of the kiln shell along its length, for example, will provide the earliest possible indication of potential problem areas. Spot monitoring of the rotary burn zone temperature is also vital for maintaining both product quality and kiln efficiency. Monitoring of the temperature on and after the clinker cooler section allows proper cooling levels, and safeguards against fire hazard and conveyor belt burn out to be set.

Non-contact thermometers have a response time in milliseconds, much faster than thermocouples and RTDs, and can be used from an optimal distance with high accuracy. Measuring temperature at a distance from the object means that the sensor can be located in a more acceptable environment - without heat, vibrations, or interferences. If it is necessary to install a sensor under harsh conditions, a rugged water-cooled housing with air purge and quick-mount facilities enables reliable operation in ambient temperatures up to 315 °C, in dust, smoke and moisture.

Ratio pyrometers for harsh environments
Ratio, or two-colour infrared temperature sensors (Figure 1), are special versions of non-contact temperature measurement instruments often used in harsh environments. The ratio of energy detected in two different narrow spectral bands is used to calculate the true temperature even through dust, smoke and vapour. The influence of emissivity can be reduced and even the temperature of very small objects can be measured with high accuracy. In addition to 4 - 20 mA analogue output, most two-colour sensors have a RS485 connection, which allows remote configuration of multiple sensors and real-time data transmission to a PC. Mounted in a water-cooled rugged thermojacket, the sensor can be used in very high ambient temperatures, making it ideal for measuring clinker temperature in the sinter zone of a kiln.

Potential kiln problems
Careful management of kilns contributes to a plant's success. There are a number of problems which may shorten the lifetime of a kiln. One of the most common relates to the build up of coating inside the kiln shell. This coating provides a protective coating for the shell, and so it is absolutely essential that it remains even across the kiln wall. However, if there is an imbalance within the kiln, perhaps due to poor flame position, the coating may become thin, thus reducing its protective factor. Even worse, the coating may fall away from the wall and bring...
refractory bricks with it. This is a sign of impending kiln failure, unless the operator can cool the kiln locally at the point and promote the build up of new scale.

Another problem, which can significantly reduce productivity is the build up of excessive deposits within the kiln. Ring-like formations towards the entrance of the kiln can seriously reduce the throughput of raw materials into the kiln. Early detection is absolutely essential to enable the operator to remove them before they become too restrictive.

A final problem relates to the position of the flame within the kiln. While it is important to ensure its correct position, length, and form for optimum combustion, it is equally important that refractory bricks in the vicinity of the flame are able to respond correctly by promoting acceptable levels of protective coating.

**Kiln shell temperature monitoring**

By monitoring the temperature of the kiln surface, it is possible to detect each of the above problems before they become too serious. While localised areas of cool temperatures equate to high levels of coating or deposits, relatively higher temperatures indicate low coating and hence poor protection of the kiln shell. By monitoring how much the temperature changes and over what distances, it is even possible to identify the exact nature of the fault, be it a ring around the circumference of the kiln shell, or a localised area of poor coating.

Accurate kiln shell temperature measurement is necessary for optimising a kiln’s operating economy and maximising campaign duration. Measuring kiln shell surface temperature is crucial for detecting and evaluating hot spot development from loss of refractory, refractory performance and insulation, fan cooling effects, flame position and shape, and live ring migration.

**Thermal imaging used for kiln shells**

Linescanner-based packages are available specifically for the monitoring, control, and analysis of rotating kiln shells used in cement and lime production. Consisting of an environmentally-friendly infrared line scanner and a powerful software program for comprehensive, real-time temperature analysis, they provide a real-time thermal image of the surface temperature of the kiln shell to allow the accurate detection and monitoring of hot spots in refractory bricks. The recognition of sudden coating changes enables the operator to take countermeasures in order to avoid damage to the kiln and increase the lifetime of the refractory lining. In addition, rapid decrease of clinker production can be avoided with knowledge of material distribution and by detecting abnormal operating conditions.

Cement kiln thermal imaging systems, such as the CS100 system from Raytek (Figure 2), a world leader in infrared thermometry, are kept as simple and easy to maintain as possible, integrating the latest infrared technology and standard components from established suppliers. Scanner boxes, trigger units, interfaces, and other optional equipment, are pre-wired using industrial connectors for easy installation and flexible adoption to individual requirements. The heart of the system is the Raytek MP50 Line Scanner with a MTBF (Minimum Time Before Failure) of 40 000 hrs. The line scanner is housed in a protective enclosure with air purge to keep the window free of dust and condensation. An internal scanner heater for cold weather conditions and water cooling for hot weather and industrial environments are also included. Using a highly sensitive quantum detector with an optical resolution of 300:1, the high resolution scanner collects infrared radiation from 1024 points, which are pre-processed into 256 points within a 90° field of view. The automatic peak picker takes the maximum value of every four optical spots in order to process them into single pixels, assuring the recognition of every single hot spot. A fast scanning speed provides high resolution, and the unique internal blackbody system recalibrates the sensor on every scan for high accuracy assurance. The scanner’s high optical resolution allows the immediate detection of hot spots as small as 10 x 10 cm.

A variety of hardware options are also available, including Live Ring Migration (Tyre Slip Monitoring), automatic Fan Control via analogue output modules, and fibre optic communication. An internal, computer-independent hardware alarm indicates scanner overheating and a dirty scanner window. Other components of the comprehensive system include a position encoder, an interface box with I/O capabilities, and a temperature resistant inductive sensor used to synchronise kiln rotation with the scanning system.

The CS100 system’s DataTemp software has been developed together with customers in the cement industry to fulfil the specific demands of plants, including tyre slip monitoring, automatic fan control, and refractory management. It also features multiple databases with long and short-term buffers for easy data management. The software package consists of two main parts - the configuration utility and the monitoring software. The configuration utility contains the refractory management, the scanner positioning, and several set-up functions like alarms and databases. The monitoring software contains the real-time screen and the history screen, which can be displayed as thermogram and profile. Based on history data, several analytical functions are available, such as a trend view of the kiln temperature in defined areas and a difference view, displaying temperature difference across the whole kiln. This feature allows operators to detect refractory problems based on a sudden increase of the kiln shell temperature. Zooming provides enlarged views for detailed examination in small areas.

The thermal image of the kiln is updated with each rotation of the kiln and stored in the software’s short-term buffer. Reduced data, consisting of
minimum-maximum and average profile, are stored in a long-term buffer for trend analysis. An easy-to-configure, three-level alarm function alerts operators immediately of process problems. Using the internal alarm relay provides additional security if the computer fails. If there is an alarm due to overheating of even a small kiln area, the status of the system and the thermal data are stored in an alarm log file. Four different password levels enable only authorised personnel to change set-up and parameters. Internal log files make remote diagnostics of system failures quickly possible.

**Portable IR thermometers**

In addition to fixed-mounted sensors, high-precision hand-held IR thermometers and thermal imagers are available for convenient spot checks during routine maintenance inspections of production equipment. These hand-held inspection tools are easy to operate, simply point the instrument at the target, pull the trigger, and read the temperature value in the display. Scanning a surface with an IR thermometer or thermal imager shows where the hot and cold spots are located. Laser sighting helps easily locate small targets from optimal distances, even in low-light conditions. These portable IR thermometers include useful inspection features such as data logging, or the ability to store downloadable temperature data for multiple locations along an inspection route, as well as analysis and reporting capabilities supported by PC software.

**Thermography for predictive maintenance**

In addition to providing a temperature reading, infrared thermal imagers also generate detailed 2-D thermal images of a surface area, showing instantly where the hot and cold spots are located. There is a variety of thermal imagers available for predictive maintenance.

For example, the easy-to-use Fluke Ti30 thermal imager (Figure 3) provides all the necessary features, even for beginners, to conduct thorough thermal imaging inspections, and to quickly and accurately locate faults that could lead to equipment breakdowns, jeopardise product quality, and compromise safety. Ruggedly designed for indoor and outdoor use, the Ti30 provides quick, smooth scanning and high accuracy within a measurement range of -10 to 250 °C. It provides true radiometric imaging, capturing and displaying thermal images and spot temperature measurements simultaneously, allowing even the most subtle temperature differences in an image to be quickly identified and an abnormality to be determined if one exists. Single-point laser sighting allows targets to be accurately pinpointed from optimal distances. The unit’s long battery life of 5 hrs minimum, plus its ability to store up to 100 images, enables uninterrupted inspection sessions in the field. Intuitive software is included for professional analysis and reporting, as is hands-on training for those new to thermal imaging.