2. Temperature Measurement

The measurement of temperature is very important in industrial application, so therefore continuous measurement of temperature is very much essential.

Temperature can be measured through various types of sensors; all of them run on the same basic principle that they give temperature in the output according to the changes produced in their physical characteristics in the input.

According to the type of application, measurement of temperature can be divided into following parts:

◈ 2.1 CONTACT METHOD : This method is used when the body (whose temperature is to be measured) and the sensor (which is measuring the temperature) can remain in contact with each other, in other words, we can say that if the body and the sensor can remain in contact with each other during the measurement of temperature than contact method is used.

Contact method uses three types of thermometers (temp. inst.)

1) Expansion Thermometers
2) Filled System Thermometers
3) Electrical temperature Instruments

2.1.1 EXPANSION THERMOMETERS: In expansion thermometers bimetallic devices are used, in bimetallic devices there are two different materials whose rate of thermal expansion is also different. Therefore, in bimetallic devices there are strips of two metals which are bonded together. When heated, one side will expand more than the other, thus the resulting expansion is translated into temperature reading by a mechanical linkage to a pointer.

The advantage of this type of instrument is that they are portable and they do not need a power supply.

And the disadvantages of this type of instrument are that they are not as accurate as other devices and they do not readily lend themselves to temperature recording.

2.1.2 FILLED SYSTEM THERMOMETERS: Filled system thermometer simply means that they are filled with any of the substitute. They generally come in two main classifications: the mercury type and the organic-liquid type. Since, mercury is considered an environmental hazard, so there are regulations governing the shipment of that type of devices that contain it. Now a day, there are filled system thermometers which employ gas instead of liquids.

The advantages of these types of devices are that they do not require any electric power, they do not pose any explosion hazard and they are stable even

after repeated cycling. And the disadvantage of these types of devices is that they do not generate data that are easily recorded or can be transmitted and they do not make spot or point measurements.

2.1.3 ELECTRICAL TEMPERATURE INSTRUMENTS: As the name implies these types of instruments sense the temperature in the terms of electrical quantities like voltage, resistance etc. Therefore, we can say that these types of instruments are not directing indicating thermometers like mercury in glass devices.

In the majority of industrial and laboratory processes the measurement point is usually far from the indicating or controlling instrument. This may be due to necessity (e.g. an adverse environment) or convenience (e.g. centralized data acquisition).Therefore; Devices are required which convert temperature in to another form of signal, usually electrical quantities.

The most common devices used in these types of temperature instruments are (a) thermocouples, (b) resistance thermometers and (c) thermistors, the similarity is, all of them require some form of contact with the body (of whose temperature is to be measured), the mode of contact could be immersed or it could be surface, depending on the construction of the sensor and the application where it is used.

2.1.3(a) THERMOCOUPLES: Thermocouples essentially comprises of a thermo element (which is a junction of two dissimilar metals) and an appropriate two wire extension lead. A thermocouple operates on the basis of the junction located in the process producing a small voltage, which increases with temperature. It does so on a reasonably stable and repeatable basis.

2.1.3(b) RESISTANCE THERMOMETER : Resistance thermometer utilizes a precision resistor, the resistance (Ohms) value of which increases with temperature. RTD has had positive temperature coefficient. Such variations are very stable and precisely repeatable.

2.1.3(c) THERMISTORS : Thermistor is a semiconductor used as a temperature sensor. It is manufactured from a mixture of metal oxides pressed into a bead, wafer or other shape. The bead is heated under the pressure at high temperatures and then encapsulated with epoxy or glass. Beads can be very small, less than 1 mm in some cases.

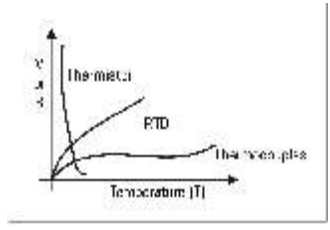
The result of all these is a temperature sensing devices that displays a very distinct non linear resistance versus temperature relationship. The resistance of thermistor decreases with increase in the temperature; this is called as negative temperature coefficient of thermistor.

Thermistor exhibits a very large resistance changes for a small temperature change. This can be as large as 3 to 5% per °C. This makes them very sensitive to small

temperature changes. They can detect temperature change as low as 0.1 °C or smaller. A thermistor element is significant smaller in size compared to RTDs.

The sensitivity of thermistors to temperature change and their small size make it ideal for use in medical equipment.

◆ DISADVANTAGE OF THERMISTORS : Because they are semiconductors, thermistors are more susceptible to permanent decalibration at high temperatures than are RTD's or thermocouple. The use of thermistors is generally limited to a few hundred degree Celsius and manufacturers warn that extended exposures even well below maximum operating limits will cause the thermistor to drift out of its specified tolerance.



Thermistors can be made very small which means they will respond quickly to temperature changes. It also means that their small thermal mass makes them especially susceptible to self-heating errors. Thermistors are good deal more fragile than RTD's or thermocouple and they must be carefully mounted to avoid crushing or bond separation.

◈ 2.2 NON-CONTACT METHOD : This method is used when the body (whose temperature is to be measured) and the sensor (which is measuring the temperature) are not allowed to remain in contact with each other, in other words, we can say that if the body and the sensor are not allowed to remain in contact with each other during the measurement of temperature then non contact method is used.

Most common thermometers (temperature instrument) using Non-Contact method are:

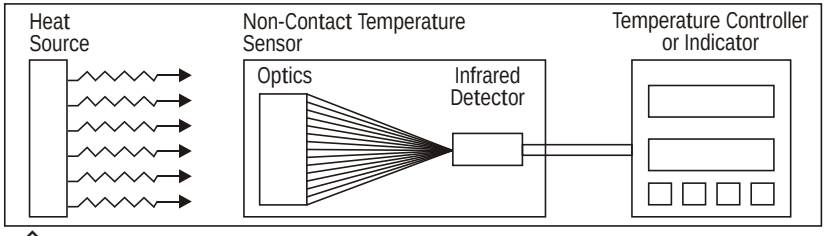
a) Infra red sensors and Pyrometers

b) Thermal Imagers

2.2 (a) INFRARED SENSORS & PYROMETERS : Infra red sensors & Pyrometer, now a day is the most common non contact temperature instrument in the industrial applications as it is easy to operate and use if the working principle is known to the user. Infra red sensor & Pyrometer measures the temperature of the object without being in the contact of the body but how is it possible? The answer is here, every object whose temperature is above absolute zero (-273.15K) emits radiation. This emission is heat radiation and its wavelength/frequency depends upon the temperature. So, this property of emission is used when the temperature is to be measured via non contact method.

The term infra red radiation is also in use because the wavelength of the majority of this radiation lies in the electromagnetic spectrum above the visible red light which is in the infra red region.

Similar to the radio broadcasting where emitted energy from a transmitter is captured by a receiver via an antenna and then transformed into sound waves, the emitted heat radiation of an object is received by detecting devices and transformed into electric signals, and in this way the temperature of an object is measured through non contact temperature measuring instruments.



2.3 TEMPERATURE SENSOR COMPARISON CHART

Sensor	Advantages	Disadvantages
Thermocouple	Simple, Rugged High temperature operation Low cost No resistance lead wire problems Faster response to temperature changes	Least stable, least repeatable Low sensitivity to small temperature changes. Extension wire must be of the same T/C type. Wire may pick up radiated electrical noise if not shielded. Lowest accuracy Cold junction compensation.
RTD	Most stable over time Most accurate Most repeatable temperature measurement Very resistant to contamination/ corrosion of the RTD element	High cost. Slowest response time. Low sensitivity to small temperature changes. Sensitive to vibration (strains the platinum element wire) Decalibration if used beyond sensor's temperature ratings. Somewhat fragile.
Thermistor	High sensitivity to small temperature changes Temperature measurements become more stable with use Copper or nickel extension wires can be used	Limited temperature range. Fragile. Some initial accuracy "drift" Decalibration if used beyond the sensor's temperature ratings. Lack of standards for replacement.
Infrared	No contact with the product required. Response times as fast or faster than thermocouples No corrosion or oxidation to affect sensor accuracy Good stability over time High repeatability	High initial cost. More complex-support electronics required. Emissivity variations affect temperature measurement accuracy. Field of view and spot size may restrict sensor application. Measuring accuracy affected by dust, smoke background radiation, etc.