

Infrared Monitoring of Kiln Shells Extends Refractory Life

Abstract

Extending the life of kiln refractory as well as preventing disastrous failures requires a good understanding of the condition of the refractory material. The easiest way to monitor the gradual degradation of the material and to detect damaged or fallen bricks is to monitor the temperature of the kiln shell. Infrared technology has long been favored to perform this task and sophisticated user interfaces have been designed to make the data easier to analyze and understand. Recent demands have prompted the development of even more complex products that do a lot more than just measure temperature.

Introduction

Perhaps the most critical step in the cement manufacturing process takes place in the rotary kiln. Here a flame that can reach temperatures of 1900°C (3452°F) heats the raw materials to about 1500°C (2732°F). The material becomes partially molten and a series of physical and chemical reactions converts the calcium and silicon oxides into calcium silicates, cements primary constituent. At the lower end of the kiln, the raw materials emerge as red-hot particles called clinker.

The kiln itself is a large steel pipe several meters in diameter and many meters long. In larger facilities lengths of over 100 meters are not uncommon. To protect the steel from the intense heat, the kiln is lined with bricks of specially compounded refractory materials, typically a blend of various ceramic compounds. This material is compounded specifically for this application and has excellent temperature and wear resistance characteristics. Inevitably though, exposure to the intense heat and abrasive qualities of the cement leads to material degradation. Wear causes the bricks to become thinner and their ability to shield the outer surface of the kiln is impacted. To maintain an adequate level of protection, at some point the kiln must be stopped and the bricks replaced. One other concern is the potential for a single brick, or a small section of bricks, to become loose and fall. In this case, the steel kiln shell will suddenly be exposed to intense heat and unless drastic action is quickly taken permanent damage may result.



Figure 1) Typical Cement Kiln Installation

By monitoring the temperature of the entire kiln shell, the operator can determine the effectiveness of the refractory material. Any fallen bricks will be quickly detected and appropriate action may be taken to prevent further damage. Combining temperature measurement capabilities with a database of historical images allows the engineer to examine the temperature trends and to predict when the refractory will reach an unsafe condition. Scheduled maintenance

can then be planned to replace the refractory with the minimum of downtime. Thus the refractory life can be extended to provide economic benefits and emergencies can be averted. Also, close monitoring of temperature will allow the operator to see the effect of the process on the refractory. Settings can be optimized to maintain the best possible combination of high production throughput and extended refractory life. It is no wonder that this technology has been widely embraced by the cement industry for more than twenty years.

Components of a kiln scanning system

There are several systems available on the market today with a variety of specifications and features. All however use infrared scanning technology to gather the temperature data.

All objects emit infrared radiation and the intensity of this radiation increases along with the temperature of the object. Measuring the intensity of this infrared energy provides the temperature of the target. Infrared temperature sensors, widely used in many industrial applications, contain a detector that will generate a current when exposed to energy of a specific wavelength in the infrared range (1 to 20 μm). As the intensity increases, so too does the current and thus the temperature of the object can be determined. Usually these sensors utilize a range of optical elements and are focused on a specific point on the target and hence are termed "point sensors". By rotating a mirror, angled 45deg to the sensor, the energy from a wider field of view can be projected onto the sensor and thus the temperature of an entire line on the target can be measured. These units, commonly known as infrared linescanners, are at the core of all kiln shell monitoring systems in use today.

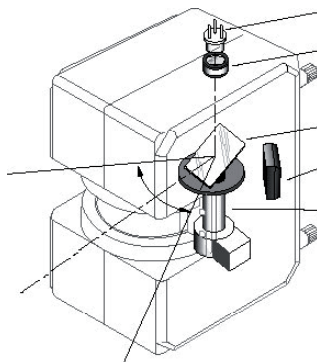


Figure 2) Infrared Linescanner

When used to monitor rotary kilns, one or more linescanners working in parallel will gather data from a line along the kiln axis. As the kiln rotates each new line of data is generated and thus the entire surface is "mapped". This data is transferred to a PC with application specific software that converts the stream of raw data into a two-dimensional thermal image of the kiln surface. A trigger signal may be used to indicate each complete revolution of the kiln and the images will be updated upon the completion of each rotation.

The software, typically loaded on a PC in the plant control room, displays each successive thermal image. This image is a false color representation of the kiln surface temperature. It is normal for the cooler areas to be represented by darker colors and the hotter areas to appear bright red or even white. Normally the image will be displayed in real-time for the operator so that any significant changes can be seen quickly. Images will also be periodically saved to a history file allowing for later analysis. Typically, this data can be used to predict the lifetime of the refractory material and schedule replacement at a time that limits downtime to an absolute minimum.

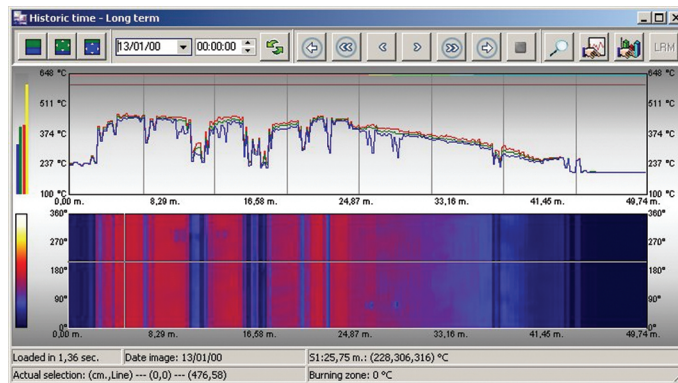


Figure 3) Screenshot showing typical thermogram

Developments in Kiln Shell Scanning

While all infrared kiln shell scanning systems offer the basic functions outlined above, newer systems address many other customer needs and offer expanded functionality.

One added function addresses the concern of shadow areas along the length of the kiln. With the wide field-of-view (FOV) of the scanner, which can range from 80 to 120deg, it is not uncommon to have several obstructions, which essentially prevent the scanner from “seeing” the entire kiln shell. These obstacles may be buildings, power poles, other equipment, etc. Further, the drive wheels or tires have a diameter significantly larger than the kiln itself and at the outer edges these too can produce areas shadowed from the linescanner. The newest systems, specifically the Raytek CS210, incorporate the use of single point sensors that are located such that they can ‘see’ the areas shadowed from the primary sensor which will always be a linescanner. The data from the point sensor and that from the linescanner are knitted into one seamless thermal image. Up to 32 point sensors can be installed and utilize multi-drop communication so that only one connection is needed back to the PC. Since the software is integrating the data from multiple sensors into a single image, “dirty lens” warnings can be easily provide as an added feature. The software compares each data point with its adjacent points and, if the difference exceeds operator-defined limits, a warning is provided that the sensor may be partially obstructed by a dirty lens or other obstruction.

Another new function involves monitoring the temperature of the clinker at the hot end of the process inside the kiln. An infrared point sensor ‘looks’ through a viewing port into the hot end of the kiln and monitors the clinker temperature. The data is displayed on the same screen as the kiln shell thermogram allowing the operator to monitor both steps of the process simultaneously. Since the environment inside the kiln is extreme with many combustion by-products between the sensor and the target, a special two-color sensor is used. This type of sensor views the target at two wavelengths and thereby returns a value that is the true temperature of the target rather than the temperature of the combustion gases.

One interesting innovation does not even involve temperature measurement. The kiln is typically driven from one end and its huge size and mass make homogeneous rotation quite a challenge. Particularly during speed changes, there is a tendency for some of the rotational energy input by the motors to cause the kiln to torque or twist rather than to rotate. While a small amount of torquing is acceptable too much twist will cause damage to the relatively fragile refractory material. The typical kiln monitoring system uses a sensor to measure each rotation of the kiln and to trigger the display of each subsequent image of the kiln shell. By installing additional sensors, one at each tire, the rotational speed of several points along the length of the kiln can be monitored. If the rotational speed varies along its length, this is an indication that twist is

occurring. During configuration, limits can be assigned and the system will trigger alarms when these limits are exceeded.

Of course, at the end of the day, the purpose of the infrared kiln shell scanning system is to monitor and report on the condition of the refractory lining within the kiln. Most programs on the market today offer some degree of refractory management. Usually this takes the form of a location within the program to record the type of refractory used along each segment of the kiln. Viewing this information alongside the temperature trend data provides the information needed to make educated decisions on how to modify the kiln settings to maximize refractory life or on when to schedule downtime to replace the brick. Some systems offer advanced refractory management capability where the user inputs some critical data on the refractory type and the system will then monitor the condition of the brick and report on refractory wear. While these systems are useful, great care should be taken to insure that the data entered into the program is accurate. Since all installations are inherently different, wear rates too will differ. Making generalized predictions on the wear rate of a given material will inevitable lead to certain installations where the brick does not last as long as the system predicts. Since plant downtime can lead to costs of seven figures per week, making decisions based solely on the predictions of such a system is unrealistic for most cement professionals.

Summary

There are many true-life case histories that demonstrate the capability to extend refractory life through careful monitoring of kiln shell temperatures. Infrared temperature scanning systems have shown their usefulness in cement plants from the Amazon, through the Sahara, in China and into the expanses of Siberia. Modern systems are adding ever more functionality in an effort to provide the cement professional with timely and complete data. In an era where everyone is asked to deliver higher and higher efficiency, infrared scanning systems are becoming an essential part of the toolkit.

Fluke Process Instruments

Americas

Everett, WA USA
Tel: +1 800 227 8074 (USA and Canada, only)
+1 425 446 6300
solutions@flukeprocessinstruments.com

EMEA

Berlin, Germany
Tel: +49 30 4 78 00 80
info@flukeprocessinstruments.de

China

Beijing, China
Tel: +8610 6438 4691
info@flukeprocessinstruments.cn

Japan

Tokyo, Japan
Tel: +81 03 6714 3114
info@flukeprocessinstruments.jp

Asia East and South

India Tel: +91 22 6249 5028
Singapore Tel: +65 6799 5578
sales.asia@flukeprocessinstruments.com

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8/2018 Kiln_RefractoryLife2