IMPROVEMENT IN THERMEL STORAGE BY USING PCM AND NANO ADDICTIVE'S

R.Abishek

Student (M.E), Department of Mechanical Engineering,

Regional Centre of Anna University, Tirunelveli.

K.Karuppasamy

Asst. Professor, Department of Mechanical Engineering,

Regional Centre of Anna University, Tirunelveli

Abstract- The present paper investigate the conventional thermal storage device largely depends upon the varying local weather condition, the result is poor performance at low weather condition. To eliminate the fluctuation in this system. The increase in thermal storage is the main objective of this project. The effect of three different phase is handled out in this project. The solar collector is designed based on the requirement of area about $2.63m^2$. The radiation incident on the solar collector is calculated by using the ambient temperature. The experimental setup consists of the solar collector and a thermal storage unit. The temperature readings are noted down by the thermometer. Three sets of readings are taken corresponding to the time and the temperature difference (i) without PCM (ii) with PCM (iii) with PCM and Nano addictive's and the corresponding change in temperature is noted down with the time of a day. For each half an hour the readings are taken. It is found that thermal storage with PCM and Nano addictive's is more efficient and the temperature output is high compared to the other thermal storage systems. And the efficiency of the collector, latent heat and the total heat stored is calculated.

Keywords: *Solar collectors, Thermal storage tank, PCM, Paraffin wax, SWH*

1. INTRODUCTION

One of the devices which can be used to convert the solar energy in to thermal energy is solar water heater (SWH). A SWH application largely depends on efficient thermal energy storage (TES). Thermal storage works like to be battery where, energy can be stored in the form of latent heat, sensible heat, or both. The latent heat of energy stored in SWH, were large quantity of energy that needs to be absorbed or released, when a material changes phase from solid state to liquid state or viceversa In conventional solar water heater process largely depends upon the varying local weather condition, the result in poor performance at low weather condition. To eliminate the fluctuation in the temperature, flat plate collectors are integrated with thermal energy storage tank using phase change material. Thermal storage tank is filled with PCM and Nano addictive's, here PCM used as paraffin wax and copper as Nano addictive's, when the hot water flows out from the flat plate collectors passes to PCM filled with thermal storage tank with well insulated. During off sunshine hours, the hot water is withdrawn and is substituted by cold water. This gains energy from the PCM on changing its phase from liquid and solid. Here more amount of heat is stored by the Nano particles aslo.

An experimental and theoretical study were conducted by Peter Atkin and Mohammed M. Farid [1] to improve the efficiency of photo voltaic cells using PCM infused graphite and aluminium fins. They also compared the performances of PCM, in four cases A,B,C,D and the thermal performance.
Out of the four thermal regulation techniques, case D was the most effective at increasing overall efficiency of the PV panel, with the greatest overall efficiency increase of 12.97[4]. The thermal regulation effects of PCM and heat sinks are additive since the PCM creates a shift in temperature. The effect of four different thermal regulation techniques (Cases A, B, C and D) on the thermal performance, point-based efficiency and overall efficiency of a PV panel was studied. Out of the four thermal regulation techniques, case D (which combines graphite infused PCM and fins) is the most effective at increasing overall efficiency of the PV panel, with the greatest overall efficiency increase of 12.97%. Reyes [2] analysed the energy and energy of PCM storage for a flat plate solar collector. In sunny days, the wax melted completely in about 4 h. The accumulated energy in form of latent heat (about 13,000 kJ) allowed to increase the temperature of 0.040 kg/s of circulate air in at least 20 C during a period of 2.5 h The use of external aluminium stripes between the cans enhanced the heat transfer processes within the accumulator, shortening the energy transfer times and increasing the accumulator thermal efficiencies.

A phase-change material (PCM) is a substance with a high heat of fusion which, melting and solidifying at a certain temperature,[5] is capable of storing and releasing large amounts of energy. Heat is absorbed or released when the material changes from solid to liquid and vice versa; thus, PCMs are classified as latent heat storage (LHS) units. The use of a latent heat storage system using phase change materials (PCMs) is an effective way of storing thermal energy and has the advantages of high-energy storage density and the isothermal nature of the storage process. (PCM) storage. [7]Consequently, it is found that overall energy efficiency without PCM storage is about 30% while the energy efficiency is about 10%. However, about 30% overall energy efficiency can be achieved for the case of using PCM storage along with the solar collector. [9]Nano fluids can also be used with synthetic oil to enhance the thermal performance in the collector field. Cascaded PCM can also be implemented within the system

A Flat plate solar collector they consist of a dark flat-plate absorber, a transparent cover that reduces heat losses, a heat transport fluid (air, antifreeze or water) to remove heat from the absorber, and a heat insulating backing. The absorber consists of a thin absorber sheet (of thermally stable polymers, aluminium, steel or copper, to which a matte black or selective coating is applied) often backed by a grid or coil of fluid tubing placed in an insulated casing with a glass or polycarbonate cover.

Latent heat storage (LHS) is based on the heat absorption or release when a storage material undergoes a phase change from solid to liquid or liquid to gas or vice versa.[6] The PCM to be added to the system is selected as paraffin wax as per their properties and the Nano particle to be added to the system is selected as copper which has the required properties for the required process.

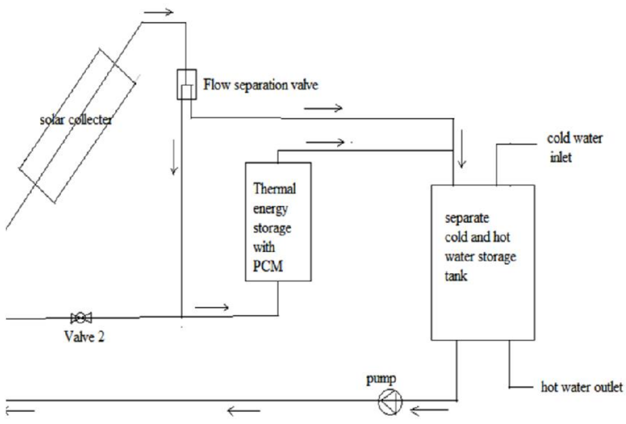


Figure.1. Proposed water heating system with the thermal storage arrangement

2. EXPERIMENTAL PROCEDURE

2.1. System description

The proposed solar water heating system has two main components: a) a solar collector unit, b) a well-insulated thermal storage tank. In this present study only the solar collector and the thermal energy storage unit was studied experimentally. When charging of the TES is done during the day time when the solar radiation is present. During charging period or day time, cold water passes through the solar collector. Water takes heat from the solar radiation and part of the hot water flows through the heat storage unit for charging the PCM tank. The rest of the water goes directly to the water storage tank. At the time of discharge during night time or in the absence of solar radiation, valve is needed to be closed as it is not necessary to circulate water directly through the TES unit for discharging heat to water. Simultaneously, the PCM starts to be solidified and being fully solidified, this PCM can be used thermal life cycle. In order to maintain constant output temperature, here phase change material is chosen as paraffin wax. The Nano addictive to be added to the system is selected as copper and added. Paraffin wax is filled the space between the copper tube and outer shell of the tank, this tank is well insulated. The input temperature of 55^0C was selected as the same output from solar collector system. This simulated the charging period of the thermal storage. Charging was continued to reach the PCM heat capacity so that the difference of input and output temperature become the same. After the charging period, the hot water was drained out and then the thermal path was filled with ambient water. The discharge cycle began with the flow of water at a temperature around 25^0C. The discharging cycle ended when the output temperature come to an environmental temperature. In this setup different sets of readings are taken with respective to the change in output temperature corresponding to the time of a day,(i)without PCM (ii)with PCM (iii)with PCM and Nano addictive's; and the corresponding graph is plotted and analysis is done.

2.2. Material selection

2.2.1 PCM selection

The PCMs having suitable melting temperature should be selected for appropriate application. PCMs with high latent heat, high thermal conductivity and specific heat are desirable for SWH application. Here the selected PCM as paraffin wax, this acid is the suitable for appropriate application for solar water heater and suitable option due to it availability, no corrosiveness, compatible melting temperature, and low cost. In this experimental study melting point was found to be 48 to 52^0C.

Table 1.Thermophysical properties of paraffin wax

Parameters	value
Melting point	50°C
Melting end point	52°C
Freezing starting point	46.93°C
Freezing end point	49.51°C
Melting peak temperature	49.53°C
Freezing peak temperature	50.70°C

Specific heat of solid (<30^{0}C)	2.565 J/g$^\circ$C
Specific heat of liquid (>65^{0}C)	2.439 J/g$^\circ$C

2.2.2 Nano particle selection

Copper is a material it consists of high thermal conductivity and can also large amount of heat. So copper is preferred in this heat storage process.

Table 2 Properties of copper

Thermal conductivity (hr-ft-F)	231
Density	0.322
Specific heat (Btu/Ib/F)	0.095

2.3. Design specification of fabricated flat plate collector and thermal storage tank

In this project work flat plate solar collector is selected for the SWH system upon that many type of collectors flat plate collector is used due to it simple in contraction and its higher efficiency in collection of solar radiation fig.2 shows the fabricated flat plat collector and also table.2 shows it size and material specification where selected.

Fig.2. Fabricated flat plate collector

Table 3 Material specifications

Material	**Specification**	**Collector**
Wooden casing	Dimension	1.5m x 0.9m x 0.12m
Aluminium	Length of the absorber Plate	1.4m
	Width of the absorber plate	0.80 m
	Plate thickness	0.002 m
Copper	Internal diameter of cupper tubes	Major = 0.28m Minor = 0.12m
	Number of flow path used	2
Thermo cool	Insulation thickness	Side = 0.15m

The above table.3 shows the properties of specifications of the wooden casing, aluminium, copper and thermo cool. These properties are plays a vital role to enhance the performance of thermal storage system.

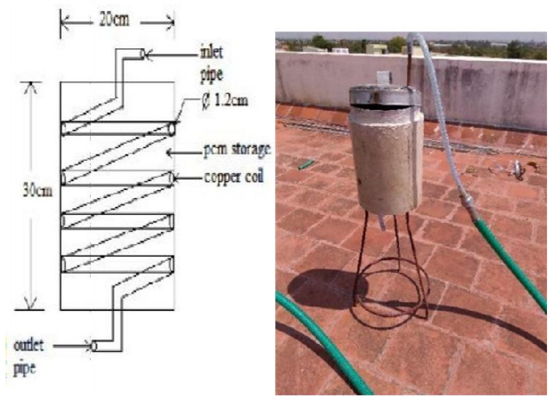


Fig.3 Fabricated thermal storage tank

Thermal storage tank is made of cylindrical aluminium casing inside there is spiral copper tube is passed its length is 2 m and diameter of the copper tube is1.2cm whereas fig.2 shows it fabricated tank. When the hot water flows from flat plate collector to copper tube inside the thermal storage tank and heat transfer is carried out between the PCM and copper tube, this tank is filled with phase change material between the outer shell and copper tube. PCM is time similarly ambient temperature also increase at the higher radiation and its gradually decrease.

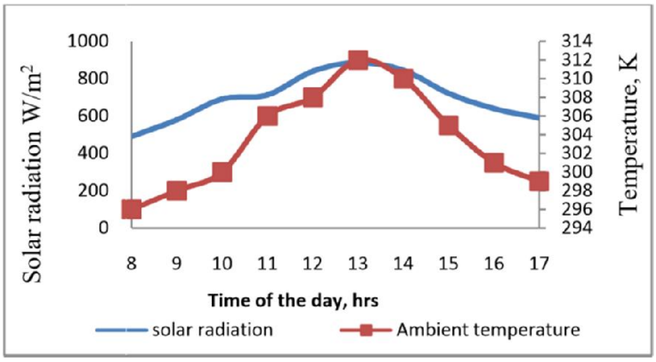


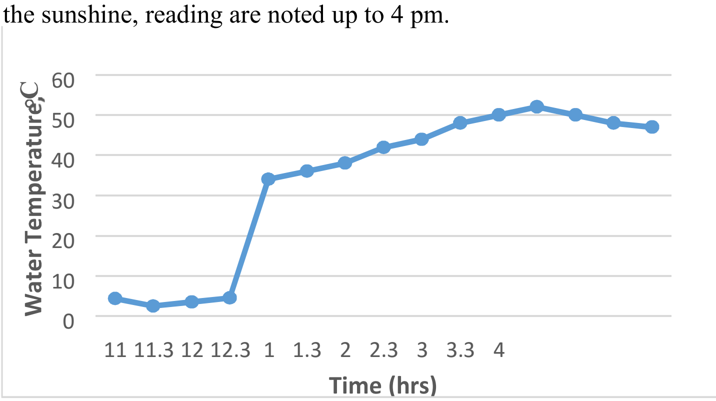
Fig.4. Solar radiation estimated by the fluent solar calculator

In the figure 5 drawn between the hot water temperature vs time of the day. Temperature of outlet water is measured at every half an hour from 11am to 4pm. according to the sunshine of temperature gradually increases. The maximum water temperature attends 52^{0}C at the time period of 1.30pm to 2.30pm and its gradually decreases according to

This tank is well insulated to avoid heat transfer losses, inner insulation is glass wool and outer insulation is polystyrene thermo cool sheets. Water inlet temperature to the collector is 28^{0}C and passes to copper

selected as paraffin wax were used in the tank.

the sunshine, reading are noted up to 4 pm.



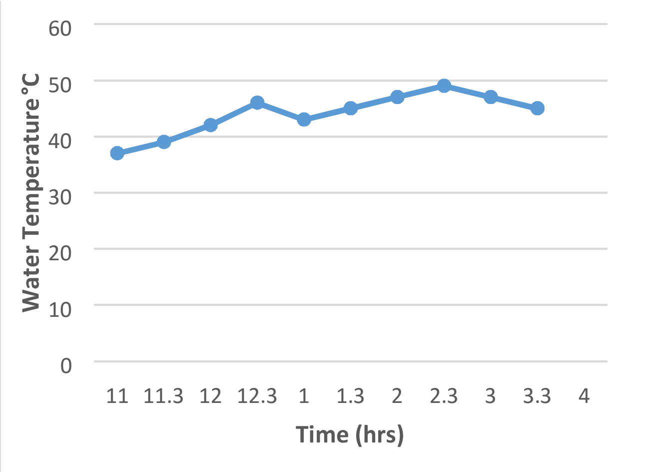
tube which is attached to the absorber plate, maximum hot water obtained by the collector is 55^{0}C. When the hot water at 55^{0}C flow outside of the flat plate collector and pass to PCM tank where its temperature is measured by the thermometer. Different sets of readings are taken with respective to the change in output temperature corresponding to the time of a day,(i)without PCM (ii)with PCM

(iii)with PCM and Nano addictive's. The corresponding graphs are drawn and the analysis is done.

3. RESULTS AND DISCUSSION

Solar radiation was calculated by theoretical using the formulation and ambient temperature is measured for the particular sunshine day at time of days in hour this graph explains according to the time of day solar irradiation gradually increase and obtained higher at particular period of Fig.5. Temporal evaluation of the water average temperature in SHW without PCM

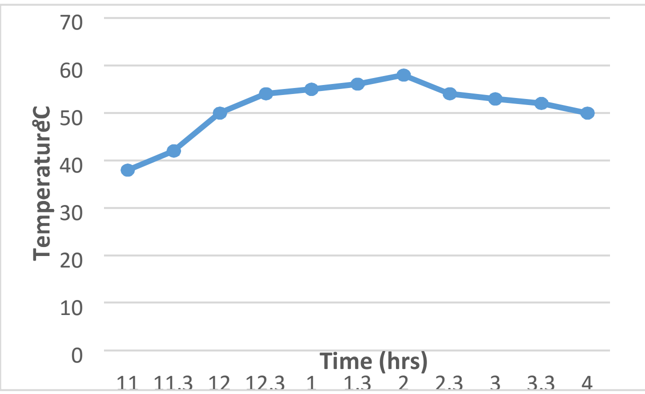
When the flat plate collector is integrated with PCM thermal storage tank then the temperature variation of water is shown in the figure 6. This describes the water temperature is maintained constant at certain period, the



heat from solar collector is absorbed by the PCM and it melts gradually; when the temperature range of about 50 55°C is obtained constantly. The variation is shown in the graphs.60^{0}C at the time period of 1pm to 2pm and the curve slightly decreases, and then the temperature is maintained constant at 56^{0}C due to thermal storage tank integrated with PCM material. Temperature in SHW with PCM.

Figure. 6. Temporal evaluation of the water average

In this the Nano particles copper is added to the thermal storage tank, the temperature range of about 50 -55°C is obtained constantly. The variation is shown in the graphs.60^{0}C at the time period of 1pm to 2pm and the curve



slightly decreases, and then the temperature is maintained constant at 56^0C due to thermal storage tank integrated with PCM material and Nano particle. It is found that the temperature range is increased in this process.

Fig.7. Temporal evaluation of the water average temperature in SHW with PCM and Nano additives.

4. CONCLUSION

The conclusion from the experimental study was to improve the thermal performance of the solar water heating system, and the analysis is done using the PCM with Nano addictive's Regarding the daily operation of the proposed systems presents positive thermal efficiency for longer period of time by using paraffin wax as PCM and copper as Nano addictive's . When compared with the conventional SWH this integrated PCM storage tank, the SWH integrated with PCM and Nano particle is more efficient. During discharging period, the heat transfer fluid gained heat from PCM and it withstands heat more than 3 hour. The output temperature is greater when the Nano particle sis used in the system. Paraffin wax with Nano addictive's allows achieving the maximum water temperature with the advantage of higher valves during this PCM melting process, so this PCM is most beneficial for this solar application.

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