Characteristics of Thermistors When Used as Power Sources of Known Temperature

ALBERT GOMEZPLATA
University of Maryland, College Park, Maryland

The relation between electrical resistance and surface temperature at different power levels was determined for General Electric ¾ in. diameter washer type of thermistors 0.191, 0.145, and 0.046 in. thick in order to evaluate the feasibility of using thermistors as power sources of known temperature. Because of their high negative temperature coefficient of resistance and high specific resistance, thermistors are not limited to small cross sections as are metal components, and they are easier to work with.

EXPERIMENTAL

The washer thermistors were clamped between copper cooling faces, which also acted as electrical contacts. A bridge circuit was used to keep the thermistor at known resistances with different cooling loads. Thermocouples were used to measure the surface temperature and the circumferential surface of the thermistors. Care was taken to insure a good electrical and thermal contact, and the apparatus was insulated to limit the study to unidirectional heat flow.

RESULTS

The behavior of the thermistor was found to be dependent on the power level. At low power levels the thermistor heated up uniformly, and a constant surface and circumferential temperature were observed. As the cooling load was increased, definite temperature gradients occurred. These temperature irregularities increased with increased power until a hot spot, or avalanche of current through a local zone, was formed. The existence of this condition can easily be imagined when one considers the element of instability that a thermistor has because of its negative temperature coefficient of resistance. An irregularity in contact, or in the thermistor material, which causes nonuniform heating will be magnified by the fact that a hot section is a lower resistance section and a large proportion of the total current will pass through it, resulting in a still hotter section. The only stabilizing force is the heating by conduction of the entire thermistor by these local hot areas. Once a hot spot was present, the thermistor was found to have practically constant voltage characteristics.

Hot spots on the surface were observed to have temperatures from 100° to 600°F., and no more than one was observed at one time. The spots were very local, and a sharp drop in temperature was noted just a few degrees from their exact location. Although a large number of them were found on the outside circumference, they were not restricted to the surface, and as a matter of fact they were not restricted to the same position even during a run. At times their movement along the surface would be followed, and at other times they would disappear from the surface, only to come back later. Hot spots did not seem to damage or change the characteristics of the thermistors, although it is conceivable that they would be damaged if the temperature at the spot rose higher than the working temperature of the thermistor material.

The relation between the surface temperature and the current passing through a thermistor, while the thermistor was maintained at a constant resistance, is shown in Figure 1. Three

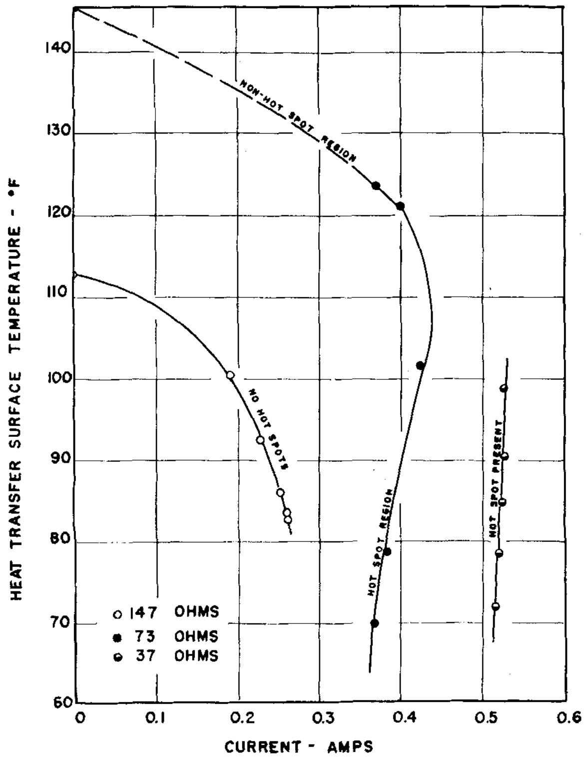

Fig. 1. Temperature vs. current characteristics of 0.145 in. thick thermistor.

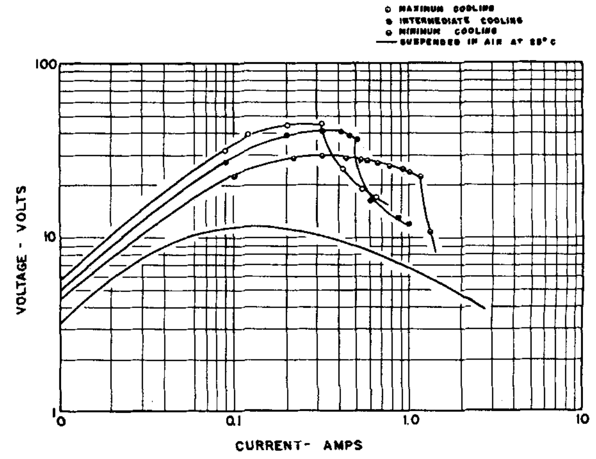

Fig. 2. Static characteristic curves for 0.191 in. thick thermistor.

regions are covered in the figure: a region where the thermistor does not have a hot spot, a transition region, and a region where a hot spot is present. It was possible to obtain data before and after a hot spot had formed for only a few runs, since the transition region was very unstable.

Static voltage characteristic curves were taken between the maximum and minimum limits of cooling for the thickest thermistor and are shown in Figure 2. These clearly show the thermistor breakdown to occur earlier with greater cooling. At the low power dissipation level needed when the thermistor is suspended in still air at 25°C., the thermistor does not break down and no temperature irregularities are observed.

In conclusion the study showed that the temperature of a thermistor will depend on the heat flux as well as its resistance when the thermistor is used as a power source and that care must be exercised when using thermistors as power sources of known surface temperature. If they are used at high heat fluxes, a nonuniform radial temperature will exist and the thermistor will eventually break down with the formation of a hot spot. Thermistors, when they contain a hot spot, exhibit a practically constant voltage drop and there is the possibility of their use as constant voltage electrical components.

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Effect of a Surface Active Agent on the Velocity of Rise of Benzene Drops in Water

JOSEPH H. GIBBONS, GERALD HOUGHTON, and JAMES COULL

University of Pittsburgh, Pittsburgh, Pennsylvania

Previous work has shown that the presence of small quantities of surface active agents in liquid-liquid extraction processes reduces the rate of mass transfer (1, 2, 3, 4, 5, 6, 7, 8), while large quantities of detergent may cause an increase in the rate (2, 4). The reduction in the mass transport rate has been attributed to either a reduction in the internal circulation of the drops (5, 7, 8) or to a true barrier effect caused by a surface layer of detergent (4, 6). The increase in mass transfer has been ascribed to an increase in the oscillation of the drops caused by a reduction in the surface tension (4), or simply to a reduction in the drop size (2) where this was unknown. The purity of the surfactants used was found to have no effect (8).

Although numerous workers had observed the effects of detergents on mass transfer, Garner and Skelland (5) and also Lindlan and Terjesen (7) were the first to note that surface active agents also reduce the velocity of fall of drops, although Stuke (9) had already demonstrated that surface active agents had a pronounced effect on the rate of rise of bubbles in water. Garner and Skelland (5) found that a 0.003 wt. % solution of sodium dodecyl sulfate 6 reduced the velocity of fall of nitrobenzene drops (3.0 to 5.4-mm. diameter) in water, and their technique of visual observation with aluminum particles showed that the effect of the detergent was to reduce the internal circulation in the drops. About the same time Lindlan and Terjesen (7) found that 0.003 wt. % sodium oleyl *p*-anisidinesulfonate could lower the velocity of fall of carbon tetrachloride drops (2.0 to 3.5-mm. diameter) in water by as much as 7 to 10%; they also found that the amount of detergent necessary to produce the maximum reduction in the velocity of fall was only 30 to 50% of that required to cause the maximum reduc*tion in the mass transfer rate of iodine.* The reduction in the velocity of fall was also attributed to a suppression of the internal circulation in the drops. Recently Boye-Christensen and Terjesen (8) used sodium oleyl *p*-anisidine sulfonate and sodium hexadecanyl sulfate to inhibit the extraction of both iodine and *o*-nitrophenol from water by carbon tetrachloride drops and again inferred that the action of the detergents was to reduce the velocity of internal circulation, which in turn caused a reduction in the velocity of rise and rocking motion.

In most of the above work the reduction in velocity of fall of drops was observed as incidental to the effects on mass transfer or internal circulation, so that only a narrow range of drops sizes was used. Although no work has been done with detergents over a wide drop-diameter range, such work (10, 11) has been carried out with pure liquids with a wide variety of physical properties, so that the effect of interfacial tension on the velocity of rise could be correlated empirically. The object of the present work is to investigate the effect of small quantities of a detergent on velocity of rise over as large a diameter range as possible, since Stuke (9) in *his work on bubbles observed that the* effects of the surface active agents capric and caproic acids depended on the bubble diameter. Small quantities of detergents were used to avoid significantly changing the bulk properties of the liquid phase, such as density and viscosity. In this connection Houghton, Ritchie, and Thomson (12) have used the effect of detergents on the velocity of bubbles to demonstrate that trace quantities of surfactants are present in sea water; they also showed that, depending on the bubble diameter, surfactants may also have a pro-