



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 13, April 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com



Fabrication of Thermal Energy Storage Using PCM Material with Integrated Solar Water Heater

Mohamed Sajil.V², Mohammed Safuwan.Cv², Naseeb.M³, Mr. P. Raj Kumar¹, Dr.S.Seenivasan¹

U.G. Student, Department of Mechanical Engineering, Dhaanish Ahmed Institute of Technology, Dhaanish Avenue, Coimbatore, Tamilnadu, India

Assistant Professor, Department of Mechanical Engineering, Dhaanish Ahmed Institute of Technology, Dhaanish Avenue, Coimbatore, Tamilnadu, India

ABSTRACT: The main aim of our project is to design and fabricate a solar water heater using the concepts of heat exchangers and phase change materials(PCM).Thermal energy storage has always been one of the most critical components in residential solar water heating applications. Solar radiation is a time-dependent energy source with an intermittent character. The heating demands of a residential house are also time dependent. However, the energy source and the demands of a house (or building), in general, do not match each other, especially in solar waterheating applications.

The peak solar radiation occurs near noon, but the peak heating demand is in the late evening or early morning when solar radiation is not available. Thermal energy storage provides a reservoir of energy to adjust this mismatch and to meet the energy needs at all times. It is used as a bridge to cross the gap between the energy source, the sun, the application and the building. So, thermal energy storage is essential in the solar heating system. Therefore, in this paper, an attempt has been taken to bridge the gap of the solar water heating system incorporating with PhaseChange Materials (PCMs)..

KEYWORDS: Phase Change Material; Paraffin Wax; Charging; Discharging.

I. INTRODUCTION

The increasing gap between the global demand and supply of energy is becoming a major threat as well as a challenge for the engineering community to fulfill the needs of the energy hungry society. Many forums and energy management groups have been formed to emphasize the storage of energy in both industrial and domestic sectors, in any possible form. The utilization of the abundant source solar, thermal energy and hot waste streams available in industries has attracted the scientific community to provide attractive solutions for the problems on energy conservation and storage/retrieval. Different configurations of latent heat thermal storage (LHTS) units find their wide applications. LHTS 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.

Thermal energy can be stored as a change in internal energy of a material as sensible heat, latent heat and thermo - chemical or combination of these. In Sensible Heat Storage (SHS), thermal energy is stored by raising the temperature of a solid or liquid. The extractable energy from the LHS during the discharge period can be calculated by the following equation under the assumption that there was no heat loss from the system. $Q = mC_p\Delta T$ Where Q is the rate of extractable energy from the LHS (KJ/min), m is the inlet liquid flow rate (kg/ min), Cp is the specific heat (kJ / kg K) and ΔT is the temperature difference between inlet and outlet fluid (K) A suitable PCM with its melting point in the desired temperature range. – A suitable heat exchange surface and a suitable container compatible with the PCM. Any latent heat energy storage system must therefore, possess at least following three properties.

II. RELATED WORK

A phase change material (PCM) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature, is capable of storing and releasing large amounts of energy. Materials that melt below 150°C are used for storing coolness in air conditioning applications, while materials that melt above 90°C are used for absorption refrigeration. High Conductivity and Low Density Materials Due to relatively high density, the metal particles/metal structures may settle on the bottom surface of the container and add considerable weight to the system. All metal particles are not compatible with all PCMs. For example, with paraffin, aluminium is compatible, whereas copper and nickel are not compatible. Similarly, aluminium and copper are not compatible with some salt hydrates. Hence, there has been a search for low density high conductivity additives, which should be compatible with all PCMs. Since the densities of carbon fibers are relatively lower than those of metals and the thermal conductivities are almost equal to that of aluminium and copper, these can be better alternatives to enhance the thermal performance of LHTS systems.

The study was extended to investigate the effect of surface characteristics of fibers on solidification rate and found higher transfer rate with surface treated fibers than that with fibers of untreated surface. The study has also revealed the importance of uniform distribution of fibers in the PCM to obtain further enhancement in the performance. In a cylindrical capsule, carbon fibers were added in the PCM in two ways. In the first case fibers were randomly distributed, whereas in the second case brush type fibers were used. The effective thermal conductivity with brush type was found to be three times higher than that with random type. This is because in brush type the fibers were distributed uniformly in such a way all the fibers were arranged in radial direction, which was the heat flow direction.

The normal paraffin's of type C_nH_{2n+2} are a family of saturated hydrocarbons with very similar properties. Paraffins between C5 and C15 are liquids, and the rest are waxy solids. Paraffin wax is the mainly used commercial organic heat storage PCM. It consists of mainly straight chain hydrocarbons that have melting temperature from 23 to 67°C.

III. METHODOLOGY

The following methodology was adopted to carry out the project: Demand of hot water during non-sunshine period is estimated. Amount of heat needs to be stored is calculated. A suitable type of heat exchanger is selected. Dimensional parameters of heat exchanger are calculated. A suitable testing rig is constructed, to measure the performance of the heat exchanger. Inlet and outlet temperatures, and temperature distribution of PCM in the heat exchanger, during charging and discharging is recorded. The melting and solidification pattern of the PCM is studied during charging and discharging.

IV. EXPERIMENTAL RESULTS

The temperature distribution of the phase change material, during charging and discharging was taken at three different mass flow rates at 15, 11 and 7 kg/min. For each mass flow rate, curve was plotted for variation of temperature at each point in the wax against time elapsed, to get melting curve in case of charging and solidification curve in case of discharging. 4.1

CASE : At mass flow rate of 15 kg/min

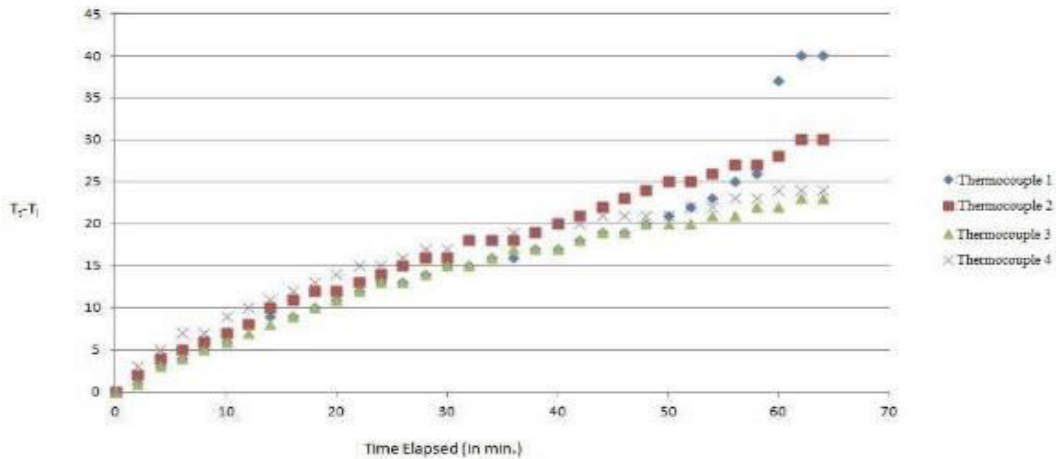
In this case, the mass flow rate of the heat transfer fluid was taken as 15 kg/min. The melting and solidification curve for the phase change material was obtained and are shown in Figure 4.1 and 4.1 respectively. The variation of temperature in the wax during charging and discharging is shown in Table 4.1 and 4.2 respectively.



Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, India

4.1.1. Melting curve



Thermocouple 1 represents curve of temperature variation at point 2, Thermocouple 2 represents curve of temperature variation at point 3, Thermocouple 3 represents curve of temperature variation at point 4 and Thermocouple 4 represents curve of temperature variation at point 5, where points 2 to 5 are according to Figure 3.4.

4.1.2. Solidification curve

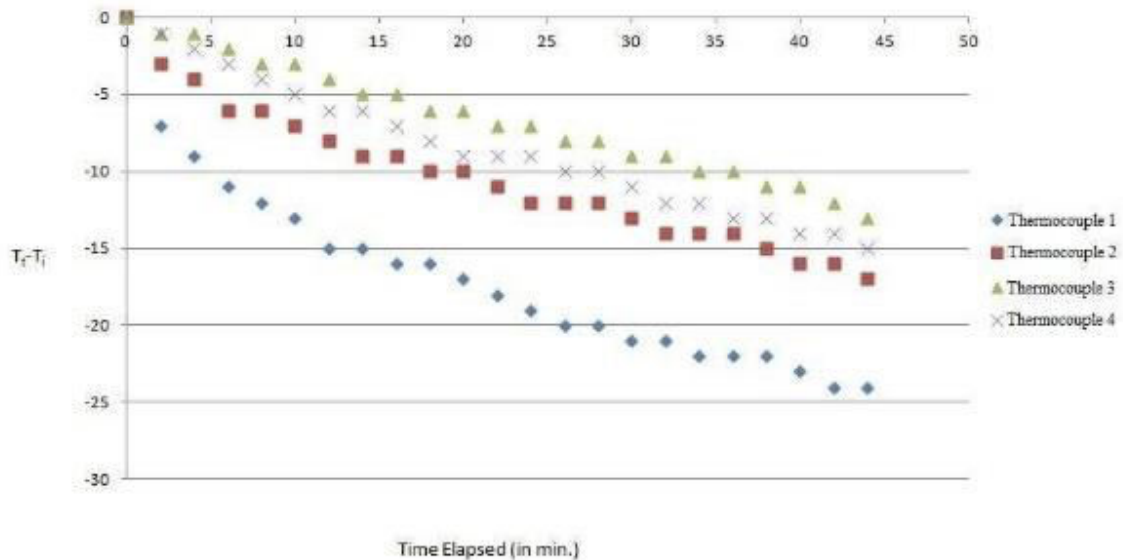


Figure 4.2 Solidification curve

Thermocouple 1 represents curve of temperature variation at point 2, Thermocouple 2 represents curve of temperature variation at point 3, Thermocouple 3 represents curve of temperature variation at point 4 and Thermocouple 4 represents curve of temperature variation at point 5, where points 2 to 5.

V. CONCLUSION

The experimental results show the feasibility of using phase change material as storage media in heat recovery systems. Latent heat system with phase change material can be successfully used for recovery and reuse of water heat. The thermal behavior of the latent heat thermal energy system is investigated experimentally for different operating

Organized by

Dhaanish Ahmed Institute of Technology, KG Chavadi, Coimbatore, India

conditions. The system's charge and discharge characteristics with respect to the heat transfer fluid are analyzed. So by increasing the heat transfer area or the surface area of the copper pipe with phase change material and increase the heat transfer fluid flow rate the efficiency of the system can be increased.

REFERENCES

- [1] Telkes M. Nucleation of super saturated inorganic salt solution. *Indust EngChem* 1952; 44:1308.
- [2] Beasley D.E, & Clark, J.A.(1984). Transient response of a packed bed for thermal energy storage. *Int. J.Heat \ Mass Tranfer*, 27(9), 1659-1669.
- [3] Dincer, I., Dost, S & Xianguo Li. (1997), Performance analysis of sensible heat storage systems for thermal applications. *Int. J. Energy Research*.
- [4] Reddy, K.S., Avanti, P. & Kaushika, N.D. (1999). Finite time thermalanalysis of ground integrated collector-storage solar water heater with transparent insulation cover. *Int. J.Energy Research*, 23, 925-940.
- [5] Fouda, A.E., Despault, G.J.G., Taylor, J.B. & Capes, C.E. (1984). Solar storage systems using salt hydrate latent heat and direct contact heat exchange-II Characteristics of pilot system operating with sodium sulphate solution.*Solar Energy*, 32(1), 57-65.
- [6] Saitoh, T. & Hirose, K. (1986), High performance phase-change thermal energy storage using spherical capsules. *Chemical Engg. Commun.*, 41, 39-58.
- [7] Ananthanarayanan, V., Sahai, Y., Mobley, C.E. & Rapp, R.A. (1987). Modeling of fixed bed heat storage units utilizing phase-change materials. *Metallurgical Transactions B*, 18B, 339-346.
- [8] Beasley, D.E. & Ramanarayanan, C. (1989). Thermal response of a packed bed of spheres containing a phase change material. *Int. J. Energy Research*, 13, 253-265.
- [9] Esen, M., Durmu, A. & Durmu, A. (1998). Geometric design of solar-aided latent heat store depending on various parameters and phase change materials. *Solar Energy*, 62(1), 19-28.
- [10]Ismail, K.A.R. and Henriquez, J.R. (2002). Numerical and experimental study of spherical capsules packed bed latent heat storage system. *Appl. Thermal Eng.*, 22, 1705-1716.
- [11]Mehling, H., Cabeza, L.F., Hippeli, S. & Hiebler, S. (2003). PCM – module to improve hot water heat stores with stratification. *Renewable Energy*, 28(5), 699-711.
- [12] Nallusamy, N., Lakshmi Narayana Rao, G., sampath, S. & Velraj, R. (2003). Effective utilization of solar energy for water heating applications using combined storage system. In *Proc. of The International Conference on New Millennium Alternative Energy Solution For Sustainable Development, Coimbatore, India*, pp.103-108.



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details