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A Review on Paraffin Wax as Phase Change Material in Latent Heat Thermal Energy Storage System

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***Abstract*: This paper deals with the latent heat storage system using phase change materials (PCM) is an effective way of storing thermal energy storage system. The PCM is used for various purposes as a suitable heat exchanger and is to enhance the heat transfer. It has a advantage of high storage density and the isothermal nature of storage process. PCM is for different applications are space heating and cooling, solar cooking, greenhouses, solar water heating and waste heat recovery systems.**

***Keywords*: Phase change Material, Latent Heat System, Sensible Heat System**

1. Introduction

Researchers search the new and renewable energy sources to reduce the CO_2 emissions from the combustion of fossil fuels, particularly in areas where low temperature applications are involved [1]. Solarenergy has an enormous potential for the heating and cooling of buildings, producing hot water for domestic and industrial purposes, cooking, warming greenhouses for agricultural crops, etc. [3]. However,solar energy is intermittent, unpredictable, and available only during the day. Hence, its application requires efficient thermal energy storage so that the surplus heat collected during sunshine hours maybe stored for later use during the night [5]. Similar problems rise in heat recovery systems, where the waste heat availability and utilization periods are different, requiring some thermal energy storage. In thermal energy storage, the useful energy from the collector is transferred to the storage medium where it is transformed into an internal energy [6]. This may occur in the form of latent heat, sensible heat, or both. Latent heat storage is more attractive than sensible heat storage because of its high storage density with smaller temperature swing. However, many practical problems are encountered with latent heat storage due to low thermal conductivity, variation in thermo-physical properties under extended cycles, phase segregation, subcooling, irregular melting, volume change and high cost [7]. These problems have to be technically resolved before latent heat storage can be widely used.

2. Energy storage systems

- Sensible heat system

The Thermal Energy is stored by increasing the temperature of a solid or liquid

- Latent heat system

The additional heat energy is stored in the system without any alter in the temperature, then the stored energy in the material experience a phase change from solid to gas or reserved. It is called as latent heat storage system.

3. Heat transfer improvements method in LHS

- Metallic Fillers
- Metal Matrix Construction (Hybrid Composite)
- Finned Tubes

4. Techniques

- Active method of agitators, vibrations, scrapers and clay
- Microencapsulated PCM
- PCM with graphite composite material
- Extensive surface such as fins and honeycombs

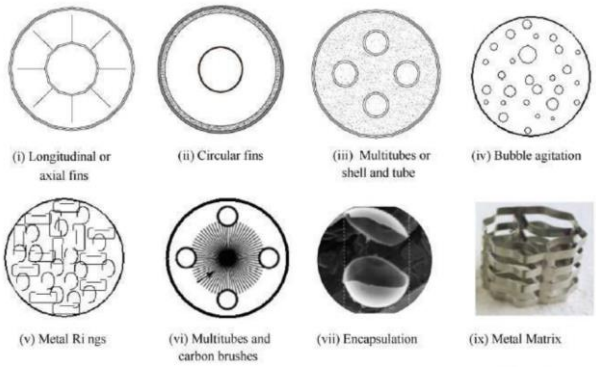

Fig. 1. Different kinds of heat transfer improvements fins

By using phase change material like paraffin and stearic acid during thermal energy Storage system using both sensible and latent heat storage capacity in a unit volume, while charging and discharging the solar energy is maintained at constant temp and pressure [1].

PCMs like paraffin (aluminium is filled with paraffin) it maintain that hot water is accessible throughout the day the

storage unit stores the heat in the PCM storage during the day time and supplies hot water during at night and overcast time[2]. By using he PCM (wax based storage system is improved by fixed copper, aluminium and iron spring).we can store the loss of energy during changing and discharging of solar energy [3]. His review is using the PCM the latent storage system is obtained in effective way and it has the many advantages high storage, isothermal in nature .PCM is widely used for many applications [4]. The focus on solar power plant using the thermal energy storage technology and system to get a low economic analysis as high efficiency [9]. He describe focus on solar and power plant using the latent thermo Celine energy storage system is performed for repeated charging and discharging process and movement of process using the encapsulated PCM[10]. He describe using the PCM as salt instead of paraffin wax to increase the solidification of storage system and it has high thermal conductivity and low cost compared to the paraffin wax [11]. She describe the storage .The energy interns of temperature distribution heat transfer and energy storage rate by using multi tank storage system [12]. The solar energy storage based on the metal hybrids particularly to get the better performance, optimization and good economic feasibility [13]. He describes that energy storage system based on latent heat storage and thermo chemical heat storage mainly concentrate on limited life of methods energy source is the achievement of sustainable energy is not available at all the time the need of heat storage system obtained[14]. He describe in order to reduce operation cost of solar plant and the limitation is their low heat conductivity based on different types of thermal storage system sensible, latent and chemical heat using PCM[15].

5. Classification of thermal energy storage

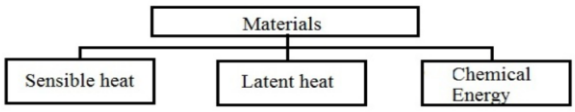

Fig. 2. Classification of thermal energy storage

A. *Sensible heat*

Sensible Heat is heat exchanged by a thermodynamics system that changes the temperature of the system without changing some variables such as volume or pressure. As the name implies, Sensible heat is the heat that you can feel. The Sensible heat possessed by an object is evidenced by its temperature.

B. *Chemical energy*

Chemical Energy is Released when bonds form in a chemical reaction, often producing heat as a byproduct (exothermic reaction) There are two important terms to know in the study of chemical energy e.g. (Batteries, Biomass, petroleum, Natural gas and coal).

6. Classification of phase change material

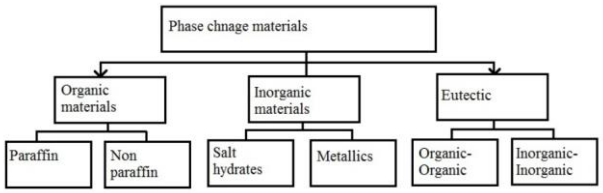

Fig. 3. Classification of phase change material

A. *Organic phase change materials*

This type of PCM classify in to paraffin and non-paraffin. Majority Phase change materials (PCMs) are characterized by their capability to freeze and melt under the different temperature condition. Paraffin is saturated hydrocarbons from CnH_2n+2 groups12. It has very similar properties in which C5 and C15 paraffin are in liquid state and others are in wax solid state. The paraffin wax contains the straight chain hydrocarbons and it has low melting temperature in the range of 23°C to 70°C. So paraffin wax is most effective PCM for domestic applications. Similarly non paraffin organic phase change materials have various properties. The review states that it includes alcohols, glycols are used for thermal energy system.

B. *Inorganic phase change materials*

Salt hydrates and metallic are the classification of inorganic Phase change materials. In salt hydrates contain the water and salt. This combination of water and salt create the crystalline matrix after getting the solidification. Salt hydrates are available in different types of melting temperature ranges between 15°C to 117°C. Salt hydrates have unique characteristics of latent heat thermal storage so it is used in PCMs. Due to segregation in hydrates and dehydrates salts reduces its volume for thermal energy storage. In thermal energy storage metallic containers are used for storage purpose but corrosion caused due to salt hydrates. Likewise metal eutectics and low melting metals are the parts of metallic. Metallic materials as a PCM survey are limited due to its high melting temperature and heavy weight. However such materials are used where weight is not a major parameter and only focuses on the volume. Also these materials have Low specific heat and High heat of fusion per unit volume.

7. Encapsulation of phase change materials

There are many merits in using an encapsulated phase change materials, which rising the heat transfer area, decrease the PCM reactivity towards the outside surroundings, and manage the changes in the storage material sizes. The phase change materials are encapsulated in clear design closed vessel with metal or plastic materials.

8. Thermal energy storage system based on the solar system

Thermal energy storage consists a number of technologies that store thermal energy in artificial lake for afterwards. They

Table 1
Different types of PCMs

Name	Types	Melting Temperature in °C
Lauric Acid	Organic	44.2
Paraffin carbons	Organic	5.5 to 75.9
Formic Acid	Organic	7.5
Caprilic acid	Organic	16.3
Glycerin	Organic	17.9
Paraffin 18 carbons	Organic	28
p-Lattic acid	Organic	26
Methyl palmitate	Organic	29
Paraffin 19 carbons	Organic	32
Methyl eicosanate	Organic	45
Methyl fumarate	Organic	59.5
Diphenyl amine	Organic	102
$NaNO_3$	Inorganic	310
$NaNO_2$	Inorganic	282
$Na_2SO_4{\cdot}10H_2O$	Inorganic	32.4
KOH	Inorganic	360
NaCl	Inorganic	284
Zinc	Inorganic	420
KNO_3	Inorganic	337

can be employed to equilibrium the energy demand between the day time, nighttime and the overcast period. Solar energy is a greater renewable energy resource, of a sporadic nature, and its effectual utilization is a part of expense and effectual storage system. No storage is utilize in solar energy system, the major part of the energy demand will be come across by the Sharmaet al (1999) handled experimental test on commercial grade of stearic acid, paraffin wax and acetamide. Throughout the investigation latent heat of fusion, melting temperature and specific heat of PCM have been addressed. He terminated that acetamide and paraffin wax were found to be more stable pcm than stearic acid and protracted his study with erythritol as PCM. He builds a prototype solar cooker based on an evacuated tube solar aggregator with PCM. Solar energy is stored in the PCM storage unit during daytime and is utilized for cooking in overcast period. Cooking experiments and PCM storage processes were carried out simultaneously. It was observed that noon cooking didn't affect the evening cooking, and evening cooking using PCM heat storage was found to be faster than noon cooking .Developed a framework of open-loop passive solar water-heating system joint with sodium thisulfate pentahydrate pcm. It was determined that the water temperature at the midpoint of the storage tank reduced regularly by day until the temperature of pcm. Heat storage action of the same solar water heating system joined with the other salt hydrate pcm's were checked theoretically by using meteorological data and thermo physical properties of PCM with some premise, finally he proved that the PCM solar water header had a higher thermal efficiency than conventional solar water-heating system concentrated Experimental Study of Heat Transfer improvement in Latent Heat Thermal Storage System during Charging and Discharging Processes. Hybrid thermal energy storage system used for PCM, for managing simultaneously the storage of heat from solar and electric energy. This is developed and declared with experimental data. Simulations carried out for a period of 4 continuous winter months point that, with such a system, the electricity consumed for space heating is reduced above 32% Also more than 90% of the electric energy is very intense during off-peak hours. For electricity fair where time of use schemes are in effect, the return on the finance in such a thermal storage system is very desirable.

9. Various PCM materials with their applications

- Paraffin and stearic acid

While charging and discharging the solar is maintained at constant temperature and pressure

- Paraffin(Aluminium filled with paraffin)

Maintain the hot water which is accessible throughout the day the storage unit stores the heat

- PCM (Wax based storage system is improved by cu, al, fe springs)

We can store loss of energy charging and discharging of solar energy

- PCM as salt instead of paraffin wax

Increase the solidification of storage system and has high thermal conductivity and low cost compared to paraffin wax

- PCM as sodium thiosulphate , pentahydrate in stainless steel

Large amount of thermal energy stored in smaller volume.

10. Conclusion

The review of this paper carried out various methods of heat transfers techniques to improve the thermal energy storage system. The paper mainly focus on PCM based thermal energy storage system, which is more adaptability and useful to the energy conservative system and wrapped current research papers in particular field.

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