THERMAL ENERGY STORAGE SYSTEM USING PHASE CHANGE MATERIAL (PCM)

M.Aravind Raj [1], Dr. P. Navaneetha Krishnan [2], Dr. T. Senthilkumar [3]
[1](PG Student, Department of Mechanical Engineering, University College of Engineering, BIT Campus, Anna University, Trichy, Tamilnadu, India)
[2](Dr. P. Navaneetha Krishnan, Asst. Professor, Department of Mechanical Engineering, University College of Engineering, BIT Campus, Anna University, Trichy, Tamilnadu, India)
[3] (Dr. T. Senthilkumar, Professor & Head, Department of Mechanical Engineering, University College of Engineering, BIT Campus, Anna University, Trichy, Tamilnadu, India)

Abstract – **Phase change materials (PCM) has been used widely as latent heat thermal storage (LHTS) systems. PCM materials has the ability to store the solar energy and other forms of heat energy as latent heat. By using PCM, we can reduce the energy usage. PCM has been recognized widely and it acts a substitute system for Electric and Kerosene based Space heaters. This system will control the fluctuations of temperature during the day time and night time. It will absorb the heat during daytime and will heat the room during night for better comfort. It will bridge the gap between the supply and demand of energy. The PCM is potentially used in Building applications, shelters, Containers and in defense applications.**

Keywords: **Thermal Storage System, Phase Change Material (PCM), Latent Heat Thermal Storage (LHTS) System.**

I. INTRODUCTION

The gap between the Energy demand and supply in the commercial, industrial, and utility sectors can be sorted out by Thermal Energy Storage (TES) System. Energy demand will vary with respect to season and ambient conditions and the gap can be bridged by using suitable TES System. TES deals with the storage of energy by cooling, heating, melting, solidifying, or vaporizing a material; the thermal energy becomes available when the process is reversed. Storage by causing a material to rise or lower in temperature is called sensible heat storage; its effectiveness depends on the specific heat of the storage material and, if volume is important, on its density. Storage by phase change (the transition from solid to liquid or from liquid to vapor with no change in temperature) is a mode of TES known as latent heat storage. Sensible storage systems commonly use rocks, ground, or water as the storage medium, and the thermal energy is stored by increasing the storage medium temperature. Latent heat storage systems store energy in phase change materials (PCMs), with the thermal energy stored when the material changes phase, usually from a solid to a liquid. The specific heat of solidification/fusion or vaporization

and the temperature at which the phase change occurs are of design importance. Both sensible and latent TES also may occur in the same storage material. This paper summarize the different types of PCM's available and selection of suitable PCM to heat the room when the ambient temperature is very low.

II. THERMAL ENERGY STORAGE

Thermal energy may be stored as sensible heat or latent heat. Sensible heat - by elevating or lowering the temperature of a substance (i.e., altering its sensible heat), Latent heat - by changing the phase of a substance (i.e., altering its latent heat) or through a combination of the two. TES is the temporary storage system like storage of solar energy in the PCM for overnight heating, storing summer heat to use during winter, using ice from winter to summer for space cooling, storing energy generated by electricity during off peak hours and use the same stored energy when the demand is high.

III. SENSIBLE HEAT STORAGE

Sensible heat storage SHS is the simplest method where the thermal energy is stored by heating or cooling a liquid or solid storage medium. The thermal energy is stored by raising the temperature of the solid or liquid using its heat capacity. Main advantage of SHS are : Cheap, readily available and less risk. Water is the commonly used system to store energy which has high specific heat, high density and cheap. SHS system utilizes the heat capacity and the change in temperature of the storage medium during the process of charging and discharging. The amount of heat stored depends on the specific heat of the medium, the temperature change, and the amount of storage material.

$$Q = \int_{Ti}^{Tf} m \,.\, cp \,.\, dT$$

$$Q = m.\ cp.\ (Tf - Ti)$$

IV. LATENT HEAT STORAGE

Latent heat storage system (LHS) uses the energy released or absorbed in the phase change region. When the material reached its the phase change temperature it absorbs or releases a huge amount of energy to carry out the phase change which is known as the latent heat of fusion or evaporation depending on the state and in this way the energy is stored. The materials used are known as phase change materials (PCM). They have very high energy density and hence they reduce the volume and hence the cost. Latent heat storage uses the latent heat of the material to store thermal energy. Latent heat is the amount of heat absorbed or released during the change of the material from one phase to another phase. Two types of latent heat are known, latent heat of fusion and latent heat of vaporization. Latent heat of fusion is the amount of heat absorbed or released when the material changes from the solid phase to the liquid phase or vice

versa, while latent heat of vaporization is the amount of thermal energy absorbed or released when the material changes from the liquid phase to the vapour phase or vice versa. Indeed, latent heat of vaporization is not paid attention for latent thermal energy storage applications because of the large change in the volume accompanied by this type of phase change. The amount of thermal energy stored in form of latent heat in a material is calculated by

$$Q = m. LH$$

Where Q is the amount of thermal energy stored or released in form of latent heat (kJ),
m is the mass of the material used to store thermal energy (kg), and
LH is the Latent heat of fusion or vaporization (kJ/kg).
It is clear from above Eq. that the amount of thermal energy stored as latent heat depends on the mass and the value of the latent heat of the used material. Materials used to store thermal energy in form of latent heat are called phase change materials.
When a solid is heated, its temperature rises up to its melting temperature. After this point the temperature come to an end to increases and the phase change occurs. After the PCM has completely melted, the temperature rises again up till it reaches the boiling temperature. After this the temperature remains constant till everything is evaporated. In PCM application one can give and extract the energy within the phase change region and therefore without changing the temperature [1].

V. PHASE CHANGE MATERIALS

When a material melts or vaporizes, it absorbs heat; when it changes to a solid (crystallizes) or to a liquid (condenses), it releases this heat. This phase change is used for storing heat in PCMs. Typical PCMs are water/ice, salt hydrates, and certain polymers. Numerous organic and inorganic PCMs melt with a high heat of fusion in the temperature range 0–120 ◦C. However, for their employment as heat storage materials in TES systems, PCMs must also possess certain desirable thermodynamic, kinetic, chemical, technical, and economic characteristics. Some of the criteria considered in evaluating PCMs follow

Thermodynamic criteria:	Chemical criteria	Technical criteria	Economic criteria
• a melting point at the desired operating temperature; • a high latent heat of fusion per unit mass, so that less amount of material stores a given amount of energy; • a high density, so that less volume is occupied by the material; • a high specific heat, so that significant sensible TES can also occur; • a high thermal conductivity	• chemical stability; • no susceptibility to chemical decomposition, so that a long operation life is possible; • noncorrosive behavior to construction materials; • nontoxic, nonflammable, and nonexplosive characteristics.	• simplicity, • applicability, • effectiveness, • compactness, • compatibility, • viability, and • reliability.	• commercial availability, • low cost.

Table.1. Characteristics of PCM

VI. CLASSIFICATION OF LATENT HEAT STORAGE MATERIALS

Phase Change Materials (PCM) are also called as Latent heat Storage Materials and it is classified as follows:

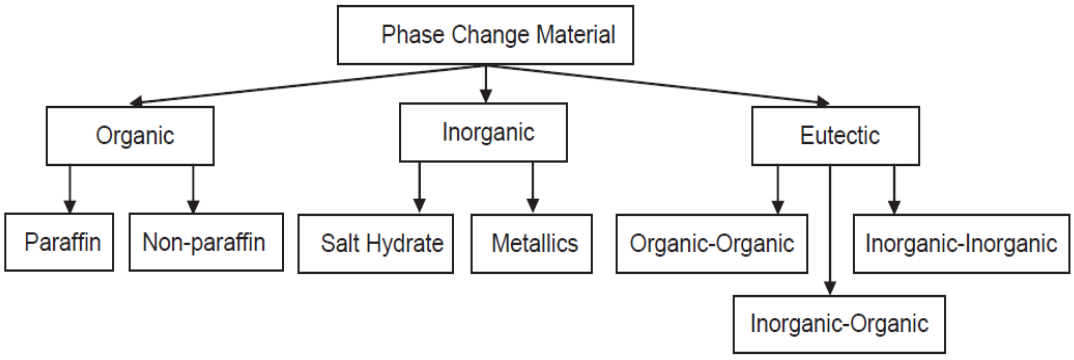

Fig 1. Classification of PCM

VII. PROPOSED

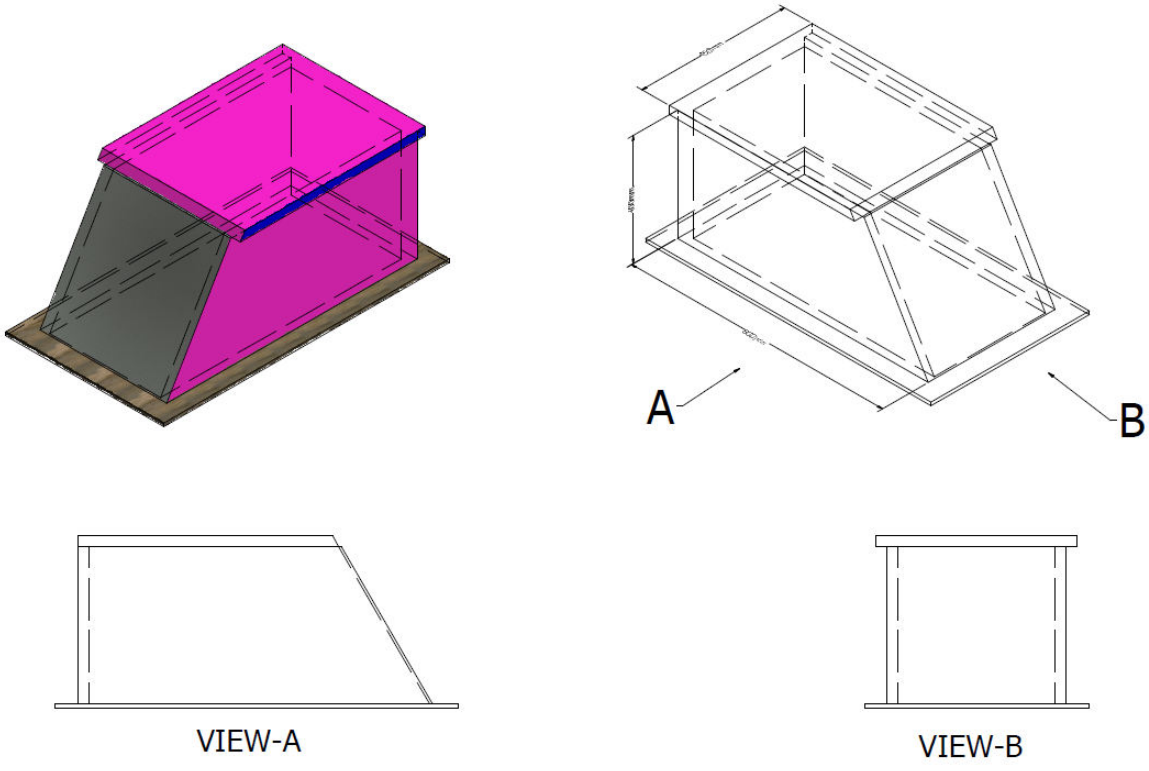

Fig 2. Typical Sketch

The shelter prototype will constructed with steel sheet (outer and inner) with PUF or Rockwool insulation on all the sides. One side of the shelter is provided with Polycarbonate sheet for better solar radiation on the PCM stored behind the polycarbonate sheet.

Polycarbonate Sheet = 0.282 m²
Total Surface Area = 1.362 m²
Panel Thickness = 25 mm
U - Value of Insulation = 0.297 W/m²K
U - Value of Polycarbonate Sheet = 0.32 W/m²K
Solar Irradiation = 4 kwh/m2/day (appx)
PCM – Latent heat = 199 KJ / Kg
Amount of PCM to be stored = 3.2 Kgs

The prototype shelter to be manufactured as insulated wall construction. The outside surface of the side walls, End walls and Roof are covered with CRCA sheet (1 mm) and inner plain GI sheet (0.6 mm). Side walls, End walls and Roof panels are sandwiching an insulation of 50 mm thick Rockwool or PUF Insulation. Marine grade plywood shall be used as floor plate.

PCM slabs shall be placed on one side based on the sunlight light direction and it shall be covered with Polycarbonate sheet for better light transmission. Based on the Solar Irradiation, the Phase Change duration will vary. The proposed PCM having the freezing temperature of 24°C and melting temperature of 25°C. It stores the thermal energy as latent heat in its crystalline form. Once the ambient temperature reaches more than 25°C during day time, the phase change will happen and the PCM will absorb the heat and stored it as latent heat. When the ambient temperature drops below 24°C, the PCM will emits the stored heat to the shelter and change the conditions inside the shelter.

VIII. CONCLUSION

It is clear from the above discussion that the PCM plays a major role on the human comfort and energy saving. Though the sensible thermal energy system has high specific heat, the latent type thermal energy system can be used in the critical applications. Higher the latent heat, higher the temperature difference which can achieved during reversal process. By using PCM, we can save the energy requirement for room heating or cooling and we can use this kind of PCM shelters in worst atmospheric conditions.

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