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Solar Water Heater with Rotating Reflectors and Light Dependent Resistor (LDR)

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Abstract: *Solar energy is a type of renewable energy and it is expected to play a very important role in the future world. The purpose of this project is to increase the efficiency of solar water heating system by using moving reflectors, which tracks the sun's rotation using light dependent diodes. In today's world solar energy applications are enhanced. Like solar water heating systems.it can be used as an alternative to replace the electrical water heating system. Solar energy helps in reducing the consumption of limited resources, such as petroleum resources. Solar energy is used in many applications like in solar water heater which is used in domestic (provides hot water) as well as in industrial (generates electricity).Heating water by using sun energy is not a new idea. In the past century many countries used black painted water tanks as simple solar water heaters. Solar energy applications have improved greatly in the last 3-4 decades.*

Keywords: *Efficiency Renewable Energy Sources , Solar Energy , Solar Water Heater.*

I. INTRODUCTION

Solar water heater absorbs the sun energy (solar radiation) falling on the reflector and converts this energy into heat and transfer this heat to water flowing through the heater.

1.1 Types of solar water heating systems:

In Asia specially in India, where the countries energy imports account for more than 65% of total exports, fossil fuels are often scarce, making solar thermal energy one of the few low cost options available. Generally solar water heater can be classified in two categories:

(i) Direct absorption of solar radiation where the sun's rays incident on the absorber material after passing through a transparent material.
(ii) Indirect solar water heater where the water is fast heated in a solar collector and then stored in a storage tank.

1.2 Passive and Active solar water heating system:

In passive solar water heating system, the absorber pipe is coated with a material that absorbs the solar radiation falling on it. Surface is coated with the black paint which can absorb maximum solar radiation(more than others). The absorbed solar radiation is converted into heat. Some of this absorbed heat is conducted through the pipe to the riser tubes and then through the riser tubes walls to the water. This will increase the water temperature. Some of the heat is lost to the surroundings. The passive solar water heating systems are cheap and have very low or no maintenance, but the efficiency of a passive system is generally lower than the active solar water heater system .The heat loss should be keep as low as possible.

1.3 Methods of reducing heat loss:

- By putting the absorber pipe in an insulating box.
- By placing extra insulation behind the absorber pipe to reduce heat loss from the back of the pipe.
- By placing a transparent cover over the box for two reasons
  (a) It prevents the wind from blowing over the hot absorber pipe and cooling it.
  (b) It transmits solar energy but prevents heat radiated from the absorber pipe.

Active solar water heating systems use one or more pumps to circulate water in the system.Acive system have more efficiency than the passive system.

1.4 Solar power in India:

India has high solar insolation, ideal for using solar power in India .In the solar energy sector, some large projects have been proposed, and a 35,000 km^2 (14,000sq mi) area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 GW. Solar Energy in India is one of the most exciting growing industries in the world right now. Solar Energy in India is poised to take off in a exponential manner because of a unique confluence of favorable Supply and Demand factors. In India the rates of electricity are going up rapidly each year due to various factors like higher costs of fossil fuels, increasing capital expenditure by utilities and privatization of power .And the cost of solar energy is very low comparatively .So the solar water heating system is a very good alternate in India to replace the electrical water heating system.

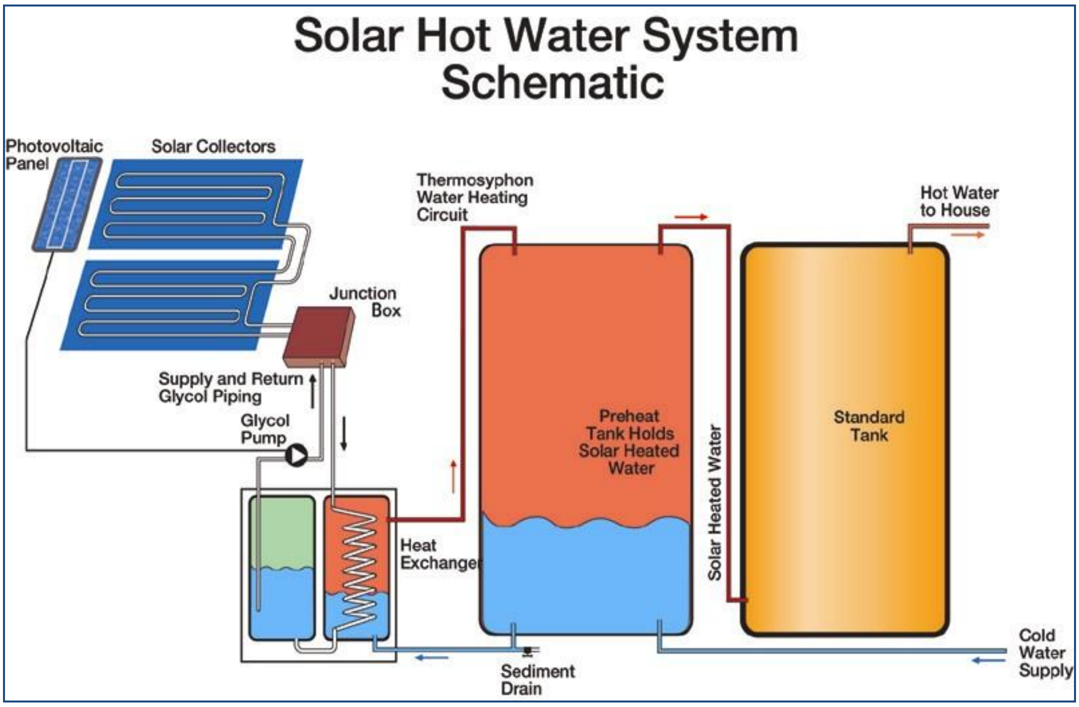


Fig-1 SWH Schematic Diagram

II. Design

2.1 Specifications

- Cardboard base of dimension **18*12 inches**
- Aluminum sheet of dimension **21*15 inches**
- Wooden frame of dimension 18*12*1.3 inches with inside border of 0.78 inch
- Copper pipe of length 96 inch & mean diameter of 0.27 inch with outlet tap, inlet pipebeing connected to plastic pipe
- Acrylic sheet of dimension 18*12 inches

2.2 Fabrication Methods

A wooden frame of above dimension is fixed to the cardboard base initially with the help of the nails .The holes are drilled in the wooden frame on left bottom and top right side for inlet & outlet flow of water through copper pipes.

Aluminum sheet is placed over an entire frame combination and fixed to wooden frame. Copper pipe is bent in shape of ‘U’ to provide large exposure of solar energy to flowing water. Finally, An acrylic sheet secured firmly to wooden frame for completion of FPC

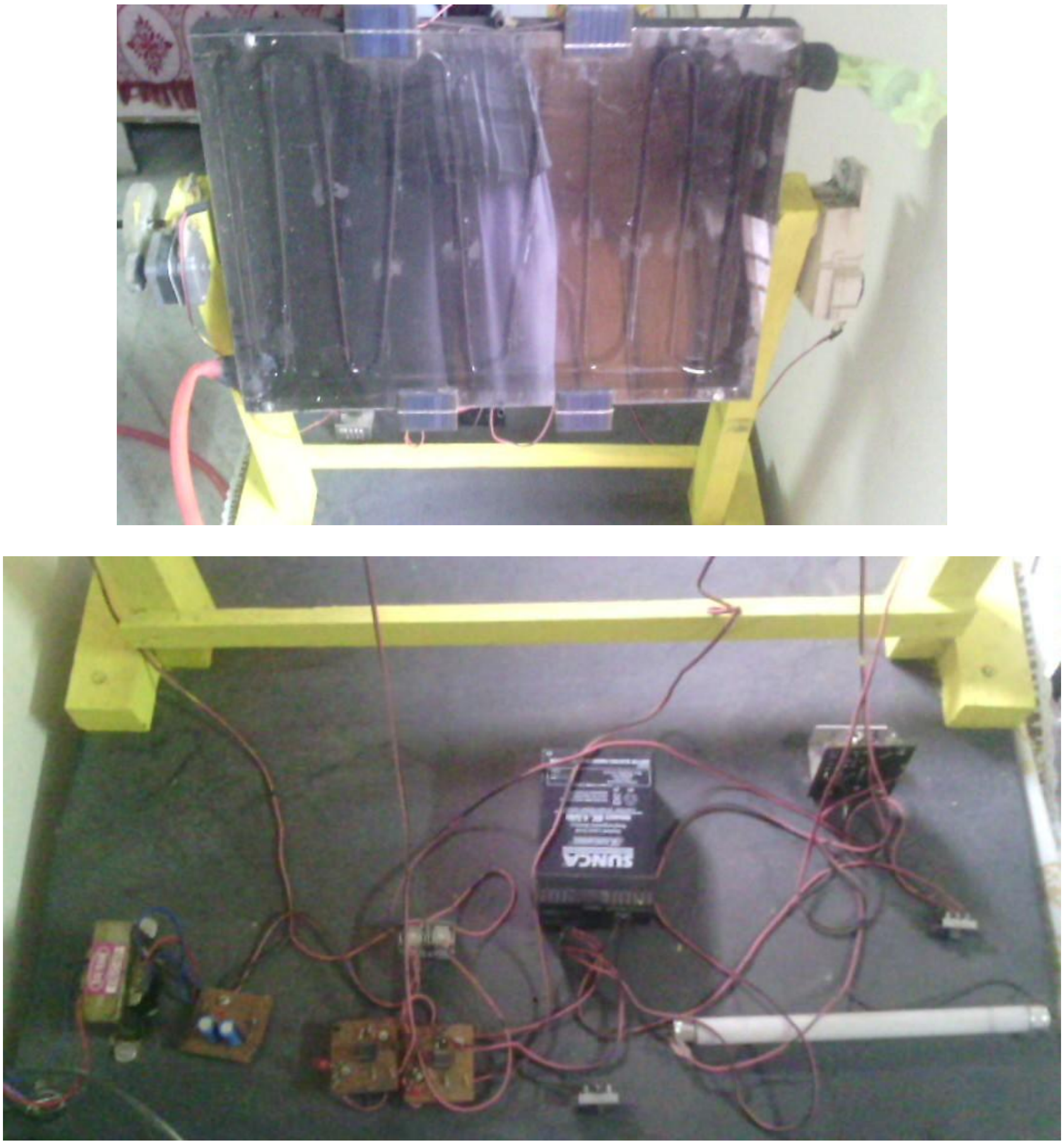


Fig-3 Flat Plate Collector

- Step Down Transformer is used that convert 220v AC supply to 12v AC supply.
- Dual Power Supply that works as a rectifier which convert 12v AC supply to 12v DC supply and works as dual +ve as well as –ve voltage regulator between 24v to 12v.
- 2 LDR circuits. are attached to the battery as per the connections shown in Fig-4.
- Relay which act as circuit breaker in either operating condition of one of the LDR connected to the motor,
- LDR which are light dependent resistors whose resistance vary with the intensity of solar light intercepted .These are used in pairs on both side of FPC to reverse it automatically according to the sun's rotation
- 4-3v each solar cells get attached to FPC generates electricity to power up the battery whose efficiency also improved by facing always towards sun
- 12v motor is attached to shaft which is fixed to FPC to provide desired angular rotation w.r.t. sun
- 6v Battery which gets charged from dual power source , one being solar cells and other is dynamo attached to shaft producing electricity through simple EMI principle.
- 6w Tube light is also joined just to demonstrate the use of solar cells which can be used to heat water in absence of electricity and sun using immersion rod connecting it to rechargeable battery.

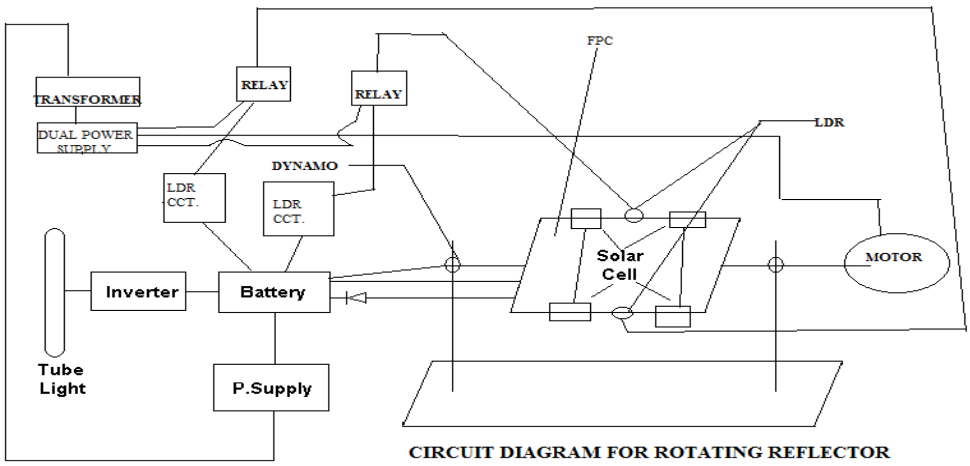


Fig-4

2.3 Storage Tank

A insulated (to reduce heat losses) plastic bucket of 40 litre capacity is used for hot water storage along with cover. A separate hole is made on cover for the easy movement of outlet plastic pipe along with rotation of FPC. Another hole of small size is made to accommodate the digital thermometer to measure hot water temperature.

Fig 5

III. Theoretical Analysis

Length of Acrylic sheet = 18 inch
Breadth of Acrylic sheet = 12 inch
Area of Acrylic sheet = 0.140 m^2

Length of Copper pipe = 240 cm
Diameter of Copper pipe = 0.7 cm
Area of copper pipe(A_c) = πDL = 527.8 cm^2
= 0.053 m^2
Average daily solar intensity falling on India (I_T) = 5000 w/m^2
Transmittance value of Acrylic sheet (T) = 0.92
Solar energy trapped by Acrylic sheet = T . I_T = 0.92*5000
= 4600 w/m^2
Absorptivity value of copper pipe(α) = 0.6
Heat energy gained by copper pipe(H_c) = α.4600.A_c
= 0.6*4600*0.053
= 146.28 w

IV. Experimental Results

4.1 Table I

Initial level of water in Bucket (l)	Measured level of water at Reading (l)	Time taken (seconds)
13	12	1020
12	11	1020
11	10	1020
9	8	1020

Discharge through outlet pipe = 0.98ml/s
Mass flow rate = 0.98gm/s
Assuming no pipe loss through plastic pipe
Heat energy absorbed by water = m*c*Δt
Taking T_{mean} = 38$^{\cdot}$c
Ambient temperature = 29$^{\cdot}$c
Δt = 9$^{\cdot}$c
Specific heat of water (c) = 4.186 J/gm$^{\cdot}$c
Heat energy absorbed by water(H_W) = 0.98*4.186*9
=36.9 w
Mean efficiency (η_{mean}) = Heat energy absorbed by water/Amount of energy absorbed by copper pipe
η_{mean} = 36.9/146.28
= 25%

4.2 FPC-ROTATING (Weather Condition :Sunny)

(Date 06.05.14)
Weather condition – Sunny
FPC – Rotating

<table>
<tr><th>Day Time</th><th>Inlet water temp. (°C)</th><th>Outlet water Temp. (°C)</th><th>Temperature Difference (°C)</th><th>EE_W (w)</th><th>E_C (w)</th><th>Efficiency %</th></tr>
<tr><td>10.30 a.m.</td><td>27.8</td><td>31.9</td><td>4.1</td><td>16.41</td><td rowspan="11">146.28</td><td>11.2</td></tr>
<tr><td>11.00 a.m.</td><td>27.9</td><td>33.6</td><td>5.7</td><td>22.56</td><td>15.42</td></tr>
<tr><td>11.30 a.m.</td><td>28</td><td>35.8</td><td>7.8</td><td>32.81</td><td>22.43</td></tr>
<tr><td>12.00 p.m.</td><td>28.6</td><td>39.4</td><td>10.8</td><td>43.48</td><td>29.72</td></tr>
<tr><td>12.30 p.m.</td><td>29</td><td>43</td><td>14</td><td>56.6</td><td>38.7</td></tr>
<tr><td>1.00 p.m.</td><td>29.5</td><td>44</td><td>14.9</td><td>60.2</td><td>41.2</td></tr>
<tr><td>1.30 p.m.</td><td>29.9</td><td>44.9</td><td>14.7</td><td>59.9</td><td>41</td></tr>
<tr><td>2.00 p.m.</td><td>30</td><td>44.8</td><td>14.8</td><td>60.7</td><td>41.5</td></tr>
<tr><td>2.30 p.m.</td><td>30</td><td>44.7</td><td>14.7</td><td>60.4</td><td>41.2</td></tr>
<tr><td>3.00 p.m.</td><td>29.7</td><td>44.5</td><td>14.8</td><td>59.9</td><td>40.9</td></tr>
<tr><td>3.30 p.m.</td><td>29.7</td><td>43.3</td><td>13.4</td><td>55.1</td><td>37.58</td></tr>
<tr><td>4.00 p.m.</td><td>29.6</td><td>41.3</td><td>11.7</td><td>47.99</td><td></td><td>32.81</td></tr>
<tr><td>4.30 p.m.</td><td>29.6</td><td>40.5</td><td>11</td><td>10.9</td><td></td><td>30.84</td></tr>
<tr><td>5.00 p.m.</td><td>29.4</td><td>40</td><td>10.6</td><td>43.37</td><td></td><td>29.7</td></tr>
</table>

Table 2

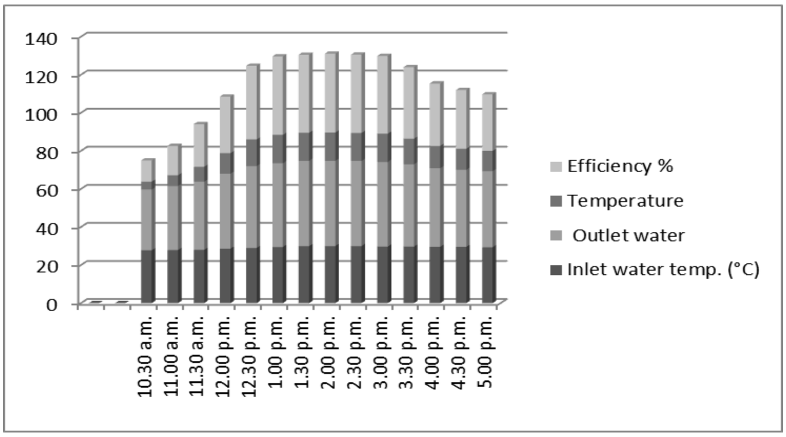
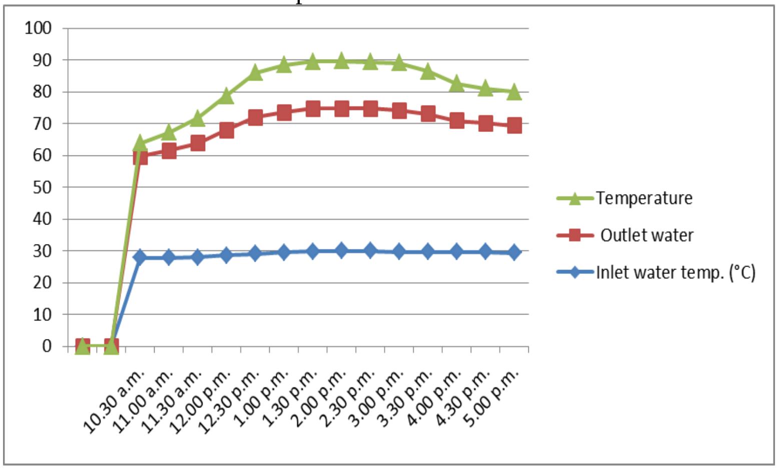


Fig 6
Graph Based On Table 2



4.3 FPC-ROTATING (Weather Conditions: Partly Cloudy)

(Date 08.05.14)

Weather condition – Partly cloudy

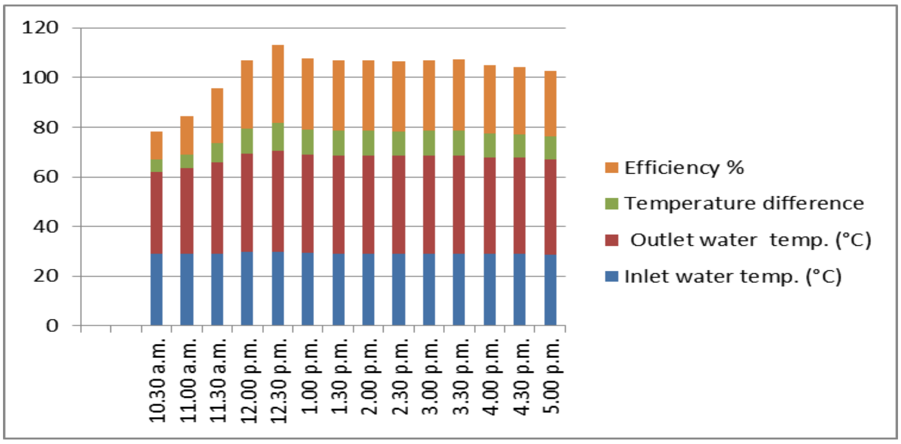
FPC - Rotating

For mass flow rate $\mathring{m}$ = 59gm/min

Day Time	Inlet water temp. (°C)	Outlet water temp. (°C)	Temperature difference	$E_{W(w)}$	E_C	Efficiency %
10.30 a.m.	29	33	5	16.41	146.28	11.2
11.00 a.m.	29	34.5	5.5	22.56		15.42
11.30 a.m.	29	36.8	7.8	31.99		21.87
12.00 p.m.	29.7	39.6	9.9	40.6		27.76
12.30 p.m.	29.7	40.9	11.2	45.94		31.41
1.00 p.m.	29.3	39.5	10.2	41.8		28.6

1.30 p.m.	29.2	39.3	10.1	41.43		28.3
2.00 p.m.	29.2	39.3	10.1	41.43		28.3
2.30 p.m.	29.2	39.2	10	41.02		28.04
3.00 p.m.	29.2	39.3	10.1	41.43		28.3
3.30 p.m.	29.1	39.4	10.2	41.84		28.6
4.00 p.m.	29	38.6	9.8	40.2		27.48
4.30 p.m.	29	38.6	9.6	39.38		26.9
5.00 p.m.	28.8	38.2	9.4	38.56		26.36

Table 3



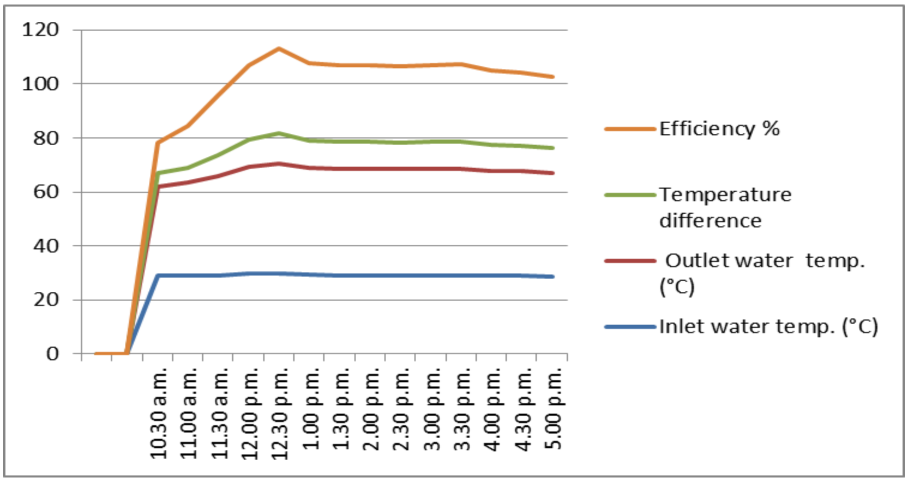


Fig 8 Graphs Based On Table 2

4.4 FPC-STATIONARY & FACING TOWARDS SOUTH

(Weather Conditions: Sunny)

(Date 06.05.14)

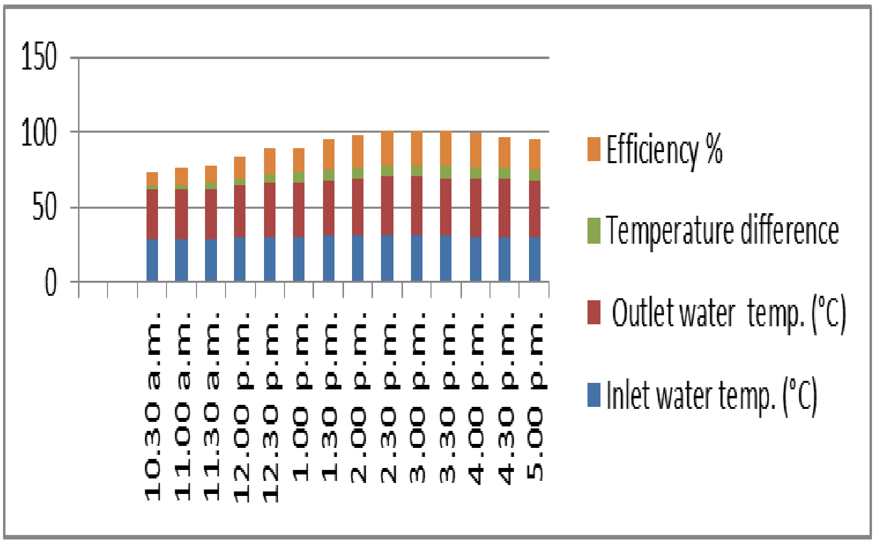
Weather condition – Sunny

FPC - Stationary & facing towards South

Day Time	Inlet water temp. (°C)	Outlet water temp. (°C)	Temperature difference	$E_{W\,(w)}$	E_C	Efficiency %
10.30 a.m.	29	32.3	3.3	13.53	146.28	9.2

11.00 a.m.	29	32.7	3.7	15.17		10.3
11.30 a.m.	29	33.2	4.2	17.23		11.77
12.00 p.m.	29.5	34.5	5	20.51		14.2
12.30 p.m.	30	35.5	6.1	25		17.1
1.00 p.m.	30.3	36.4	6.1	25		17.1
1.30 p.m.	30.7	37.4	7	28.71		19.6
2.00 p.m.	31	38.5	7.5	30.77		21.03
2.30 p.m.	31	39	8	32.8		22.42
3.00 p.m.	30.8	39.1	8.3	34.05		23.3
3.30 p.m.	30.8	38.9	8.1	33.23		22.7
4.00 p.m.	30.6	38.5	7.9	32.41		22.16
4.30 p.m.	30.6	38.1	7.5	30.76		21.03
5.00 p.m.	30.3	37.4	7.1	29.13		19.9

Table 4



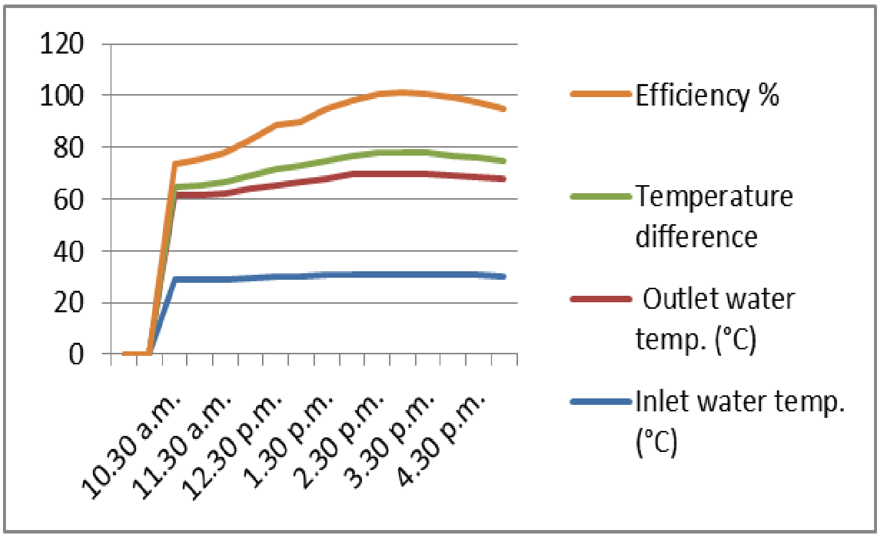


Fig 9 Graphs Based On Table 4

V. Conclusion

The efficiency of the solar water heater depends on the heat intensity. The more the intense heat on absorber pipe the more the water heater is efficient.

The intensity of solar energy varies according to the sun position. Thus the intensity is depending at different time in a day.

The solar cell was used to measure the intensity of solar radiation. When the sky was cloudy the intensity of solar radiation was less. It was found from the experimental data that the efficiency was high at noon, it increases from 9.00 am to 12.30 pm and decreases after 1.00 pm.

The project work was started with the four main objectives and those were design, fabrication and performance test of a solar water heater and all the objectives have been fulfilled. The main point of view was to make a simple design and to minimize the cost and to use the local available materials properly. The design of the heater was made carefully and the materials required for fabrication were selected, which were inexpensive comparison with the other materials. The highest efficiency was found at noon. Due to discontinuity of flow rate and variation of intensity the efficiency was not found accurately. The efficiency was found different at different water flow rate.

The main consideration is to improve stationary FPC efficiency by rotating with sunlight which however increases SWH efficiency. But the use of external power supply limits its effectiveness that reduces its overall performance, this can be compensated by the use of solar cell combination that drive LDR cct. and tubelight.

Hence , future scope of this project is to remove dependency of SWH on external power to rotate as tracking solar rays.

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