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A Review on Phase Change Material as Energy Storage Materials

[1]*P.K. Chidambaram, [2]M. Ramachandran, [2]Kurinjimalar Ramu, [2]Vidhya Prasanth, [2]S. Sowmiya
[1]New Prince shri bhavani college of Engg. & Tech Chennai, Tamil Nadu, India.
[2]REST LABS, Kaveripattinam, Krishnagiri, Tamil Nadu, India.
*Corresponding author Email: hodmech@newprinceshribhavani.com

Abstract. Phase transducers when a large amount of absorbing or releasing the material changes from a solid state to a liquid state it is called 'latent' heat. There are two main classes of transition materials petroleum, organic matter derived from plants or animals and salt hydrates, which are commonly used in natural salts from the sea or from mineral deposits. A level change is the transition of an object from one stage to another. These changes occur when enough power is supplied to the system, and also when the system pressure is changed. Although Stanford Ovshinsky is generally regarded as the inventor of phase modifiers for data storage, the discovery of phase-changing electrical properties began in the early 1900s in one of Yale's Alan Tower Waterman's little - known and rarely cited pioneers. Salt hydrates are specific Salts that can bind to the water of crystallization tend to change phase during their freezing process. The organic materials used as PCMs are primarily polymers with long chain molecules made of carbon and hydrogen. A phase transition is a physical process in which an object moves from one stage to another. The change usually occurs when heat is added or removed at a certain temperature, which is called the melting point or boiling point of the material. PCMs are generally divided into three main types: organic PCMs, inorganic PCMs, and eutectics of organic and inorganic compounds. Any substance that experiences the process of phase change is called phase change material (PCM). Such materials collect, dissipate, or absorb heat when oscillating between solid and liquid forms. When they turn to solid state they expel heat and absorb when they go back to the liquid state. Melting and evaporation are endodermic processes that absorb or require energy, while freezing and condensing are external heat processes that release energy.
Keywords: Energy Storage, Thermal Energy Storage, Latent Heat, Heat Transfer, Energy Efficiency.

1. Introduction

Energy saving is the capture of energy produced at a time for later use to reduce the imbalance between energy demand and energy production. An energy storage system, it is defined by its storage capacity and the amount of energy. Potential energy is the stored energy and state energy. In simple terms, energy storage helps to store electricity later, when and where it is needed. It builds performance and capabilities for the power grid, including the ability to reduce greenhouse gas emissions. In simple terms, energy storage helps to store electricity later, when and where it is needed. It builds performance and capabilities for the power grid, including the ability to reduce greenhouse gas emissions. Thermal energy storage is the process of then heat or cools a medium to use the energy when needed. In its simplest form, it refers to the use of a water tank for heat storage, where the water heats up when there is more energy. According to the thermal mechanism used to store energy, TES can be divided into three types: sensory latent and thermo chemical reactions. Depending on the type of thermal energy used, the thermal efficiency can range from 50 percent to 90 percent. Latent heat is the energy that is absorbed or released during a change without changing its temperature in the physical state of an object.

Figure 1. Phase Change Matrials

The two most Heat transfer is the process of converting a gas phase from liquid to liquid and from liquid to solid. But the temperature of the material remains unchanged. Therefore, the heat required changing the water level from solid to liquid or gas or liquid to liquid or gas without any temperature change is called the latent heat of water. Heat transfer, any or all types of phenomena, it is considered as a means of transporting energy and entropy from one place to another. Specific mechanisms are commonly referred to as convection, thermal radiation, and conduction. There are various heat transfer mechanisms including convection, convection, heat radiation and evaporative cooling. Heat is transferred by liquids, gases and electromagnetic waves. Heat is usually transferred to a mixture of these three types and rarely occurs spontaneously. Energy efficiency offers a variety of benefits. Reducing greenhouse gas emissions, reducing the need for energy imports and reducing our housing and economic costs. Energy efficiency refers to the use of less energy to provide energy service.

2. Energy storage

Energy storage is produced while reducing the imbalance between energy demand and energy production. An energy saving device is commonly called an accumulator or battery. Storage options include batteries, heaters or mechanical systems. All of these technologies can be integrated with software that controls the discharge of electricity and energy. The micro-encapsulated cocoa fatty acid compound is used in a variety of important materials. Significant temperature or enthalpy change was observed in the latent state. Thermal energy storage applications will disappear after a significant temperature or NTP change. Chemical stability MMA / tocosane micro capsules were explored by repeated thermal cycling FT-IR analysis. Thermal energy saving purposes such as solar space heating applications. The structure of the micro capsules is not affected by the heat cycle. Occurred during the heat cycle. In addition, thermo gravimetric examination showed. PMMA / diocesan micro capsules decompose in three steps. Resistant to high temperatures. Based on these results, it can be concluded that the manufactured MEPCMs have good efficiency **[11].** Thermal energy storage systems offer several alternatives. TES are materials that provide heat regulation at a given phase transition temperature by absorbing and releasing medium heat. At TES although the amount of important information in general and last research is enormous Widespread in the literature, difficult to find. Nuclear and thickening agents may be added to the mineral level modifiers Reduce super cooling and corrosion. Unlike conventional sensitive heat storage PCMs offer high energy saving density and heat storage, while PCMs can be used both active and passive. There may be T they can capture solar energy directly or through natural convection [16]. Creating new energy sources is important. Thermal energy storage Age systems have the potential to help save energy. Thus reducing environmental impact. In fact, these systems balance the energy supply for the required internal heat storage. Using a phase converter (PCM) to recover waste heat the following are the most attractive options from the four professions. It stores heat in the form of latent fusion and then releases it. [21]. Thermal energy storage is always one of the most important components solar radiation is a source of energy based on time intermediate nature. Heating requirements for residential homes also depend on the time. However, the source of energy and home requirements are generally incompatible, especially with applications in solar heating. Peak solar radiation occurs at noon, and peak temperatures are required in the evening when sunlight is not available. Provides energy savings to Correct Meets this incompatibility and energy requirements at all times. It is used as a bridge to bridge the gap between electricity [32]. Although thermal Layer Storage tanks are an effective thermal energy saving technique that is widely used in energy storage and load management, they said, adding that the use of PCM helps maintain heat layers and increases hot water time. Reduces the size of storage tanks and reduces the ability to evaluate and compare the thermal performance of energy saving age systems. Their numerical results show that the efficiency of the latent heat storage system can be improved by reasonable ones. The choice of melting temperature of the PCM and the use of multiple PCMs can improve the energy storage of the tank [41].

3. Thermal energy storage

Thermal energy storage systems can then use heat or cooling differently levels Such as temperature, location or power. TES systems are subdivided into three types sensitive heat, latent heat and absorption and chemical energy. Storage. Solar energy is an example of the use Thermal energy storage. Most practical solar heating systems save a few hours' worth of energy per day. This study examined the influence of EG inclusion on the thermal conductivity using transsinte, aimed at obtaining a stable mixture of phase-absorbed paraffin in expanded graphite. Exploring the latent thermal energy storage properties of paraffin such as hot wire method and **[42].** These tests can simplify into two-dimensional problems and purpose. Verification for number simulation must first be provided. The shell and tube thermal energy storage system was commonly used however, the experiments use metal foam. Was rarely used to increase heat transfer efficiency. In addition, tests for shell and tube with or without improved heat transfer can save thermal energy Technology only measures time-dependent temperature variations, while interfacial evolution at the symmetric axis is not always possible. The interface on this aircraft is a remarkable performance indicator that can express the effect intuitively. Shows natural convection and which part melts faster. Does not melt while charging **[47].** Shukla has designed two solar water heaters as a thermal energy storage material containing paraffin. One system had a tank type storage tank the second uses an integrated storage type reflector. Both systems were able to provide hot water at night both Systems were found to be 45% and 60% effective, respectively, based on the 24-hour cycle in the morning. Cullen and Vandan used paraffin to heat hot water and space in the home **[52].** Cold thermal energy storage requires the process of Adds cold heat energy to a medium and extracts at any time. Change in internal energy or phase change of storage media. During the charging process, the available cold heat energy can accumulate. Cold thermal energy is stored during exhaust. Cold heat energy can be saved through it. Phase-convertible

Material-based cold thermal energy storage is now common and is used in many applications such as free cooling and building air conditioning, medicine and cold packing. But there are some practical issues like low heat. PCM container exchange, super cooling, corrosion and lubrication. These can be problems. This can be overcome by adapting advanced technologies such as adding, merging, and nanostructures **[72].** The basic types of thermal energy saving techniques can be described as sensory heating. Storage and latent heat storage. In sensible heat storage, the temperature of the storage material will vary depending on the amount of energy stored in the solar heating system. Water is used for heat storage in liquid-based systems, while a rock bed is used as an air base. **[83].**

4. Latent heat

Latent heat is the absorption or release of energy that occurs when an object changes its physical state without changing its temperature. Two common forms of latent heat these names describe the direction of energy flow moving from one phase to the next. Solid and gaseous from liquid. Latent heat is the heat required to change the phase of an object that is closely related to this energy enthalpy. Severely weakens the and phase change regression, which is considered promising. PCMs for low temperature LHS applications have been identified as rotation based solar heating power station connected PCMs designed to eliminate fluctuations in HTF Tempera diuretic when charging and discharging in the organic range of the spherical-filled packed bed LHS system. Latent thermal energy storage system for storing and releasing energy significantly improved by increasing mass flow rate and inlet charging [49]. The basic types of thermal energy saving techniques can be described as sensitive heating. In sensible heat storage, the temperature of the storage the material will vary depending on the amount of energy stored in a solar heating system is such that water is used for heat storage in liquid-based systems, while a rock bed is used as an air base. Heat in the application of load balance is usually stored in passive bricks. Media and metals such as aluminum, magnesium and zinc can also be used for energy. Latent heat storage is a particularly attractive technique because it has a high energy saving density and the ability to store fusion latent heat. Constant temperature associated with changing temperature of changing materials (PCMs). For example, in the case of water, 1 kg of ice requires 80 times more energy to melt, which increases the temperature. 1 kg of water to 1 1C. It requires very small weight and size material to store a particular item. The analysis of heat-transfer problems in the process of melting and solidification of energy In the scientific literature, levels are called moving boundary problems, which are more complex. The solid-liquid boundary moves according to the velocity of the latent heat, the boundary is absorbed or lost, so the boundary level is unknown. Sample Follows the two-dimensional melting process of a solid PCM. With the exception of the layer closest to the solid, the mode of dominance in the molten region is only at the boundary where conduction is assumed to occur [83]. Thermal cycling test was used to determine the thermal reliability of the form-stable composite PCM, which is based on the phase change temperature and the change of latent Temperature depending on the heat cycle number. Thermal cycling test is the exposure of the PCM compound to the melting and freezing process. Tests were carried out continuously for up to 500 heat cycles using a heat cyclist [122]. Latent-liquid, liquid-gas, solid-gas and solid-solid state transitions accomplish latent heat storage. This negates their potential use in heat storage systems. Major changes in the module make the system more complex and impractical [123]. The latent thermal energy storage system (LHESS) can use available thermal energy to improve its utilization difference between the energy supply and demand providing a promising solution for further softening. Specialties LHESS is double. High energy saving density and almost constant temperature applications during phase transition the LHESS grid [144]. Energy saving in much Position change of applications the temperature changes when materials melt due to latent heat during the melting process. One of the most important latent heat storage applications is solar water heating. In which a solar collector is connected to a hidden Heat storage. The unit is filled with PCM, and a heat transfer fluid circulates through the solar collector, collecting a portion of the recovered solar energy and converting it into PCM in charging mode. The thermal energy stored in the charging system is exhausted. The cold water is then recovered to produce hot water [148].

5. Heat transfer

The thermal properties of these emulsions are different from those of PCM and the liquid in question, which is essential for evaluating the fluid and heat transfer properties of a system. The thermal properties to be discussed in these emulsions are the thermal conductivity and the convective heat transfer coefficient. Analysis of various studies related to convection is presented in a separate section [18]. Where heat transfer problems are related. Has attracted attention for the past two decades due to their comprehensive nature. It's Emphasis on phenomenon and engineering practices in nature. Weir and Giaconda studied the melting and freezing events of water-glass beads. Water-aluminum bell systems are calculated and tested in a cylindrical capsule with a combination of Beckerman and Wisconda numbers and the gallium-glass bell system melting and freezing test rectangular closure. Improving Melting and freezing heat transfer rates associated with the transition phase of materials with low thermal conductivity (PCMs) [38]. They reported better results with n-octadecane, but recognized that phase separation reduces heat transfer efficiency. The suspension was assessed by Kassa and Sen. Suspension Colvin and Mulligan have been reported to increase to specific temperatures when using the microencapsulated phase three times. 5 times and increases the heat transfer coefficient. 2.8-fold micro-linked phase transition Material suspensions and recommended applications Avionics, spacecraft and electronic systems developed a model that amplified heat transfer using Zen and Zen low-phase suspension flows. They reported excellent agreement on their experimental and theoretical results. It showed a three-fold increase. The curve for heat transfer is provided by the single phase fluid. Therefore, the phase transition material suspension results are provided by a heat transfer coefficient comparable to the standard single-phase results. The number of noses is also related to the reason for this. Problems in defining the appropriate

heat transfer coefficient when phase shift suspensions are used Fluids for purity are defined in terms of heat transfer coefficient. In practice, radial displacement is attached. Affects float-induced separation velocity. The integrity and suspension of the profile can Affects heat transfer [40].

Advances in micro-encapsulation technology over the past decade have made it possible to change the status quo. The size of the smallest particles from the ratio is relatively small. Larger, the The heat transfer rate per unit volume is higher than the material in the particles. The broth works on both energy storage and heat transfer. The need for media and separate heat transfer eliminated the medium. In addition, attach the phase change material in small capsules. Any cracks in the phase are expected to be removed. There may be a heat transfer coefficient around the spheres. Based on which it was estimated from the abduction model. This includes effective thermal conductivity [70]. The convection the heat transfer mechanism loses motion and the shape of the liquid-solid interface as a result of local orientation. The mold asymmetry makes it clear that the melting process will show a completely different behavior Solid PCM is not fixed, so it is allowed to sink. In contrast to the heat transfer mechanism controlled by natural convection, the introduced 'heat transfer coefficient' AT increases and the temperature difference decreases with AT. Mathematically, this is due to the mutual influence of the Stephen number, which develops with AT. Physically this behavior results in a melting interval, increasing its thickness and increasing heat resistance by increasing the melting rate [90]. During the three heating and cooling cycles, the oil mixed with erythritol B showed good chemical stability. The total mass of the PCM and heat transfer oil was constant and did not form a mixture suspension even after three rounds of heating and cooling. The fact is that the thermo physical properties of the compound are maintained. The chemical stability of PCMs under conditions of maximum available temperature and mixing with the heat transfer medium, despite their importance from an engineering point of view, is unknown. In addition, a basic knowledge of the heat transfer characteristic between the selected PCM and the heat transfer oil is essential in designing the TH system [92].

6. Energy efficiency

Energy efficiency refers to the use of less energy to do the same task, eliminating energy wastage. Energy efficiency offers a variety of benefits, including reducing greenhouse gas emissions and reducing energy demand. Import, and reduces our housing and economic costs. Energy efficiency refers to the use of less energy to provide energy service. For example, incandescent lamps with energy efficient LEDs lights can produce the same amount of light 75 to 80 percent less electricity are used. Power systems include the heat transfer rate per unit volume is higher than the material in the particles. The broth works on both energy storage and heat transfer. The need for media and separate heat transfer eliminated the medium. In addition, attach the phase change material in small capsules. Stabilization, aggression sensors, energy efficient lighting controls. Energy Efficiency means using less energy to do the same job - and in the process, reducing energy costs and reducing pollution. Many materials, homes and buildings use more energy than is actually needed through inefficiency and energy waste. Experimental study reveals the progress of a model solar water heater using PCM. Paraffin with certain thermo physical properties is selected as PCM and incorporated spherically into the tank of the solar water heater. The solar tank jacket is designed in three shell stages of shell type and solar radiation, Constant temperature water circulation at 40, 60 and 80 C through the tank jacket. The mass flow rates of the charging water for each case are selected according to the temperature and are 0.2, 0.3 and 0.4 l / min for the three modes, respectively. A flow rate equal to 0.2 l / min is used in the exhaust section for all events. By testing the time the heater can deliver hot water and checking the power and efficiency of both tanks with and without PCM, we have made progress in all cases. As a result of using PCM, the hot water supply time of the solar heater in 80C charging mode is extended by up to 25%. The maximum improvement in energy efficiency is the 80 C charge mode. Exercise efficiency at 39% and 40C charge mode. 16% Finally, the impact of using PCM in the tank to retain the heat layers is examined by examining the temperature profiles of the hot layers in the tank during charging and discharging conditions [30].

The A photovoltaic Level Transformation Material (PV-PCM) structure is explored as a building element with improved energy efficiency through PV cooling and reduced heat transfer. The PV-PCM system was created by adding a PCM layer behind the PV and an insulated chamber behind the PV-PCM. The impact of the added PCM layer is tested experimentally on the electrical and thermal energy capacity of PV and indoor space, respectively, in hot climates. Delay in PV unstable temperature drop, indoor unstable temperature and peak indoor temperature observed by PCM application [167]. Thermal energy storage using construction materials (PCMs) plays a significant role. Maintaining the heating facility and reducing the energy consumption in a building due to its efficiency. Absorption / release of heat within small temperature variations. In this paper, thermal performance roofs were explored based on various factors such as single PCM layer integration, dual PCM layer integration, PCM thickness, transition temperature and PCM fusion temperature. Analysis shows that the integration of different single PCM layers results in incomplete solidification and melting of the thickness and phase change temperature and the inability to maintain the fusion temperature in the roof structures of the PCM at a comfortable constant temperature inside the building [168]. High cost and unstable thermal performance limit the use of PCMs in the energy generation industry. In this study, co-soluble hydrous salt / E ash compound PCMs were prepared by direct tipping using the relatively inexpensive sodium sulfate dehydrate as the primary alternative energy storage agent and solid waste flying ash as a carrier material [169]. Total building energy consumption in the BRIC countries is already high. For those in developed countries, its construction role continues to grow. Therefore, improving energy efficiency is mandatory. Heating, ventilation and air conditioning services account for 50% of building consumption and 20% of total consumption in developed countries. The use of proper thermal energy storage (TES) systems in the building increases energy efficiency. In particular, the incorporation of phase converters (PCMs) in buildings allows the use of many more energy dynamics, and one of the

main advantages of using PCMs in buildings is the maximum load conversion energy required for heating and cooling. Furthermore, the storage temperature provided by the PCMs heating facility is increased by fluctuations due to latent heat transfer. For example, these technologies are generally classified as active or passive systems, which include improving energy efficiency and implementing peak conversion technology in domestic hot water applications [170].

7. Conclusion

Energy storage is produced Storage options include batteries, heaters or mechanical systems. All of these technologies can be integrated with software that controls the discharge of electricity and energy. The micro-encapsulated cocoa fatty acid compound is used in a variety of important materials. Significant temperature or enthalpy change was observed in the latent state. Thermal energy storage applications after heat cycle. The chemical stability of MMA / tocsins micro capsules was explored by repeated thermal cycling FT-IR analysis. Thermal energy storage purposes such as solar space heating Applications. Solar energy is an example of the use of thermal energy storage. Most practical solar heating systems save a few hours' worth of energy per day. This study examined the influence of EG inclusion on the Thermal conductivity using transcinte aims to obtain a stable mixture of phase-absorbed paraffin in expanded graphite. Exploring the latent thermal energy storage properties of paraffin such as hot wire method and Melting time, melting temperature and latent heat capacity using different scanning calorimetry technique. The melting time test showed an increase in heat. The conductivity of paraffin significantly reduced its melting time. The solid-liquid boundary moves according to the velocity of the latent heat, the boundary is absorbed or lost, so the boundary level is unknown. Sample follows the two-dimensional melting process of a solid PCM. With the exception of the layer closest to the solid, the mode of dominance in the molten region is only at the boundary where conduction is assumed to occur. This is based on the phase change temperature and the change of latent temperatures depending on the heat cycle number. A thermal cycling test is the exposure of a composite PCM to a melting and freezing process. Tests were carried out continuously up to 500 heat cycles using a thermal cyclist. Energy efficiency offers a variety of benefits, including reducing greenhouse gas emissions, reducing the need for energy imports, and reducing our household and economic costs.

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