Study on Encapsulation of Energy Storage Material in Northern Rural Residential

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Abstract

According to the summary and analysis of phase change material (PCM, phase change materials) that commonly used in packaging mode, as to the liquid leak problem which is difficult to solve in the application of the process of PCM, this paper proposed a method of decentralized packaging which are convenient for farmers to operate. Using PCM which is suitable for rural residential buildings and heating system, according to the principles of simple, effective and economic, put forward a way of decentralized packaging. Introduce the process of decentralized packaging, and then the basic analysis of performance was carried out on the different forms of energy storage unit of PCM. At last, identifying that heat stored - released performance of plate package is stronger than the tubular and spherical package, which is more suitable for applying in rural residential and heating system.

Keywords: Rural residential, Phase change material, Encapsulation Technology

1. Introduction

Phase change energy storage technology is excellent in the field of building energy efficiency. The main advantage of the PCM is that in the phase change (solid - liquid, solid - solid and vapor - liquid) process, absorb or emit environmental heat (cold) and release it into the environment at a specific time. It has an extensive application prospects and it was caused widespread concern of scholars in the early of 1880s.

With the environment temperature changes, changes from one phase to another phase of the storage material called Phase Change Material(PCM,phase change materials). Using its characteristics of absorbing or releasing...
energy during the phase transition can ease the conflicts between the energy supply sides and the energy demand sides which do not match the time, intensity and location [1-3]. At present, PCN has become a hot research field of energy because of its advantage of small changes in volume, per unit mass storage more.

Energy storage material exist many problems of applications during the process of energy storage. The heat storage material of sensible heat of the liquid medium and "solid - liquid" phase change energy storage materials change phase in the process of storage and release energy. From solid to liquid or from a solid to a liquid, liquid stability of the material must be maintained through the container package. At the same time, liquid sensible heat material and "solid - liquid" PCM encapsulated in a suitable container. Not only can solve the problem of leaked liquid, but also can effectively prevent the volatile of the polyols materials, and the corrosion of inorganic hydrated salt accumulator material to environmental. In addition, storage material which is effectively encapsulated can also extend heat transfer area and enhance heat transfer, enhance the overall mechanical properties of materials, expand its scope of application. Therefore, the study of meeting the actual requirements of the packaging system with multiple functions is particularly significant.

2. Decentralized Packaging Materials And Packaging Process

2.1. Phase Change Material

According to the principles that are suitable for rural residential buildings and heating systems to select phase change heat storage material[4-5], using of existing literature selected fatty acids as typical PCM, diaconate(Phase transition temperature:31°C, Latent heat:159J/g), as our experimental material.

2.2. Encapsulation process

Mainly use of stainless steel pipes, PPR pipes, and stainless steel and polyethylene spheres to package the phase change thermal storage materials.

2.3. Laboratory instruments

PPR Hot melt machine, Pipe Cutting Machine, Cutter, Meter stick, Super-heated water bath, Thermometer, Paperless recorders, etc.

2.4. Tube packaging process

Experimental study of tubular package, with corrosion-resistant and high temperature stainless steel pipe and PPR pipe that has a strong corrosive. Stainless steel tube with screw cap and plastic cap and PPR pipe using hot melt sealing. Specific packaging process is as follows:

(1) Cutting. Utilizing cutting machine in the factory and according to the size to cut stainless steel pipe and using plastic to cap seal.

(2) Encapsulated phase change thermal storage unit. Threaded stainless steel tube with screw closures tightened seal. Constant temperature water bath heat storage experiment found water floating oil-like substance, phase change heat storage material leak. Therefore, using of raw materials along with threaded clockwise winding then thread seal.

2.5 Plate encapsulation process

Seal in the form of stainless steel plates and stainless steel tube of screw-less are the same. According to the size to cut stainless steel pipe and using plastic to cap seal.

2.6. Ball packaging process
The encapsulation method of polyethylene spheres and threaded stainless steel pipe are similar. Mainly using hemisphere’s own slot to bite seal. It was found in a water bath leak that as the ambient temperature rises, thermal expansion of the sphere material phenomenon occurs and lead to internal phase change thermal storage material partially leak, a small amount of water oily substance will be appear. After hemisphere rotating seal adhesive applicator interface slot, it can be used in the experiments.

2. Analysis

In order to react the effect of the application of the differently decentralized package of phase change heat storage unit (PCHSU, phase change heat storage unit) in rural buildings and heating systems. The experiment used the rural kang temperature field as exothermic conditions. That melting process of regenerator carried out at 40°C, and the solidification process was 25°C. Research and analysis of the same volume of the plate, tubular and spherical package of PCM, and identified the time of three kinds of PCHSU. E lecting decentralized encapsulation method with optimum heat transfer effect, which is suitable for rural residential building energy storage material.

3. Test Equipment

Using super-heated water bath to provided melting and solidification environment for phase change thermal storage unit. The internal temperature phase change thermal storage unit records and temperature curve display are completed by the Fushi brand paperless recorder.

5. Results

5.1. Analysis of heat storage performance of plate package

Figures 1 and 2 respectively are endotherms and isotherms curves of PCHSU. From endothermic curve, in the condition of water bath at a constant temperature of 40°C, the center of PCHSU’s temperature rises rapidly before 500s. Analysis of the reasons are: Initial temperature of 25°C of PCHSU and the ambient temperature (40°C) exist big difference, under the same heat transfer, the temperature changes quickly and that the temperature rises rapidly. When the temperature rises to about 31°C, it reached melting temperature of PCM, PCHSU begins to melt and absorb ambient heat. At this time, the temperature was maintained at about 31°C and appears an endothermic "platform". When reach3780s, Phase change energy storage system is completely melted and end regenerative process, the whole process lasted about 1h.

Fig.1. Endothermic curve of plate package.                                                                 Fig. 2. Exothermal curve of plate package.
Exothermic process of PCHSU was performed at a constant temperature of 25 °C. Analysis exotherm of figure 2 Shows: in the center of PCHSU, the temperature drop rapidly within the first 300s, and appear exothermic "platform" when the temperature is reduced to about 31°C. When the 5780s, PCHSU completely solidified and end exothermic process, the exothermic time of PCHSU nearly 1.6h.

5.2. Analysis of heat storage performance of tube package

The melting and solidification environment of tubular PCHSU is the same as plate package. Figures 3 and 4 are respectively endotherms and exotherms curves of tubular PCHSU. Analysis of the thermal storage and release curves shows: the regenerative time of tubular PCHSU is 2750s and exothermic time 3241s.

5.3. Analysis of heat storage performance of ball package

Under the same experimental conditions, Using super-heated water bath and paperless recorder to test the temperature changes over time in the center of the sphere in the melting and solidification process of Ball-type PCHSU. Figures 5 and 6 are respectively endotherms and exotherms curves of ball PCHSU.
Analysis of the thermal storage and release curves shows: In the regenerative process of ball-type PCHSU, its temperature fluctuation rate is less. The time required of entire regenerative process is 13900s, about 3.9h. In the exothermic process, there was a significant exothermic "platform" when the temperature is reduced to about 31°C. Compared with the endothermic time, the exothermic longer. The whole process of exothermic lasting 17800s, about 4.9h.

6. Discussion

Based on the above results it is clear that: for the plate, tubular and spherical PCHSU, which volume are the same, the regenerative time of spherical package are longer than the plate and tube package, it is easy to story more surplus heat; At the same time, exothermic time of ball-type PCHSU is the longest, nearly 4.9h, exothermic time of plate nearly 1.6h, while the tubular heat time shortest, only 0.9h. According to the characteristics of rural intermittent heating system, each time of interval in heating about 4 hours, phase change material of plate and tubular PCHSU can fully solidified before the next heating. The time of make indoor temperature comfortable, plate regenerators’ is longer than the tube regenerator, and it has a better energy efficiency.

7. Conclusions

For the problems of liquid leak when PCM apply in rural residential buildings and heating systems, this paper proposes a solution of decentralized package and introduce in detail its packaging process, also text and analysis the performance of phase change heat storage unit, concluded as follows: according to the principle of selecting phase change energy storage materials in rural housing and heating systems, choose deaconate which phase change heat storage temperature is 31°C as experimental material, select the stainless steel pipe and stainless steel plate as decentralized package material; Using the same volume of the plate, tubular and spherical package phase change thermal storage unit for testing, the results show: storage - exothermic performance of plate package is stronger than the tubular and the spherical package and it is more suitable for rural housing and heating systems.

Acknowledgement

The work is supported by the National "Twelfth Five-Year Plan" Technology Support Program (No. 2012BAJ26B02).

References