APPLICATION STORY

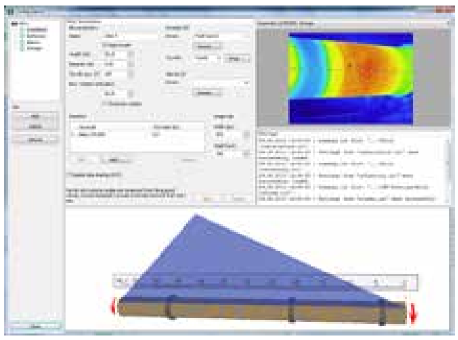
FLIR THERMAL IMAGING CAMERAS MONITOR CONDITION AND PERFORMANCE OF CEMENT KILNS

FLIR A-Series cameras make potentially dangerous hot spots clearly visible.

Today, it's impossible to imagine the building industry without cement. As an important component of masonry mortar and concrete, the manufacturing of and use of cement products make cement one of the most valuable and useful mineral products in the world. Cement production is a complex process, in which one of the steps consists of blending limestone – cement's main ingredient – with other components in big rotary furnaces. These furnaces or kilns are a critical asset of a cement production plant, heating their contents to temperatures up to 1,500°C. There is however a risk of overheating, which can cause serious damage to the kiln shell. In order to monitor this delicate heating process and prevent possible damage to the kiln, thermal imaging cameras from FLIR Systems are used to measure temperatures on a 24/7 basis.

Two companies recently teamed up to develop the IRT KilnMonitor®, an advanced computer system that allows cement production operators to monitor, process and trace data from several kilns at once. The first company, INPROTEC IRT, is an official FLIR Systems distributor for Italy. Based in Milan (Italy), the company has a wide expertise in high-tech equipment for industrial safety applications. The second company, Grayess, is a leader in the design, manufacture and marketing of special customized infrared thermal imaging solutions and software for a wide variety of applications. Grayess is based in Bradenton, FL, USA.

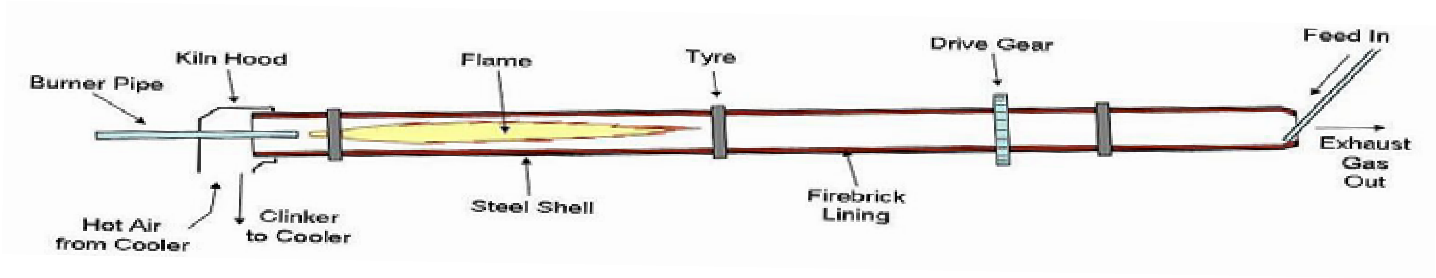
The IRT KilnMonitor® system includes FLIR A-Series cameras, which monitor the kiln temperature in real time. In addition, it includes – among other things – a kiln visualization module (2D and 3D) and a thermographic analysis module. Roberto Ricca, Director of Sales at INPROTEC IRT is very happy with the quality of the FLIR thermal imaging cameras. "We have designed the system to be integrated with the FLIR A315 and /or A615 cameras. These products provide exactly the detailed thermal data that is needed for this type of application."



IRT KilnMonitor® set-up view

CEMENT PRODUCTION

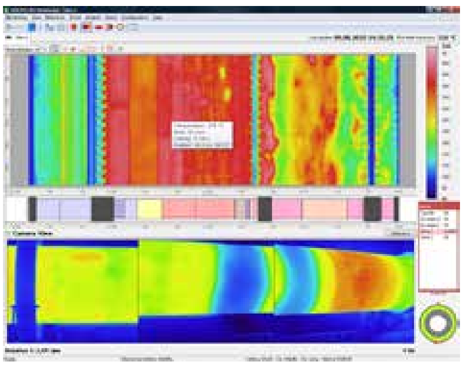
To understand the importance of the rotary kiln in the cement production process and the use of thermal cameras for this process, let's first take a look at how cement is made. Cement plants are usually located closely either to hot spots in the market or to areas with sufficient quantities of raw materials. Basic constituents for cement (limestone and clay) are taken from quarries in these areas. Basically, cement is



Schematic representation of a rotary kiln

produced in two steps: first, clinker is produced from raw materials. In the second step cement is produced from cement clinker.

The raw materials are delivered in bulk, crushed and homogenized into a mixture which is fed into a rotary kiln. This is an enormous rotating pipe of 60 to 90 m long and up to 5 m in diameter. This huge kiln is heated by a 1,500°C flame inside of the structure. The kiln is slightly inclined to allow for the materials to slowly reach the other end, where it is quickly cooled to 100-200°C. Four basic oxides in the correct proportions make cement clinker: calcium oxide (65%), silicon oxide (20%), alumina oxide (10%) and iron oxide (5%). These elements mixed homogeneously will combine when heated by the flame



The IRT KilnMonitor® provides operators with a 24/7, real-time view of the kiln operation and performance.

at a temperature of approximately 1,450°C. The final product of this phase is called "clinker". These solid grains are then stored in huge silos.

The second phase is handled in a cement grinding mill, which may be located in a different place to the clinker plant. Gypsum (calcium sulphates) and possibly additional cementitious or inert materials (limestone) are added to the clinker. All constituents are ground leading to a fine and homogenous powder: cement.

THE ROTARY KILN

Inside the rotary kiln, there is a refractory lining which insulates the steel shell from the high temperatures inside the kiln and protects it from the corrosive properties of the process material. This lining consists of refractory bricks or cast refractory concrete and needs to be replaced on a regular basis whenever the lining gets worn. The lifetime of the refractory lining can be prolonged by maintaining a coating of the processed cement material on the refractory surface. The thickness of the lining is generally in the range 80 to 300 mm. A typical refractory layer will be capable of maintaining a temperature drop of 1,000°C or more between its hot and cold faces. The shell temperature needs to be maintained below around 350°C in order to protect the steel from damage. This is where thermal imaging comes in. Thanks to thermal imaging cameras, the kiln shell can continuously be monitored and when needed, early warnings of "hot-spots" indicative of refractory failure can be given.

PROTECTING THE KILN SHELL

The shell is critical for the operational performance of the kiln. Thermal imaging cameras can at least detect two different problems regarding this shell.

Firstly, during operation, a ring of cement coating is piling up inside the shell on the refractory brick surface. On the one hand, this is beneficial, because it lowers the shell temperature, reducing heat losses and protecting the refractory material. On the other hand, furnace operators need to be aware that this coating doesn't get too thick, because this will reduce the internal diameter and as a result, reduce the furnace's production performance. By detecting low temperatures on the kiln shell, thermal imaging cameras can make operators aware of this problem.

Secondly, unstable cement coating or sudden detachment of coating material easily leads to problems with the refractory material and can cause refractory bricks to fall off. As the protecting layer is then damaged and its thickness reduced, hot spots are formed inside the shell, which results in loss of energy and disturbed kiln operation. To protect the steel shell from damage, its temperature should remain below 350°C. This can of course easily be monitored with thermal imaging cameras.

KILN MONITORING SYSTEM

The IRT KilnMonitor®, developed by INPROTEC IRT and Grayess, makes use of three A315 cameras each scanning one third of the 60m long rotary kiln. These thermal video streams are distributed to a visualization system inside the central control room, and provides operators with a 24/7, real-time view of the kiln operation and performance. The kiln has a rotation time of around 30 seconds and the IRT KilnMonitor® is synchronized to the rotation time to build up a thermal image.

Whenever the kiln shell reaches an undesired temperature, operators receive dedicated software alerts which allow them to take the appropriate remedial actions. For example, hot spots in the thermal image of the furnace can indicate that refractory bricks got detached from the refractory lining and that the protective kiln layer is getting less thick. This may require the furnace operators to reduce the temperature of the burner or even shut the system down in order to prevent severe damage and avoid huge costs.

ACCURATE THERMAL VIEWS

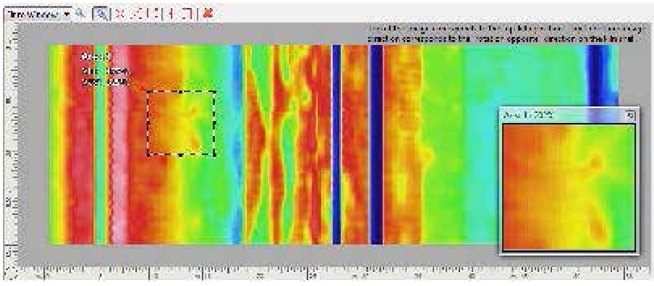
To give control room operators the best possible view of the situation, the IRT KilnMonitor® generates several different viewing modes based on the information received from the FLIR thermal imaging cameras:

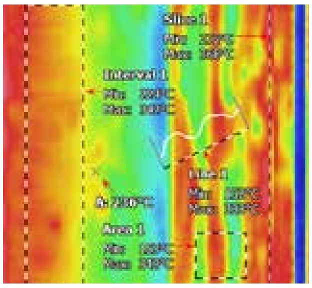
THERMAL IMAGING CAMERAS VERSUS SCANNERS

INPROTEC IRT's Roberto Ricca is not only enthusiastic about the image quality of the FLIR A315 thermal imaging cameras. When you compare them with thermal imaging scanners, another often used technology for kiln shell monitoring, then it is clear that thermal imaging cameras offer the end customer a less expensive solution.

"When scanners are used, then theoretically one scanner unit can suffice to monitor an entire 60 meter rotary kiln," comments Roberto Ricca. "However, when using a scanner, the unit needs to be placed at a certain distance and the rotary kiln should be fully visible. In practice, this is not always possible. Thermal scanners can be quite bulky and are not very flexible in terms of installation. In many cases, a rotary kiln is installed inside a dedicated production hall. Taking into account that a thermal

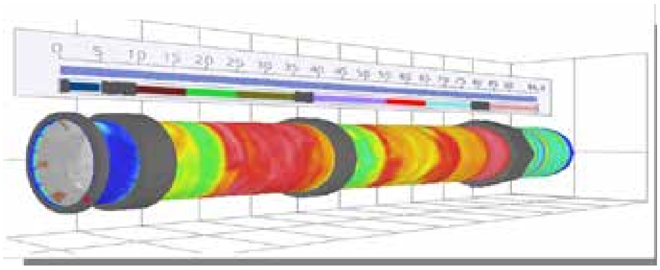
Two-dimensional infrared view (Temperature Map 2D)





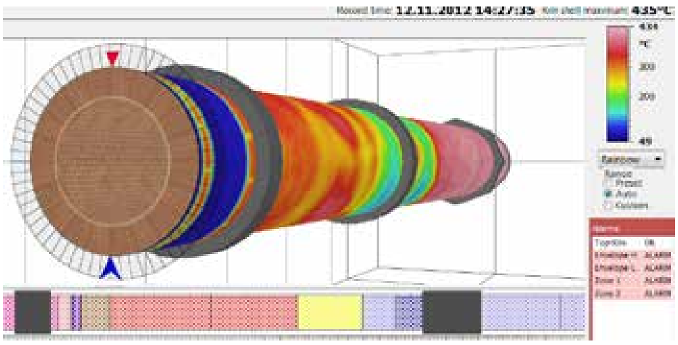
The IRT KilnMonitor® allows operators to select their own color palette and temperature range of interest. They can read information about temperature at a specific spot, position of the spot, brick thickness, coating thickness, etc. The software also allows them to zoom in on a specific area in a separate window.

Three-dimensional view of the whole kiln in motion (Virtual Kiln 3D)



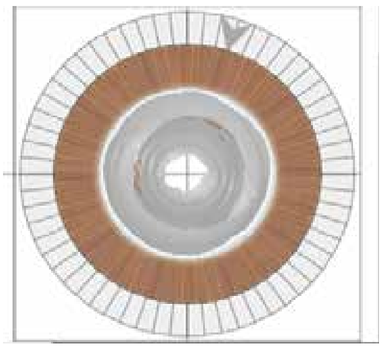
This view presents the kiln "pipe" temperature on the surface as a thermal image. The kiln is rotating in real speed.

Three-dimensional view of the kiln interior (Kiln Section 3D)

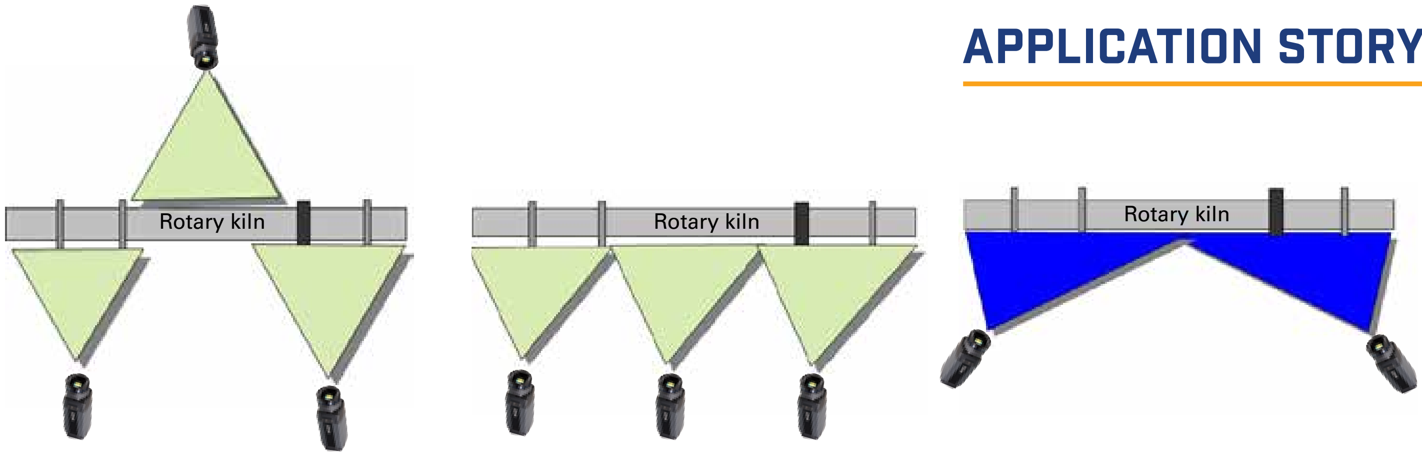


This viewing mode virtually cuts the kiln at some position and shows the kiln interior (bricks and coating).

Three-dimensional view from the kiln end (Kiln End-view)



The kiln end-view is a special case of the Kiln Section 3D view.



Possible camera positions

imaging scanner has a maximum viewing angle of 120°, it is very often impossible to install a thermal scanner at sufficient distance from the rotary kiln and avoid obstacles that are blocking the view. For example, with many rotary kiln installations, there is a secondary air tube which directs hot air out of the rotary kiln to be used as an energy source. This secondary tube will often be an obstacle."

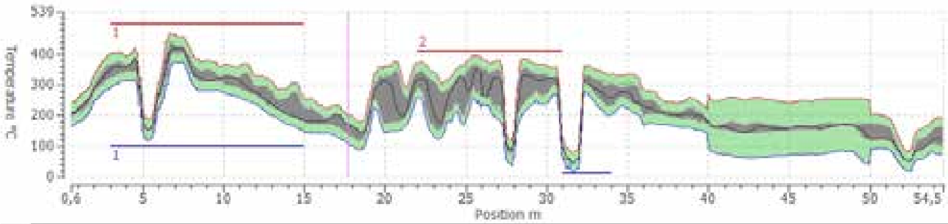
"In contrast, thermal imaging cameras are much smaller, much lighter and much more flexible in terms of placement and installation," Roberto Ricca continues. "In fact, they are the preferred solution for installations where space is limited. In our system design, we used a FLIR A315 with 90° lens. In this case, you would need three thermal imaging cameras to cover the total pipe length of 60 meters, which is still cheaper than one thermal imaging scanner."

HIGH RESOLUTION

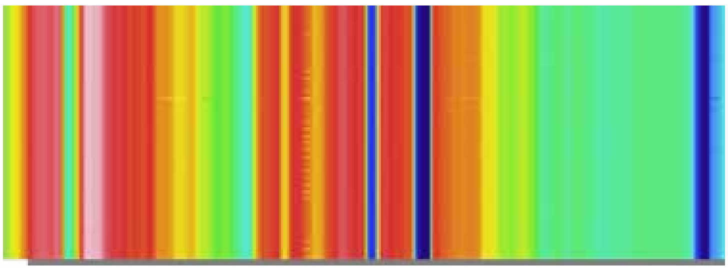
The FLIR A315 and A615 are a compact and affordable thermal imaging camera, fully controlled by a PC. With a thermal sensitivity of < 50 mK, it captures the finest image details and temperature difference information. "We definitely need the high resolution," Roberto Ricca adds. "For an ideal installation, we often opt for a 90° lens, because then you only need to use two or three cameras to cover the entire kiln length. For a German customer, we integrated the FLIR A315 with 90° lens and it delivered on the promise: very high image quality, very accurate detail!"

"We are also interested in the FLIR A615 for future installations of the IRT Kilnmonitor® system, because this will provide us with even higher resolution. The FLIR A615 has a resolution of 640x480 pixels that allows more accuracy and shows more details at a longer distance. In fact, taking into account a rotary kiln of 60 meters long, it would give us an image where each pixel represents 10 centimeter of the pipe."

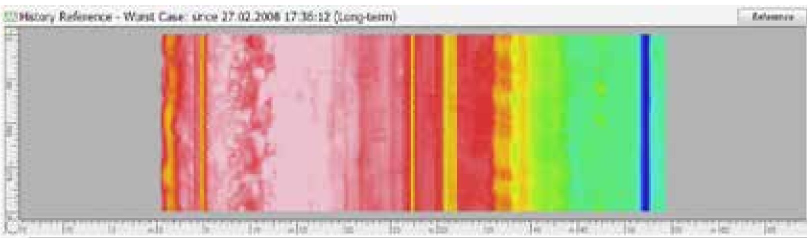
The IRT Kilnmonitor® provides several valuable summary reports and kiln history views which operators can use to evaluate the performance of the rotary kiln.



Permissible temperature envelope profile with the possibility to define individual limits for different kiln zones



This image presents the kiln history. Every line represents one record in the history.



This "worst case image" is a thermal image composed from many thermal images taken from the kiln history. Every point shows the maximum temperature measured at this point since the indicated time.

For more information about thermal imaging cameras or about this application, please visit:

www.flir.com/automation

The images displayed may not be representative of the actual resolution of the camera shown. Images for illustrative purposes only.