EXPERIMENTAL ANALYSIS OF THERMAL ENERGY STORAGE SYSTEM USING INORGANIC PCM FOR HVAC APPLICATIONS

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Abstract

In this we are mainly dealing the interrelation of temperatures at hot and cold the experimental analysis of thermal energy storage. We are implementing the new technique of adding the hydrated salts and increasing the solidification of the storage system .The phase change material which helps in the storage of energy. LHS in a phase change material (PCM) is very attractive because of its high storage density. Hydrated salts are attractive materials for use in thermal energy storage due to their high volumetric storage density, relatively high thermal conductivity and moderate costs compared to paraffin waxes, with few exceptions. The high storage density of salt hydrate materials is difficult to maintain and usually decreases with cycling. The salts such as KCL and water is mixed in the correct proportions to intimate the change temperature in the material .The KCL with the 30% and water with the 70% which may decreases the temperature range to -9° C and KCL 25% and water70% decreases the temperature range up to -13° C all the changes make the helpful range in saving the food preservation and environmental cooling and the main thing is we can save the renewable resources. The cooling effect will with stands for longer period and the energy can be saved.

Key words---*Thermal energy storage, Phase change material, Inorganic PCM*

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1. INTRODUCTION:

The use of renewable energy sources and increased energy efficiency are the main strategies to achieve better thermal energy storage. In both strategies, heat and cold storage will play an important role. Refrigerators, space heating, and domestic hot water are a part of every household. Thermal energy storage (TES), which is heat and cold storage, plays an important role in many energy systems, not only households but also industrial processes. Even though storage itself will never save energy, it is often able to improve a system in a way that it is more energy or cost efficient. Thermal energy can be stored in the form of sensible heat in which the temperature of the storage material varies with the amount of energy stored. Water or rock can be the best example. Alternatively, thermal energy can be stored as latent heat in which energy is stored when a substance changes from one phase to another by either melting or freezing. Thus the temperature of the substance remains constant during phase *change*. The energy used can have different sources, which are renewable and non-renewable. Especially solar energy is not continuous and thus heat storage is necessary to supply heat reliably. When solar collectors are used to heat domestic hot water, the storage also matches the different powers of the solar collector field, which collects the energy over many hours of the day, to meet the demand of a hot bath that is filled in only several minutes. Sensible heat storage is used for example in hot water heat storages or in the floor structure in under floor heating. An alternative method is changing the phase of a material. The best-known examples are ice and snow storage. The storage of thermal energy in the form of latent heat in phase change materials (PCMs) represents an attractive option for low and medium temperature range energy applications. Wide ranges of PCMs have been investigated, such as paraffin wax, salt hydrates and non-paraffin organic compounds. The economic feasibility of employing a latent heat storage material in a system depends on the life span and cost of the storage materials. In other words, there should not be major changes in the melting point and the latent heat of fusion with time, due to thermal cycles of the storage materials. For latent heat storage, commercial grade PCMs is preferred due to various reasons, such as low cost and easy availability. The thermo-physical properties of commercial PCMs are found to be much different from those quoted in the literature for laboratory grade PCMs. The matching of transition temperature range for the PCMs is to deliver the energy at a suitable temperature for a given application. This is one of the important aspects for a PCM-based energy storage system. Eliminating the problems of super cooling, phase separation and stability over a long period of application is an important criterion for the successful application of suitable PCMs for thermal energy storage systems. The latent heat over the sensible heat is clear from the comparison of the volume and mass of the storage unit required for storing a certain amount of heat. It shows that inorganic compounds, such as hydrated salts, have a higher volumetric thermal storage density than the most of the organic compounds due to their higher latent heat and density. The various PCMs are generally divided into three main groups: organic, inorganic and eutectics of organic and/or inorganic compounds. Organic compounds present several advantages such as no corrosiveness, low or no under cooling, possess chemical and thermal stability, ability of congruent melting, self-nucleating properties and compatibility with conventional materials of construction. Subgroups of organic compounds include paraffin and non-paraffin organic. Technical grade paraffin has been extensively used as heat storage materials due to wide melting/solidification temperature ranges and has a relatively high latent heat capacity. They also have no sub cooling effects during the solidification as well as small volume change during the phase-change process. They are chemically stable, nontoxic and non-corrosive over an extended storage period. Widely used non-paraffin organics, as latent heat storage materials are fatty acids like lauric, myristic, palmitic and stearic acid. Their advantages are a possibility for reproducible melting and solidification behavior and little or no subcooling effects. Disadvantages of organic compounds include lower phase-change enthalpy, low thermal conductivity and inflammability. Inorganic phase changes of materials are a perspective way of thermal energy storage. Big latent heat, good thermal conductivity and inflammability are the main advantages of inorganic materials. But they cause corrosion and suffer from loss of H2O. Incongruent melting and super cooling are the biggest problem with their exploitation. During melting and freezing there are precipitations of other phases which do not take part in next process of charging and discharging. The use of phase change materials (PCMs) in energy storage has the advantage of high energy de*nsity* and isothermal operation. Although the use of only non-segregating PCMs is a good commercial approach, some ***desirable*** PCM melting points do not seem attainable with non-segregating salt hydrates at a reasonable price. The inorganic mixtures would show a similar thermal behaviour as the salt hydrate, with the same melting point and an enthalpy decreases depending on the type and amount of material used.

1.1 Energy Storage System

Thermal energy storage (TES), also commonly called heat and cold storage, allows the storage of heat or cold to be used later. To be able to retrieve the heat or cold after some time, the method of storage needs to be reversible. Sensible heat By far the most common way of thermal energy storage is as sensible heat. As fig.1.1.1 shows, heat transferred to the storage medium leads to a temperature increase of the storage medium. A sensor can detect this temperature increase and the heat stored is thus called *sensible heat*. Latent heat If heat is stored as latent heat, a phase change of the storage material is used. There are several options with distinct advantages and disadvantages. The phase change solid-liquid by melting and solidification can store large amounts of heat or cold, if a suitable material is selected. Melting is characterized by a small volume change, usually less than 10 %. If a container can fit the phase with the larger volume, usually the liquid, the pressure is not changed significantly and consequently melting and solidification of the storage material proceed at a constant temperature. Upon melting, while heat is transferred to the storage material, the material still keeps its temperature constant at the *melting temperature*, also called *phase change temperature*.

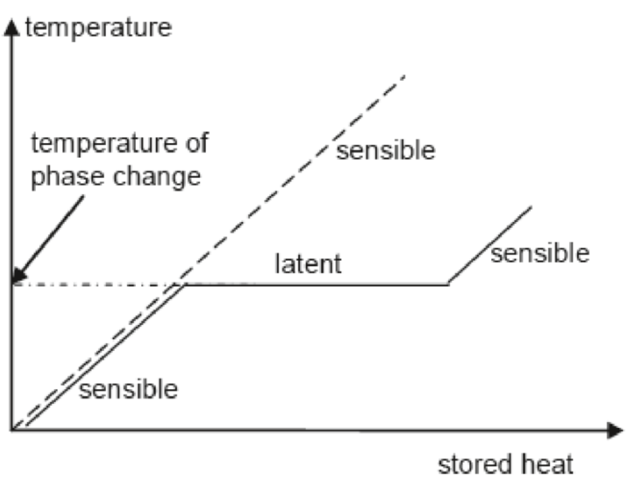

Fig-1: Sensible and Latent Heat Curve 1

1.2 Physical, Technical and Economic Requirements

A suitable phase change temperature and a large melting enthalpy are two obvious requirements on a phase change material. They have to be fulfilled in order to store and release heat at all. However, there are more requirements for most, but not all applications. These requirements can be grouped into physical, technical, and economic requirements. Physical requirements, regarding the storage and release of heat Suitable phase change temperature Tpc to assure storage and release of heat in an application with given temperatures for heat source and heat sink. Large phase change enthalpy Δpch to achieve high storage density compared to sensible heat storage. Reproducible phase change, also called ***cycling stability*** to use the storage material as many times for storage and release of heat as required byan application. The number of cycles varies from only one, when the PCM is used for heat protection in the case of a fire, to several thousand cycles when used for heating or cooling of buildings. One of the main problems of cycling stability is phase separation. When a PCM consists of several components, phases with different compositions can form upon cycling. *Phase separation*s the effect that phases with different composition are separated from each other macroscopically. The phases with a composition different from the correct initial composition optimized for heat storage then show a significantly lower capacity to store heat. Little sub-cooling to assure that melting and solidification can proceed in a narrow temperature range. *Sub-cooling* (also called *super-cooling*) is the effect that a temperature significantly below the melting temperature has to be reached, until a material begins to solidify and release heat (fig 2.). If that temperature is not reached, the PCM will not solidify at all and thus only store sensible heat. *Phase separation*s the effect that phases with different composition are separated from each other macroscopically. The phases with a composition different from the correct initial composition optimized for heat storage then show a significantly lower capacity to store heat. Phase *separation*s the effect that phases with different composition are separated from each other macroscopically. The phases with a composition different from the correct initial composition optimized for heat storage then show a significantly lower capacity to store heat.

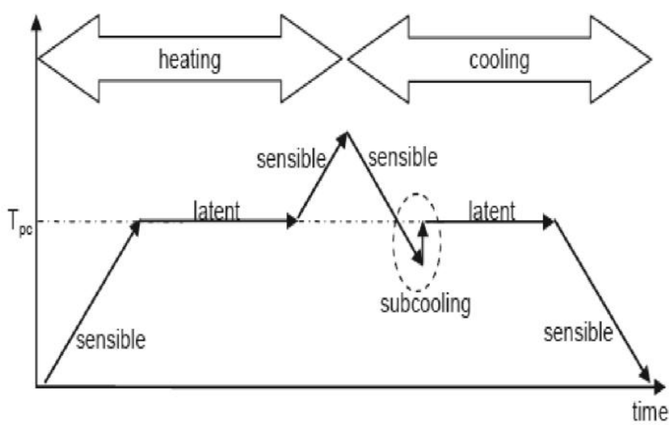

Fig- 2: Sensible and Latent Heat Curve 2

2. SELECTIONS OF PCMs

The selection of inorganic PCMs depends upon their cost, availability and chemical stability. Hence, the following salt hydrates have been tabulated for their easy availability and chemical stability, which have been given along with its molecular weight and melting point.

Table-1: Different kind of PCMs

Molecular weight g/mol	Melting Point (°C)	Salt Hydrates	Sl.No
208.25	-8.00	Barium Chloride	1
110.98	-29.00	Calcium chloride	2

74.59	-10.70	Potassium Chloride	3
58.43	-21.20	Sodium Chloride	4
18.01	0.00	Water	5

3. EXPERIMENTAL SETUP

The experiments consists deep freezer at the centre of the deep freezer a sphere is filled with PCM as shown in Fig. 3 The temperature of the fluid can be varied between - 25 to 50 ◦C. Constant wall temperature of the cylinder can be maintained during the experiment through the circulation of the external fluid from the constant temperature bath. PCM chosen for the experiment mixtures are 25%%KCl+75%H_2O (Mixture I) and 30%KCl+70%H_2O (Mixture II), claimed to be suitable for cool thermal energy storage is 30%KCl+70%H_2O.

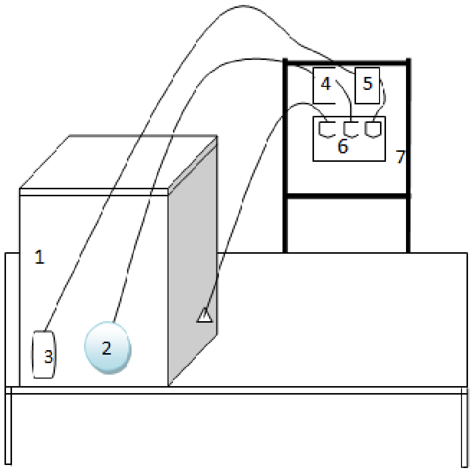

Fig-3: Experimental Setup

1. Deep Freezer
2. Spherical ball filled with PCM
3. RTD Sensor
4. PCM temperature Indicator
5. Deep Freezer Temperature Indicator
6. Supply Unit
7. Stand.

This setup is used to determine the solidification and melting time of the phase change material.

4. RESULT & DISCUSSION

The proportion of the liquid in the mixture increases due to energy generation and sensible heat addition from the warm surface. Once the entire sphere melts, liquid temperature will rise until steady state is reached. This problem can be resolved by defining conduction as the dominant mode of heat transfer and merging the convective effects in the thermal conductivity of the liquid.

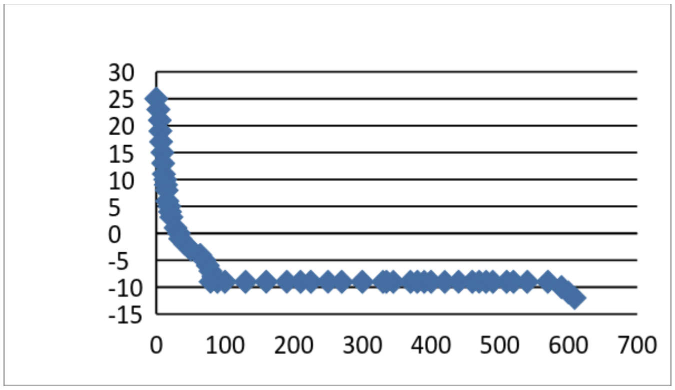

Fig-4: Freezing curve (Mix-I)

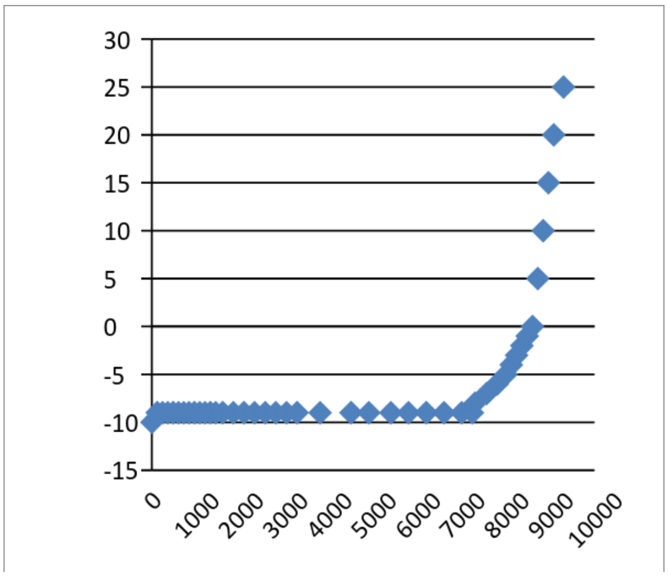

Fig-5: Thawing curve (Mix-I)

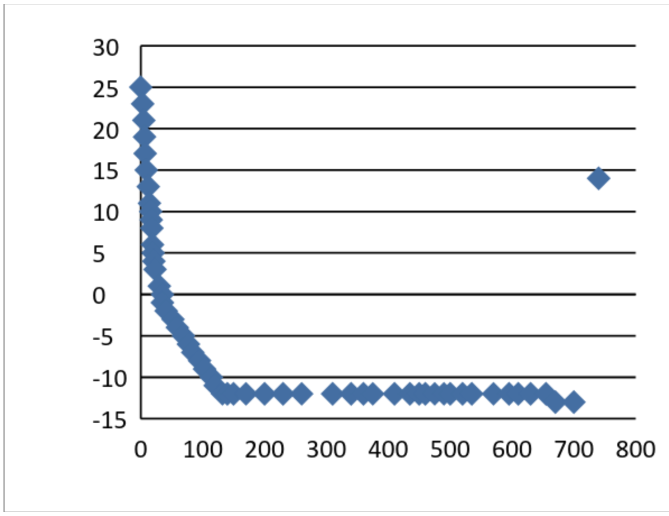

Fig-6: Freezing Curve (Mix-II)

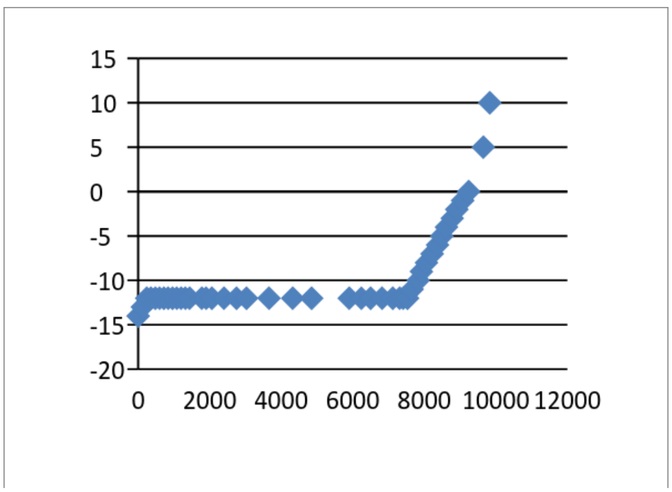

Fig-7: Thawing Curve (Mix-II)

In the above graphs (Fig. 6 & 7) were shows that illustrating the freezing and thawing curve of two different mixtures of KCl and Water. The first mixture (25%KCl+ 75%Water) was a perfect compsition of thermal energy stroge.

5. CONCLUSION

The PCM mixtures I has been recommended for cold storage application because of its low cost and conventional temperature of melting, which makes it suitable for HVAC application. Initially the melting and solidification temperatures mixture I were found theoretically and the values obtained is -13^{0}C respectively. Experimentation was later performed to estimate the solidification and melting time as well as the phase change temperature. As a result, the higher thermal performances of the PCMs have proved its potential as substitute for conventional PCMs in HVAC applications.

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