Infrared Linescanners: Latest Advancements Simplify Implementation And Improve Performance

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Introduction

English astronomer Sir William Hershel is credited with discovering infrared (IR) radiation in 1800. In his first experiment, Hershel subjected a liquid in a glass thermometer to different colors of the spectrum. Finding that the hottest temperature was beyond red light, Hershel christened his newly found energy "calorific rays," now known as infrared radiation.

Two centuries later, noncontact IR temperature measurement allows engineers to obtain accurate temperature readings in applications where it is impossible or very difficult to use any other kind of instrument. In some cases, this is because the application itself would literally destroy a contact thermometer, such as a thermocouple or resistance temperature detector used to measure molten metal.

Implementation of infrared linescanners has enabled plants to address a host of industrial processing requirements, such as the need for noncontact temperature measurements and data to be presented in the form of a two-dimensional image. Real-time thermal imaging provides a rapid, intuitive understanding of dynamic thermal conditions and clues to their underlying causes. It can instantly identify both unexpected temperature events and developing conditions, including temperature decay, ramping, and thermal propagation across surfaces.

The following paper discusses the latest advancements in infrared linescanner technology, and describes new developments that have simplified the implementation of these systems while providing a higher level of performance in harsh environments.

Background

In industrial plants, temperature plays an important role as an indicator of the condition of a process, product or piece of equipment. Precise temperature monitoring improves product quality and increases throughput. It also minimizes downtime, since production processes can proceed uninterrupted under optimal conditions.

Manufacturing operations use noncontact IR technology to obtain accurate temperature measurements in a wide range of automation applications. IR instruments measure temperature according to Planck’s Law of blackbody radiation, which states every object
emits radiant energy and the intensity of this radiation is a function of the object's temperature. The IR device simply measures the intensity of the emitted radiation, thereby measuring an object's temperature.

An IR sensor can be compared to the human eye. The lens of the eye represents the optics through which the radiation (flow of photons) from the object reaches the photosensitive layer (retina) via the atmosphere. This is converted into a signal that has been adjusted for ambient temperature variation and then sent to the brain of the unit.

Every form of matter with a temperature above absolute zero emits infrared radiation according to its temperature. This phenomenon, known as “characteristic radiation,” is caused by the internal mechanical movement of molecules. The intensity of this movement depends on the temperature of the object. Since the molecular movement represents charge displacement, electromagnetic radiation (photon particles) is emitted. These photons move at the speed of light and behave according to known optical principles. They can be deflected, focused with a lens, or reflected off of reflective surfaces.

Today’s infrared solutions enable temperature measurement from a distance without contacting the object to be measured. As such, an IR device is useful for measuring temperature under circumstances where thermocouples or other probe type sensors cannot be used or do not produce accurate results. These include applications where the object to be measured is moving; where the object is surrounded by an EM field; where the object is contained in a vacuum or other controlled atmosphere; or in situations where a fast response is required.

**How a Line Scanner Operates**

Infrared linescanning has been around for decades and today, this technology is used throughout the process and discrete manufacturing industries. IR linescanners offer an effective online monitoring solution for obtaining a complete temperature profile or image of a moving product. Such scanners are easily integrated into process equipment for continuous temperature monitoring and trend analysis.

An infrared linescanner provides a "picture" of the surface temperatures across a moving product, such as metal slabs, glass, textiles, coiled metal or plastics. The scanner includes a lens, a rotating mirror that scans across the lens' field of view, a detector that takes readings as the mirror rotates, and a microprocessor to interpret the data.

As the mirror rotates, the linescanner takes multiple measurements across the entire surface, obtaining a full-width temperature profile of the product. As the product moves forward under the sensor, successive scans provide a profile of the entire product, from edge-to-edge and from beginning to end. This data may be processed within the linescanner itself to create alarms or other outputs, or it may be transferred to a PC for higher level processing.
The computer converts the temperature profile into a thermographic image of the product, with various colors representing temperatures, or it can produce a "map" of the product. The measurement points across the width can be arranged in zones, averaged, and used to control upstream devices, such as cooling systems, injectors or coating systems.

The wide field-of-view of a linescanner allows a 1:2 ratio of distance to product, which permits continuous fixed scanning of very wide objects, such as cement kilns, or close proximity to processes, such as glass float lines. Unlike lightweight hand-held portable IR scanners, fixed-head process line scanners tend to be robust instruments with built-in features, such as air purging, water-cooling, and protective windows. They are often incorporated into monitoring or alarming and control systems with factory-floor interfaces.

**Latest Technology Advancements**

In recent years, instrumentation manufacturers have introduced a new generation of infrared linescanners specifically designed for automated, high-speed, discrete and continuous manufacturing processes. These systems feature the latest electronics, optics, communications and mirror mechanisms.

End-users can now select rugged linescanners designed with cast aluminum housings and integrated water-cooling. Intended for use in highly demanding industrial environments, the scanners also utilize an integral air-purge collar producing laminar airflow across the scanner window to prevent contamination build-up.

To speedup alignment, some linescanners employ an internal line laser, which indicates the exact line-of-sight of the unit. This laser, protected by the line scanner housing, projects a visible laser line on the target even while the line scanner is collecting data at full speed.

The most advanced infrared linescanners have achieved scan speeds up to 150 Hz—well in excess of earlier scanner technology—and can deliver over 1000 measurement data points. Increased scan speed allows the IR system to gather high-resolution data from even the fastest manufacturing processes. It also allows rapid detection of temperature variations and hot spots, such as those commonly found in food drying and plastics processing applications.

In addition, thermal images from multiple linescanners can now be combined with related process measurements on a single PC-based system. The scanners’ display formats typically include thermal image, thermal profile, 3D waterfall and sector trending. Facilities can include rolling buffer snapshot, zone/sector alarms, configuration recipes and history review.

Infrared linescanner technology has further benefited from the development of real-time, Windows-based thermal imaging software, which provides a simultaneous view of cross
machine temperature profiles, contour graphs, and thermograms in multiple windows. Users can select a portion of the thermal image and zoom in for a more detailed view, or compare a stored reference image with the current image to ensure consistency. The software automatically triggers an alarm when the temperature falls outside of the desired range and produces a report showing the exact location and time of occurrence.

**Trends in Data Communications**

Data communications standards ensure the successful transfer of data among sensors, computers, as well as other instrumentation and control devices. Recognized standards for industrial data communications include RS-232 and RS-485 (the RS designation stands for recommended standard). Duplex communications allow devices to act as transmitters or transceivers. In this communications mode, data flows in both directions, which allows verification and control of data reception/transmission.

The ability to network multiple sensors or measurement devices to a computer as part of an instrumentation and control system is the most economical method for acquiring, processing and archiving data. A multidrop LAN offers reduced installation cost and complexity compared with a non-multidrop configuration, which relies on multiplexing individual analog signals into a computer.

Industrial end-users now demand manufacturers of IR temperature measurement equipment and other instrumentation provide connectivity solutions for plants wanting to use a wide variety of bus standards and data communications protocols. All device suppliers provide suitable analog outputs (i.e., 4-20 mA) for interfacing instruments to Programmable Logic Controllers (PLCs) and Distributed Control Systems (DCSs), and the need for this functionality will continue for years.

Increasingly, however, emerging trends indicate a decided shift away from the traditional analog and serial port solutions toward more universal connectivity and open system platforms, ensuring greater freedom of choice.

**Adoption of Industrial Ethernet**

The demand for digital communications challenges instrument manufacturers to offer cost-effective products that do not restrict interface choices. This isn't an easy undertaking. Generally speaking, the proliferation of disparate bus structures, dissimilar hardware and different software precludes general connectivity or interoperability.

The major influence driving current network trends emanates not from the industrial sector of our economy, but from the commercial sector—namely, the rapidly growing digital business community fueled by enterprise-wide Ethernet and Internet, and TCP/IP-compliant systems and software.

When Ethernet first arrived a couple of decades ago, its use for industrial automation networking was dismissed. But usage has steadily increased in the automation
environment and Ethernet-ready products for device-level networks continue to expand. Most plant engineers have installed some sort of Ethernet network in their homes, so the technology is already seen as familiar and user-friendly.

The big advantage with industrial Ethernet is the ability to standardize an entire enterprise—from the plant floor to the corporate boardroom—on one network, providing access to data from anywhere around the world. Ethernet networks provide an infrastructure to acquire, view, process, and transmit files, graphics and information over a company's intranet or the Internet. The increased use of industrial PCs on the factory floor reinforces this trend. This, in turn, influences trends in industrial software.

Ethernet reduces installation costs by eliminating the need to run wires for connecting various field devices and computers to a PLC or DCS. The user simply connects an Ethernet-compatible device to the nearest Ethernet hub. This technology also removes the constraints of proprietary network protocols, offering greater openness and accessibility to the network architecture.

Industrial Ethernet is fast becoming a universal networking systems interface for all types of measurement and control devices—including noncontact IR temperature measurement equipment. Unlike the RS-485 protocol, Ethernet supports the increased data flow rates of modern IR linescanners. It also offers the prioritization and robustness essential for industrial automation networks.

Today’s new breed of IR scanner offers an on-board Ethernet TCP/IP communication capability. Within an existing industrial Ethernet infrastructure, users can connect directly to these scanners without the need to go through manufacturer-specific software or run wiring to proprietary controllers or connection boxes. Just like a network printer, the line scanner can be assigned a unique IP address and accessed from any computer in the factory. This innovation has a considerable effect on the total installed cost, eliminating additional wiring, conduit, etc., while at the same time providing unprecedented access to process data.

**Growth of Open Protocols**

Traditionally, large process control manufacturers built significant volumes of interconnected technologies, all communicating using common communication protocols. With equipment (instruments and/or software) provided by any one supplier, the user was ensured that communication would be easy to set-up and robust in operation. Picking the best of each sensor type on the market was not possible. Further, smaller niche manufacturers could not provide their technology in a useful format without creating multiple versions, one for each protocol—a process which resulted in extremely high license fees and huge product complexity.

Industrial end-users, who need to run software on their process control systems, now strongly advocate the move to open systems. Object-oriented technology, object linking and OLE for Process Control (OPC) are at the forefront of this trend. OPC provides
increased interoperability and facilitates the exchange of information among different sensors, automation devices, control systems, and production applications running across an entire manufacturing enterprise. With open-network protocols, a user can modify one part of the system without affecting communications to other areas.

For example, plants utilizing thermal imaging software with OPC server functionality can integrate infrared linescanners with an OPC-compliant Distributed Control Interface (DCI) or Human Machine Interface (HMI) system.

OPC makes it easier to integrate measurement devices into different plant information systems by standardizing the interfaces between dissimilar software and hardware. OPC software drivers allow full interoperability with instruments using third-party OPC-compliant software. The creation of these drivers by instrument manufacturers will help minimize their involvement in software development (at least at the application level), allowing them to focus on sensor and measurement technology.

**Conclusion**

Like other process measurement technologies, noncontact infrared linescanning has undergone much advancement in recent years—offering users robust new capabilities for controlling fast-moving production processes and eliminating a host of temperature-related problems. Instrumentation manufacturers are responding to industry demands by designing IR scanners that not only provide better online performance, but also greater simplicity and ease-of-use.

**References**
