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Experimental Analysis of Thermal Energy Storage System Using $Mgso_4.7h_2O$ Pcm for Hvac Applications

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Abstract: *In we are mainly dealing the interrelation of temperatures at hot and cold the experimental analysis of thermal energy storage, 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* $MgSO_4.7H_2O$ *and water is mixed in the correct proportions to intimate the change temperature in the material. 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.*

Keywords: *Thermal Energy storage, Phase change material, Inorganic material.*

I. Introduction

The continuous increase in the level of greenhouse gas emissions and the climb in fuel prices are the main driving forces behind efforts to more effectively utilize various sources of renewable energy. In many parts of the world, direct solar radiation is considered to be one of the most prospective sources of energy. The scientists all over the world are in search of new and renewable energy sources. One of the options is to develop energy storage devices, which are as important as developing new sources of energy. The storage of energy in suitable forms, which can conventionally be converted into the required form, is a present day challenge to the technologists. Energy storage not only reduces the mismatch between supply and demand but also improves the performance and reliability of energy systems and plays an important role in conserving the energy. It leads to saving of premium fuels and makes the system more cost effective by reducing the wastage of energy and capital cost.

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 ho t 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.

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 Thermal Energy Storage:

Thermal energy storage (TES) is one of the key technologies for energy conservation, and therefore, it is of great practical importance. One of its main advantages is that it is best suited for heating and cooling thermal applications. TES is perhaps as old as civilization itself. Since recorded time, people have harvested ice and stored it for later use.

Large TES systems have been employed in more recent history for numerous applications, ranging from solar hot water storage to building air conditioning systems. The TES technology has only recently been developed to a point where it can have a significant impact on modern technology. In general, a coordinated set of actions has to be taken in several sectors of the energy system for the maximum potential benefits of thermal storage to be realized.

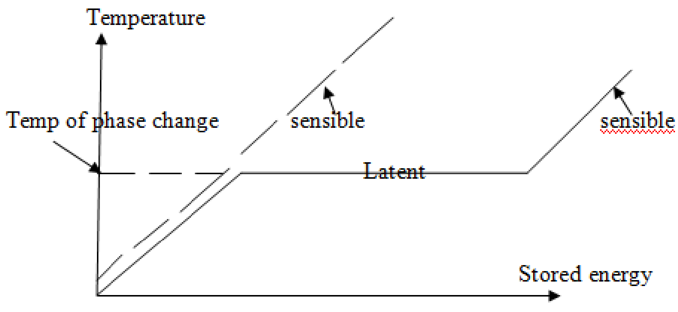

Fig 1.stored energy vs temperature

II. Phase Change Material

"When a material melts or vaporizes, it absorbs heat; when it change solid (crystallizes) to liquid (condenses), it releases this heat. This called phase change". This used for storing heat in is called phase change materials(PCMs).

The latent heat method of storage has attracted a large number of applications. This method of heat energy storage provides much higher energy storage density with a smaller temperature swing when compared with the sensible heat storage method. The materials used in this method of storing latent heat are called as Phase Change Materials (PCM).

LHS in a phase change material (PCM) is very attractive because of its high storage density with small temperature swing. It has been demonstrated that for the development of a latent heat storage system in a building fabric, the choice of PCM plays an important role in addition to heat transfer mechanism in the PCM.

2.1 PCM Classification:

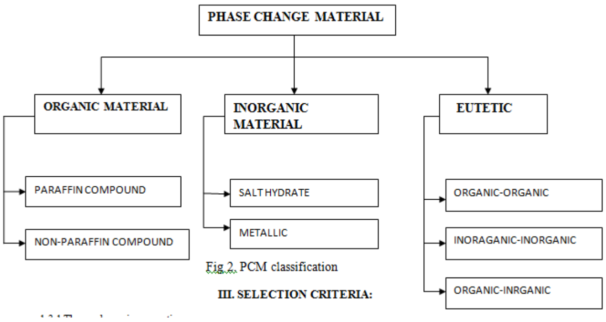

Fig 2. PCM classification

III. Selection Criteria

1.3.1 Thermodynamic Properties:

- High latent heat of fusion per unit volume
- High specific heat &High density &High thermal conductivity

NON-PARAFFIN COMPOUND

- High nucleation rate
- High rate of crystal growth

1.3.3 Chemical Properties:

- Chemical stability.
- Complete reversible freeze &melt cycle.
- Non-corrosiveness, Non-flammable & Non-toxic.

1.3.4 Economic properties:

- Low cost.
- Availability.

IV. Literature Review

- ✓ **GAURAV S. WANI(2014)** : In this project To increase the efficiency the air conditioning system desiccant materials are used at the inlet of the air conditioning test rig. Desiccant materials attract moisture based on differences in vapor pressure. Due to their enormous affinity to absorb water and considerable ability to hold water**.**

- ✓ **D.G.RANDALL, J.NATHOO and A.E.LEWIS(2013):** However, a significant problem arises if there is more than one salt crystallizing at the same temperature since the one salt will contaminate the other. The system can in theory be manipulated into only crystallizing one salt by merely adding seed crystals of the desired salt product. If this approach is successful it would make EFC a very attractive process for hypersaline brine treatment because it would then allow for the production of a number of pure salts as well as pure, potable water from an otherwise unusable and environmentally harmful waste stream.

- ✓ **CLAIRE J. FERCHAUD , ROBBERT A.A. SCHERPENBORG(2013):** An interesting thermochemical material for compact seasonal heat storage is magnesium sulfate heptahydrate $MgSO_4·7H_2O$. Previous studies in the field showed that this material presents a storage energy density of 1 GJ/m3 when the material is built in a TC storage system with a 50% porosity packed bed reactor. However, the material has slow reaction kinetics under the low vapor pressure typically occurring in a seasonal heat storage (13 mbar). The kinetic study presented in this paper shows that a higher water vapor pressure of 50 mbar increases the reaction kinetics of the dehydration process of $MgSO_4•7H_2O$, improving the performance of the material.

- ✓ **D.G. RANDALL, J. NATHOO AND A.E. LEWIS(2009):** The results from this study seem to indicate that sodium sulphate seeding promotes the selective crystallization of sodium sulphate while magnesium sulphate seeding does not promote the crystallization of magnesium sulphate. Thus sodium sulphate should be the first component to be removed by seeding with Na2SO4.10H2O followed by the removal of magnesium sulphate at a lower temperature from a then predominately binary magnesium sulphate system.

- ✓ **J.M.KAVITHA AND C.K.MAHADEVAN(2013):** In the present study, aiming at discovering new useful materials, we have grown Epsomite (MSH) single crystals by the free evaporation method and investigated the effect of glycine (a simple and interesting amino acid) as an impurity (added in the Epsomite solution used for the growth of single crystals) with impurity concentration ranging from 2000- 10000 ppm (i.e. 0.2 - 1.0 mol%) on the properties of Epsomite. Six crystals (in total) were grown and characterized structurally, chemically, optically, mechanically and electrically.

V. Experimental Setup:

The experiments consists deep freezer at the centre of the deep freezer a sphere is filled with PCM as shown in Fig.5.1 The temperature of the fluid can be varied between - 20 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 20% $MgSO_4$+80%H_2O, 25% $MgSO_4$+75%H_2O and 30 % $MgSO_4$+70%H_2O mixture, claimed to be suitable for cool thermal energy storage to find This setup is used to determine the solidification and melting time of the phase change material.

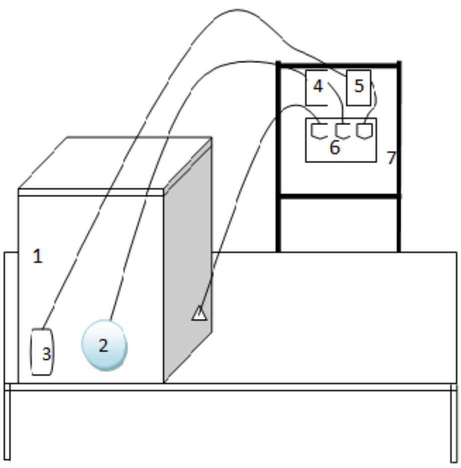

Fig 3. Experimental setup 1.Deep Freezer 2. Spherical ball filled with PCM 3. RTD Sensor 4. PCM temperature Indicator 5. Deep Freezer Temperature Indicator 6. Supply Unit 7. Stand.

VI. 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.

Testing I:(80% of water +20% of $MgSO_4.7H_2O$ salt) result

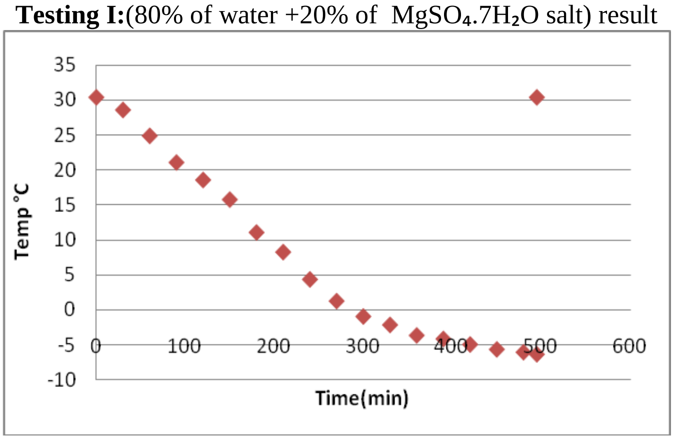

Fig 4.freezing curve

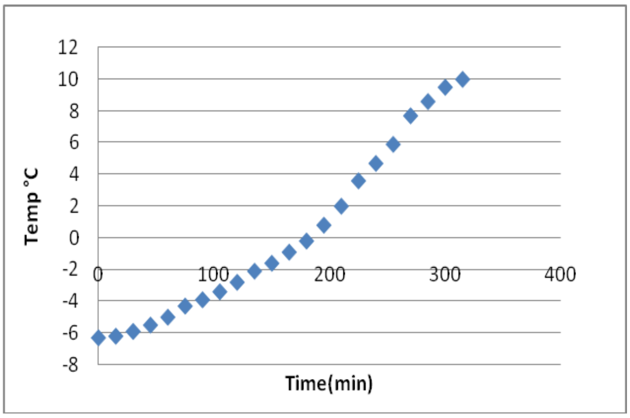

Fig 5.thawing curve

Testing II:(75% of water + 25 % of $MgSO_4.7H_2O$ salt) result

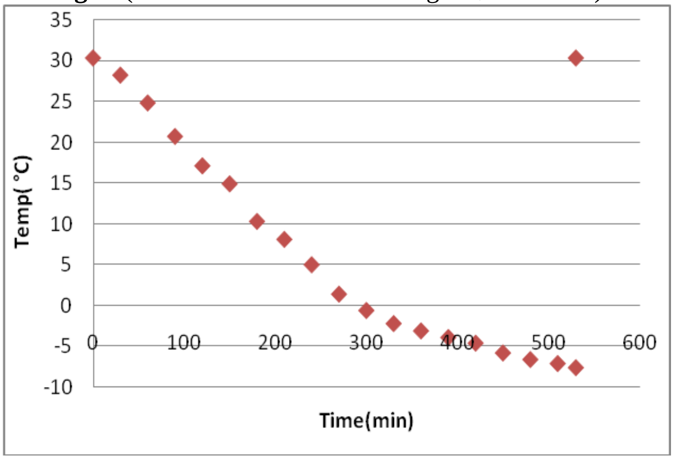

Fig 6. freezing curve

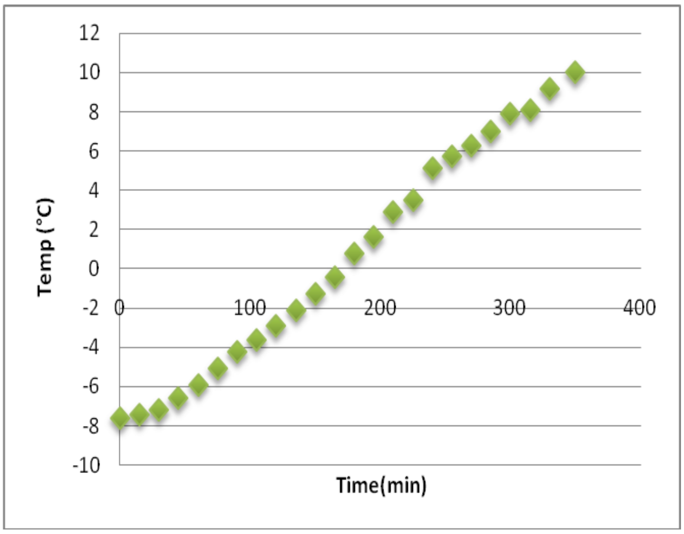

Fig 7.thawing curve

Testing III:(70% of water + 30 % of $MgSO_4.7H_2O$ salt) result

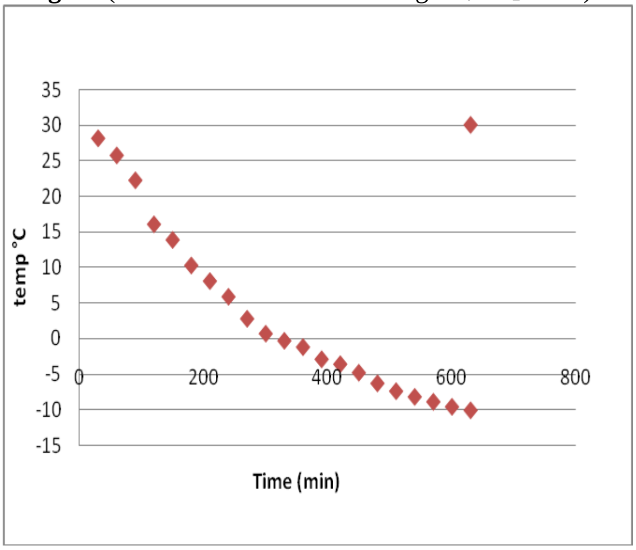

Fig 8.freezing curve

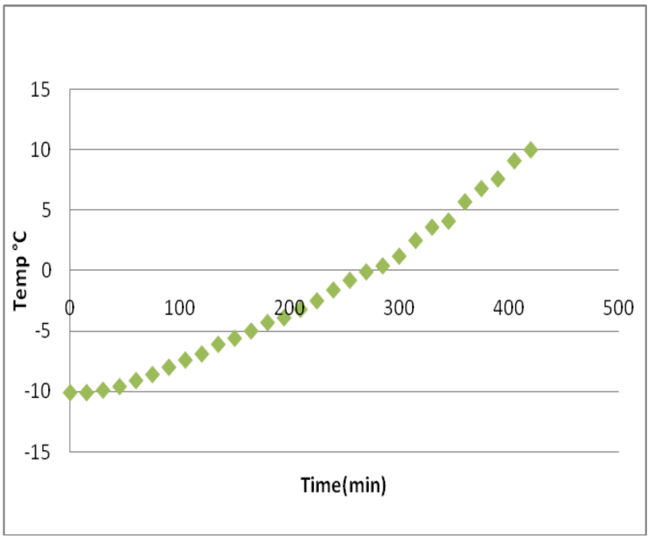

Fig 9.thawing curve

VII. Conclusion

The PCM mixture of water 70 % + magnesium sulphate hepta hydrate salt 30% has been recommended for cold storage application because of its low cost and conventional temperature of melting, which makes it suitable for HVAC application. The melting and solidification temperatures of mixture (70%water+30%salt) are found experimentally the values obtained is-10.1^{0}C respectively.. 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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