Characteristics of Thermistor

Aim

To plot the characteristics of thermistor and hence find the temperature coefficient of resistance.

Components

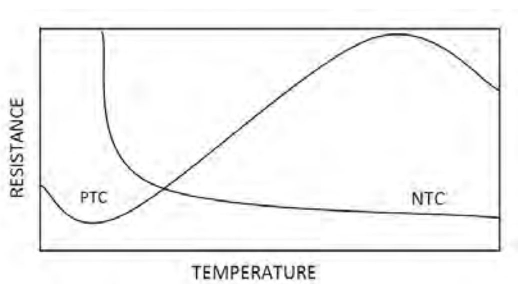
Thermistor,rheostat,voltmeter,multimeter,oil bath arrangement.

Theory

A thermistor is a type of resistor whose resistance strongly depends on temperature. The word **thermistor** is a combination of words "**thermal**" and "**resistor**". A thermistor is a temperature-sensing element composed of sintered semiconductor material and sometimes mixture of metallic oxides such as Mn, Ni, Co, Cu and Fe, which exhibits a large change in resistance proportional to a small change in temperature. Pure metals have positive temperature coefficient of resistance, alloys have nearly equal zero temperature coefficient of resistance and semi conductors have negative temperature coefficient of resistance.

Thermistors can be classified into two types:
- Positive temperature coefficient (**PTC**) thermistor:-resistance increase with increase in temperature.
- Negative temperature coefficient (**NTC**) thermistor:-resistance decrease with increase in temperature.

The thermistor exhibits a highly non-linear characteristic of resistance vs. temperature.



PTC thermistors can be used as heating elements in small temperature controlled ovens. NTC thermistors can be used as inrush current limiting devices in power supply circuits. Inrush current refers to maximum, instantaneous input current drawn by an electrical device when first turned on. Thermistors are available in variety of sizes and shapes; smallest in size are the beads with a diameter of 0.15mm to 1.25mm.

There are two fundamental ways to change the temperature of thermistor internally or externally. The temperature of thermistor can be changed externally by changing the temperature of surrounding media and internally by self-heating resulting from a current flowing through the device.

The dependence of the resistance on temperature can be approximated by following equation,

$$R = R_0 e^{\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)} \quad \text{----------------------------------- (1)}$$

R is the resistance of thermistor at the temperature T (in K)
R_0 is the resistance at given temperature T_0 (in K)
β is the material specific-constant

The material specific-constant of a NTC thermistor is a measure of its resistance at one temperature compared to its resistance at a different temperature. Its value may be calculated by the formula shown below and is expressed in degrees Kelvin (°K).

Differentiating (1) w.r.t T, we get

$$\frac{dR}{dT} = -\frac{R\beta}{T^2}$$

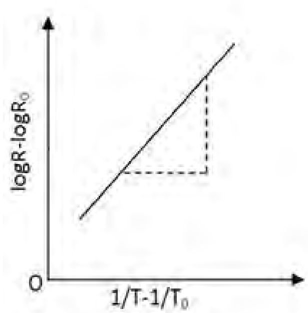
and $\alpha = -\frac{dR}{RdT}$ is the temp coefficient of resistance.

Taking log of (1) and simplifying we get,

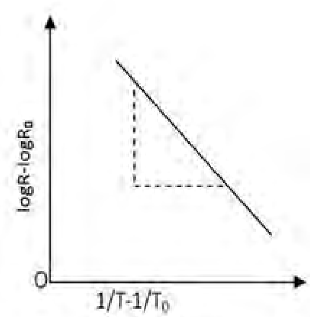
$$\beta = \frac{\log R - \log R_0}{\frac{1}{T} - \frac{1}{T_0}} \text{ ---------------------------------- (2)}$$

$$\text{and so} \quad \alpha = -\frac{\beta}{T^2} \text{ -------------------------------------- (3)}$$

A graph plotted with $\log R - \log R_0$ in Y axis and $\frac{1}{T} - \frac{1}{T_0}$ in X axis for NTC and PTC is shown below. The slope of graph gives value of β.

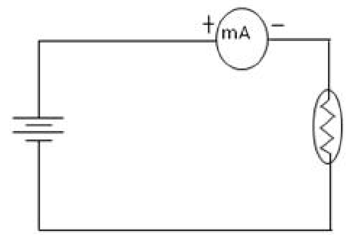


i) NTC



ii) PTC

Procedure



- Connections are made as shown in the figure.
- Place the thermistor in an oil bath using the heating arrangement.
- Note the room temperature (T_0).
- Turn on the power supply and fix to a constant voltage.
- Note the current readings using a digital multimeter or a milliammeter.
- Corresponding resistance is found , using equation $R = \frac{V}{I}$ and is noted as R_0.
- Vary the temperature of the oil bath using the heating arrangement.
- Note the current readings at regular intervals of temperatures.
- Corresponding resistances R is found using the same equation.
- From the readings, $\log R - \log R_0$, $1/T - 1/T_0$ is calculated.
- Value of β is calculated from equation $\beta = \frac{\log R - \log R_0}{\frac{1}{T} - \frac{1}{T_0}}$
- Temperature coefficient of resistance is found from the equation, $\alpha = -\frac{\beta}{T^2}$.
- Repeat the experiment for another voltage.