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Topic 1

In order to measure hot surface temperatures in an energy audit, the instruments used have to be portable, easy to handle and reliable. For this purpose two basic types of temperature measuring instruments are used.

1) Contact type: The temperature measurement is done by touching the temperature measuring sensor to the surface of the object.
2) Non-contact type: The temperature measurement is done without touching the sensor to the surface of the object.

Contact type temperature measuring Instruments:

These are thermocouple based temperature instruments. The thermocouple couple material selection depends on the temperature range desired. For measuring temperature of a stream, insertion probes are used. For measuring surface temperature a leaf type probe is used with the same instrument. However, many times due flawed design by using of heavy thermocouple wire the measurement junction is not isothermal in use. Also, by putting the probe at right angle, the thermal gradient occurring is large. As a result, most commercial probes give an error of about 5% to 10% in temperature measurement. With careful design by using a fine wire and placing it along the surface with insulation behind wire, accuracy of about 1% can be achieved. Surface temperature error can also be caused due to the probe inhibiting the emission of radiation from the surface.

There are three problem areas in determining surface temperature of a solid, which is in equilibrium with surrounding. The first error results by bringing a cold measuring probe in contact with surface of the object. The heat flow from the surface in contact with the probe increase from the equilibrium value. The result is a disturbance and a drop of the temperature at that point. The second error is due to non-ideal thermal contact between the probe and the surface of the object, which results in a thermal resistance at the interface between the two. The third error is caused by the temperature drop with distance from the surface of the object to the “sensitive point” of the probe at which the temperature reading is taken. Due to the practical constraints of the thermocouple construction, the junction is offset by some distance from the physical tip of the sensor.

Nowadays, contact type portable temperature measuring instruments cover the range from –45 ^{0}C to 650 ^{0}C.

Non-contact type temperature measuring instruments:

In this category there are two main types:

1) Optical pyrometers
2) Infrared pyrometers

The main advantage of non-contact type pyrometers is that you can measure a temperature of a stream or surface from a distance without going near to it as required in contact type temperature measuring instruments.

Optical Pyrometers

Optical pyrometer operates by allowing the operator to compare the intensity of light radiated from a target at visible wavelength to the known brightness of an internal calibrated lamp. This is achieved by utilizing a rotating optical photoscreenic wedge that functions as a variable neutral density filter. A typical portable optical pyrometer is shown below:

Optical pyrometer is used for many industrial applications. This is useful for temperature measurement of molten iron & steel.

Infrared Pyrometers:

The use of Infrared pyrometers are based on following principle:

All the matter above absolute zero continuously emits energy in the form of infrared (IR) radiation. This emitted energy is detectable and quantified as an object's temperature through the technique of infrared thermography. The human eye can see in a very narrow range of the electromagnetic spectrum, in wavelengths from 0.4 to 0.7 microns. The infrared portion of the spectrum ranges from 1 to 100 microns.

A sufficiently hot object will emit light or visible radiation, a phenomenon called incandescence. A light bulb filament, smoldering ember, and a billet of red-hot steel are examples of this phenomenon. The hotter the object, the brighter and whiter its color. It is possible to estimate the temperature of an object this way.

Spot instruments are the oldest form of Infra red (IR) thermometer. They measure temperature of a spot of a target. They can measure temperature as low as $-45\ ^{0}C$ to as high as $3600\ ^{0}C$. A photograph of typical spot temperature measuring instrument widely used is shown below.

Line scanners are available for measuring the temperature of hot webs of moving material such as glass and steel.

Nowadays thermal imagers IR thermometer are becoming more popular for static targets. They provide a thermal image of the entire product. They can measure temperature from –40 ^{0}C to 2500 ^{0}C and can see small targets also.

Causes of errors in IR thermometers are:

- Emissivity: All IR thermometers are calibrated against a device called black body, which is considered to be perfect emitter. It is the only target that emits maximum infrared energy at any temperature and wavelength. Every other target emits less than the maximum and has an emissivity error. For example, oxidized steel has an emissivity of 0.8 at almost all wavelengths, which means it emits 80% of its infrared energy compared to a black body. As a result, when an instrument that operates at 1 micron sees this target at 870 ^{0}C it would indicate a temperature of 849 ^{0}C, an error of 21 ^{0}C.
- Reflections: Many applications for infrared thermometers require measuring the temperature of a subject inside an oven. The problem is, the oven is hotter than the subject, and every target has a factor called reflectivity.

  For example, steel with an emissivity of 0.8 is a 20% reflector. When looking at steel inside a reheat furnace, the instrument measures the radiant energy from the steel and 20% of the reflected energy from the furnace walls. The final temperature reading would be as much as 100 ^{0}C too high.

- Transmission: For transparent materials, such as glass, plastic, and some semiconductor products, there is a factor to consider that is called transmission. If the instrument is looking at a target that is being heated from the other side, the instrument could measure the heater rather than the transparent material.

  For example, glass is opaque to any thermometer that operates at wavelengths of 5 microns or longer. When viewing a light bulb with a 7.9-micron thermometer, the instrument will only measure the glass temperature and not see the 1600 ^{0}C filament inside the bulb.

- Focus: All infrared thermometers have a specific target they can measure. For the thermometer to indicate the correct temperature, the hot target should be at least two times larger than the design spot size of the instrument.
- Interference: When looking at a hot target the instrument needs a clear line of sight. Dust, smoke, and a dirty lens can all cause the instrument to indicate an incorrect temperature. For dusty applications, the dust is usually moving, and if the eye were as fast as an infrared thermometer the real target would be seen intermittently. If the lens gets dirty, use a clean, dry air purge.

  Most infrared thermometers have a function called a peak picker that picks hot spots and prevents the instrument from indicating cold spots when dust is in the way.

  If flames are clean gas flames, the instrument looks through them. If flames are dirty, such as oil or coal flames, the instrument cannot see through them.

Calibration: All infrared thermometers should be calibrated on a regular basis. Most ISO procedures suggest once a year as a normal time period. The only way to properly calibrate

- the instrument is to use a certified black body source as the standard.

IR pyrometers are found to be reliable and easy to use in measuring wide range of temperatures and can be used with proper training in a number of applications. They are very useful in monitoring surface temperature of reformer tubes in ammonia industry.

IR pyrometers are not manufactured in India. However they can be bought in India. Following are some of the addresses of companies dealing in IR Pyrometers:

1.Electronic Instrument., Cawasji Patel Street .Fort, Mumbai.
Tel No.22856099/ 22045439

2.General Instrument, Daulat Mansion, Behind Metro Cinema, Mumbai
Tel. No.22037695/ 22089538

3.Modsonic Instrument, Cawasji Patel Street, Fort Mumbai.
Tel No.22871937/ 22872673