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Phase Change Material Based Solar Water Heater

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Abstract: *The sun is the source of solar energy and the solar energy is pollution free and available in ample amount which can be used for heating, electricity generation and coking purpose.The position of sun constantly varies so its intensity also varies which affect the heat quantity incident upon the system. The aim of present work is overcome this difficultly using wax type phase change material which behaves like heat storage medium as position of sun changes. This phase change material based solar water heater is fabricated and thermal performance evaluation can be carried out using K type thermocouple.*

I. Introduction

Solar radiation is an alternative energy source for numerous industrial and domestic applications. One of the simplest and most direct applications of this energy is the conversion of solar radiation into heat. Hence the domestic sector can lessen its impact on the environment is by the installation of solar flat collector for heating water. Conventional natural circulation flat plate solar water heaters are the most economical and large scale use of solar energy all over the world. Its thermal performance and efficiency which depends on its design parameters, thickness, type of insulation, number and type of glass covers, spacing between absorber and inner glass. Apart from these parameters its performance also depends on climatic and operational parameters.

Solar water heater systems are generally very simple using only sunlight to heat water. A working fluid is brought into contact with a dark surface exposed to sunlight which causes the temperature of the fluid to rise. This fluid may be the water being heated directly, also called a direct system, or it may be a heat transfer fluid such as a glycol/water mixture that is passed through some form of heat exchanger called an indirect system. Due to the nature of solar energy, two components are required to have a functional solar energy system. These two components are a collector and a storage unit. The collector simply collects the radiation that falls on it and converts a fraction of it to other forms of. The storage unit is required because of the non-constant nature of solar energy; at certain times only a very small amount of radiation or no radiation will be received. The storage of thermal energy as latent heat of fusion has attractive features over the sensible heat due to its high storage density and isothermal nature of storage process at melting temperature. The phase change from solid to liquid or vice-versa is preferred because the operating pressure is lower than liquid to gas or solid to gas phase change. The objective of present work is thermal performance evaluation of phase change material (PCM) based solar water heater.

F.B.A. Amin et. al. [1]studied the present work has been undertaken to study the feasibility of storing solar energy using PCM and utilizing this energy to heat water for domestic purposes. **R. Meenakshi Reddyet. al[2]** focused on the present experimental results of a combined sensible and latent heat thermal energy storage system integrated with a varying (solar) heat source is presented. **Vikramet. al[3]** investigatedthe thermal behavior and feasibility of a cylindrically encapsulated PCM as a Latent heat thermal energy storage system medium. **Apurv Samaiyaret. al [4]** focused on the temperature distribution pattern of the phase change material (paraffin wax) during the process of charging and discharging. **RazaliThaib, Hamdaniet. al [5]** studied the experimental set up fabricate with thermosyphon type of solar water heating system. A flat plate solar collector is equipped with heat storage material. **Sumitambadeet. al [6]** focused on low cost combined batch type solar water heater cum regenerative solar still. The effort is being is made to integrate two different solar appliances so that they could work in much better way. Solar water heater cum distillation system is designed and fabricated to carry out two operations simultaneously heating of water and distillation. **Ruchishuklaet. al [7]**Recent developments in heat pump based solar collector technology exhibit a promising design to utilize solar energy as a reliable heating source for water heating applications in solar adverse regions.

II. Experimental Setup

2.1Detail of set up

In the present experimental setup following parts may be used

1. Copper pipes of 1/2 inch diameter, 20 gauge thickness and 1 m length. (3 nos.) as Risers
2. Copper pipes of 1/2 inch diameter, 20 gauge thickness and 0.5 m length. (2 nos.) as Headers
3. 0.5 mm thick MS sheet of dimensions 1m X 0.5 m as Solar heater (Straight Tube).

4. 0.5 mm thick MS sheet of dimensions 0.75m X 0.5 m as Solar heater (Serpentine Tube).
5. Plain glass with above mention size and 3 mm thick (2 nos)
6. K type thermocouple (6 nos)
7. Digital Temperature indicator
8. Serpentine copper coil with ½" ID
9. Wooden box of above mentioned dimension will be used as a insulation box as well as structure box.
10. 2 mm thick wooden sheet will be attached at the bottom of MS sheet to reduce heat leakages from the bottom of absorber plate.
11. Mild steel cylindrical box with 0.5" diameter and 1' length as PCM storge

2.2 Experimental System Descriptions

The solar radiation passes through the glass in front of the absorber plate and strikes the flat black surface of the absorber plate where the solar energy is absorbed as heat (i.e., by increasing the internal energy). This causes the flat-plate collector to become very hot, and so the water contained in the risers and headers bounded to the plate also absorb the heat by conduction. The water inside the tubes (risers/headers) expands and so becomes less dense than the cold water from the storage cylinder. On the principle of thermosyphon, hot water is pushed through the collector and rises by natural convection to the hot water storage tank and cold water from the cold water tank simultaneously descends to the bottom header of the collector by gravity pull. Therefore, there is circulation as a result of an increase in temperature and volume of the warmer water to the hot water storage tank. The circulation continues as hot water goes out, while cold water comes in. The partly energy absorbed by PCM which store the energy can be utilized as the sun position will vary.

Fig 1 Thermocouple with measuring Flask

Fig 2 Water Tank

Fig 3 Solar Water Heater with Wax Box

III. Result And Discussion

In the present experimental set up ½" copper tubes are fabricated using brazing process afterwards the metal or glass tube will be inserted on it in which wax will be placed and then whole assembly will be placed in the wooden box and placed above the absorber plate and copper pipes are connected to PVC pipes through with water enters and exits from solar water heater. The observations are taken at water inlet, outlet and body temperature at an interval of 20 minutes.

Table 1 Observation Table

TIME (hh:mm)	$\dot{m}$ (ml/sec)	$T1_{in}$ (°C)	$T2_b$ (°C)	$T3_{out}$ (°C)
11:20	3.5	32	50	45
11:35	3.5	33	52	42
11:50	3.5	34	51	42
12:00	3.5	35	52	41
12:30	3.5	35	54	42
1:05	3.5	35	55	44
1:20	3.5	37	55	44
1:30	3.5	36	56	45
1:40	3.5	37	58	49

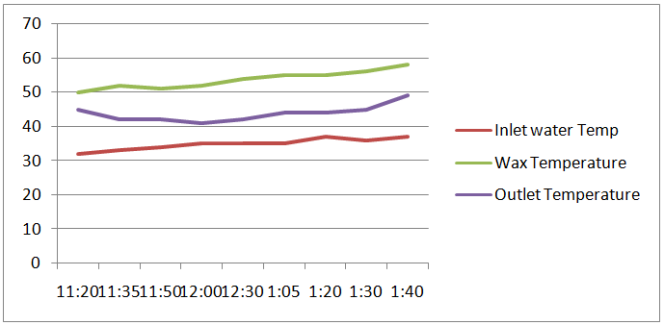

Fig 4. Various Temperature Distribution w.r.t time

Table 2 Result Table

Mass flow rate	Qw	Qi	Efficiency
kg/s	kw	kw	
0.0048	0.259	0.825	31.42
0.0048	0.179	0.825	21.75
0.0048	0.160	0.825	19.33
0.0048	0.120	0.825	14.50
0.0048	0.140	0.825	16.92
0.0048	0.179	0.825	21.75
0.0048	0.140	0.825	16.92
0.0048	0.179	0.825	21.75
0.0048	0.239	0.825	29.00

From the result table and it is quite clear that in case of solar water heater with PCM though the solar energy intensity decreases with time the temperature of water increases continuously.

IV. Conclusion

The major conclusion drawn from this work is by using PCM the though the intensity of solar energy decreases with time due latent heat of PCM the water temperature increases because the PCM behaves like good phase change material.

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