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HEAT STORAGE BY USING PARAFFIN WAX AS A PHASE CHANGE MATERIAL

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Abstract

Storing extreme amount of latent heat during its phase change is a thermodynamic property of phase change materials. Phase change material converts its state to solid on drop of ambient temperature giving off its latent heat. By comparing conventional materials Phase change materials have the property of storing extreme amount of latent heat giving more heat storage capacity. The storage of energy in the forms, which can be conventionally converted into the required form, is a present-day challenge to the technologists. Energy storage is reduces the mismatch between supply and demand and improves the efficiency and reliability of the systems and plays a major role in conserving the energy. Thermal energy can be stored as latent heat. This latent heat is changing during melting and freezing of PCM. In latent heat storage the principle is that when heat is applied to the material it changes its phase from solid to liquid by storing the heat as latent heat of fusion or from liquid to vapor as latent heat of vaporization. Stored heat is extracted by the load, the material will again change its phase from liquid to solid or succeeding states. The latent heat of transformation from one solid phase into another is small. The state transformations consists relatively small changes in volume. That materials are available in a span of transition temperatures.

Index Terms: *Phase Change Material, Paraffin Wax, Latent Heat.*

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1. INTRODUCTION

Storing extreme amount of latent heat during its phase change is a thermodynamic property of phase change materials. Phase change material converts its state to solid on drop of ambient temperature giving off its latent heat. PCM gets solidify on drop of ambient temperature release its latent heat of fusion. As compared to conventional materials PCMs exhibits the property of storing large amount of latent heat giving more heat storage capacity. The storage of energy in suitable kind, which can conventionally be converted into the required kind, is a present-day challenge to the technologists. Energy storage not only reduces the mismatch between supply and demand but also rises the efficiency and reliability of energy systems and plays a major role in conserving the energy. Thermal energy can be stored as latent heat. This latent heat is changing during melting and freezing of PCM. In latent heat storage the concept is that when heat is supplied to the material it changes its phase from solid to liquid by storing the heat as latent heat of fusion or succeeding states as latent heat of vaporization. When the stored heat is extracted by the load then material will again change its phase from liquid to solid or succeeding states. The latent heat of transformation from one solid phase into other is small. The solid to liquid transformations involve relatively negligible changes in volume. That materials are available in a range of transition temperatures.

Paraffin wax have been used in large scale for latent heat thermal energy storage system applications because of large latent heat and desirable thermal properties such as no super cooling, various phase change temperature, low vapor pressure in the melt, good thermal and chemical stability. Paraffin wax exhibits lesser heat transfer rates during melting or freezing processes because of inherent low thermal conductivity. To improve the effective thermal conductivity usually highly conducting materials are inserted into paraffin wax.

The analysis of heat transfer in melting and solidification processes, called moving boundary problems in engineering literature, is especially complicated due to the fact that the solid to liquid boundary moves regards with the speed at which the latent heat is absorbed or lost. The review on experimental work in the area of phase change, specifically freezing and melting processes was carried out.

The main Merits of this Process are:

• The equation is directly applicable to the three phases such as solid, liquid and vapor.

• The temperature is determined at each point and corresponding value of the thermo physical properties can be determined.

• It is possible to ascertain the position of the two boundaries if so desired, although as indicated above this is not necessary, according to field of temperature.

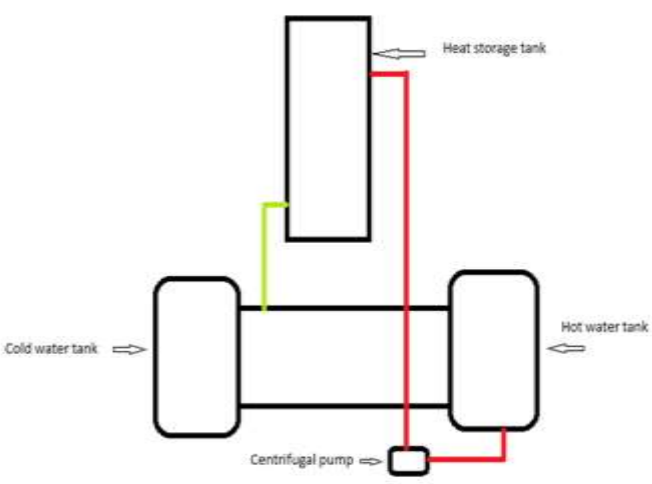

Figure 1. Experimental Setup.

2. LITERATURE REVIEW

In this chapter, a comprehensive review of previous work done in the field of thermal energy storage using phase change materials is presented. Thermal energy storage techniques are known from long time ago, but in latest years, more concern has been paid for the development of thermal energy storage because many countries are trying to promote Renewable Energies with special concern on solar energy. Due to intermittent nature of solar energy, thermal energy storage is an essential need for more efficient and economic use for solar energy. [1]

Latent Heat Thermal Storage units employ phase change materials (PCMs) which undergo change of phase (solid-to-liquid and vice versa) during the energy transfer process. During the last four decades many such materials, with wide range of melting/freezing point, have been identified and studied extensively. [2]

Though LHTS units serve as a better energy storage device as they have a high thermal energy density and possess a nearly isothermal operation, the phase change material loaded in the unit possesses a very low thermal conductivity, which drastically affects the performance of the unit. The effect of the lower value of conductivity is reflected during energy retrieval or withdrawal with an appreciable temperature drop during the process. As a result, the rate of phase change process (melting/solidification of PCM) has not been up to the expected level and the large-scale utilization of LHTS units, remains unsuccessful. Therefore, to tackle the above-mentioned drawbacks, it becomes necessary to improve the thermal performance of the LHTS units employing PCMs. [3]

2.1 Heat Transfer - About the thermal gradient, information about the analysis of irreversibility and the application of the second principle of thermodynamics can be found in studies of latter authors show that the use of energy is very important in developing a good understanding of the thermodynamic behavior of TES systems, and for rationally assessing, comparing and improving their efficiencies. In particular, the use of energy analysis is important because it clearly takes into account the loss of availability and temperature of heat in storage operations, and hence it more correctly reflects the thermodynamic and economic value of the storage operation. [4]

2.2 Extended Surfaces - Different metal structures, internal fin or extended surfaces are used to provide additional heat transfer surface in thermal systems. In

LHTS, the role of different configurations of fins in enhancing the performance has been studied extensively by various researchers. During melting, heat is transferred to the PCM first by conduction and later by natural convection. This is because, the solid region moves away from the heat transfer surface and the thickness of the liquid region increases near the heat transfer surface. Since thermal conductivity of liquid PCM is less than that of solid PCM, the heat transfer by conduction almost becomes negligible as the melting process continues. *Belen Zalba* experimentally studied thermal energy storage with phase change materials, heat transfer analysis and applications, which was discretely heated at a constant rate from one side of an enclosure. Thermal energy storage in general, and phase change materials (PCMs) in particular, have been a main topic in research for the last 20 years, but although the information is quantitatively enormous, it is also spread widely in the literature, and difficult to find. In this work, a review has been carried out of the history of thermal energy storage with solid–liquid phase change. Three aspects have been the focus of this review: materials, heat transfer and applications. [5]

2.3 PCM Methods - Employing multiple families of PCMs in LHTS system has been reported as another attractive performance enhancement technique in the literature. Employing multiple PCMs means, the LHTS system is packed with more than one PCM of different melting temperatures. The heat transfer rate in LHTS unit and thus the performance of the system during charging (melting) and discharging (solidification) mainly depends on the difference between the HTF temperature and the melting point of PCM. [6]

A good amount of work has been devoted to investigating the performance enhancement by employing multiple PCMs indifferent configurations of LHTS units. Three PCMs of different melting points were employed and packed in cylindrical capsules. Air was used as HTF. During both charging and discharging about 10% increase in heat transfer rate was obtained with three PCMs as the melting/solidification started in all three PCMs simultaneously, where as in single PCM system the phase change process started at different times. Experimental study has revealed the benefit of using multiple PCMs also in shell and tube module. The shell side was loaded with three PCMs and synthetic oil was allowed to flow through the inner tube. This unit corresponds to the one used for solar power plant. It was observed that in case of three PCMs unit larger portion of PCM underwent phase change process during the cycle. Hence, over a period of time three PCMs unit possessed higher phase change fraction and storage/discharge capacity as compared to the unit with single PCM of higher melting point. [7]

It was reported that if single PCM is used in the system then the phase change temperature distribution would be constant. On the other hand, with multiple PCMs linear phase change temperature distributions are possible. In the systems with constant temperature boundary conditions, a proper arrangement of different PCMs could lead to an optimum linear phase change temperature distribution. This results in 25% reduction in phase change time as compared to that in case of single PCM unit. It was also found that enhancement due to multiple PCMs was dependent on number of PCMs. The authors have concluded that practical and economical number of PCMs may vary from 5 to 10. [8]

3. CONCLUSION

The performance parameter computed from experimental readings was compared with melting and solidification processes of pure paraffin wax and paraffin wax with metal structure by mass concentration. Following are the performance parameters were discussed.

The experimental results show the feasibility of using PCM as storage media in heat recovery systems. Latent heat storage (LHS) system with PCM is successfully used for recovery and reuse of waste heat.

To optimization of performance of the heat exchanger is achieved by,

a. Reducing cycle time for charging and discharging processes for pure paraffin wax with different inlet fluid temperature
b. Reducing cycle time for melting and solidification processes for pure paraffin wax with variable inlet fluid temperature (Stefan number)
c. Increasing enhancement effect with insertion of flat copper plates in phase change material.
d. Enhancement effect with insertion of flat aluminum plates in phase change material and at variable inlet fluid temperature.

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