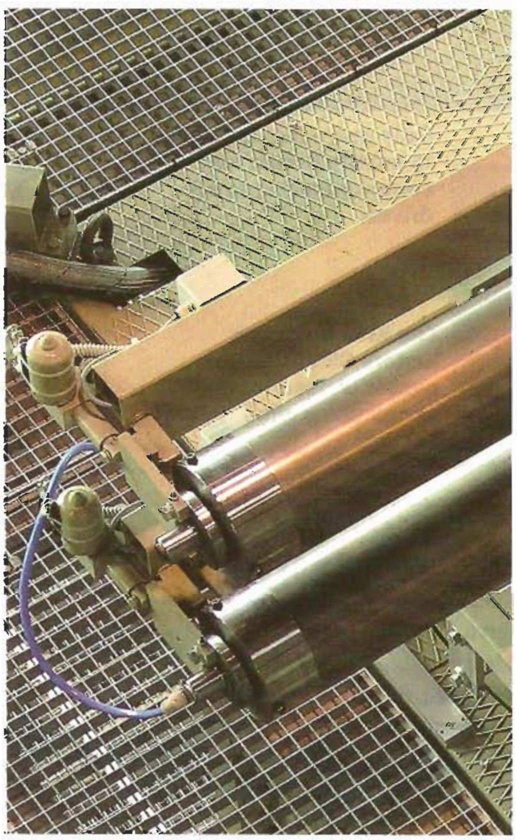
Infrared temperature

Noncontact infrared temperature measurement provides a telling metric to improve the reliability of demanding operations, saving end users thousands of dollars and hundreds of man-hours.



Frank Schneider
IR thermometry product manager
Raytek Corp.
Santa Cruz, Calif.

Infrared (IR) technology has been successfully used for years for ongoing temperature measurement and control. Now, new designs are boosting the accuracy, reliability and ease-of-use of IR solutions in more demanding production environments.

Recent advancements in noncontact IR temperature measurement not only help designers optimize their production, but also enable them to meet industry standards defining guidelines for final product quality and reliability.

Basic principles

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

IR instruments measure temperature according to Planck's Law of black body radiation, which states that *every object emits radiant energy, and the intensity of this radiation is a function of the object's temperature.* The sensors simply measure the intensity of radiation, thereby measuring an object's temperature.

To clarify, IR thermometers can be compared to the human eye. The lens of the eye can be likened to the optics through which the radiation (*or flow of photons*) from the object reaches the photosensitive layer (retina) via the atmosphere. This is converted into a signal that is sent to the controller (brain) after compensation for ambient temperature variation.

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

The infrared sensor configuration enables temperature measurement from a distance without contact with the object to be measured. As such, an IR device is useful for measuring temperature in situations where thermocouples or other probe-type

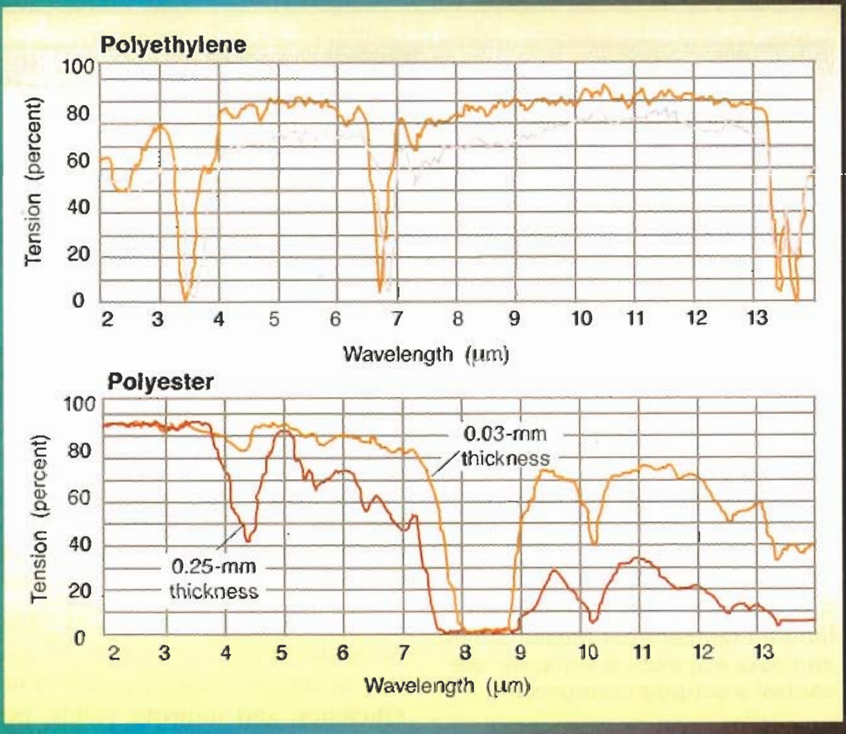
measurement

Measuring plastics

The transmittance of a plastic varies with the wavelength and is proportional to its thickness. Thin materials are more transmissive than thick.

For optimal temperature measurement, select a wavelength at which transmittance is nearly zero. Some plastics (polyethylene, polypropylene, nylon, and polystyrol) are not transmissive at 3.43 μm; others (polyester, polyurethane, Teflon FEP, and polyamide) at 7.9 μm.

For thicker films (greater than 0.4 mm) or strongly colored films, choose a wavelength between 8 and 14 μm. Or, send a sample of the plastic to the manufacturer of the infrared device to determine the optimal spectral bandwidth for measurement. Note that almost all plastic films have reflectance between 5 and 10%.



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 (as in induction heating), where the object is contained in a vacuum or other controlled atmosphere, or in applications where a fast response is required.

Critical considerations for employing IR thermometers include the field of view, including target size and distance, the type of surface being measured (or emissivity considerations), spectral response (for atmospheric effects or transmission through surfaces), the temperature range, and mounting — choosing between a handheld portable or a fixed-mount unit. Other factors include response time, environment, viewing port or window applications, and signal processing.

Technology advantages

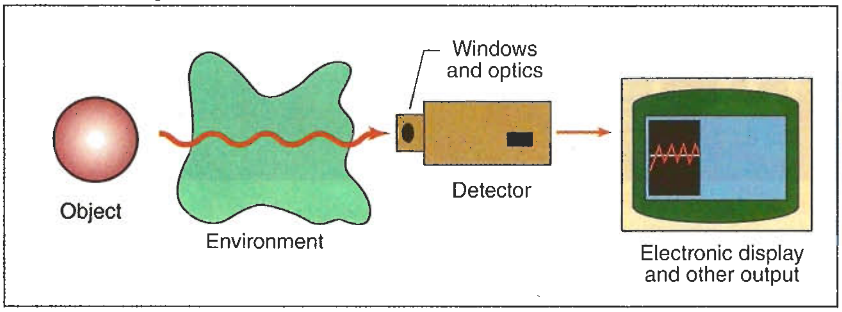
The advantages of using noncontact IR temperature measurement include:

- Increased productivity
- Higher throughput
- Reduced energy costs
- Less downtime
- Higher quality products
- Improved maintenance
- Easy data recording

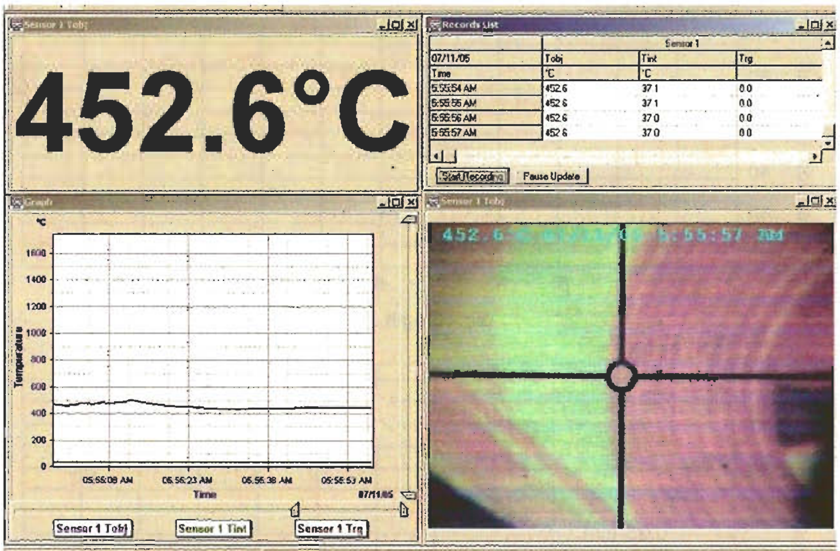
Newer infrared sensors take temperature measurement a step further. Simultaneous analog and digital output allows temperature data to be integrated into a closed-loop control system and simultaneously output for remote temperature monitoring and analysis.

Smart IR sensors, with digital electronics and two-way communications, can also be configured remotely from the safety of the control room — especially important for metals with changing emissivities. The result is increased functionality

Detection system



An IR thermometer can be compared to the human eye, and the lens of the eye can be likened to the optics through which radiation from an object reaches the photosensitive layer (retina) via the atmosphere.



A system combining noncontact infrared temperature measurement and data acquisition software can control a set-point temperature.

and greater control.

Other advancements are line scanners and imaging systems that address several application challenges.

Infrared thermometers can now monitor temperatures of dynamic systems quickly and efficiently. Unlike other devices, they measure the temperature of the product directly — allowing users to quickly adjust process parameters to optimize product quality. IR instruments also increase production efficiency, and improve yields, by enabling smaller units of measurement and a greater accumulation of temperature data. Temperature measurements can be made of a large area or a small spot.

Integrated sighting techniques

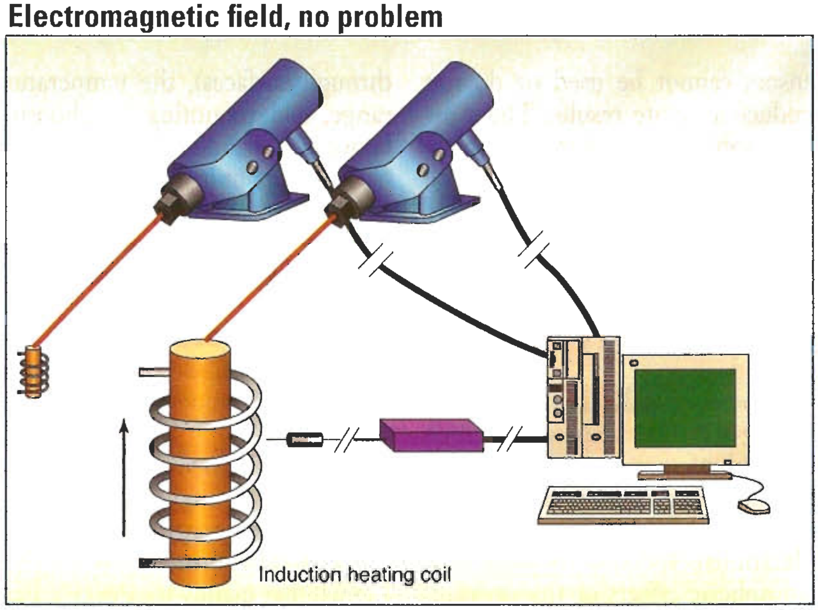
Some sensor platforms provide integrated through-the-lens target sighting, plus laser or video sighting. This combined approach ensures correct aiming and target location under the most adverse conditions.

IR sensors may also incorporate simultaneous real-time video monitoring and automated image recording and storage to help users obtain valuable new process information. Operators can take quick snapshots of the system and include temperature and time/date information in their documentation.

Miniaturized packaging

Modern IR thermometers offer twice the optical resolution of early,

Electromagnetic field, no problem



Probes and thermocouples don't do well in strong electromagnetic fields, but IR thermometers excel here. Right: The most suitable unit depends on system geometry, and the geometry of the part within the coil.

Instrument designers have developed sensor platforms with integrated through-the-lens target sighting, plus either laser or video sighting.

bulky sensor models, extending their performance in demanding control applications and allowing direct replacement of contact probes.

Newer IR sensors utilize miniature sensing heads and separate electronics, achieving up to 22:1 optical resolution and operating in temperatures approaching 200° C without any cooling. This allows accurate measurement of very small spot sizes in confined spaces and difficult ambient conditions. The sensors are small enough to be installed in very tight spaces, and when housed in a stainless steel enclosure, they withstand harsh industrial processes.

Innovations in IR sensor electronics have also improved signal processing capabilities, including emissivity, and sample, peak, and valley hold, as well as averaging functions. With some systems, these variables can be adjusted from a remote user interface for added convenience.

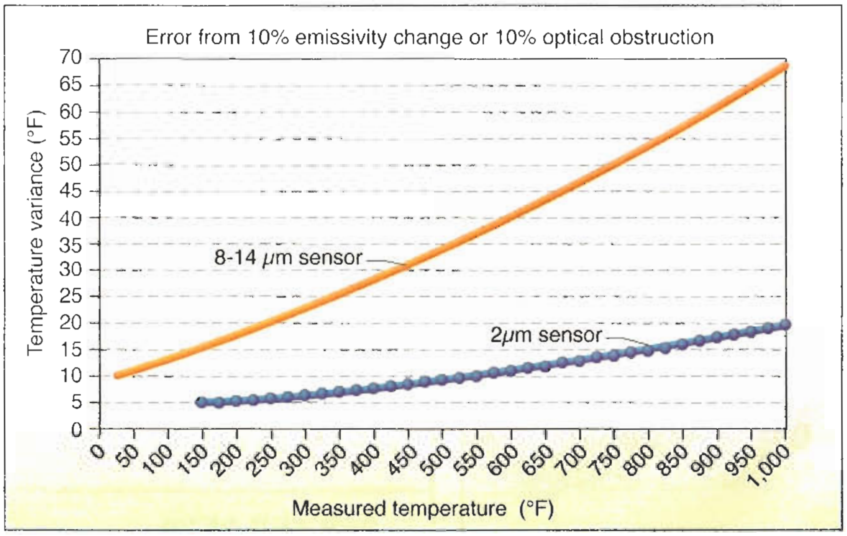
Remote controlled variable target focusing

Some IR thermometers include motorized, remote-controlled variable target focusing for fast and accurate adjustment of the focus of measurement targets, either manually at the rear of the instrument or remotely via an RS232/RS485 PC connection, where adjustments can be seen real-time through video.

With remote-controlled variable target focusing, engineers can fine-tune the sensor's measurement target focus from the safety of their own office and continuously observe and record temperature variations in their system to take immediate corrective action. The variable target focusing capability is particularly useful for large, multiple-sensor installations, where sensors are periodically replaced or the distance to the measurement object changes.

Systems with field calibration software allow users to calibrate sensors on site. Some units also offer different means for physical connec-

Tuning out emissivity, boosting accuracy



Short-wavelength IR sensors are not as sensitive to changes in emissivity on the target material as conventional, high-temperature sensors.

Measuring glass

When measuring the temperature of glass with an infrared thermometer, both reflectance and transmittance must be considered. By carefully selecting the wavelength, it is possible to measure temperature of both the surface and at a depth.

- When taking measurements below the surface, a sensor for 1.0, 2.2, or 3.9 μm wavelength should be used.
- A sensor for 5 μm is recommended for surface temperature measurement.

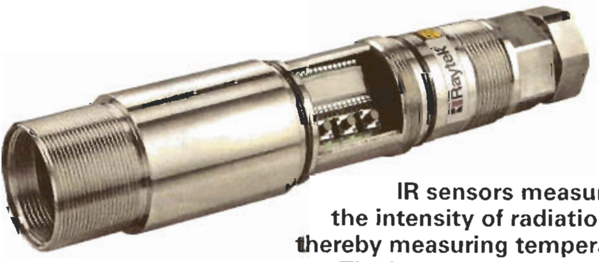
At low temperatures, 8 to 14 μm should be used with the emissivity set to 0.85, to compensate for reflectance. Because glass is a poor conductor of heat, and can change surface temperature rapidly, a measuring device with a short response time is recommended.

tion, including quick disconnect and terminal connections, as well as different wavelengths for high and low-temperature measurement, and milliamp, millivolt, and thermocouple signals.

Automatic emissivity correction

IR sensors can have emissivity issues. To correct this, short-wavelength units minimize errors due to the uncertainty of emissivity in low-temperature applications like annealing. These devices are not as sensitive to changes in emissivity on the target material as conventional, high-temperature sensors. So, they provide more accurate readings across varying targets at varying temperatures.

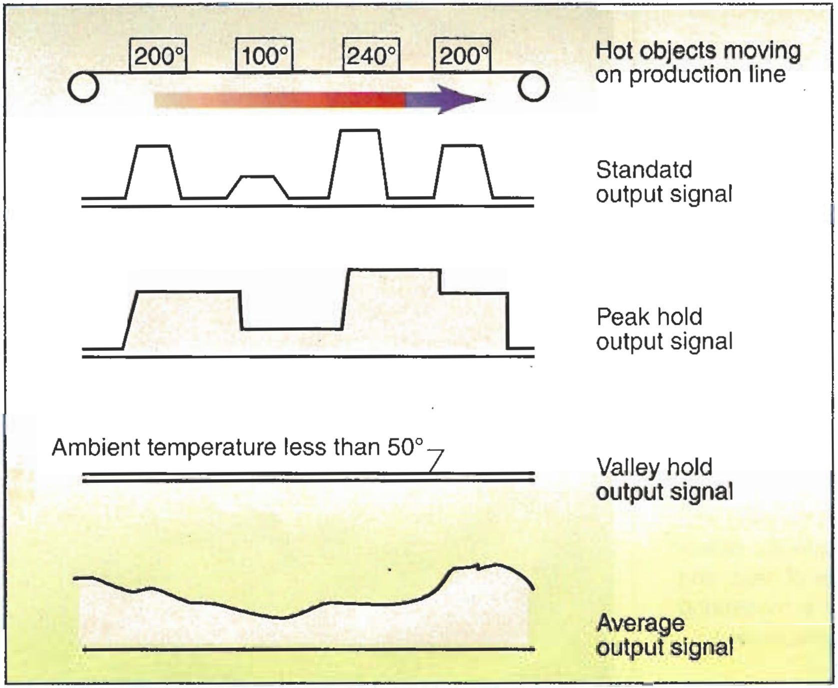
Systems with automatic emissivity correction mode allow manufacturers to setup predefined recipes to accommodate frequent product changes. By identify-



IR sensors measure the intensity of radiation, thereby measuring temperature. The latest designs boost productivity in new applications.

Temperature sensing

Smarter analysis



Innovations in IR sensor electronics have also improved signal processing capabilities, including emissivity, sample and hold, peak hold, valley hold, and averaging functions.

ing thermal irregularities within the measurement target, they allow users to improve product quality and uniformity, reduce scrap, and improve operating efficiency. If a fault or defect occurs, the system can trigger an alarm to allow for corrective action.

Enhanced data acquisition software

Noncontact infrared technology employing enhanced data acquisition software can streamline production. For example, when using an IR temperature measurement system to monitor induction heating, operators can pick a part number from an existing temperature set point list, and automatically record each peak temperature value.

For more information, visit raytek.com.