Non-Contact Temperature Measurement
in the Textile and Paper Industry

INTRODUCTION
Infrared, non-contact thermometers are ideal for measuring temperatures of moving webs of textiles or paper. Accuracy is far better in determining actual product temperature than rolling thermocouples or oven air thermometers. Figure 1 shows a comparison of the three types of measurement.

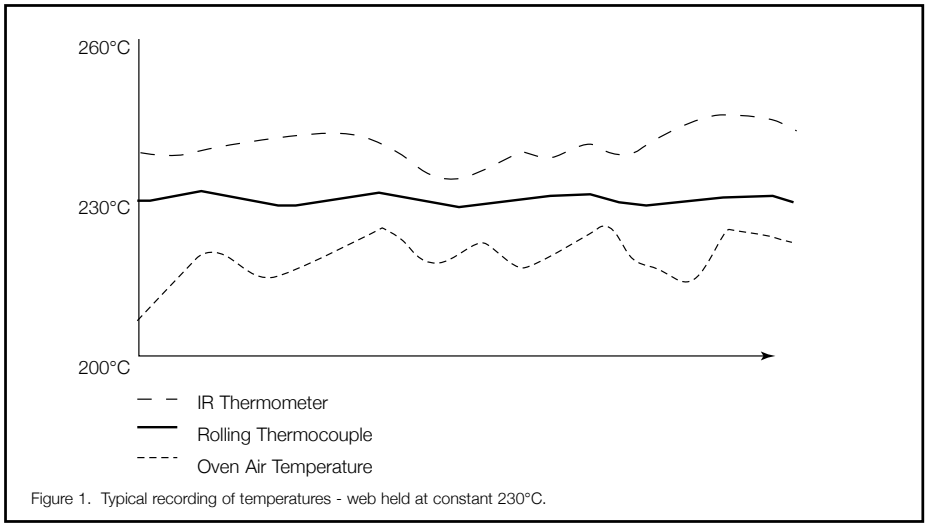

Figure 1. Typical recording of temperatures - web held at constant 230°C.

Not all objects are strong emitters of infrared energy. Emissivity is measured on a scale of 0 to 1.0, with a perfect emitter having an emissivity of 1.0. Those objects which do not have an emissivity of 1.0 tend to somewhat reflect IR energy, or pass it (transmission). Fortunately for textile and paper producers these materials tend to have emissivities very closed to 1.0. Also, IR sensors are not influenced by product colour, which is a phenomenon occurring only in the visible spectrum for almost all fabrics and papers.

TODAY'S IR INSTRUMENTATION
A variety of configurations for IR sensors have been developed during the past thirty years. Below are the three most common for textile and paper product applications.

1. Fixed-mount transducer. This device is permanently mounted to continuously monitor and/or control process temperature. The transducer-type unit is self contained, and if given a voltage input from a power supply , or put in a current loop, it will supply an output signal proportional to process temperature. It has the advantage of being a single piece, Example: Calex PyroCouple.
2. Fix-mount two-piece system. Used for the same purpose as the transducer, this system is composed of a small detector head containing only essential detector elements, with the electronic amplifiers and signal processors in another module, connected by a cable. Setup is more complex, but long-term rewards are improved stability and/or possibly eliminating the need of water-cooling systems. Also, process damaged sensor heads can be replaced at low cost. Example: Calex PyroCouple M.
3. Portable, hand-held thermometers. These are ideal for process spot-checks and maintenance work, as well as heat loss detection. Example Calex Pyropen L.

Oven air temperature is measured by a thermocouple in an enclosed oven; IR temperature by an IR sensor at the exit of the oven. There will always be a gradient between these two temperatures depending upon the type of heating used, the speed of the material and material characteristics such as weight, colour, moisture content, and heat absorption coefficient. Even if one tries to keep all variables the same, changes in ambient temperature and that of the surrounding machinery itself will affect the gradient, making actual product temperature sensing necessary for accuracy.

Another means of sensing product temperature is a rolling thermocouple at the oven exit. This device may produce variations in contact coefficient; the device is not always in contact with the product. Readings are low and varying.

By examining Figure 1, it is apparent that if a 10°C control band is needed for the best product quality, only an IR thermometer can guarantee this quality. But let us suppose that good product can be obtained anywhere within the range of 200°C to 260°C product temperature. Using thermocouple or air temperature control, we would probably have to control at no lower than 220°C average temperature to guarantee that product temperature never drops below 200°C. With IR thermometers, however, we would control on an average of 205°C. The energy savings on a 15°C reduction in process temperature would be appreciable. IR temperature control can improve not only product quality, but conserve energy.

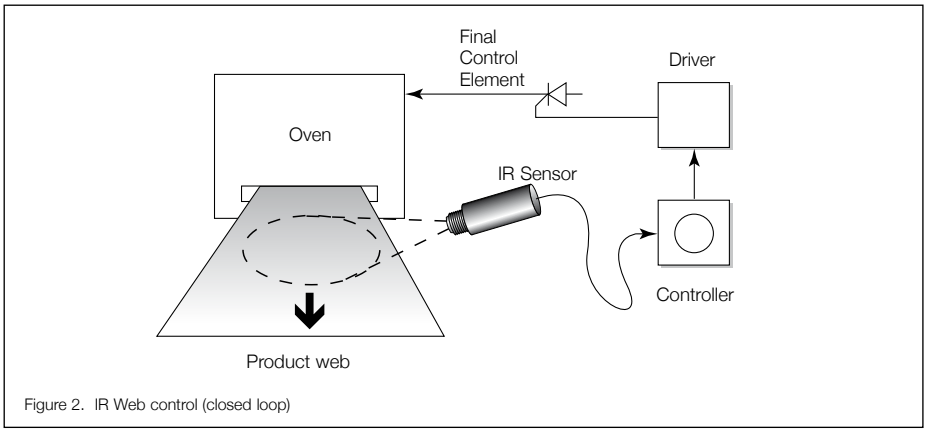

Figure 2. IR Web control (closed loop)

INFRARED THEORY

If a temperature difference exists between any two objects, infrared energy is emitted by the hotter object, and absorbed by the colder one. An infrared detector can measure the difference in IR energy between itself and another object. This measurement can be amplified, converted to temperature information, and displayed on a digital meter. The same information can be sent to a temperature controller, alarm circuit, recorder, or computer system.

SPECIFIC APPLICATIONS.

1. Tenter frame web temperature control. Goods being cured or dyeset can be monitored and/or controlled by IR temperature sensors as shown in Figure 2. It is best to keep the angle between the sensor's line-of-sight and the plane of the web as small as possible (while still keeping the sensor's field-of-view filled with the web) for two reasons. 1) the sensor will not tend to "look through" sheer fabrics, and 2) rather than looking at a single spot on the web, it will instead view a long oval across the web, giving a good average temperature indication for the entire width of the web (Figure 3). Another important point is to view product immediately after emerging from the last heater bank, or as near the exit of an enclosed oven, as possible. Otherwise a "lag time" is introduced, which can cause severe oscillations in closed-loop control.
   An air purge should be used if vapours or lint tend to coat the sensor lens. Only a light laminar flow is needed; a turbulent flow can actually coat foreign substances onto the lens.
2. Paper web monitoring and control (dryer temperature control in offset web presses, curing and laminating operations). Basically, this operation is the same as the one previously discussed, except that the angle between the sensor line-of-sight and the web should not be less than 20°, as some glossy stock can become very reflective (low emissivity) at smaller angles. Angles of 30 to 45° are optimum.
3. Moisture control. Although the IR sensor was not designed to measure moisture content, it can be used to control moisture with certain applications. When fabric is run under heater banks, a certain amount of moisture is driven out, and more of the heat from downstream heaters is used to increase product temperature. By controlling to a given exit temperature, moisture content can be controlled. An increase in IR sensor output can be used either to lower heater currents, or increase the feed rate through the heater banks.
4. Plant maintenance. Portable IR thermometers can scan breaker panels and buss bars for overheated connections before they fail, causing costly shutdowns, or to locate overheated bearings and motors. Other maintenance diagnostics include testing of steam traps, insulation, calendar rolls, heater coils, and air compressors.

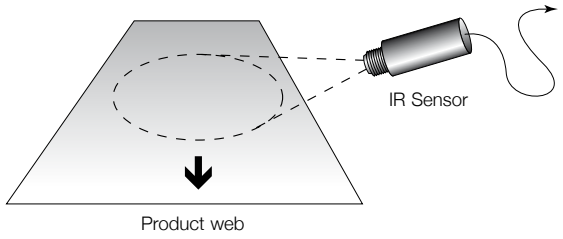

Figure 3. Proper sensor orientation

CONCLUSION

Infrared non-contact thermometers provide an excellent means of monitoring or controlling textile or paper product temperature. In some cases, product moisture content can be controlled. The user can choose between a self-contained transducer, or a two-piece system, as his needs dictate. Portable, battery operated units are excellent for process spotchecks, and double as a valuable maintenance and energy conservation tool.