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Experimental Analysis of Solar Water Heating System using Phase Change Material

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Abstract: Energy one of the basic need of human being for existence. It plays important role in development and progress. The main source of energy is fossil fuels but sources are depleting now days. So we are forced to move on to another renewable energy sources like sun, wind, tidal etc. India is also investing heavy amount of money into non-renewable energy sources. Considering about the solar energy it can be utilise in two ways either converting it into electrical energy using solar cell or use as a thermal energy. The second method is being use form ancient time for house hold purpose like drying food, cloths etc. in U.S. the use of solar water heater is dated back to 1900. Solar energy apparatus which we use need a efficient and proper thermal storage unit. Therefore, it largely depends on the method and apparatus which we will use to store thermal energy. The property of latent (PCM) should be such that it can store large amount of latent heat while changing its phase and also release the heat during night time. It is obvious that any energy storage systems incorporating PCM will comprise significantly smaller volume when compared to other materials storing only sensible heat. A further advantage of latent heat storage is that heat storage and delivery normally occur over a fairly narrow temperature range the phase change temperature. Solar water heater is one of the most popular methods to utilise the solar energy. Solar water heater accounts for 80% of the solar thermal market. But the limitation of solar thermal energy is that we can only use it in day time. So to overcome this limitation we can use the solar heating setup with additional setup of PCM (Phase Change material). The property of PCM is that is changes its phase during heat addition and store the heat in the form of latent heat and when temperature decreases it again changes the phase and release the heat energy. In this research we will analyse that this method is how much efficient. The following paper deals with the experimental investigation of effectiveness of a parabolic collector and its results have been verified experimentally.
Keywords: Phase Change Material, parabola, collector, irradiation, phase, change, latent, renewable, thermal, solar, fossil, HTF, paraffin wax.

I. INTRODUCTION

A. Introduction to Project Title

Solar water heater is one of the most popular methods to utilise the solar energy. Solar water heater accounts for 80% of the solar thermal market. But the limitation of solar thermal energy is that we can only use it in day time. So to overcome this limitation we can use the solar heating setup with additional setup of PCM (Phase Change material). The property of PCM is that is changes its phase during heat addition and store the heat in the form of latent heat and when temperature decreases it again changes the phase and release the heat energy. In this paper we will analyse that this method is how much efficient. The following paper deals with the experimental investigation of effectiveness of a parabolic collector and its results have been verified experimentally.

The solar system consists of mainly solar concentrator, Fresnel lens, automatic solar tracking. These components were arranged on a flat structure having the same focus and properties for light perpendicular to their axis or revolution. Imported Anodized Aluminium Sheet was used as the reflective material. The pot was placed on the focal point of the concentration which is suspended such that it rotates freely about the focal axis. In this way, the pot remains stationary irrespective of tracking. Tracking the sun is by automatic way by 150 rotation of concentration by the help of DC motor for change in the sun's position. A solar system was instrumented with two temperature sensors (PT 100), the temperatures of the refrigerant at two different points, were measured with PT 100 temperature sensors. Water boiling, Oil heating, melting of metal and controlled cooking tests carried out with the concentrator under various levels of atmospheric turbidity yielded very encouraging and satisfactory results.

B. Background of Study Work

Solar Water Heater enables substantial energy savings, as the sun shining on 1m² of roof replaces 100 l of heating oil or 100 m³ of natural gas (approximately 1 000 kWh) a year. Supplying a washing machine or dishwasher with this hot water also cuts out the by these appliances to heat the water and shortens the washing cycles.

The solar water heater passes this heat to a water tank by means of a circulating pump. The exchange is triggered by the thermal regulator, but only when the collector is hotter than the water in the tank. This prevents the circulating pumps using electricity needlessly. Conversely, it also prevents overheating. The efficiency of the collectors is at its highest at midday, in summer, when the sky is cloudless, and when the collectors face south. Likewise, the efficiency is best at a gradient of 35° to the horizon, but good results can be achieved with collectors fitted vertically to a façade.

C. Statement of Problem

The main problem with conventional solar water heater is that it does not provide the hot water during the night time. Also the whole idea of heating the water will be most efficient in summer only. To overcome this we had done some modification in the conventional setup to overcome problem of hot water availability in night also.

D. Objectives of Wor

Provide heated water during night time.

Comparison of Results with,

1) HS-34.
2) Paraffin wax.

Incorporating Parabolic Collector instead of Flat plate counterpart.

Store heat in PCM and supply the same when needed.

E. Hypothesis of Work

Since we usually say that solar energy is free energy but the installation cost is high. The solar energy also cannot be captured fully. Some of it get scattered in atmosphere also and some get reflected.

F. Purpose of Study

The purpose of the study was to check the feasibility of solar water heater and current scenario .of awareness in people about renewable energy sources.

G. Future Scope

The future scope of project involves to checking the efficiency of setup using different Phase Change Materials (PCM). Also we may install some focusing lenses to achieve maximum temperature by concentrating the sun rays on one point.

H. Limitation of Work

The setup cannot work in cloudy days. If the setup is being installs on height like Terries of building the due to high velocity of air the forced convection can be occurred due to which we can see significant temperature change. Also the dust being collected on parabola reduces its efficiency.

II. LITERATURE REVIEW

A. Introduction

Energy one of the basic need of human being for existence. It plays important role in development and progress. The main source of energy is fossil fuels but sources are depleting now days. So we are forced to move on to another renewable energy sources like sun, wind, tidal etc. India is also investing heavy amount of money into non-renewable energy sources. Considering about the solar energy it can be utilise in two ways either converting it into electrical energy using solar cell or use as a thermal energy. The second method is being use form ancient time for house hold purpose like drying food, cloths etc. in U.S. the use of solar water heater is dated back to 1900. Solar energy apparatus which we use need a efficient and proper thermal storage unit. Therefore, it largely depends on the method and apparatus which we will use to store thermal energy. The property of latent (PCM) should be such that it can store large amount of latent heat while changing its phase and also release the heat during night time. It is obvious that any energy storage systems incorporating PCM will comprise significantly smaller volume when compared to other materials storing only sensible heat. A further advantage of latent heat storage is that heat storage and delivery normally occur over a fairly narrow temperature range the phase change temperature. Efficient and reliable thermal energy storage systems play an important role in most of applications. Water heating is one of the most common fields where solar energy is being utilised.

Solar water heaters are becoming more popular since they are comparatively simple and not so much expensive to manufacture and maintain. They are very good alternative to gas or electric hot water production system. They reduce the carbon content which is generated in the process of electricity generation. Hot water is required in most of the commercial and household work like drinking, cleaning, bathing etc .in a 20-year period, one solar water heater can prevent emissions of over fifty tons of carbon dioxide. Depend upon requirement and climate, a well design, install, and maintained solar water heater can provide nearly half of the hot water need. It can operate in any whether and climate although the efficiency depends upon the amount of solar heat energy available and the how much cold water coming into the system.India is blessed with abundant amount of solar energy. In India we usually have 7 to 8 months of solar days. The total amount of sun radiation falling on India in year is more that all the non renewable energy sources combined. India has total capacity of 5.525 GWa. Indian government is also providing subsidy on installing the solar instrument.

B. Findings of the Literature Review

1) *Prof. H.M. Dange et. al:* Conducted a experiment to check the efficiency of solar water heater without and with phase change material thermal storage system. They conducted this experiment to find and compare the efficiency of both. For this prepared a experimental setup consisting of a thermal storage tanks made up of aluminium and a solar water heater. During without thermal storage unit they just passed the cold water from solar water heater and stored in insulated tank. After sunset its was found that the hot water was available for short time. Then they repeated the procedure but this time they stored that into a storage tank with phase change material. This time the water was after sunset for enough time. In S.H.S (Charging without PCM) heat storage system heat transfer fluid continuously through system and temperature rises gradually till it's temperature reaches 70 ° constant for 45 to 50 minutes. During combined heat storage system i.e. SHS and LHS (charging with PCM) heat transfer fluid is circulated continuously and gradually reaches up to 62 to 63 ° remain constant for period more than conventional system i.e. 60 to 70 Since temperature reaches 9 to 1 less, temperature loosed in sensible form is stored in latent heat form. • During initial period of charging heat storage is high and then it is decreasing in temperature due to decreases in temperature differences between HTF and temperature of storage tank.
2) *Anant Shukla et. al:* Latent heat thermal storage is the most efficient way of storing thermal energy for heating of water by the energy reception by sun. The researcher has investigated and analysed experimentally with and without PCM used in solar water heaters. The relative study was classified based on the sensible and latent heat. Paraffin wax was used as a PCM for heating using solar power. Two identical units were used, one unit contained 17.5 kg paraffin wax with melting temperature of 54 Deg Celsius. The storage material was stacked in heat exchanger constructed of aluminium tubes and the counterpart contained water as storage material in galvanised tank.

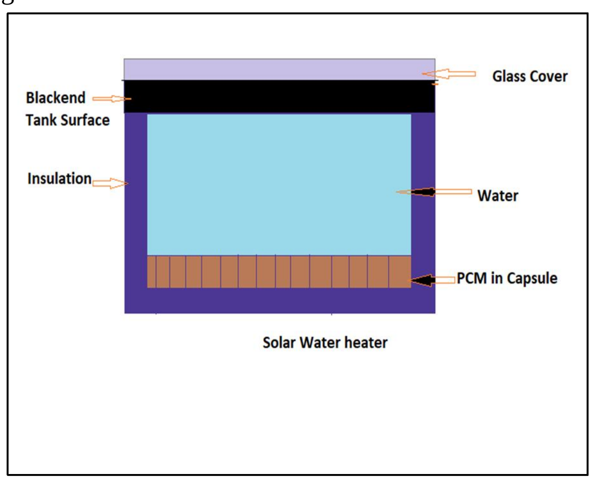

Figure 2.1- Solar Water heater [3]

Both the units were charged using flat plate collectors of same area during the day time and having the same heat transfer area. It was found that the latent heat storage system was successful in storing water with more elevated temperature as compared with the sensible counterpart.

3) *Alexander Papadimitratos et. al:* The researcher demonstrated the performance of a solar water heater making use of integrated which were evacuated and integrated with phase change materials. The phase change material stored inside the inner tubes was found to store thermal energy in form of latent heat besides the heat pipes and it provided a delayed cooling after sunset.

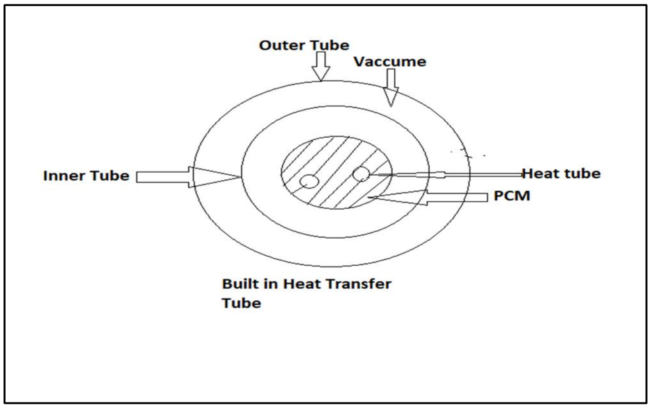

Figure 2.2- Built in Heat transfer tube [4]

The solar collector proposed by researcher used two types of phase change materials, viz. Tritiacontane and Erythritol having melting temperatures of 72 degcel And 118 degcel. respectively. Normal operation and on-demand operation was analysed and its efficiency was observed. Feasibility of the same was tested using large scale commercially used solar water heaters. It was observed that these dual phase change material collectors had and improved performance as compared with the solar collectors having no phase change materials. Along with the enhanced functionality of the solar heaters the efficiency of the same during normal operations was found to be increased by 26% and the same during stagnation mode to be 66%.

4) *R. Senthilkumar et. al:* The researcher proposed that the performance of solar collector can be improved by increasing the size of the absorbing area of the plate and the size of water tubes. During the daytime, the performance of solar water heater having PCM is less as compared with that of the solar water heater having no PCM. It is due to the fact that some amount of heat energy is stored in PCM. However the performance can be enhanced by using a PCM having thermal storage capacity more. Orientation of the absorbing plate plays a major role in determining the performance of the heater. By increasing the collector area, efficiency can be improved. During the sunset or no sunshine hours, the thermal storage system can be used to increase the outlet temperature of water. This outlet temperature can be improved by using a better quality PCM and increasing number of thermal storage units. The presence of PCM improves the solar water performance during sunshine hours. Also the heater gives high heater temperature of water during the night time at high flow rates due to the fact that high transfer area is present during this time. A PCM material having excellent thermos-physical properties gives better efficiency. On similar lines, the unit having PCM proposed for operation during evening hours or cloudy days yields better efficiency due to presence of thermal energy storage.
5) *Prof M.V. Kulkarni and Dr. D.S. Deshmukh:* The researcher conducted a experiment to determine the feasibility and efficiency of solar water heater with Phase Change Material. They fabricated two experimental setup one with thermal heat energy storage that is with PCM and other without PCM. During the charging process the water was circulated from tank to solar water heater unit continuously throughout the day time. The water absorbs the heat sensibly and exchange with tank containing PCM which is initially at room temperature. Slowly the PCM gets heated and exchange the heat. It slowly starts getting heated.
6) *R. Meenakshi Reddy et. al:* In current year scenario is that to decrease the cost solar equipment and improve the efficiency of heat energy storage system. There are only two type of storage system developed yet, one is latent heat and another is sensible heat system. In this experiment the researcher has explained that there is a spherical capsule which is filled with phase change material and insulated with glass wool of 50 mm thickness. The sensible and latent heat storage capacity of thermal energy storage tank is 70 ^{0}C which is around 10,000KJ. For increasing the output of phase change material there is a combination of fluid researcher has used which is paraffin and stearic acid. The thermal energy storage tank divided into 4 segments, which is placed in each equal distance, at each segments inlet and outlet there was a resistance thermal detectors are placed to measure the temperature of phase change material.

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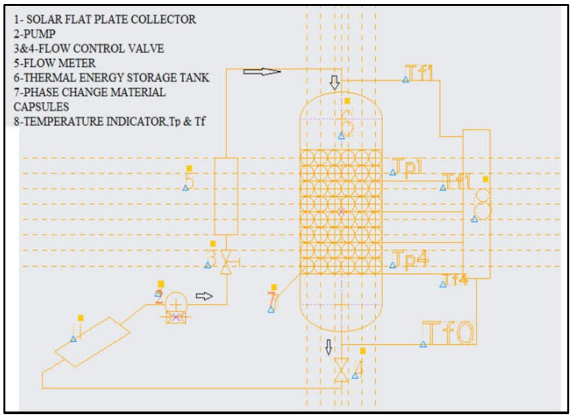

Figure 2.3- Experimental setup [7].

The researcher had identified the solution by varying the flow rates from 2 to 4 to 6 litre per minute. In capsule initially the energy stored in form of sensible heat until it melts the phase change material, after continuing the heating of phase change material it superheated, and then energy stored in liquid phase change material in the form of sensible heat. The discharging processes are carried out into batches for 20 litre of water per batches and take 20 minute to transfer heat to water. The researcher had shown in conclusion that the varying the flow rates during charging time does not affect because the charging duration was only for 4 hours. As the performance during charging and discharging process there is not any difference between paraffin and stearic acid as phase change materials, but paraffin's performance was slightly better because of latent heat and thermal conductivity variation.

7) *R. Sivakumar et. al:* The major resource of the solar energy is the sun. Also, the utilization of the solar energy is largely in the form of solar water heat. The simplest solar water heater available in the market is flat plat solar water heater (FPSWH). To improve the storage of the solar energy, phase change material (PCM) are used. The PCM have properties to emits the stored solar energy when the solar radiation is unavailable. The experiment is conducted with the Fresnel lens which is introduced to spot heating or concentration area heating. The Fresnel lens is cheap and light weight and have better focal length. It is also easy to combine with the FPSWH because of simplicity of both the component. Due to this combination the time required to heat the water in flat plate solar water heater (FPSWH) is comparatively less than the ordinary flat plate water heaters available in the market. Also, the temperature of the water is greater than the ordinary FPSWH. There are many advantages of FPSWH with the PCM in the combination of Fresnel lens. The solar heater with Fresnel lens is causes in improvement in the surface temperature of the system. Due to this this type of solar heater also used in the heating the ambient temperature of the building and it can also easy to control the temperature. One of the major importance and advantage of this combination of solar water heater is can work in low solar radiation area and also with the PCM it becomes more superior than any other solar water heater present in the current market.

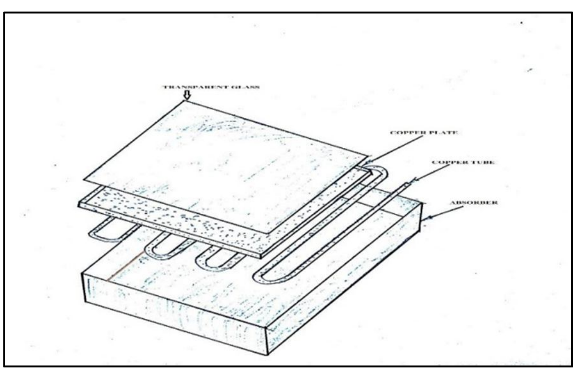

Figure 2.4- Experimental diagram [8]

This setup performance efficiency also can be improvised by the increasing in the total no of passes. Further it can use in many applications. In the future there will be more dependency on the solar energy so this experiment can play vital role in the upcoming solar power application.

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8) *Abhilash A. et. Al:* The continuous increase in fuel price and pollution , the effort is taken for effective utilization of renewable source of energy. Covering energy from one form to another and storing it, reduces the wastage of energy and improves the utilization. In this experimentation researcher has used PCM (C-32) to store the thermal energy as change in internal energy. He has used conventional solar water heater system and placed PCM into hot water tank to store the thermal energy by phase change of PCM. Water is heated with sun radiation using solar collector.It provides the hot water at night time in ruler area for domestic use. The heat energy is absorbed and released by changing state of PCM melting temperature. In this experimentation, the conventional solar water heater is 60 litres was used and modified by placing PCM tank of 14 litre volume of steel into storage tank. The temperature at essential points were measured for comparison of water heating with PCM and without PCM. monitoring discharge rate of flow so as to use hot water at evening time. The comparison was made for conventional setup and setup with PCM.Using conventional water heater system gives hot water For 5 hours and 15 minutes . But when PCM (C-32) was incorporated into storage tank, it gives hot for 8 hours and 30 minutes. Hence by using pcm increase the efficiency by around 24% on increasing small amount of cost.

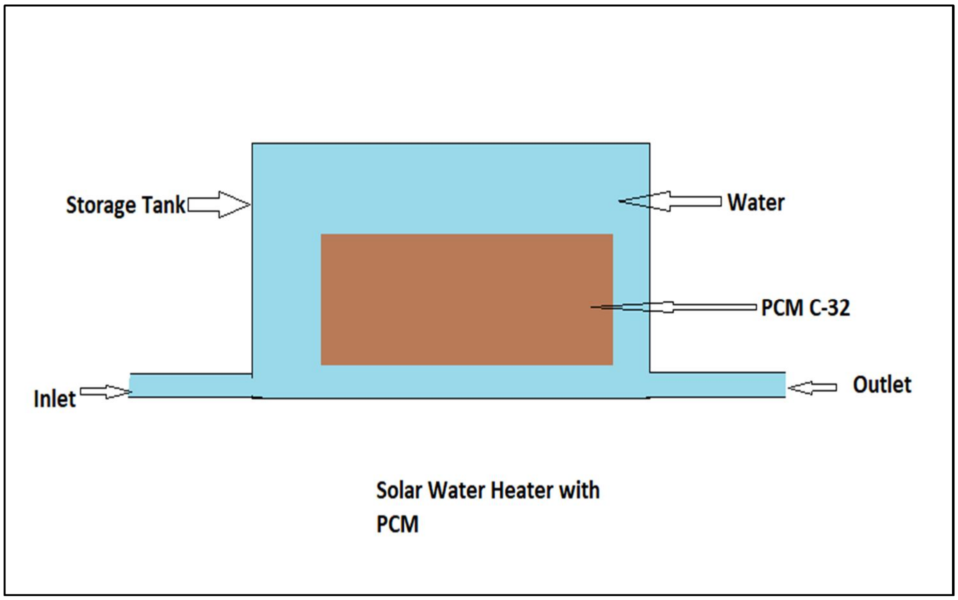

Figure 2.5- Solar water heating process [9]

III. METHODOLOGY

A. According to consumption rate the capacity of apparatus is determined.
B. The area of parabola is calculated and fabricated.
C. The dimension and material of tube is selected.
D. The type of PCM is selected based on its thermal property and heat storing capacity.
E. The amount of PCM is calculated.
F. The setup is installed as shown in layout.
G. The temperature difference reading is achieved using two type of pipe one is straight and other is in the form of helical coil.
H. Then the reading is taken in by placing PCM in the tank.
I. The final calculation is done.

IV. CALCULATIONS

A. Diameter of Absorber Pipe

According to S P Sukhatme Page number 163, Concentration ratio= 5 to 30.
Assuming C= 12-15 and width of collector, W=500mm for calculating diameter,
C= (W- D)/(3.14xD)
13=(500-D)/(3.14xD)
D= 11.95mm.
Taking standard pipe available in market, D=0.5 inch.

B. Collector Dimension

After conducting more research on solar energy and solar collection, the decision was made to have:
Cylinder length= L= 1.5m
Diameter, W= 500mm
Focal length, F = 4R/3x3.14
F= 4x 250/ 3x3.14
F= 106.103 mm
Aperture Area= (W- D)xL
Aa= (0.5- 0.0012)x 1.5
Aa= 0.732 m^2
Absorber Area = (D)x 3.14x L
Ap= 3.14 x 0.0012 x 1.5
Ap= 0.0565 m^2

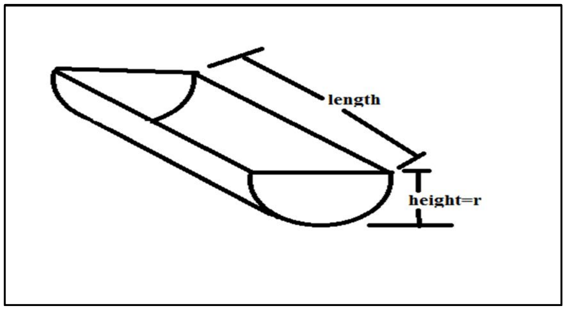

Figure 4.1- Parabola Calculations

C. Reflector Surface

After a lot of research the material for reflecting was selected to be Aluminium Sheet because

1) The weight of aluminium is 1/3rd of Steel.
2) Cost of aluminium is very less (12 rs/ sq. ft.)
3) Reflectivity of aluminium is exceptionally good.

D. Phase Change Material

After experimenting with a lot of PCM viz. Paraffin wax and other inorganic salts, the decision was made to select HS34 as PCM for the setup. HS34 is an inorganic chemical based PCM having nominal freezing temperature of 340C and melting temperature of 350C. It stores thermal energy as latent heat in its crystalline form. On changing phase this latent heat is released or absorbed, allowing the ambient temperature within the system to be maintained. HS34 is constituted of the right mix.

Properties of HS34-

1) Melting Temp (0C)= 35
2) Freezing Temp (0C) =34.0
3) Latent Heat (kJ/kg) =150
4) Liquid Density (kg/m3) =1850
5) Solid Density (kg/m3) =1980
6) Liquid Specific Heat (kJ/kgK)= 2.4
7) Thermal Conductivity (W/mK)= 0.47
8) Solid Thermal Conductivity (W/mK) =0.5
9) Base Material =Inorganic

Amount of PCM required,

For experimental purpose, the calculation has been carried out for 6 litre water,
Let V be the volume of PCM required,
1000 x 6= 1850 x V
V= 3 litres.

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E. Collector Efficiency

Useful heat= Qu= (Aa- Ap) X S

S= 1050 W/m2

Qu= (0.732- 0.0565) x 1050

Qu= 709 W/m2/day

Efficiency= η = Qu/ (Aa x Ib.Rb)

Ib.Rb= Solar irradiation= 5.22 kw/m2/day

η = 13.58%

V. OBSERVATIONS

A. For Straight Copper Tube

Readings without PCM,

Table 6.1 Without PCM, Date- 20-02-2018

TIME	INLET TEMP.(C)	TEMP . OUTLET C
9:00 AM	29	34
10:00 AM	31	37
11:00 AM	32.6	43.5
12:00 PM	34.5	49.9
1:00 PM	36.8	53.8
2:00 PM	35.7	51.3
3:00 PM	33.3	49.6
4:00 PM	32.1	43.7
5:00 PM	31.5	42.6
6:00 PM	30.4	40.5
7:00 PM	29.6	37.1
8:00 PM	29.2	36.3
9:00 PM	28.5	33.4

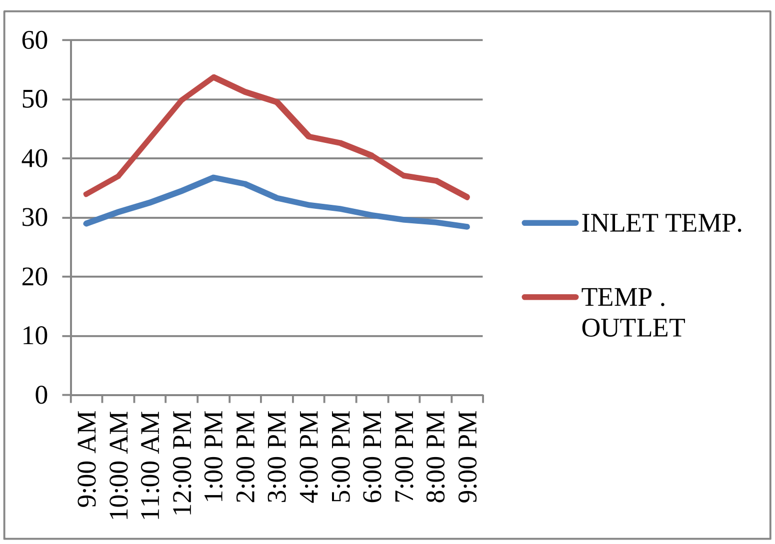

Figure 6.1 - Graph for flow rate 2 lph

Table 6.2 Without PCM, Date- 24-02-2018

TIME	INLET TEMP.°C	OUTLET TEMP.°C
9:00 AM	29.3	38.6
10:00 AM	31.4	44.7
11:00 AM	33.6	48.2
12:00 AM	35.2	52.4
1:00 PM	37.2	58.6
2:00 PM	36.5	54.5
3:00 PM	34.2	51.6
4:00 PM	33.4	47.9
5:00 PM	32.8	46.3
6:00 PM	31.8	41.3
7:00 PM	30.9	38.1
8:00 PM	30.4	34.6
9:00 PM	29.5	31.5

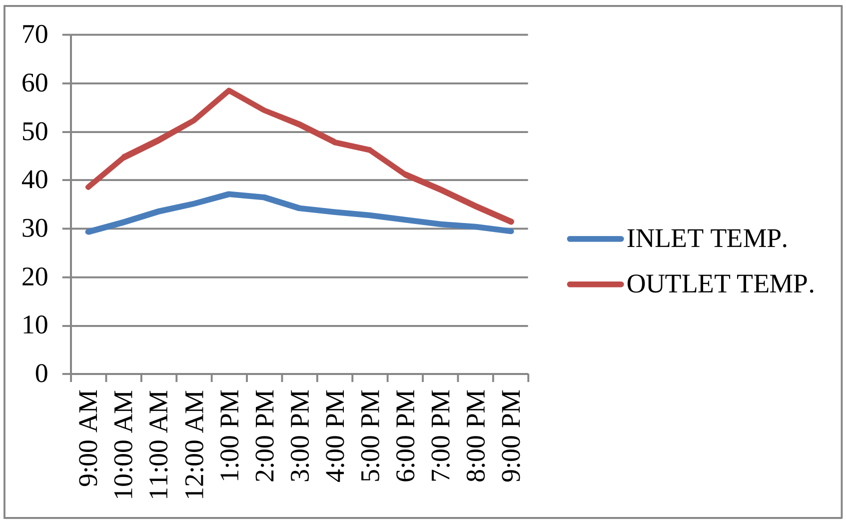

Figure 6.2- Graph for flow rate 3 lph

Table 6.3Without PCM, Date- 4-4-2018

TIME	INLET TEMP°C	OUTLET TEMP°C
9:00 AM	29	38.7
10:00 AM	31.4	42.3
11:00 AM	32.8	49.2
12:00 AM	34.5	54.7
1:00 PM	37.2	57.8
2:00 PM	35.7	53.9
3:00 PM	34.8	50.4
4:00 PM	33.4	48.7
5:00 PM	33.1	47.6
6:00 PM	32.6	45.4
7:00 PM	31.2	40.5
8:00 PM	30.4	36.2
9:00 PM	29.8	33.8

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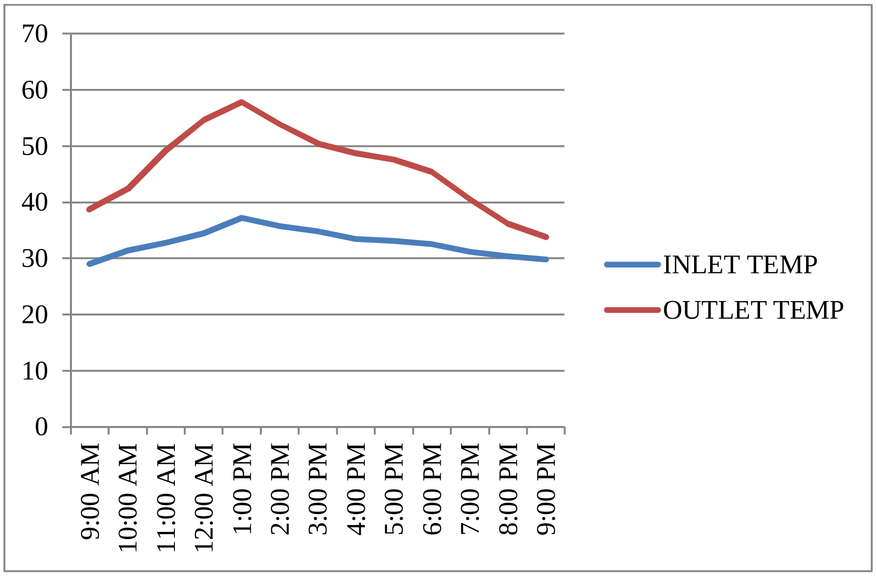

Figure 6.3- Graph for flow rate 2 lph

Table 6.4 Without PCM, Date- 08-04-2018

TIME	INLET TEMP.°C	OUTLET TEMP.°C
9:00 AM	31.4	39.8
10:00 AM	33.4	42.7
11:00 AM	34.9	49.6
12:00 AM	36.5	56.7
1:00 PM	38.7	58.6
2:00 PM	39.2	59.2
3:00 PM	38.4	57.4
4:00 PM	37.3	55.3
5:00 PM	36.6	51.4
6:00 PM	35.3	46.5
7:00 PM	34.5	40.6
8:00 PM	32.8	34.8
9:00 PM	31.5	32.6

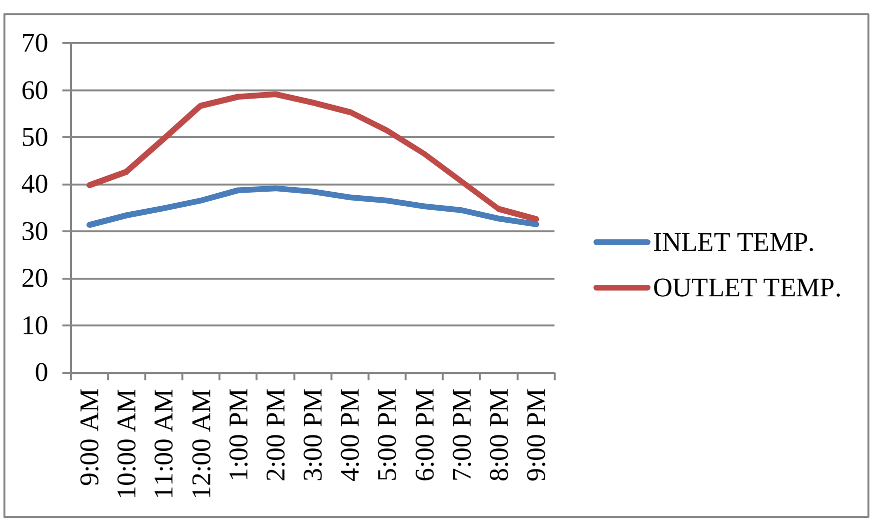

Figure 6.4- Graph for flow rate 3 lph

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B. Readings with PCM

Table 6.5 With PCM, Date- DATE=21-02-18

TIME	INLET TEMP°C	OUTLET TEMP°C	PCM TEMP°C
9:00 AM	29.4	39.4	38.4
10:00 AM	30.7	44.3	43.4
11:00 AM	32.4	47.9	46.1
12:00 AM	34.6	52.8	49.2
1:00 PM	35.9	53.4	51.3
2:00 PM	34.2	52.3	48.6
3:00 PM	33.8	50.6	47.3
4:00 PM	33.1	48.2	46.2
5:00 PM	30.3	46.7	45.3
6:00 PM	29.7	44.8	42.7
7:00 PM	28.4	41.6	41.6
8:00 PM	27.9	39.6	40.3
9:00 PM	27.6	38.4	39.8

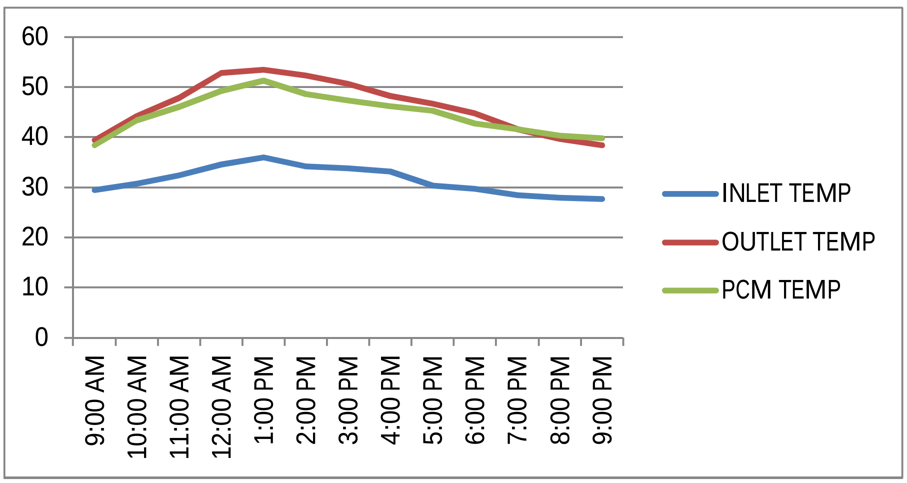

Figure 6.5- Graph for flow rate 3 lph

Table 6.6 With PCM, Date- 25-02-2018

TIME	INLET TEMP.°C	OUTLET TEMP.°C	PCM TEMP.°C
09:00	28.3	40.8	38.1
10:00	29.9	45.3	42.7
11:00	31.6	49.2	46.8
12:00	33.7	52.4	50.8
01:00	36.4	56.8	53.2
02:00	35.8	54.3	53.1
03:00	33.4	52.9	52.8
04:00	32.8	51.7	50.3
05:00	32.1	48.7	47.6
06:00	31.6	46.2	45.2
07:00	31	42.1	43.1
08:00	29.4	40	41.2
09:00	29.1	38	39.7

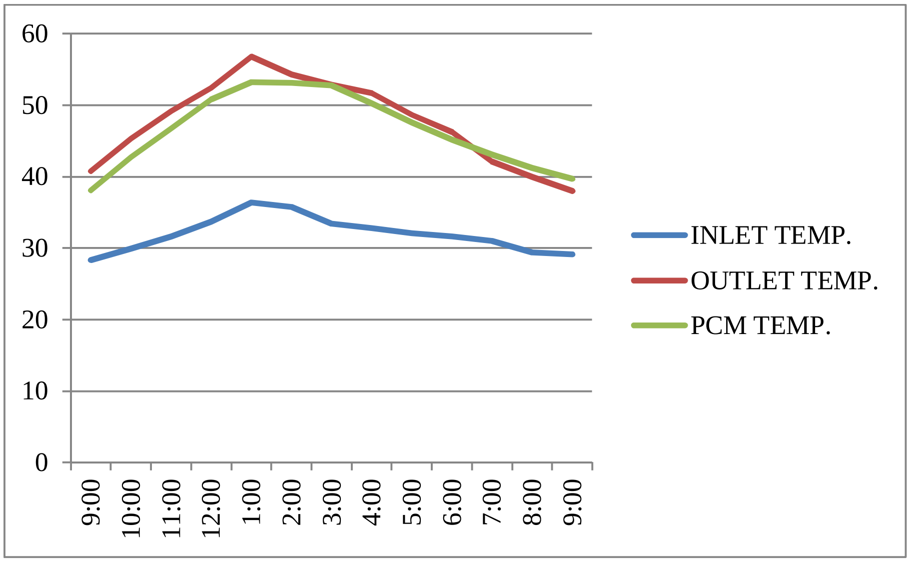

Figure 6.6- Graph for flow rate 2 lph

Table 6.7With PCM, Date- 5-4-2018

TIME	INLET TEMP°C	OUTLET TEMP°C	PCM TEMP.°C
9:00 AM	29.6	40.4	37.5
10:00 AM	28.1	43.2	41.2
11:00 AM	31.4	49.7	46.8
12:00 PM	32.4	51.8	49.4
1:00 PM	34.8	54.6	52.3
2:00 PM	33.9	53.2	51.7
3:00 PM	32.7	51.8	50.4
4:00 PM	30.5	48.2	50.1
5:00 PM	30.2	47.6	48.7
6:00 PM	29.4	43.2	43.33
7:00 PM	29.2	39.7	42.7
8:00 PM	29	39.2	41.2
9:00 PM	28.7	38.6	40.7

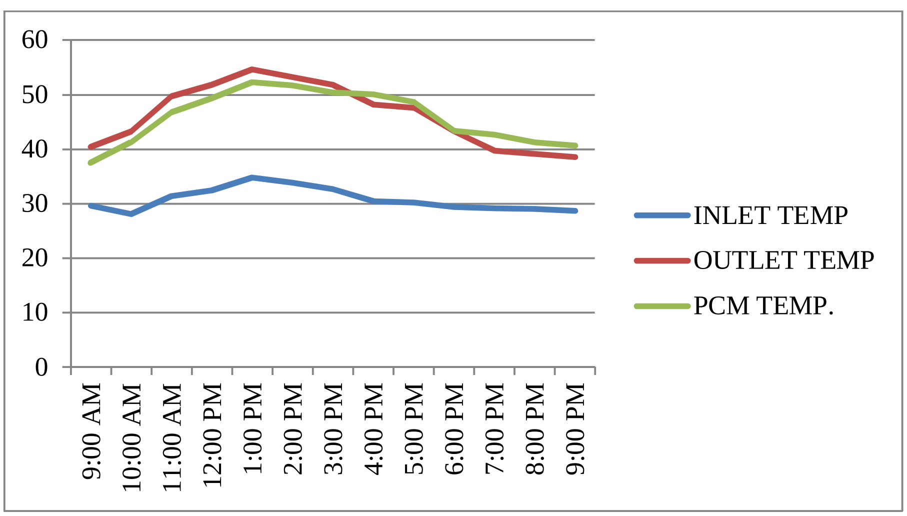

Figure 6.7- Graph for flow rate 3 lph

C. *For Helical Copper Tube*

Readings without PCM,

Table 6.8 Without PCM date 22-2-2018

TIME	INLET TEMP.°C	TEMP . OUTLET°C
9:00 AM	29	33
10:00 AM	31	36
11:00 AM	32.6	42.5
12:00 PM	34.5	50
1:00 PM	36.8	53
2:00 PM	35.7	52
3:00 PM	33.3	49
4:00 PM	32.1	43.5
5:00 PM	31.5	42.2
6:00 PM	30.4	40
7:00 PM	29.6	37.1
8:00 PM	29.2	36.3
9:00 PM	28.5	34

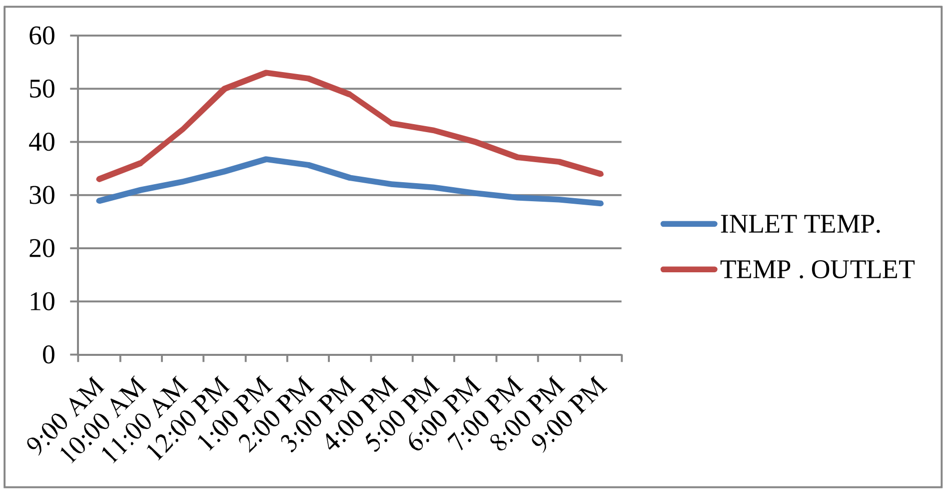

Figure 6.8- Graph for flow rate 8 lph

Table 6.9 Without PCM date 26-02-2018

TIME	INLET TEMP.°C	OUTLET TEMP.°C
9:00 AM	29.3	38
10:00 AM	31.4	44
11:00 AM	33.6	48
12:00 AM	35.2	53
1:00 PM	37.2	58
2:00 PM	36.5	52
3:00 PM	34.2	50
4:00 PM	33.4	46
5:00 PM	32.8	45
6:00 PM	31.8	42
7:00 PM	30.9	40
8:00 PM	30.4	37
9:00 PM	29.5	34

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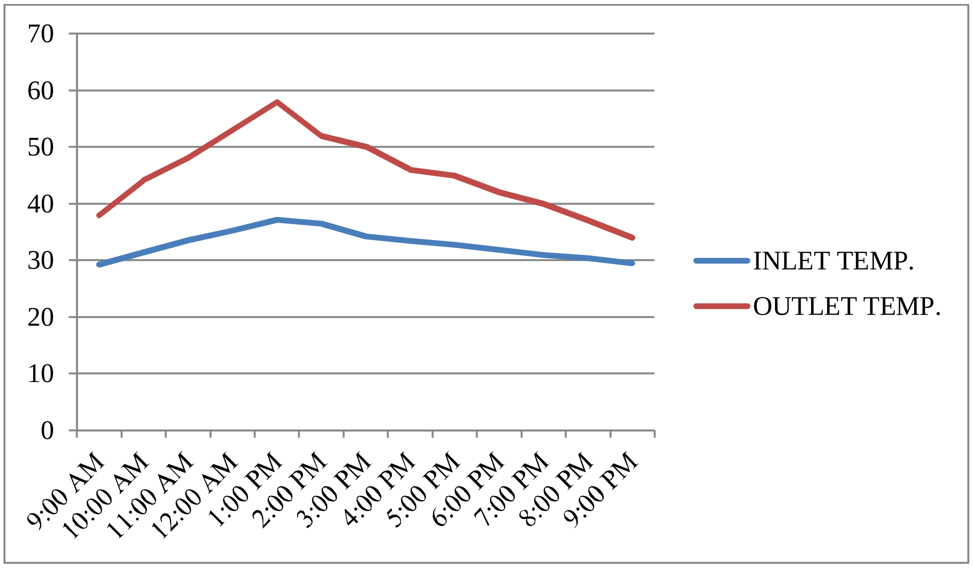

Figure 6.9- Graph for flow rate 8 lph

Table 6.10Without PCM date 6-4-2018

TIME	INLET TEMP	OUTLET TEMP
9:00 AM	29	38.7
10:00 AM	31.4	42
11:00 AM	32.8	50
12:00 AM	34.5	55
1:00 PM	37.2	58
2:00 PM	35.7	53
3:00 PM	34.8	50
4:00 PM	33.4	48
5:00 PM	33.1	46
6:00 PM	32.6	44.5
7:00 PM	31.2	42.5
8:00 PM	30.4	38.2
9:00 PM	29.8	35

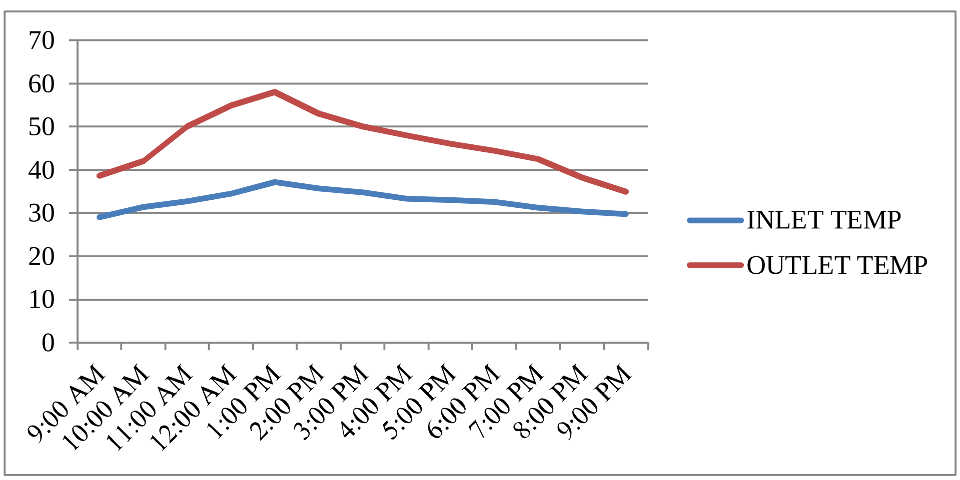

Figure 6.10- Graph for flow rate 8 lph

Table 6.11Without PCM date 10-4-2018

TIME	INLET TEMP.	OUTLET TEMP.
9:00 AM	31.4	40
10:00 AM	33.4	43
11:00 AM	34.9	50
12:00 AM	36.5	57
1:00 PM	38.7	59.6
2:00 PM	39.2	57.2
3:00 PM	38.4	52.4
4:00 PM	37.3	48.3
5:00 PM	36.6	45
6:00 PM	35.3	41
7:00 PM	34.5	39
8:00 PM	32.8	37
9:00 PM	31.5	35

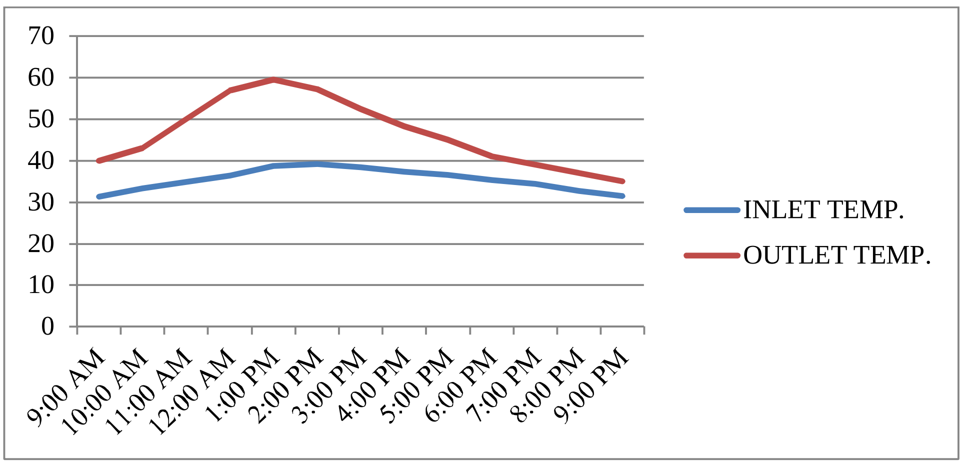

Figure 6.11- Graph for flow rate 8 lph

D. Readings With PCM,

Table 6.12 With PCM date 23-2-2018

TIME	INLET TEMP	OUTLET TEMP	PCM TEMP
9:00 AM	29.4	40	38
10:00 AM	30.7	44	43
11:00 AM	32.4	48	47
12:00 AM	34.6	53	50
1:00 PM	35.9	54	52
2:00 PM	34.2	53	48
3:00 PM	33.8	51	49
4:00 PM	33.1	48	47
5:00 PM	30.3	46	45
6:00 PM	29.7	44	42
7:00 PM	28.4	41.6	41.6
8:00 PM	27.9	39	40
9:00 PM	27.6	37	39

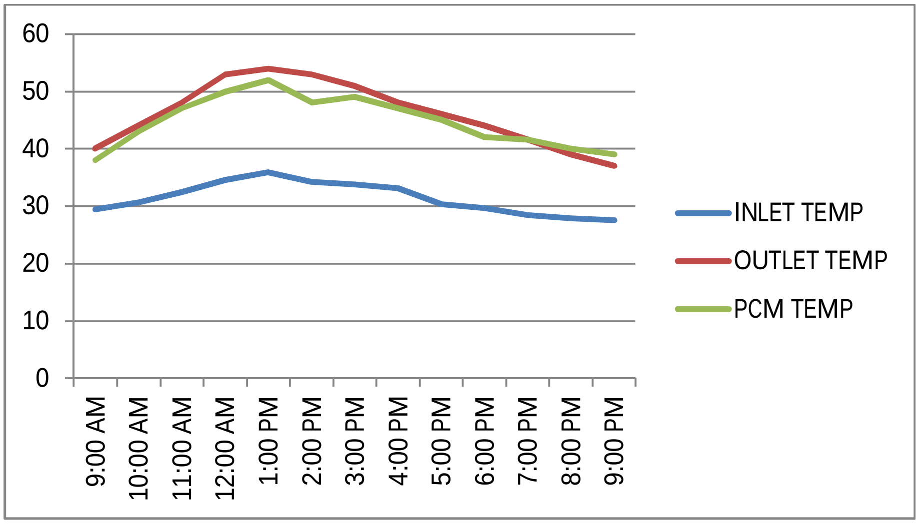

Figure 6.12- Graph for flow rate 10 lph

Table 6.13 With PCM date 27-02-2018

TIME	INLET TEMP.	OUTLET TEMP.	PCM TEMP.
09:00	28.3	40.8	38.1
10:00	29.9	45.3	42.7
11:00	31.6	49.2	46.8
12:00	33.7	52.4	50.8
01:00	36.4	56.8	53.2
02:00	35.8	54.3	53.1
03:00	33.4	52.9	52.8
04:00	32.8	51.7	50.3
05:00	32.1	48.7	47.6
06:00	31.6	46.2	45.2
07:00	31	42.1	43.1
08:00	29.4	40	41.2
09:00	29.1	38	39.7

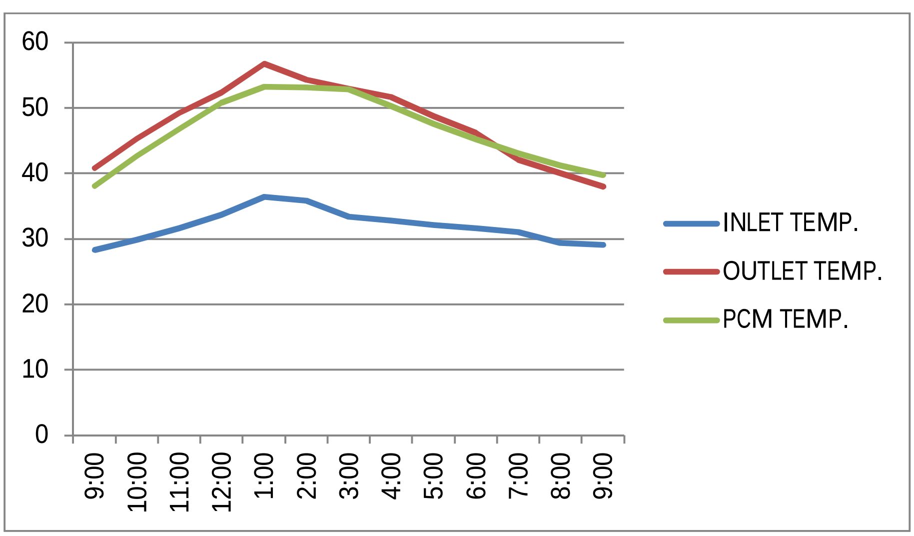

Figure 6.13- Graph for flow rate 10 lph

Table 6.14 With PCM date- 7-4-2018

TIME	INLET TEMP	OUTLET TEMP	PCM TEMP.
9:00 AM	29.6	40.4	38
10:00 AM	28.1	43.2	41
11:00 AM	31.4	50	47
12:00 PM	32.4	52	50
1:00 PM	34.8	56	54
2:00 PM	33.9	53.2	51.7
3:00 PM	32.7	52	50
4:00 PM	30.5	48	50
5:00 PM	30.2	46	47.5
6:00 PM	29.4	43.2	43.33
7:00 PM	29.2	39	42
8:00 PM	29	38	40
9:00 PM	28.7	36	39

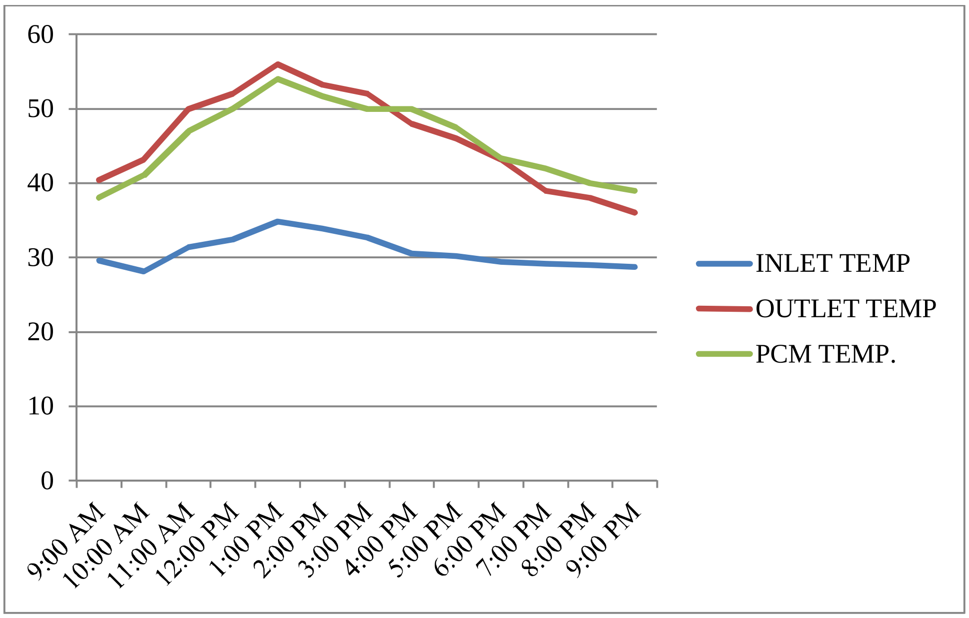

Figure 6.14- Graph for flow rate 10 lph

VI. CONCLUSION

A parabolic solar System has been designed, built and tested. The experimental results showed that the favourable conditions of elevated temperature may be achieved. In this study, a solar concentrator design has been installed.

This equipment is based on a parabolic concentrator. Experimental measurements temperature distribution on the receiver has been carried out. By using parabolic concentrator, there is increase in temperature more than the parabolic concentrator.

A. The heat energy is absorbed and released by changing state of PCM melting temperature.

B. After complete melting is achieved, further heat addition from the water causes the PCM to superheat, thereby again storing heat sensibly.

C. As the phase change material melts its decreases its density and increases the volume.

D. Along with the enhanced functionality of the solar heaters the efficiency of the same during normal operations was found to be increased by 26%

E. The best hour for getting maximum temperature was between 12h: 30 – 13h: 30.The sun concentration was more effective if the solar tracking is perfect.

REFERENCES

[1] Experimental Studies on Phase Change Material-Based Thermal Energy Storage System for Solar Water Heating Applications R. Meenakshi Reddy,1 N. Nallusamy,2 and K. Hemachandra Reddy3 1Sri Venkateswara College of Engineering & Technology, Chittoor 517 127, India 2Sri Venkateswara College of Engineering, Sriperumbudur 602 105, India 3Jawaharlal Nehru Technological University Anantapur, Anantapur 516 390, India Address correspondence to R. Meenakshi Reddy, rmreddy123@gmail.com

[2] Experimental studies on PCM filled Flat Plate Solar Water Heater without and with Fresnel lens glazing R. Sivakumar. Int. Journal of Engineering Research and Application ISSN : 2248-9622, Vol. 6, Issue 7, (Part -5) July 2016, pp.43-46

[3] INTEGRATED SOLAR COLLECTOR STORAGE SYSTEM BASED ON A SALTHYDRATED PHASE CHANGE MATERIAL. Solar energy vol. 55 no. 6, pp 435-444, 1995 copyright ©1995 Elsevier science ltd. Printed in the usa.

[4] International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974 IJAERS/Vol. II/ Issue III/April-June, 2013/89-92, COMPARATIVE STUDY OF SOLAR WATER HEATER WITH AND WITHOUT LATENT HEAT STORAGE SYSTEM, Mr. F.B.A. Amin, Prof. A.M. Patil, Prof. H.M. Dange

[5] International journal of science, spirituality, business and technology (ijssbt), Vol. 3, No. 1, Dec 2014 ISSN (Print) 2277—7261 39 improving efficiency of solar water heater using phase change materials Mr. M.V. Kulkarni, Dr. D. S Deshmukh

[6] J.A. Duffle, Reflective solar cooker designs. Trans. Con[i on the Use of Solar Energy, University of Arizona, Tucson, AZ, 3, 79 86 (1955).

[7] J. R. Jennes, Jr, Recommendation and suggested tech- niques for the manufacture of inexpensive solar cookers. Solar Energy 4, 22 24 (1960).

[8] G. O. G. L6fand D. Fester, Design and performance of folding umbrella-type solar cooker. Proc. UN Con[i on New Sources of Energy, Rome, Paper 5/100, Vol. 5, pp. 347 352 (1961).

[9] H. Tabor, A solar cooker for developing countries. Solar Energy 10, 153- 157 (1960).

[10] J. A. Duffle, G. O. G. L6f and B. Beck, Laboratory and field studies of plastic reflector solar cooker. Solar Energy 6, 94 98 (1962).

[11] M. L. Ghai, Performance of reflector type direct solar cooker. J. Sci. Ind. Res. 12A, 165175 (1953).

[12] M. L. Khanna, Heating of vegetable oil. Solar Energy 6, 60 63 (1962).

[13] S. Natraja Murthy and N. Narasaiah, Energy dis- tribution in the focal region of an offset feed paraboloid solar stove. Solar Energy 34, 279 285 (1985).

[14] D. Mishra, C. K. Teckchandani and N. M. Nahar, Per- formance and testing of a parabolic spheroidal con- centrator type solar cooker. Reg. J. Energy Heat Mass Tran~?[br9, 51 55 (1987).

[15] S. C. Mullick,T. C. Kandpal and Subodh Kumar, Ther- mal test procedure for a paraboloid concentrator solar cooker. Solar Eneryy 46, 139 144 (1991).

[16] Subodh Kumar, T. C. Kandpal and S. C. Mullick, Effect of wind on heat loss factor for a paraboloid solar cooker. Paper presented at NSEC 1992, held at I.I.T., Delhi (1992).