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AN OVERVIEW ON THERMAL ENERGY STORAGE FOR SOLAR THERMAL POWER PLANT

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ABSTRACT

In the current situation of high energy consumption, exclusive reliance on fossil fuels would almost definitely result in a future catastrophe, particularly for emerging countries. Although renewable energy sources such as solar energy are now widely used, the issue lies in the law and economics, namely social and acceptable. The main causes of these problems are the low density of solar radiation on the earth's surface, and if it is accessible, its fluctuation in nature with time of day and year. Solar energy storage units must be used in solar thermal power applications to overcome these challenges. The literature on thermal energy storage units using phase change materials has been thoroughly examined in this article in order to choose the appropriate PCMs and materials for the construction of a thermal energy storage unit test bench.

KEYWORDS: *Helical Coil, Pcms, Solar Cavity Receiver, Storage Unit.*

1. INTRODUCTION

In the current situation, when demand exceeds available resources, we must design an energy storage device that can store energy while it is available and provide it when demand exceeds supply. Although sensible heat storage is the most prevalent form of thermal energy storage, current research on advanced materials and systems has shown that latent heat storage has a higher density of stored energy than sensible heat storage. In a latent heat storage system, phase change material is often utilized, and this kind of technology has been extensively used in heat pumps, solar engineering, and spacecraft thermal control applications[1]–[4]. The storage of thermal energy is shown in Figure 1.

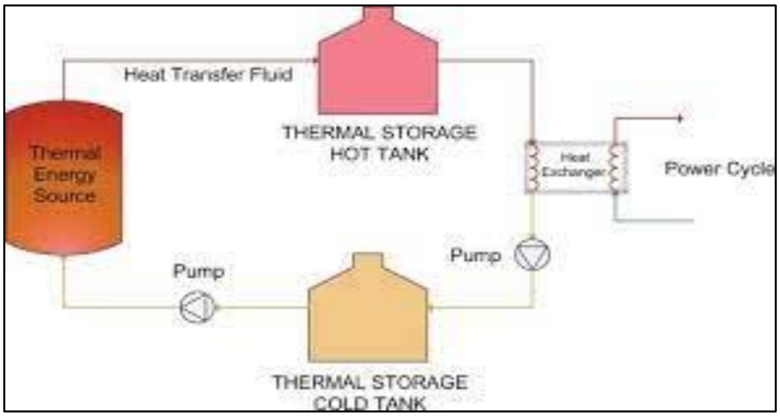

Figure 1: Illustrates the storage of thermal energy[5].

The major driving factors behind the efficient use of non-conventional energy resources are a massive rise in the price of fossil fuels and a continual upgrade in the amount of greenhouse gas emissions. The storage of energy in appropriate forms that can be easily transformed into the necessary form is a current technological problem. The following are the features of a solar energy storage unit: a) To save energy; b) to enhance the performance and reliability of energy systems; and c) to decrease the supply-demand mismatch. Scientists from all around the globe are looking for new and renewable energy sources, and they have identified direct solar radiation as a potential renewable energy source, as well as the solar energy storage unit as a new energy source. In other words, solar energy storage units are considered nonrenewable energy sources. Because of its high latent heat and appropriate thermal properties such as no super cooling, low vapour pressure, excellent thermal and chemical stability, and self nucleating tendency, paraffin has become a popular choice for latent heat thermal energy storage systems[6]–[10].

1.1 Energy Storage Methods:

There are many types of energy, and the techniques or processes for storing them are explained here. In their review article on thermal energy storage using phase change materials and applications, Atul Sharma et al. discuss several types of energy storage techniques and their processes. The latent heat storage technique for storing solar thermal energy is the focus of this article.

i. Mechanical Energy Storage:

Storage owing to gravity, such as hydropower storage, storage due to pressure difference, compressed air energy storage, and storage due to inertia, such as flywheels, are all examples of mechanical energy storage devices. For large-scale energy storage, hydropower storage and compressed air energy storage may be utilized, whereas flywheels are better suited for intermediate storage. When off-peak electricity is available, storage is performed, and the storage is discharged when power is required due to inadequate supply from the base-load plant.

ii. Electrical Energy Storage:

Batteries are used to store electrical energy. When the battery is linked to a direct electric current, ionic reactions occur, resulting in the separation of positive and negative ions and the formation of chemical potentials. This chemical energy is transformed into electrical energy when the main source goes out. Lead acid and Ni–Cd batteries are the most popular types of storage batteries. Off-peak power, load balancing, and storage of electrical energy produced by wind turbines or solar plants are all possible uses for batteries.

iii. Thermal Energy Storage:

Thermal energy may be stored as a change in a material's internal energy in the form of perceptible heat, latent heat, thermo chemical energy, or a combination of these. Sensible heat storage is caused by a change in material temperature, while latent heat storage is caused by a phase transition, such as solid-liquid, liquid-gas, or solid-solid.

1. Sensible Heat Storage:

Thermal energy is stored in sensible heat storage (SHS) by increasing the temperature of a solid or liquid. During the charging and discharging processes, the SHS system makes use of the heat capacity and temperature change of the material. The quantity of heat stored is determined by the medium's specific heat, temperature changes, and the amount of storage materials. Because it is cheap and has a high specific heat, water seems to be the best SHS liquid accessible. Oils, molten salts, and liquid metals, among other things, are utilized over 100°C. Rock bed storage materials are utilized for air heating applications.

2. Latent Heat Storage:

Charging and discharging phenomena occur in latent heat storage systems when the storage medium changes phase from solid to liquid, liquid to gaseous, or solid to solid. The storage capacity of a PCM media in a latent heat storage system.

1.2 Transition From Solid To Solid:

- Modification of the crystalline structure.
- Small volume change.
- Solid liquid transition has a smaller storage capacity than solid liquid transition.
- Less containment is needed, which allows for more design freedom.

Organic solid solutions of the followings, whose properties, melting temperatures, and latent heats of fusion are listed below, are the most preferred materials for solid-solid phase transition.

1.3 Transition from Solid to Gas or Liquid to Gas:

- Higher phase transition latent heat.
- During phase transitions, larger volume changes occur.
- Larger containment required.
- A system that is both impractical and complicated.

1.4 Transition from Solid to Liquid

- Volume change, intermediate latent heat of phase transition.
- The most practical and cost-effective method Classification of phase change materials (PCMs):

The materials used in thermal energy storage units must have a high latent heat and thermal conductivity value. They should have a melting temperature that is within the realistic operating range, melt uniformly with little sub cooling, and be chemically stable. It must be inexpensive, nontoxic, and noncorrosive. Hydrated salts, paraffin waxes, fatty acids, and eutectics of organic and non-organic substances have all been investigated in the past 40 years. The melting temperature of phase transition materials, as well as their applications, should be considered first. Materials with a melting temperature of less than 15°C should be used for air conditioning, whereas materials with a melting temperature of more than 90° C should be utilized for absorption refrigeration systems. All other materials that melt between these two temperatures may be used for solar heating and heat load balancing. These materials constitute the most researched class of materials.

- **Organic Phase Change Materials:**

Paraffin's and nonparaffins are two types of organic PCMs. Organic materials are of particular importance because they have long-term cyclic chemical and thermal stability without phase segregation and, as a result, crystallize with little or no super cooling. Finally, they are non-corrosive, which is a key characteristic as previously said. Organic materials are divided into two categories: paraffin and non-paraffin organics. The crystallization of the (CH_3) - chain is responsible for a significant proportion of energy absorption in paraffin, which is made up of a combination of alkenes CH_3-(CH_2)-CH_3. Between 5°C and 80°C, the latent heat of fusion of paraffin ranges from approximately 170 kJ/kg to 270 kJ/kg, making it ideal for construction and solar applications. The most prevalent PCMs are non-paraffin organic compounds, which have a wide range of characteristics. Buddhi and Swaney performed a comprehensive study of energy-storing esters, fatty acids, alcohols, and glycols. These materials have a high heat of fusion but poor thermal conductivity, inflammability, toxicity, and high-temperature instability. Fatty acids are more costly than paraffin, while being somewhat better than other non-paraffin organics. The knowledge of three key topics is required for the construction of a latent heat thermal energy storage system: phase change materials, container materials, and heat exchangers.

- **Inorganic Phase Change Materials:**

Salts hydrate, salts, metals, and alloys are examples of inorganic substances. The first was looked at due of its cheap cost, which is a major consideration in most projects. Inorganic PCMs also allow for high density storage because to their high volumetric latent heat storage capacity and conductivity, which may be double that of organic materials. The authors utilized salt hydrates, however they had problems with super cooling, phase segregation, and thermal stability. Furthermore, some are said to be caustic. In certain instances, super cooling and phase separation might be avoided, but the economics would suffer. Metal eutectics and low melting point metals such as Gallium are examples of metallic PCMs. Because of their size, they have not yet been fully studied. When space is limited, they may be considered because they have a high latent heat of fusion and high conductivities when compared to other PCMs.

- **Eutectics:**

A eutectic is a minimum-melting combination of two or more components, each of which melts and freezes congruently during solidification, resulting in a mixture of the component crystals. A vast variety of inorganic and organic eutectics have been discovered. In terms of segregation, Eutectics are usually superior than pure inorganic PCMs.

2. DISCUSSION

Energy storage has become a critical component of renewable energy systems. Thermal energy storage (TES) is a technique for storing thermal energy by heating or cooling a storage medium, which may then be utilized for heating, cooling, or power production at a later time. TES systems are utilized in a variety of applications, including buildings and industrial operations. The use of TES in an energy system has many advantages, including increased overall efficiency and dependability, as well as improved economics, lower investment and operating expenses, and less pollution of the environment, such as less carbon dioxide (CO2) emissions. Solar thermal systems, unlike photovoltaic systems, are industrially developed and use a significant portion of the Sun's heat energy throughout the day. However, it lacks sufficient (thermal) backup to continue functioning during periods of little or no solar energy. TES is becoming more essential for energy storage in conjunction with concentrating solar power (CSP) facilities, where solar heat may be stored and used to generate electricity when the sun isn't shining.

3. CONCLUSION

A thermal energy storage unit is connected with a solar thermal power plant to provide continuous electricity even at night or when there is cloud cover in the sky. Various kinds of storage units are discussed in this article, but the focus is on thermal energy storage units using phase change materials. This article not only describes several types of PCMs and their characteristics, but it also describes a unique and relatively new kind of PCM termed composite PCMs. In compared to single PCMs such as paraffin wax, composite PCMs have improved characteristics such as thermal conductivity, heat of fusion, density, and melting point. So, if composite phase change materials are given significant consideration, a better and more efficient thermal energy storage unit may be developed. Thermal energy storage systems that store latent heat store 5- 14 times more heat than thermal energy storage materials that store sensible heat. When taken as a whole, we can conclude that latent heat thermal energy storage is more cost-effective, and their strong design may allow them to store enough energy to feed the helical coil solar cavity reception system of the parabolic trough concentrator on a continuous basis. There are a lot of phase materials, but only a handful of them are used for the right purposes. Materials with a melting temperature below 15°C should be utilized for air conditioning, whereas materials with a melting temperature over 90°C should be used for absorption refrigeration systems. All other materials that melt between these two temperatures may be used for solar heating and heat load balancing. The major problem in designing the most efficient thermal energy storage unit is the selection of phase change material and its compatibility with the confinement where PCM is encapsulated.

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