SOLAR WATER HEATER USING PHASE CHANGE MATERIAL

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ABSTRACT

Solar energy is available in ample amounts throughout the year and can be used for heating and power generation purposes. The present work has been undertaken to study the feasibility of storing solar energy using Phase Change Materials (PCMs) and utilizing this energy to heat water for domestic purposes during night time This ensures that hot water is available throughout the day. The system consists of solar water heater and a heat storage unit filled by phase change material(PCM). The use of latent heat storage system using phase change material(PCM) is an effective way of storing thermal energy as it has high-energy storage density. Parrafin wax that commercially available in the market used for heat storage material. They store 5-14 times more heat per unit volume than sensible storage material such as earth, masonry or rock. The main aim of this work is the design of a solar water heater in which a wax type Phase Change Material (PCM) is used as the heat storage substance. The storage unit stores the heat in PCMs during the day and supplies hot water during the night. The storage unit utilizes small cylinders, made of aluminum, filled with paraffin wax as the heat storage medium.

Keyword: *Solar water heater, Parrafin wax, Copper tubes, Absorber Plate, Thermocouple.*

1.INTRODUCTION

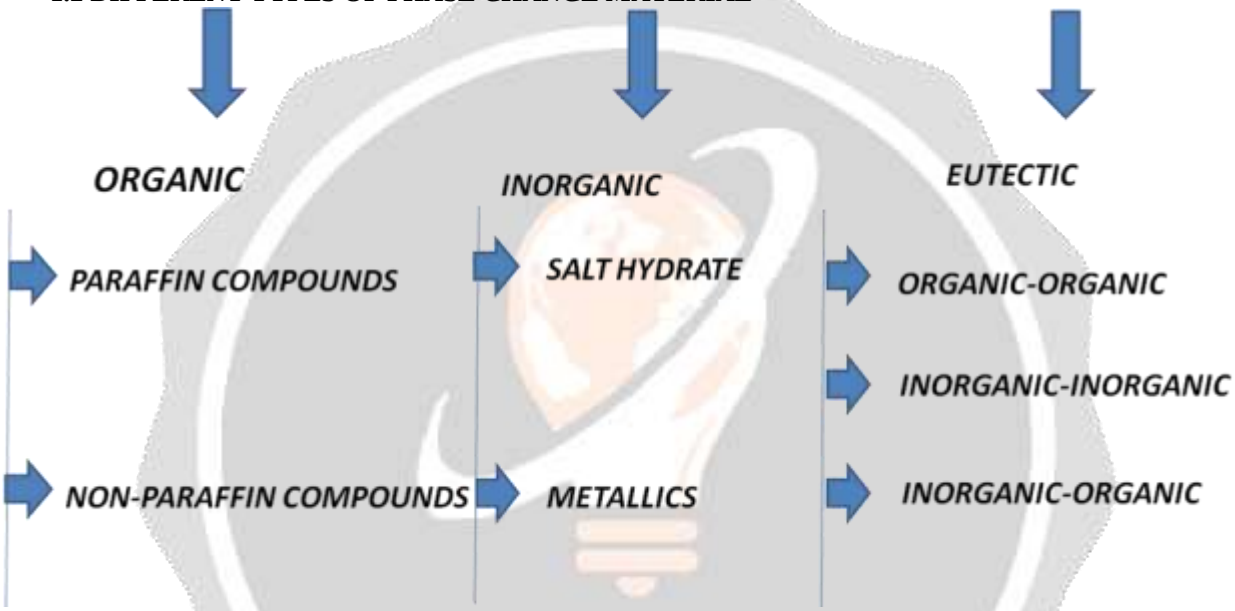
Solar radiation is an optional energy source for industrial and domestic applications. Phase change material (PCM) is a substance with a high heat of fusion which melting & solidifying at a certain temperature. It is capable of storing & releasing large amount of energy. Thermal performance and efficiency of solar water heater depends on its thickness, design parameters, number and type of insulation and glass covers, space between absorber and inner glass. Its performance also depends on climatic and operational parameters. The water circulation in solar water heater is natural due to the density differences between the hot water and cold water. The block diagram of solar water heater is shown in figure. Collector panels are used solar water heating systems to collect the sun's radiation and convert it into useful heat in the form of hot water. A solar collector conjugate with solar water storage reduces the fuel needed for house hold hot water. Solar thermal systems could make a share to space heating as well as furnishing hot water. Water flows through tubes and get in black metal absorber plate. The absorber plate is enclosed with an insulated box with a crystal clear window to let in sunlight. The hot water is transferred to a tank from where we can use it for home or institutional use.

1.1 Importance of PCM in case of SWH

The solar energy supply is variable with the position of sun. In afternoon we can get maximum and zero at night. To overcome the zero supply at night, considerable amount of solar energy should be stored during the daytime. Therefore Energy storage is the essential to any system that depends largely on solar energy. Solar radiation cannot be stored as such, so first of all an energy conversion has to be brought about & depending on this conversion, a storage devices needed. For this purpose we require the material which can store the energy itself & release the energy. We require two components, Collector and a storage unit to save

the solar energy. The collector collects the radiation which comes in direct contact with it & by the help of storage unit, the non-constant nature of solar energy; at some times only a very less amount of radiation or no radiation will be received. The storage of thermal energy as latent heat of fusion has advantage over the sensible heat due to its high storage density and isothermal nature of storage process at melting temperature. The use of phase change materials (PCMs) as latent heat storage material is an effective way of storing thermal energy. High-energy storage density and the isothermal nature of the storage process also the advantages. Phase change materials (PCM) are ‘‘Latent heat storage materials’’. It releases the latent heat when a material changes from solid to liquid, or liquid to solid. This is called a change in state or ‘‘Phase’’. Initially, these solid–liquid PCMs perform like conventional storage materials, their temperature rises as their capacity of absorbing heat. Unlike conventional (sensible) storage materials, PCM absorbs and release heat at a nearly constant temperature. They store 5-14 times more heat per unit volume than sensible storage material such as water, masonry or rock. A large number of PCMs are known to melt with a heat of fusion in any required range.

1.2 DIFFERENT TYPES OF PHASE CHANGE MATERIAL



1.2 Properties of paraffin wax thermo-physical

DESCRIPTIONS	**VALUE**
Melting temperature	46.7 ^{0}C
Thermal conductivity(solid)	0.1383 W/m ^{0}C
Thermal conductivity(Liquid)	0.1383 W/m ^{0}C
Specific heat (solid)	2890J/Kg.K
Specific heat (Liquid)	2890J/Kg.K
Density(Solid)	947Kg/m^3
Density(Liquid)	750Kg/m^3
Latent Heat	209KJ/Kg

2. WORKING

In the present project work the Solar Water Heater consist Of three Pipes of One meter length One half inch diameter are fabricated with 0.5m length 1/2 inch dia copper pipe. At top and bottom as soon as dia around 300mm of centre span of all three copper pipe covered with cylindrical tube's of dia 1.5inch. In between the gap wax will be placed so when Solar energy incident the water which is flowing throw pipe gets heated and at the Same time wax will melt.So when Solar intensity decreases as the position of sun will change the melted wax will transfer it's latent Heat to the copper pipe and ultimately to the water and so in winter Days the intensity of Solar energy is low by using PARAFFIN WAX type PCM Material will increase the water heating and temperature of water. The thermocouple are Placed at water inlet & Outlet. One inside the wax zone & One with copper pipe to measure various Temperature.We provide easy arrangement for adding/removing of wax, and also provide partition in M.S attachment so that wax do not concentrate on lower side due to angle. M.S attachment is shown below.

Fig -1: MS Attachment Of Solar Water Heater

3. SPECIFICATIONS OF COMPONENTS

1) K type Thermocouple

2) 100ml measuring glass

3) Copper pipe with 1/2 inch dia

4) Wooden box

5) Paraffin wax

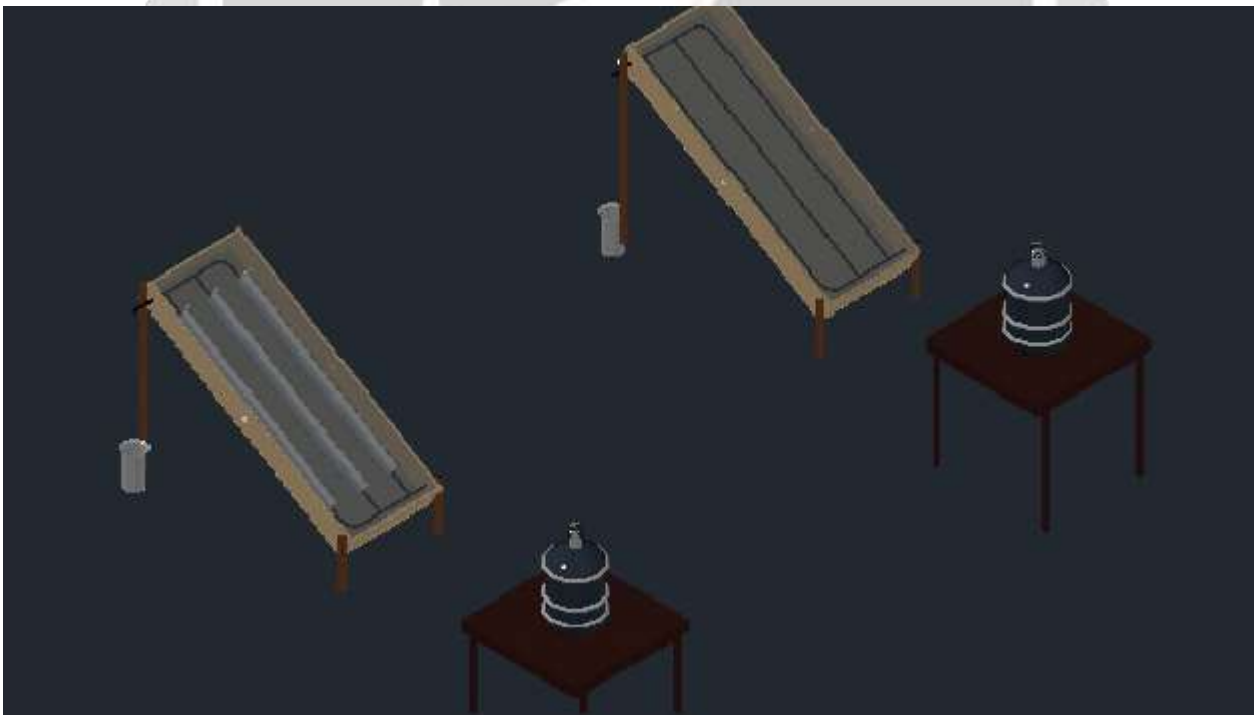
6) 3mm glass sheet

7) 1mm MS sheet

8) Storage tank

4. ACTUAL SETUP

5.DESIGN OF SOLAR WATER HEATER



6. PARAMETERS STUDY

- Melting temp. of wax
- Minimum temp. of absorber plate
- Maximum temp. of absorber plate
- Efficiency

7.EXPERIMENTAL READING

Table 1: Reading of SWH without PCM

TIME	INLET TEMP. (T1)	OUTLET TEMP. (T2)	BODY TEMP. (T3)	EFFICIENCY IN PERCENTAGE	MASS FLOW RATE
10:00 am	30	33	35	14	2.20min/litter
10:30 am	30	35	37	23.33	
11:00 am	31	37	39	28	
11:30 am	32	40	42	37.33	
12:00 pm	33	43	45	46.66	
12:30 pm	34	46	47	56	
01:00 pm	36	50	52	65.33	
01:30 pm	38	54	55	74.66	
02:00 pm	40	57	57	79.33	
02:30 pm	40	59	58	88.66	

03:00 pm	39	54	56	70	
03:30 pm	38	50	52	56	
04:00 pm	37	47	50	46.66	
04:30 pm	36	44	46	37.33	
05:00 pm	35	41	43	28	
05:30 pm	33	37	39	18.66	
06:00 pm	32	34	36	9.33	

Table 2: Reading of SWH with PCM

TIME	INLET TEMP. (T1)	OUTLET TEMP. (T2)	ABSORBER PLAT TEMP. (T3)	EFFICIENCY IN PERCENTAGE	MASS FLOW RATE
10:00 am	30	34	35	18.66	2.20 min/litter
10:30 am	30	36	37	28	
11:00 am	31	39	41	37.33	
11:30 am	32	43	44	42	
12:00 pm	33	47	48	65.33	
12:30 pm	34	51	51	79.33	
01:00	36	55	54	88.66	

pm					
01:30 pm	38	58	57	93.33	
02:00 pm	40	60	59	93.33	
02:30 pm	40	61	60	98	
03:00 pm	39	58	57	88.66	
03:30 pm	38	53	55	70	
04:00 pm	37	50	52	60.66	
04:30 pm	36	48	50	56	
05:00 pm	35	45	47	46.66	
05:30 pm	33	42	44	42	
06:00 pm	32	40	42	37.33	

7. SAMPLE CALCULATION FOR EFFICIENCY

$$\eta = m\ Cp\ \Delta t\ /I \times A$$

where;

η= Thermal efficiency

m= mass flow rate of water

Cp =Specific heat of water

$\Delta t = T_2 - T_1$

I= Intensity of radiation

A= Surface area

$$m\ Cp\ \Delta t = Q\ outlet$$

&

$I \times A = Q$ inlet

According to experiment readings,

Take m = 1/2.20*60

= 0.0075

C_p = 4.2

I = 1.35 kw/m^2

A = 0.5 m^2

For without pcm,

$T_1=32^0c$

$T2=34^0c$

So, η =0.0075*4.2*(34-32)/1.35*0.5

=0.0933

=9.33%

For pcm,

$T_1=32^0c$

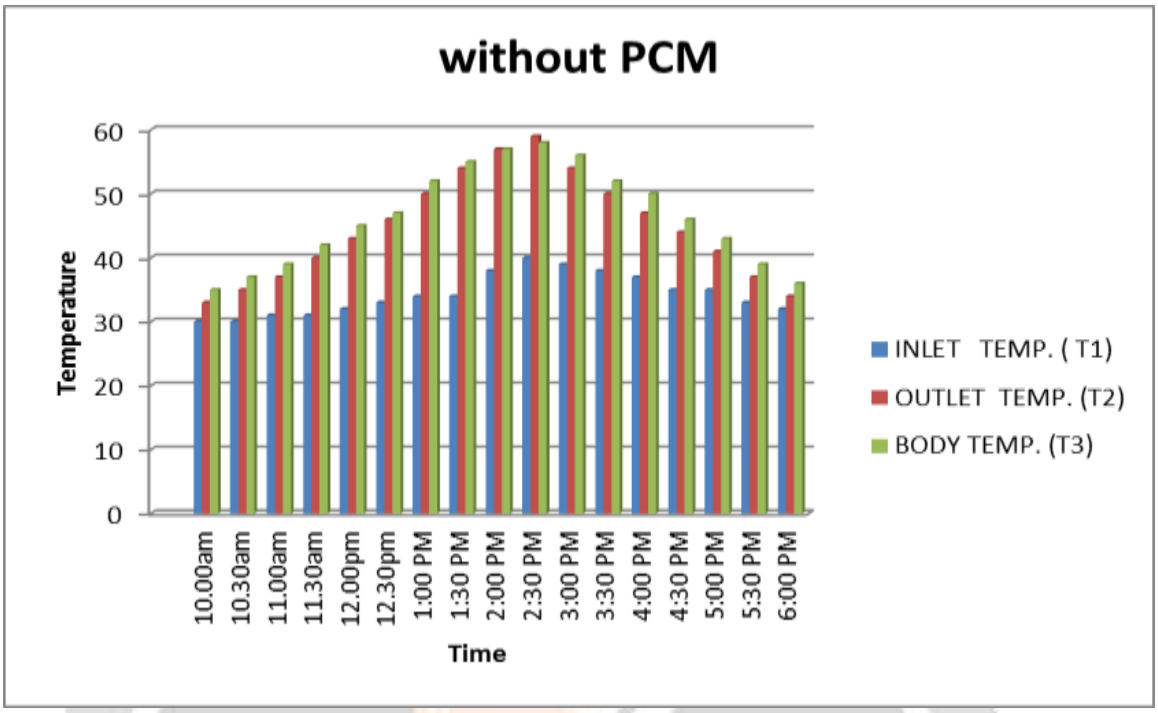
$T_2=40^0c$

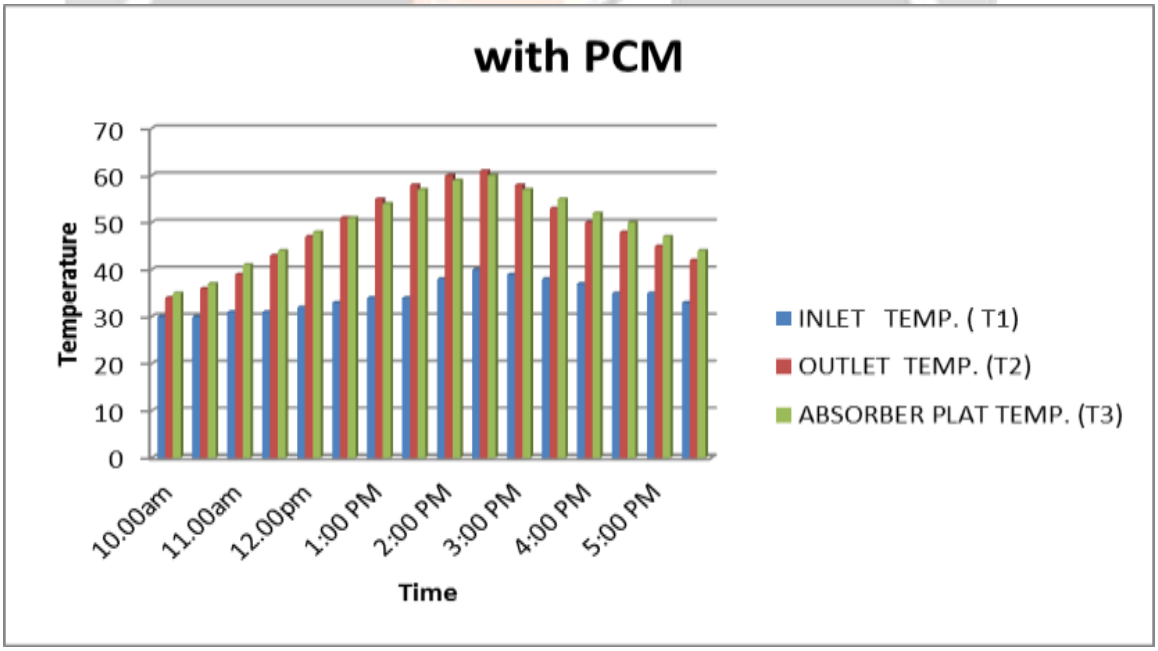
So, η =0.0075*4.2*(40-32)/1.35*0.5

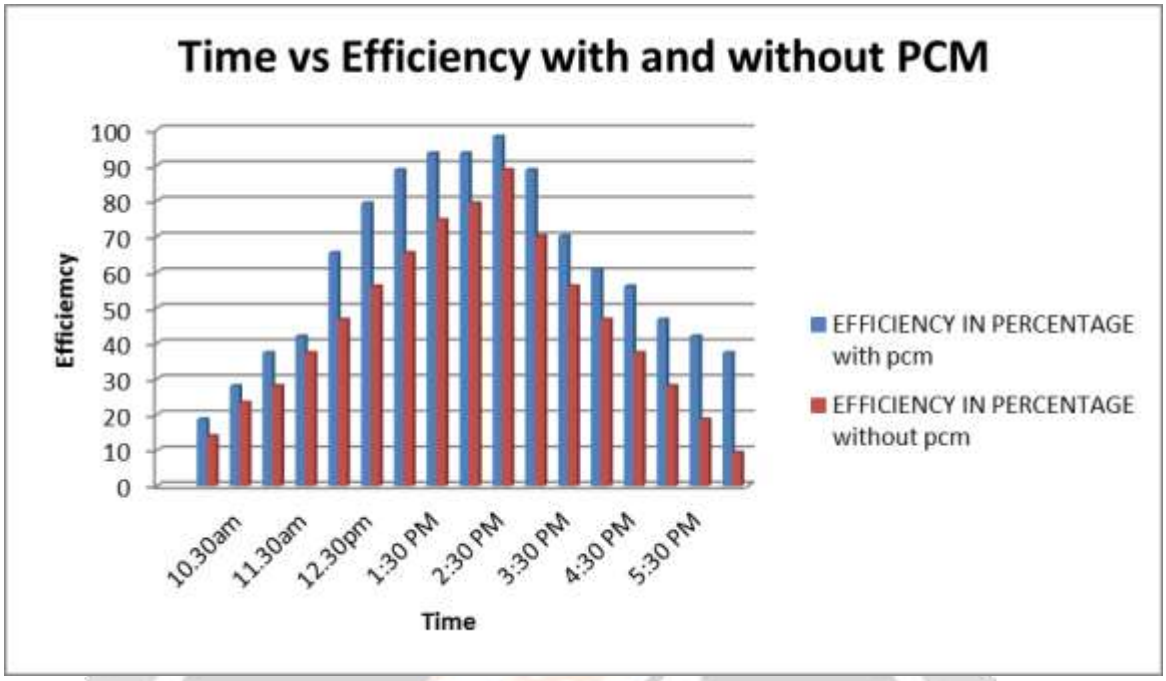
=0.3733

=37.33%

8. DATA GRAPH


without PCM
Temperature
60
50
40
30
20
10
0
10.00am
10.30am
11.00am
11.30am
12.00pm
12.30pm
1:00 PM
1:30 PM
2:00 PM
2:30 PM
3:00 PM
3:30 PM
4:00 PM
4:30 PM
5:00 PM
5:30 PM
6:00 PM
Time
INLET TEMP. (T1)
OUTLET TEMP. (T2)
BODY TEMP. (T3)


with PCM
Temperature
70
60
50
40
30
20
10
0
10.00am
11.00am
12.00pm
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
Time
INLET TEMP. (T1)
OUTLET TEMP. (T2)
ABSORBER PLAT TEMP. (T3)



9. CONCLUSION

The use of PCM in solar water heater helps to reduce cooling rate of water, thus it enhance the maximum utilization of solar energy & hence improves efficiency of system.The PCM based solar water heater store maximum solar energy. After performing the experiments as results we got that, between time period of 10:00am to 12:00pm no major difference in both solar water heater. Parrafin Wax get melt at 37 to 40^0c and when the radiation of sun get low, wax gives its latent heat to water so we got better performance in compare to normal SWH model. In addition after 4pm in normal S.W.H outlet temprature get decrease, but at that time due to pcm we got higher efficiency. By readings, if we consider overall efficiency at that case we got 12% to 16% more efficiency in compare to normal S.W.H. & if we consider efficiency between 2:00pm to 6:00pm we got 17% to 22% higher in compare to normal S.W.H. In future this project will also help to find the suitable PCM and provide the various designs for solar water heating system to store the solar thermal energy.

10. REFERENCES

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