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# EXPERIMENTAL STUDIES ON PERFORMANCE OF LATENT HEAT THERMAL ENERGY STORAGE UNIT INTEGRATED WITH SOLAR WATER HEATER

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## ABSTRACT

The energy storage leads to saving premium fuels and makes the system more cost effective by reducing the wastage of energy. Solar is being a renewable energy, which is used to store heat in the storage tank and PCM encapsulated copper tubes are kept inside the storage tank called PCM storage tank. Thealmost 90 copper tubes is used and phase change materials are filled in each tube. The varieties of PCM materials are analyzed, and suitable material is to be selected for thermal storage system. Copper tube encapsulated with paraffin wax (PCM) is going to be designed and fabricated to store the heat energy in PCM storage tank. Large quantity of solar thermal energy is absorbed in the day time.

During charging process heat can be stored in copper tube as latent heat, the same heat can be stored during discharging process by applying cold water. The PCM used is intended to enhance the heat storage capacity of the conventional solar tanks used in domestic solar heaters and to measure inlet and outlet water temperature. The tank is continuously monitored and various sets of readings are recorded at regular time intervals and graphs are to be plotted. The temperature distribution in HTF and PCM's are going to be analysed by using computational fluid dynamics at steady state and transient conditions.

**Key words**: PCM, Glass wool and PCM insulation, Solar collector, Thermal storage system, Copper tube.

## INTRODUCTION

The unremitting raises in the level of greenhouse gas emissions and limited resources of fossil fuels related to the climb in fuel charges are the main driving forces behind efforts to more effectively utilize various sources of renewal energy. PCMs are classified as latent heat storage (LHS) units. Solar thermal water heating for industrial and household applications is among the leading different solution attempting to face the uncontrollable fossil fuel cost variations, the gradual depletion of fossil fuel raw materials

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and the chain environmental consequences caused by its excessive usage. While the solar thermal heating system integrated with PCM encapsulated thermal storage tank is used, it is possible to store huge quantity of heat in a compact container. In the present work, the PCM is filled in thin copper tubes which will permit heat to be readily transferred between PCM and water, which is used as heat transfer fluid (HTF)[1]. The requirement of hot water in various process industries, treatment plants and domestic needs are increasing, which is partly met by Solar Water Heaters. Solar, being a renewable energy is very clean, efficient and cost effective. Hence, the improvement of heat storage in conventional solar tanks and its yield is very necessary to face demands of water supply Thermal storage takes place in building energy conservation due to the inclusion of latent heat storage in building products. Devices which store heat during peak power operation and release the same during reduced power operation[2,3].

The considerable properties necessary for PCM are maximum latent heat of fusion per unit mass, so that a minor amount of material stores a given amount of energy. Maximum thermal conductivity so that the temperature gradient essential for charging the storage material is undersized High density, so that a smaller container volume holds the material melting point in the preferred working temperature range. The phase change material should not have the properties of poisonous, flammable and explosive.

## EXPERIMENTAL

### A. Phase change material (PCM)

A Phase change material (PCM) is a substance with a high combination of heat, which dissolves and hardens at a specific temperature, is fit for putting away and discharging a lot of energy. Heat is assimilated or discharged when the material changes from solid to fluid and the other way around; accordingly, PCMs are named Latent heat storage (LHS) units. PCMs storage of heat can be accomplished through liquid-solid, solid-liquid, solid-gas and liquid-gas stage change. Be that as it may, the main stage change utilized for PCMs is the solid-liquid change. Fluid gas stage changes are not applicable for storage of heat because of the substantial volumes or high weights are required to store the materials when in their gas stage. Liquid–gas moves do have a higher warmth of change than solid-liquid moves. Solid-solid stage changes are normally moderate and have fairly low warmth of change. At first, the solid-liquid PCMs carry on like sensible heat storage (SHS) materials; their temperature ascends as they retain heat. Not all like, in some case, when PCMs achieve the temperature at which they change stage (their liquefying temperature) have retained a lot of warmth at a practically consistent temperature. The PCM keeps on increasing heat without a huge ascent in temperature until all the material is changed to the fluid stage. At the point when the surrounding temperature around a fluid material falls, the PCM solidifies, discharging it puts away idle heat. An extensive number of PCMs are accessible in any required temperature range from −5 up to 190°C. Inside of the human comfort range between 20-30°C, some PCMs are exceptionally acceptable.

## B. Selection criteria for PCM

The different types of PCM’s are organic, inorganic and eutectic. The selections of organic PCM’s are based onthe thermodynamic, kinetic, chemical and economic properties.

- High latent fusion heat per unit volume
- High specific heat, high density and high thermal conductivity
- Small volume changes on phase transformation and small vapour pressure at operating temperatures to reduce the containment problem
- High nucleation rate to avoid supercooling of the liquid phase
- High rate of crystal growth, so that the system can meet requirements of heat recovery from the storage system
- Non-corrosiveness, non-toxic, non-flammable and non-explosive materials

The selection of organic PCM have different grade of paraffin wax. By conducting the experimental test suitable paraffin wax can be selected. The following are the testing procedures for selection of PCM’s [4]

- Find out the starting and final melting point range for different types of PCM.
- Find out the volume of phase change materials in molten stage.
- Find out the volume of phase change materials in solid stage.
- Find out the volume of difference between the molten and solid stage of PCM’s.

**Table 1: Melting point temperature range for different grade of paraffin wax**

| S. No. | Type of wax | Starting melting point temperature ($^o$C) | Final melting point temperature ($^o$C) |
|---|---|---|---|
| 1 | Micro wax | 62 to 64 | 81 to 83 |
| 2 | Blended wax | 54 to 56 | 75 to 77 |
| 3 | Honey wax | 45 to 47 | 56 to 58 |

## C. Specification of PCM storage tank and copper tube

The PCM collection tank contains PCM collection unit, the capacity unit having 90 quantities of copper tube, every tube conveys least of 100 g. PCM, absolutely 9 Kg of PCM were utilized, and the whole setup kept in much protected tank with 100 litres limit of water. The heat exchange liquid streams by convection through the copper tubes. The capacity tank precisely considered as adiabatic so no heat exchange[5-8]. The experimental test unit comprised of two concentric chamber with 79 cm lengths. Within barrel with inward distance across of 37 cm and external measurement of 40 cm is made of stainless steel (304L), inside the tank the quantity of copper tubes is kept with measurement of length 75 cm, 1.2 cm width and thickness of 0.8 mm. With a specific end goal to decrease the heat exchange to the environment the capacity tank was thermally protected as glass fleece. Water was utilized as the HTF and it flows all through the tank between the copper tubes (Fig. 1). The tube is loaded with the PCM. Copper has high heat conductivity and is likewise accessible effortlessly, so copper materials can be utilized adequately as a part of heat storage systems. Protection is an imperative component in warm stockpiling frameworks. Subsequently appropriate topping in each of the copper tube was done in the wake of introducing the PCM material, for viable protection work. Appropriate protection and high warm conductivity of these copper tubes give secure heat storage system, which holds heat for long time and decrease energy wastage Fig. 1.

**Fabrication process**

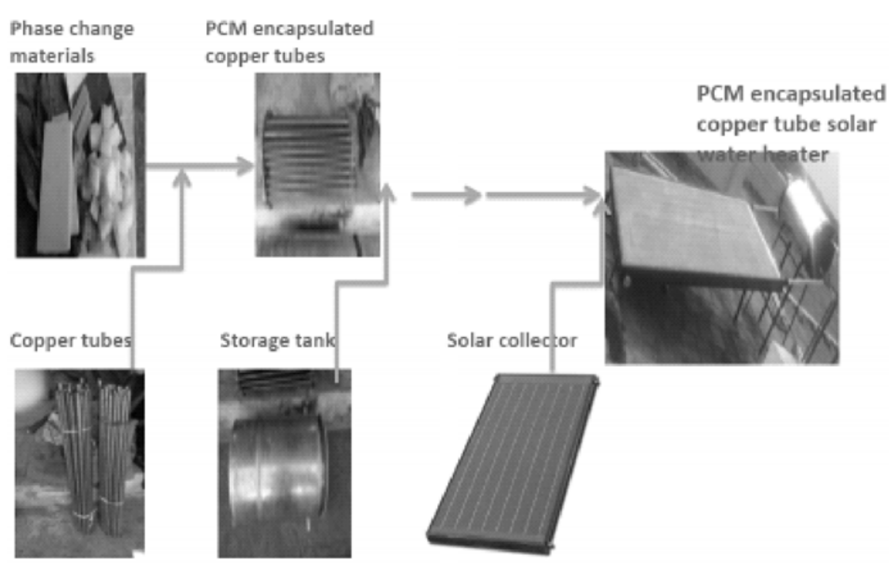


**Fig. 1**

## RESULTS AND DISCUSSION

The experimental results conducted in two different thermal storage tanks. The first tank is carrying only water (without PCM).The heat discharged per unit litre of water is steeply declining curve is indicated in Fig. 4. The average total heat discharge observed in a span of 3 days per is17973.55KJ.

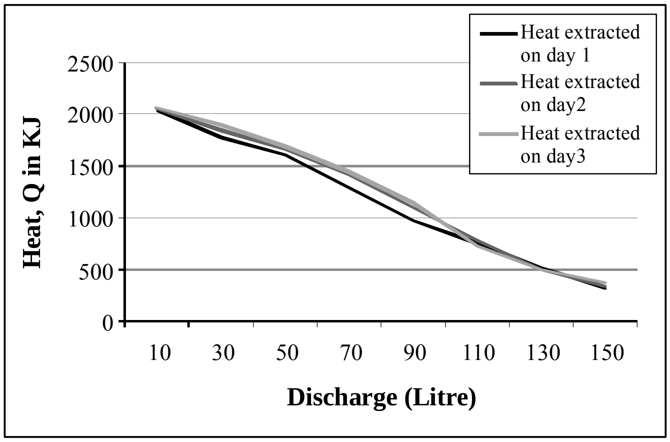


**Fig. 1: Heat discharge curve of thermal storage tank without PCM**

The second tank is carrying water with PCM encapsulated in thin copper tubes. The heat discharged per unit litre of water is stable when the water has reached a temperature close to the melting point temperature of the PCM is indicated in Fig. 5. The average total heat discharge observed in a span of 3 days per is 21485.441 KJ.

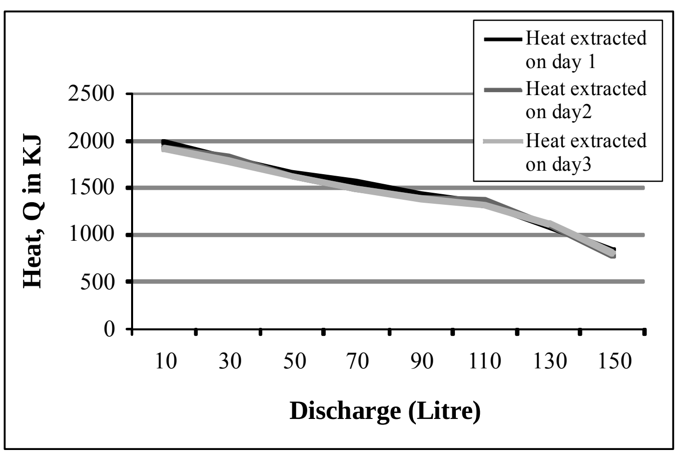


**Fig. 2: Heat discharge curve of thermal storage tank with PCM**

- The enhancement techniques were implemented through the number of thin copper tube incorporated in the fabricated thermal storage tank.
- During the discharging process heat from the PCM can be retrieved for later use, without any considerable loss.
- The selected paraffin wax in the copper tubes has good thermal energy storage performance and it is a suitable latent heat storage material for domestic solar hot water storage application.
- The comparison of two readings that the heat carrying capacity of the thermal storage tank has been improved by 20.83%.

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