Thermistor Investigation

Aim

My aim is to investigate at which temperatures will give me which resistance and present it as a graph.

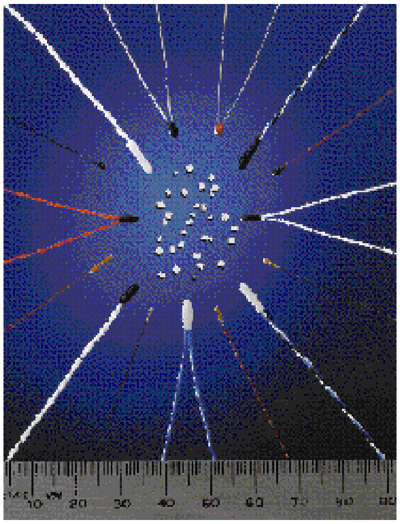
Prediction

I predict that the graph I will produce will show me that there is a clear relationship between the temperature and the resistance of the thermistor. Whether it is a negative coefficient or a positive coefficient will depend on whether thermistor is a negative temperature coefficient (NTC) thermistor or a positive temperature coefficient (PTC) thermistor. I have not been told which thermistor it is that I have been given and therefore I will also find out which thermistor I have been given.

Research

After time, temperature is the variable most frequently measured. The three most common types of contact electronic temperature sensors in use today are thermocouples, resistance temperature detectors (RTDs), and thermistors. This article will examine the negative temperature coefficient (NTC) thermistor. Positive temperature coefficient (NTC) thermistor does the same as NTC thermistor accept the resistance goes up when the temperature rises.

NTC thermistors are manufactured in a variety of sizes and configurations. The chips in the center of the photo can be used as surface mount devices or attached to different types of insulated or uninsulated wire leads. The thermistor element is usually coated with a phenolic or epoxy material that provides protection from environmental conditions. For applications requiring sensing tip dimensions with part-to-part uniformity and/or smaller size, the devices can be encapsulated in PVC cups or polyamide tubes.



General Properties and Features

NTC thermistors offer many desirable features for temperature measurement and control within their operating temperature range. Although the word thermistor is derived from thermally sensitive resistor, the NTC thermistor can be more accurately classified as a ceramic semiconductor. The most prevalent types of thermistors are glass bead, disc, and chip configurations (see Photo above).

NTC thermistors exhibit a decrease in electrical resistance with increasing temperature. Depending on the materials and methods of fabrication, they are generally used in the temperature range of -50°C to 150°C, and up to 300°C for some glass-encapsulated units. The resistance value of a thermistor is typically referenced at 25°C (abbreviated as R25). For most applications, the R25 values are between 100 Ω and 100 kΩ. Other R25 values as low as 10 Ω and as high as 40 MΩ can be produced, and resistance values at temperature points other than 25°C can be specified.

Equipment

In this experiment I used the following: 1x kettle, 1x thermistor, 1x multimeter, 2x crocodile clips, some ice cubes, 1x large beaker and 1x thermometer.

Method

Step1: - Set up the experiment as shown in the diagram above.

Step 2: - To get the correct temperature of the water in the beaker use both the ice the kettle until the thermometer reads the desired temperature.

Step 3: - I then used the multimeter set at 2000 ohms to take a reading of the resistance.

Step 4: - Record the result from the multimeter in the results table and start again from step 2 to get three results.

Step 5: - Start again for the next temperature.

Results Table

Temperature (C^{o})	Resistance (Ohms)			
	1	2	3	Average
10	876	812	784	824
20	405	610	534	516.3
30	170	453	465	362.7
40	220	237	245	234
50	211	234	230	225
60	137	200	185	174
70	174	160	170	168
80	434	88	78	200
90	43	45	43	43.7
100	29	35	34	32.7

From my results it has enabled my to draw my graph and to analyse my results further.

Conclusion

From looking at my graph I have discovered that my conclusion was wrong. The graph was not linear and there is not even a close relationship between resistance and temperature. I have however discovered that the thermistor I used was a NTC.

Evaluation

Looking at my results there are some anomalies these are highlighted below:

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The anomalies would of caused the results to come out wrong. These results could of happened due to a number of reasons. One is if the thermistor was not in thermal equilibrium, this means that the thermistor may not of been at the same temperature as the water it was placed in. Another is the thermometer might not of been exactly where the thermistor was so there could be a different in temperature. Another is if all the ice had not melted this would mean that there would be different temperatures in the beaker. This means that my curve cannot be trusted. Also in the lower temperatures there were big differences between the resistances, so more results would give a more accurate graph.

I have done further research with an equation and a graph that I can now compare my graph with:

Accurate and Repeatable R/T Characteristic.

The resistance vs. temperature characteristic (also known as R/T curve) of the NTC thermistor forms the "scale" that allows its use as a temperature sensor. Although this characteristic is a non-linear, negative exponential function, several interpolation equations are available that very accurately describe the R/T curve [1,2,3]. The most well known is the Steinhart-Hart equation: $1/T = A + B(\ln R) + C(\ln R)^3$
where: T = kelvin temperature R = resistance at temperature T

Coefficients A, B, and C are derived by calibrating at three temperature points and then solving the three simultaneous equations. The uncertainty associated with the use of the Steinhart-Hart equation is less than ±0.005°C for 50°C temperature spans within the 0°C-260°C range, so using the appropriate interpolation equation or lookup table in conjunction with a microprocessor can eliminate the potential nonlinearity problem.

Sensitivity to Changes in Temperature.

The NTC thermistor's relatively large change in resistance vs. temperature, typically on the order of -3%/°C to -6%/°C, provides an order of magnitude greater sensitivity or signal response than other temperature sensors such as thermocouples and RTDs. On the other hand, the less sensitive thermocouples and RTDs are a good choice for applications requiring temperature spans >260°C and/or operating temperatures beyond the limits for thermistors.

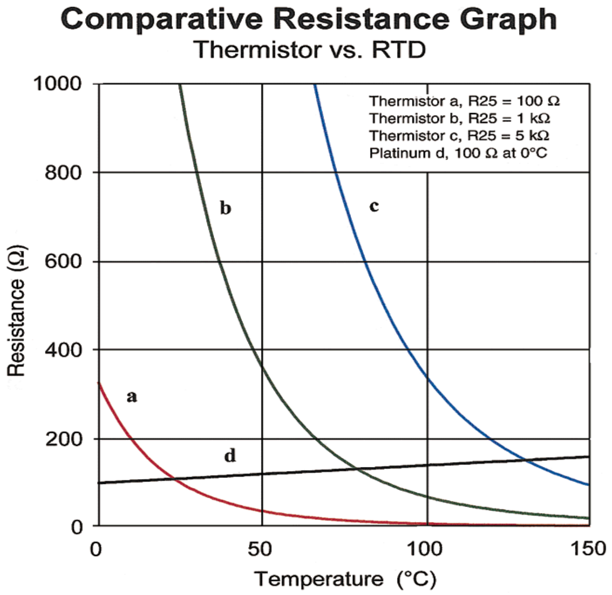

Fig1. Over the range of -50°C to 150°C, NTC thermistors offer a distinct advantage in sensitivity to temperature changes compared to other temperature sensors. This graph illustrates the R/T characteristics of some typical NTC thermistors and a platinum RTD.

Interchangeability

Another important feature of the NTC thermistor is the degree of interchangeability that can be offered at a relatively low cost, particularly for disc and chip devices. Interchangeability describes the degree of accuracy or tolerance to which a thermistor is specified and produced, and is normally expressed as a temperature tolerance over a temperature range. For example, disc and chip thermistors are commonly specified to tolerances of ±0.1°C and ±0.2°C over the temperature ranges of 0°C to 70°C and 0°C to 100°C. Interchangeability helps the systems manufacturer or thermistor user reduce labour costs by not having to calibrate each instrument/system with each thermistor during fabrication or while being used in the field. A health care professional, for instance, can use a thermistor temperature probe on one patient, discard it, and connect a new probe of the same specifications for use on another patient--without recalibration. The same holds true for other applications requiring reusable probes.

Small Size

The small dimensions of most bead, disc, and chip thermistors used for resistance thermometry make for a very rapid response to temperature changes. This feature is particularly useful for temperature monitoring and control systems requiring quick feedback.

Remote Temperature Sensing Capability

Thermistors are well suited for sensing temperature at remote locations via long, two-wire cable because the resistance of the long wires is insignificant compared to the relatively high resistance of the thermistor.

Ruggedness, Stability, and Reliability

As a result of improvements in technology, NTC bead, disc, and chip thermistor configurations are typically more rugged and better able to handle mechanical and thermal shock and vibration than other temperature sensors.

Materials and Configurations

Most NTC thermistors are made from various compositions of the metal oxides of manganese, nickel, cobalt, copper, and/or iron. A thermistor's R/T characteristic and R25 value are determined by the particular formulation of oxides. Over the past 10 years, better raw materials and advances in ceramics processing technology have contributed to overall improvements in the reliability, interchangeability, and cost-effectiveness of thermistors.

Of the thermistors beads, discs, and chips are the most widely used for precise temperature measurements. Although each configuration is produced by a unique method, some general ceramics processing techniques apply to most thermistors: formulation and preparation of the metal oxide powders; milling and blending with a binder; forming into a "green" body; heat-treating to produce a ceramic material; addition of electrical contacts (for discs and chips); and, for discrete components, assembly into a usable device with wire leads and a protective coating.

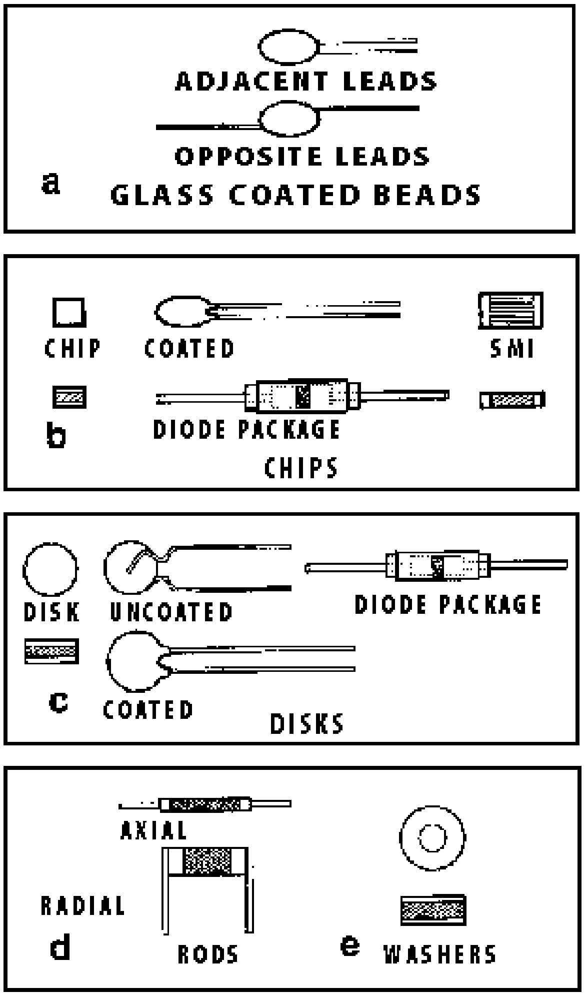

Fig 2. A variety of manufacturing processes are used to make NTC thermistors configured as beads (A), chips (B), discs (C), rods (D), and washers (E).

Bead thermistors, which have lead wires that are embedded in the ceramic material, are made by combining the metal oxide powders with a suitable binder to form a slurry. A small amount of slurry is applied to a pair of platinum alloy wires held parallel in a fixture. Several beads can be spaced evenly along the wires, depending on wire length. After the beads have been dried, the strand is fired in a furnace at 1100°C-1400°C to initiate sintering. During sintering, the ceramic body becomes denser as the metal oxide particles bond together and shrink down around the platinum alloy leads to form an intimate physical and electrical bond. After sintering, the wires are cut to create individual devices. A glass coating is applied to provide strain relief to the lead-ceramic interface and to give the device a protective hermetic seal for long-term stability. Typical glass bead thermistors range from 0.01 in. to 0.06 in. (0.25 mm to 1.5 mm) in dia.

Disc thermistors are made by preparing the various metal oxide powders, blending them with a suitable binder, and then compressing small amounts of the mixture in a die under several tons of pressure. The discs are then fired at high temperatures to form solid ceramic bodies. A thick film electrode material, typically silver, is applied to the opposite sides of the disc to provide the contacts for the attachment of lead wires. A coating of epoxy, phenolic, or glass is applied to each device to provide protection from mechanical and environmental stresses. Typical uncoated disc sizes range from 0.05 in. to 0.10 in. (1.3 mm to 2.5 mm) in dia.; coated disc thermistors generally measure 0.10 in. to 0.15 in. (2.5 mm to 3.8 mm) in dia.

Chip thermistors are manufactured by tape casting, a more recent technique borrowed from the ceramic chip capacitor and ceramic substrate industries. An oxide-binder slurry similar to that used in making bead thermistors is poured into a fixture that allows a very tightly controlled thickness of material to be cast onto a belt or movable carrier. The cast material is allowed to dry into a flexible ceramic tape, which is cut into smaller sections and sintered at high temperatures into wafers 0.01 in. to 0.03 in. (0.25 mm to 0.80 mm) thick. After a thick film electrode material is applied, the wafers are diced into chips. The chips can be used as surface mount devices or made into discrete units by attaching leads and applying a protective coating of epoxy, phenolic, or glass. Typical chip sizes range from 0.04 in. by 0.04 in. (1 mm by 1 mm) to 0.10 in. by 0.10 in. (2.5 mm by 2.5 mm) in square or rectangular shapes. Coated chip thermistors commonly measure from 0.08 in. to 0.10 in. (2.0 mm to 2.5 mm) in diameter. Very small coated chip thermistors 0.02 in. to 0.06 in. (0.5 mm to 1.5 mm) in dia. are available for applications requiring small size, fast response, tight tolerance, and interchangeability.

Washer-shaped thermistors are essentially a variation of the disc type except for having a hole in the middle, and are usually leadless for use as surface mount devices or as part of an assembly. Rod-shaped thermistors are made by extruding a viscous oxide-binder mixture through a die, heat-treating it to form a ceramic material, applying electrodes, and attaching leads. Rod thermistors are used primarily for applications requiring very high resistance and/or high power dissipation.

The graph (fig 1) is very similar to mine it too begins to curve after around 40C^{o} and before that it is straight. So from this graph my graph is correct but not accurate.