Influence of temperature on the conductivity of Magnetorheological Elastomers

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Abstract

The thermal stability of MRE electrical performance is the key factor affecting the service life of the device. With the increase of the device's use time, the resistance temperature increases, and the sample loses its use value prematurely. In this paper, the resistivity and current of MRE with two different particle volume ratios are studied by comparing and analyzing.

Keywords

MRE, particle ratio, temperature.

1. Introduction

It is generally believed that temperature is the major determinant of the thermal expansion rate of MRE matrix materials and conductive fillers, that is, the conductivity of MRE is affected greatly by temperature [1]. The matrix material of thermal expansion is far greater than the rate of conductive filler, thermal expansion rate, is generally believed that the temperature effect of composite conductive polymer materials (PTC effect) is produced by conductive fillers and the polymer matrix caused by thermal expansion, namely in the outer voltage remains unchanged, the resistivity of composites increases with the increase of ambient temperature accordingly, the conductive composite material can be used as temperature limiting element etc. Most of the composite materials exhibit obvious PTC phenomenon at a certain temperature range [2].

The conductive mechanism of effects of MRE and temperature on the electrical properties of the MRE , the resistivity of the samples increases with the increase of temperature, which is due to the electron transition between conductive polymer thermal barrier height and width of band gap size on resistivity of MRE play a decisive role. On the other hand, because the expansion coefficient of MRE conductive ferromagnetic particles is smaller than that of base material, the temperature rise causes the disorder of magnetic particle structure in MRE. Therefore, the electron transition tends to be difficult, and the resistivity of MRE sample increases with the increase of temperature[3]. The thermal expansion of the composite matrix and the conductive filler particles is, in microscopic terms, due to a change in the gap between the conductive filler particles. The disorder of the structure of the conductive filler particles in the matrix material, from the microscopic point of view, is reflected in the electron kinetic energy of the particles and the electric field changes between the particles and the micro contact region[4].

2. Experimental Study

The carbonyl iron powder as conductive filler, the conductive filler of the particle volume ratios were 1% and 0.1% MRE sample resistance temperature, determination of the resistance change with various resistance tester, test temperature control samples at room temperature 20-100 degrees Celsius, each increase or decrease in temperature and immediately record resistance value. The mechanism diagram of the experimental study is shown in Figure 1, which includes temperature measurement system, resistance current test system, electrode and MRE [5-7].

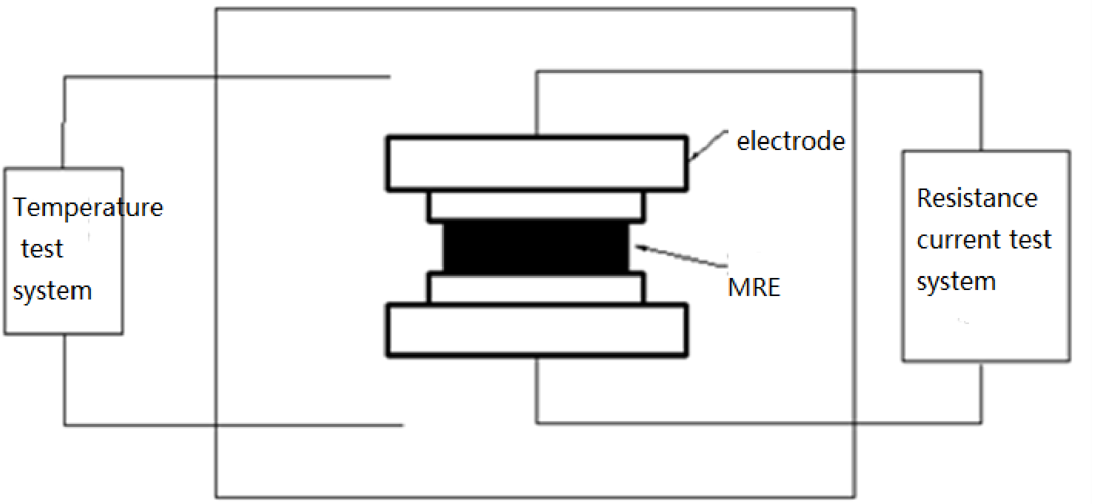

Fig. 1 The test device of the electrical properties

First, the sample of copper welding wire on both sides of the end cover, and then connect the wire into a vacuum drying box, wire penetrates from the exhaust hole of vacuum drying oven, a DC stabilized power supply, the other end of the wire connection of the multimeter, will dry box for heating, the heating rate is 2 DEG /min, resistance digital multimeter measuring the value of each stage, and with the increase of the temperature record of temperature and resistance values of samples [8].

Secondly, the particle volume ratio of 0.1% and 1% MRE samples were subjected to thermal cycling resistance test, the sample is first in accordance with the above steps from the heating room temperature 20 to 40 DEG C, and record the corresponding resistance under different voltage value, and then the temperature dropped to room temperature, test and record the resistance value, two cycles of heating, repeated heating process and record the corresponding resistance value and the current value, calculate the corresponding resistivity according to the above steps, and two groups of particle volume ratio curve changes the electrical conductivity of MRE thermal cycle after different drawing.

3. Data Analysis

When the particle volume ratio is 1%, the change of conductivity after thermal cycling is shown in figure. The resistivity change law is shown in Fig. 3, as shown in Fig. 2.

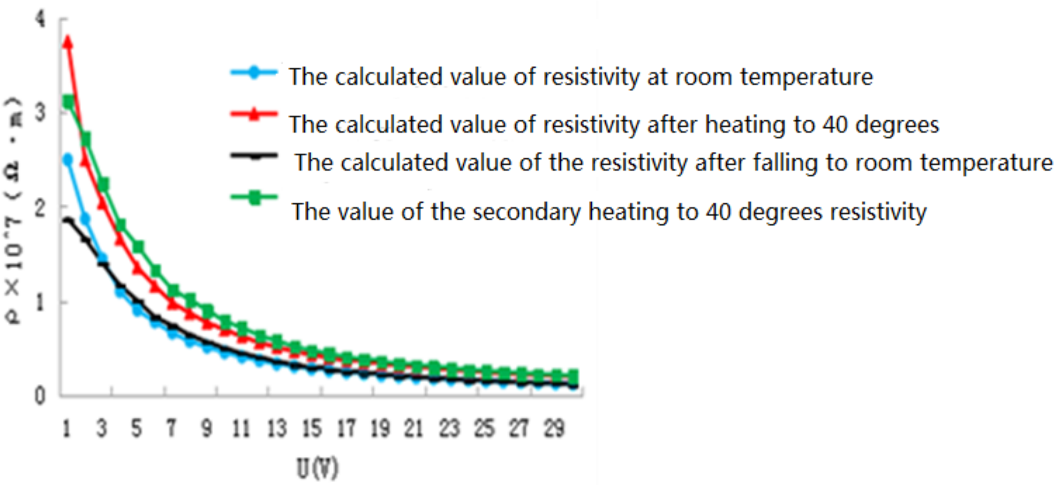

Fig.2 Resistivity voltage diagram

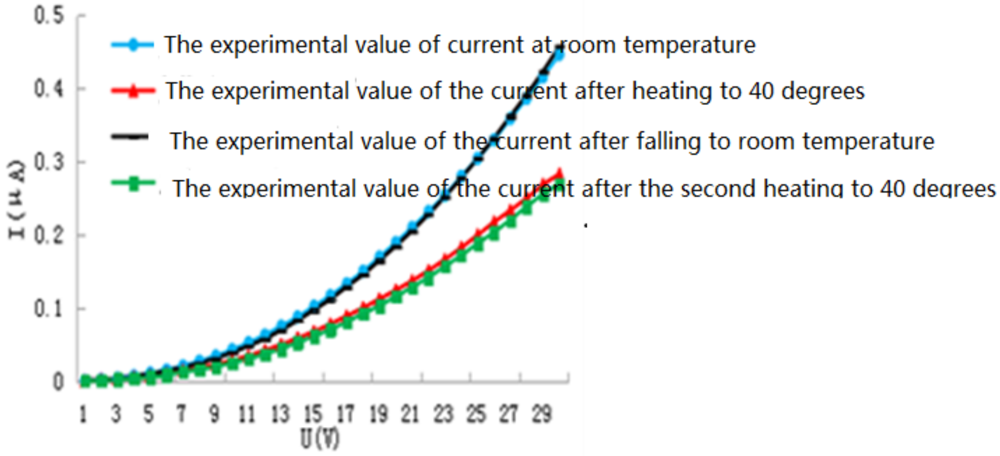

Fig.3 Current voltage diagram

The resistivity of MRE increases with the increase of temperature, when the temperature rises to the required temperature and cooling experiment, when the temperature dropped to the initial temperature, resistivity and initial test value slightly increased. The temperature is increased two times to the same temperature, and the resistivity is also slightly higher than that of the initial high temperature environment. The conductive pathways formed by ferromagnetic particles in the MRE matrix cooperate with each other, and the external temperature has a significant influence on the conductive network inside the MRE. As shown in Fig.3, the current varies with the voltage. After thermal cycling, the conductivity of the MRE sample is little changed at the same temperature.

Differences of MRE in the first and second thermal cycles in the matrix mainly because of the change of conductive network in thermal drive under the action of conductive particles can't return to the initial position, the resistivity at room temperature during the cooling process of higher resistivity at room temperature during heating. The thermal cycling equivalent of the samples were repeated heat treatment, so the MRE internal conductive filler arranged more compact, more stable structure, crosslinking structure of the sample become more perfect, so by this method to improve the stability of MRE PTC.

4. Conclusion

Based on the theoretical analysis of the influence of temperature on MRE, the temperature characteristics of MRE are studied by experiments. The temperature rises, the substrate material and the conductive filler of MRE thermal expansion rate is different, the matrix material of thermal expansion is much larger than the amount of conductive filler, thermal expansion, conductive particle spacing increases conductive network is destroyed showing PTC effect. With the increase of temperature, the strength of PTC increases gradually, and the resistivity of MRE increases with the increase of temperature. When the temperature decreases, the internal material of ferromagnetic particles due to low content of ferromagnetic particle distribution can not be completely restored to the initial state of irreversible change, there is a certain difference in resistivity caused the heating and cooling process under the same temperature. The effect of temperature on the electrical properties of MRE, the sensitivity and range of temperature control accuracy has been improved, provide some reference and technical support for solving MRE conductivity temperature stability problem in practical application.

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