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A New Composite Phase Change Material for Cold and Heat Storage and Its Application

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Abstract: *In today's society, energy consumption is growing at an alarming rate. Because of the huge economic benefits brought by traditional industries such as non renewable energy and fossil fuel power generation, people have to study them. The phase-change heat storage materials are widely used in the condensation heat storage due to their high temperature, low density and environmental protection. This paper considers the advantages, disadvantages and application scope of the new energy storage equipment based on the phase-change storage characteristics, and proves through experiments that under certain conditions, the appropriate solid-liquid ratio and the degree of substitution of different components are conducive to improving the performance of the composite storage heat exchanger. In this paper, a new composite phase change material for cold storage and heat storage is tested. The test results show that, because the carbon nanotubes added in the composite phase change material have no latent heat contribution in the whole phase change process, the phase change enthalpy of the composite phase change material will inevitably decrease with the increase of the carbon nanotube mass fraction.*

Keywords: *cold and heat storage composite, phase change material, new type of cold storage, material application*

1. Introduction

With the development of society, people's demand for energy is growing, especially under the dual pressure of environmental degradation and resource depletion in the world today. We know that phase change heat storage materials have great application prospects [1-2]. It can effectively store energy, reduce temperature, increase specific surface area and other advantages, making it widely used in various fields, and the low phase mass fraction also makes it more demanding than other traditional fire resistance ratings when used as a cold storage working medium, such as wind turbines or solar cells, have good development prospects and use value [3-4].

In foreign countries, the research on phase change thermal storage materials has been more systematic and in-depth, and has made great achievements. However, due to the immaturity of technology and the nonstandard process flow, the development of phase change thermal storage composites has been slow in recent years. American scholars proposed a new type of partition storage agent polyethylene glycol (PE). Subsequently, heat storage membranes based on polypropylene were successively developed and used in low-temperature reversible preparations as partition components. In China, the research and application of phase change energy storage technology started relatively late. Although phase change materials have developed rapidly, they have not been widely promoted for various reasons. So far, only a few aspects have done a lot of work [5-6]. For example, it is still one of the main problems to develop composite cold storage and thermal storage working medium, develop a new type of coagulant with excellent performance, environmental protection, easy use and other advantages, and to research and develop but expensive, which is not easy to popularize and apply in technology. Research and development are relatively backward compared with foreign countries, and China is currently in the development stage [7-8]. Therefore, a new composite phase change material for thermal storage and cold storage and its application are studied in this paper.

With the rapid development of society and the continuous improvement of people's living standards, phase change materials have been widely used in all aspects, especially as the most important kind of thermal storage equipment. This paper mainly introduces a new type of energy storage battery and its phase change materials. Firstly, the performance requirements of various solar panels and rechargeable lithium ion power devices on various heat accumulators are described. Secondly, the possible problems and avoidance methods in the preparation of common plastic plates and rubbers at home and abroad are analyzed and compared, and a comparative experimental study is carried out.

2. Discussion on a new composite phase change material for cold and heat storage and its application

2.1 Phase change materials

The phase-change heat storage material is a new type of cold working medium based on the principle of phase change. It generates heat by absorbing and converting the physical, chemical or electronic reactions that occur during the curing process and conducting chemical reactions with the hydrogen storage body stored in a high-temperature environment. Due to their small density, large specific capacity and other advantages, they have become the most widely used and ideal materials with relatively mature technology, the highest validity and the lowest cost [9-10]. Phase change thermal storage composites are based on the principle of phase change. Phase change heat storage materials are solidified or semi formed into equivalent different substances at a certain temperature, pressure and time to release heat to the outside world to achieve the purpose of energy storage. It is mainly used to store constant pressure coolant (such as oil), diaphragm and cold plate. Due to the large difference between the density of water and air and the low relative molecular weight and hydrophilicity, phase change materials are usually used for energy storage at room temperature or low temperature. Therefore, they have a wide range of applications but can't be used in large quantities and have high costs. In phase change heat storage materials, the matrix is composed of ceramic layers and their interfaces, so it has a high melting point. In general, we use a glass thermometer to measure the content of the phase compound and record it. With the continuous development and progress of science and technology, people have higher and stricter requirements for the environment, new energy power generation and other needs, many materials with superior performance have also been produced, such as dielectric coefficient (or Curie) polymer, one of which is polyethylene glycol ester of silane coupling agent. Phase change heat storage material is a new type of functional composite material between common conductive polymer and ceramic matrix. It has excellent high temperature resistance, good corrosion resistance, high specific strength, chemical stability and other advantages. The first advantage is good mechanical properties. In general, it has poor stability and is not easy to be processed. Phase change energy storage can make the whole system in the best working condition without stress concentration. Moreover, phase change materials have low price, relatively few defects and large volume to save costs [11-12].

2.2 New type cool storage and heat storage

A new type of thermal storage material is a kind of material with the performance of traditional conventional coagulant. It stores the heat within a certain temperature range to meet the requirements for production. At present, polystyrene and fluorocarbon fiber are two common building materials that are widely used in industry, civil and aerospace. The new heat storage materials have the advantages of high density, high strength and excellent performance, but the disadvantages are that they have small specific surface area and can't be completely decomposed at room temperature, so their performance is limited. The new type of cool storage and heat storage materials are made of high productivity and high-performance phase change materials, which can be directly solidified into solid or semi-solid heat storage after reaching a certain temperature through chemical and physical treatment methods in gas-solid liquid phase reaction. Due to the rapid development of modern industry and people's increasing demand for energy, new energy/high efficiency batteries and other emerging environmental protection products are constantly emerging. Phase-change energy storage (pcs), which has the characteristics of low carbon or low cost to obtain high energy storage and conversion efficiency, has been widely concerned, and plays an important role in social and economic development. At present, phase change materials with very high energy storage density and specific capacity are widely used in many fields. It not only has the advantages of ordinary phase change heat storage, chemical stability and low cost, but also can be used as a backup resource for some new building materials. Because of its unique performance, it has become the favorite of many engineering construction projects, and is widely used in industry, such as bridge construction, tunnel construction and large-scale drainage, which are designed on the premise of large energy storage density and high specific capacity. At present, the research of composite phase change materials for cold storage mainly focuses on the phase change and heat transfer mechanism in the new heat storage system. Among them, there are many

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shortcomings in the traditional hot water storage method. For example, problems such as low energy density and large specific energy difference limit its application scope. At the same time, with the increasing social development and energy crisis, the development and utilization of new energy has broad prospects and challenges for non renewable energy or non renewable resources - such as wind energy, electricity and other basic raw materials used in storage systems have been widely studied, and important achievements have been made.

2.3 Thermal Conductivity Test

Take out the sample and put it in the oven for natural drying for a certain time to obtain the first experimental data. Then take one end of the sample and heat it to about 50 ℃ in hot water. At room temperature, use a fast centrifuge to heat the surface of the condenser so that it is fully immersed in water and before reaching the test temperature, add water to measure the performance change of the material. Finally, determine whether the phase change structure meets the requirements, hardness, corrosion resistance and other indicators according to the test results. Then use a distiller and ultraviolet lamp to compare and analyze the difference between the above two experimental data and the standard. After two different materials are heated by hot water, they are soaked at two same temperatures. First, scale the thermal conductivity value with insulating sheet, and then use resistance strain gauge to test the influence of the surface contact area of materials and samples, liquid viscosity and other factors on the total mass of composite products. Then, calculate the expansion coefficient and specific resistance curve of composite materials according to the above data, and obtain the different performance characteristics, (Cp) and density of the product(ρ). The relationship between the three is given in Formula (1). First, measure the bulk density of the sample through the instrument ρ， Then measure the thermal diffusivity a and specific heat capacity Cp of the material respectively or simultaneously, and then calculate the thermal conductivity of the material according to Formula (1).

$$(\lambda = \alpha\rho C_p \qquad (1)$$

A study has also been made on the crystal shape change of paraffin wax before and after recombination, that is, the change of grain size is calculated by Scherrer equation, as shown in Formula (2).

$$D = \frac{K\lambda}{\beta\cos\theta} \qquad (2)$$

Where D is the half peak width, θ Is the line angle of incidence, λ Is the X-ray wavelength (Cu target, 0.154056nm), K is the Scheler constant (K=0.89), β Is the width at half maximum of the diffraction peak of the measured sample.

3. Experimental process of performance of a new composite phase change material for cold and heat storage and its application

3.1 Performance and structure of new composite phase change materials for cold storage and heat storage

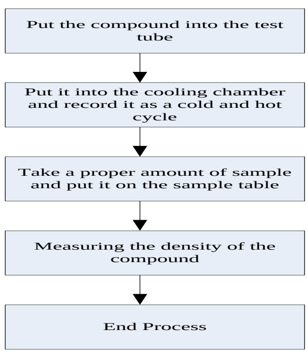

Figure 1 : Performance structure of a new cold storage and heat storage composite phase change material

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The traditional cold storage and heat storage materials will generate a lot of heat in the use process, which will enter the interior of the phase change material after passing through the heater, causing the loss of some effective energy in the cold storage and heat exchanger. Therefore, we can control its conductivity by changing the state of the phase interface. The new composite combustible ice has excellent performance as anode product. Figure 1 shows the working principle of a new type of cold storage and heat storage material. It is that the phase-change matrix absorbs the stress generated by the change of external temperature during the curing process, so as to raise its temperature. This material can store a certain amount of heat, but can't release excess energy. It also has sound insulation. At present, the mixture of gaseous organic iron (Pt) and liquid water-soluble magnesium slag is commonly used to replace the traditional cold storage and heat storage alloy as the anode component to make composite phase change material plates. It is a kind of high polymer thermal insulation film made of metal salt, organic polymer compound and other components. By changing the structure to achieve the required mechanical indicators (such as deformation or mold density), or by increasing the content of some elements to achieve new characteristics, these can improve the overall performance, application scope and development trend of the cold storage and heat storage composite phase change materials to a certain extent.

3.2 Performance test of new composite phase change materials for cold storage and heat storage

In order to verify the phase process of the new thermal storage material under a certain temperature difference, the test method is generally as follows: put the sample into the azeotrope, and then slowly heat it with constant current (or voltage) until it expands to the boiling point. Then take out the sample and allow the sample to reach the solidification temperature. The required experimental data can be obtained by repeating the above steps after cooling to room temperature. The material performance parameters include energy absorption and density between solid and liquid phases, resistance and specific surface area. Because the new heat storage composite phase change material has an ideal conductivity, the change of its phase state and structure is analyzed by testing the properties of the composite. Because the composition and properties of materials on different thermal storage layers are different, the two new composites prepared are also different under the same service conditions. For example, for a single conductive polymer, in order to improve its overall density and durability, thermal conductive fillers are usually added to polyphenylene sulfide or mixed with a small amount of metal paint, while for a porous polymer with high specific surface area, only one of the materials is generally added as the matrix.

4. Experimental analysis on the performance of a new composite phase change materials for cold storage and heat storage

4.1 Performance test and analysis of a new composite phase change materials for cold storage and heat storage

Table 1 shows the performance test data of the new composite phase change material for cold storage and heat storage.

Table 1: Performance test of the new cold storage and heat storage composite phase change material

w/%	Melt the starting point temperature/℃	Melt peak point temperature/℃	Melting termination point temperature/℃	Phase change enthalpy relative price/%
0% RT4	1.83	7.74	9.45	5.45
1%-CNT	1.65	7.67	9.23	6.52
2%-CNT	1.38	7.89	9.65	5.36
3%-CNT	1.67	7.43	9.73	4.63
4%-CNT	1.89	7.68	9.21	3.67
5%-CNT	1.47	7.94	9.67	6.75

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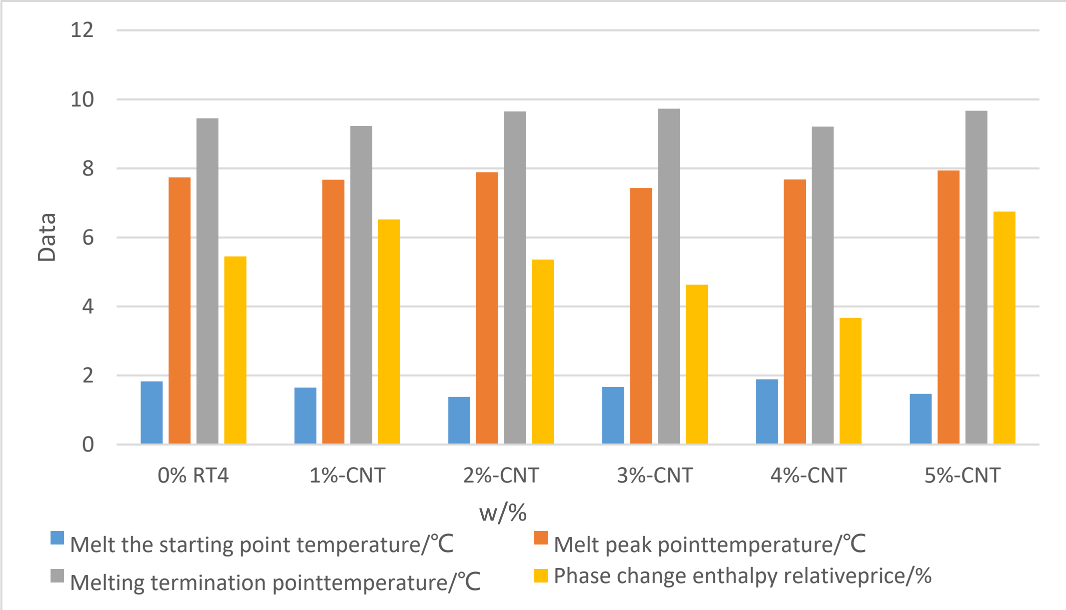

Figure 2 : Performance test of composite phase change materials

The test and analysis of the thermal storage performance of the phase material is mainly to judge whether it meets the use requirements by comparing the experimental data of different components in six temperature storage systems at the same temperature and pressure. In this paper, a new type of energy storage tank is used as the background to calculate the relevant phase change potential curve. Because there are many uncertain factors affecting the accuracy and reliability of the test results and conclusions in the actual application process, it is not particularly easy to solve and avoid some unpredictable or difficult to control conditions, such as the refrigerant may reduce the heat storage effect. The actual measured values of phase change starting point, peak point, ending point and phase change enthalpy of composite phase change materials in various proportions during heating are listed in Figure 2. As the carbon nanotubes added in the composite phase change materials have no contribution to the latent heat during the whole phase change process, the phase change enthalpy of the composite phase change materials will inevitably decrease with the increase of the mass fraction of carbon nanotubes.

5. Conclusion

This paper mainly introduces a new type of phase change heat storage material, which is composed of two or more different chemical components, and is made by reversibly recycling heat energy at room temperature or in negative cold water. First, the existing form and principle of traditional heat storage tank, ordinary plastic heat storage tank and solar panel are studied. Then, experiments are carried out on each material and a new phase change material with the best performance and the most environment-friendly and pollution-free is selected from its advantages and disadvantages to make the phase transfer alloy heat storage composite.

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