Thermal imaging offers new, non-contact option for skin-temperature monitoring on critical vessels

Wireless radiometric camera system is cost-competitive, simpler to install and maintain, while providing new data for trending and process improvement

A new generation of wireless thermal imaging cameras is now allowing operators of high-temperature pressure vessels to see in vivid color thermal behaviors of equipment that could only have been imagined at before, all while providing a non-contact, automatic alarm system for safety monitoring of shell temperatures.

The largest such system, utilizing 14 infrared cameras, has been on line for over two years monitoring a Chevron-Texaco-designed gas separation system for a major specialty gas producer in Texas. The turnkey infrared system provides continuous real-time skin-temperature monitoring, with computer-generated alarms for thermal excursions, while storing trend data for analysis and process improvement. This is the second system of its type in the Oil Patch, and the technology is applicable to any refractory-lined equipment, as well as reactors, regenerators, boilers, and furnace tubes.

The largest radiometric imaging system for safety monitoring of a petrochemical processing vessel uses14 Mikron IR cameras and MikroSpec™ R/T Software. It has been on line for over two years monitoring this Chevron-Texaco-designed gas separation system in Texas.

The gasification unit consists of two vessels operating at about 1000 psi with internal firing at approximately 2600°F and exterior shell temperatures ranging from 200°-500°F. A lining of castable refractory insulation 6”-8” thick protects the integrity of the 1” thick carbon-steel shells, which can melt at around 1700°F. Loss or breach of insulation in a monitored area is immediately visible as a temperature spike on the IR system’s monitor graphics, while the system computer generates an alarm.

This new wireless visual system replaces a thermocouple-grid system made of eutectic salt elements, fixed directly to the shell’s exterior. In the past, failures of thermocouples or problems with the connecting cables left dangerous holes in the monitoring scheme until replacement or repair could be made – always under very difficult conditions. Grid problems put both the gasification unit and maintenance personnel at risk.

According to maintenance personnel, this system started to degrade from the day it was installed, largely because it was in direct contact with the vessel shell. Over time, the elements began to react at different temperatures and operators lost confidence in it. At best, it gave only a very general idea of where a problem might be developing. And it had to be removed and reinstalled, with considerable labor and time, whenever work had to be done on the vessel internals.

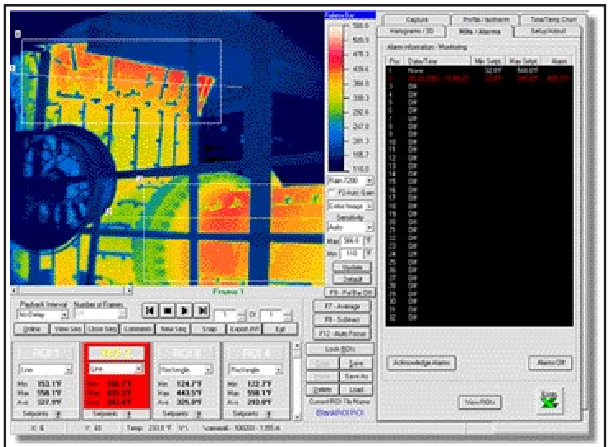
Plant operators say they are gaining an understanding of the “personality” of the gas separation system they never had before with the thermocouple grid system.

- They are beginning to store weekly thermographs of the vessel to benchmark “normal” patterns and changes over time. After rebricking the units with new refractory, they are establishing where the hot zones really are, looking for changes over time that indicate degradation of the refractory, particularly with zones getting progressively hotter or any relative change that could indicate some substrata refractory problem is developing. Operators admit they are still very much in a learning phase when it comes to understanding and trending the information they have available now.
- They have found problems they did not know existed and would not have found before. The only real process upset/alarm occurred when piping feeding a burner got too hot. This pointed up an issue they’d been unaware of, resulting in modification to controls to provide a faster purge in that part of the system.
- Operators have stated that when they do get an alarm, it gives them plenty of warning and they can now make informed decisions on how to proceed. They have developed a very high level of confidence in knowing where their safe limits are, and when to ride out an event, and when to shut down. During start up of the unit in October 2003, for example, they thought they had a hot spot developing on a nozzle connection, which they say would not have been detected with the eutectic element system. The thermal imaging system allowed them to continue monitoring this area as the unit came up, and it never did progress to an alarm. The point is, they were able to make an informed assessment of the risk in plenty of time, and determine that it was prudent to go forward while monitoring
- The plant has a very ambitious goal for time between refractory changes, and they believe this system will allow them to safely stretch to this target.
- It’s common practice to put fans and blowers on the shell in certain areas to cool it. Thermal images have shown that some of the fans are unnecessary, and the plant has been able to reduce use of blowers to cut operating costs. They had erred on the side of caution before, but now can see – via thermal imaging – they don’t need all the fans they’d been using. This also prevents them from using the blowers to the point where they cool the shell too much, leading to acid gas condensation and corrosion inside the vessel.

The 14 thermal imaging cameras are located at distances of 10 to 40 ft. from the gas separation unit. The IR cameras monitor approximately 90% of the total surface of two 60-ft. high vessels –every critical area. The plant's engineers concentrated the monitoring resources on areas they believed were most prone to a problem. Also, because the camera system was installed in an existing facility, there were inevitable obstructions that prevented 100% coverage. The cameras are mounted in totally sealed environmental enclosures with IR transparent windows and continuous purging and cooling by instrument air from a UL-certified air purge system. Positive pressure inside the enclosure prevents dirt or dust from entering, even in the harshest conditions, and protects against explosion hazard in areas where volatile gases may be present.

The 14 Mikron IR cameras are located at distances of 10 to 40 ft. from the gas separation unit. Real-time radiometric temperature data is transmitted by wireless Ethernet from each camera to a control room 1100 ft. away

Each camera's 320 x 240 pixel array is the equivalent of up to 76,800 temperature sensors aimed at the shell of the vessel. The cameras have a wireless Ethernet board built in. Real-time radiometric images and data are transmitted from each camera to a control room where they are received by antenna and fed by Cat 5 cable to a single PC running MikroSpec R/T software. Wireless capability greatly shortened and simplified system installation by eliminating the need to run conduit and wires a fifth of a mile from the cameras to the control room.



High resolution monitors provide real-time, color-coded displays of temperature at user-defined Regions of Interest (ROI's) on the vessels. MikroSpec™ R/T software allows each camera's field of view to be setup to track up to 32 ROIs with alarm values The 14-camera system enables specific temperatures to be monitored at up to 448 discrete locations

Software allows each camera's field of view to be subdivided to track up to 32 regions of interest (ROIs), each defined by any of 10 shapes, including freehand. Thus, the 14-camera system can monitor up to 448 user-defined locations, each with its own alarm limits. Operators can view real-time, color-coded displays of temperature in the ROIs. The system can be configured to show multiple camera feeds on a single monitor, or individual feeds on separate monitors. Screen choices allow data to be displayed and tracked in multiple, selectable formats.

Thermal images are displayed in a spectrum of colors from dark blue for the coolest temperatures to red/orange/yellow for the hottest. The colors are keyed to a temperature graph covering the range of temperatures to be encountered. The operator can quickly cross-reference a color to a temperature graph located alongside an image on the same screen.

Besides real-time monitoring and alarming, the software allows data to be saved for further analysis. Details can be retrieved on temperature ranges and alarm conditions within each ROI and graphs created by software tools for temperature range analysis. Data can also be exported to Excel for saving in a numerical context.

The cameras provide ±2% or ±2°C temperature accuracy, 29°H x 22°V field of view, and 30 cm to infinity focus range. Three temperature range options – -40°C to 120°C, 0°C to 500°C, and 200°C to 2000°C – allow close fit to application requirements. The camera can be remotely controlled from the PC, allowing the operators to choose from a range of monitoring/measurement modes, including interval time, display difference between points A and B, max/min temperatures in operator-defined region, temperature range, and multi-spot measurement.

While thermal imaging is typically seen as looking for hot spots, vessels may also have piping, manways, nozzles, and areas of poor combustion where cooling can be as much of a problem as overheating is in others. If temperature gets too low, condensate can build up between the shell and refractory, which can lead to corrosion and degraded pressure containment capability. Corrosion can also cause the refractory to flake off, allowing sudden burn-through of the shell.

Vessel monitoring is a significant safety issue. The temperatures and pressures of the gas separation unit present some of the most extreme conditions of any process industry. This latest system demonstrates how radiometric imaging has evolved into a mature technology that is cost competitive and offers vital advantages in terms of visual displays, information quality, installation ease, and easy interface to plant SCADA systems.

Similar systems have been installed in a wide range of pressure vessel and industrial heating applications, such as crude units, ethylene and ammonia plants, coke furnaces, asphalt and concrete plants, reformers, kilns and boilers. Mikron has even supplied a system to NASA for testing adhesives that hold ablative tiles to the space shuttle skin.

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