Working Efficiency Analysis of Working Solar Water Heater with FPC

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ABSTRACT
To ensure alternative sources of energy that are clean, reliable stable and sustainable solar energy being emerging major need in today era of expensive fuels which is used to boil water for industrial and domestic purpose . An setup of Two moveable solar water heaters with FPC's (flat plate collector solar panel fitted) of 100 liter and 200 liter were placed in roof top open sky space made available. The data of 12 months have been collected and performance of analyzed in this paper. It is found that the incoming hot tap water is about 30˚C higher than the room temperature during day time during winter months. This is about 25˚C in afternoon hours.

Keywords
Solar Water Heater, Thermosyphon Solar, Flat Plate Collector Type panel (FPC).

1. INTRODUCTION
Solar power is a form of energy harnessed from the power and heat of the sun's rays. It is renewable, and therefore a "green" source of energy.Greatest amount of solar energy is available in two broad bands [1] encircling the earth between 15˚ and 35 ˚ latitude north and south. The next best position is the equatorial belt between 15˚N and 15˚S latitude [2]. Most of the developing countries, being situated in [3] these regions, are in a favorable position in respect of solar energy. Average daily solar irradiation [5] at flat surface is around 5.0 to 7.5 kWh/m^2 (Figure 1.1). Solar water heaters are used all over the world [6,7] specifically in sunny countries where sun shine is abundant. The hot water is used for household purpose and in restaurants, hospitals, dormitories, etc. for cleaning dishes and other works. These heaters are also used for preheating water for industrial purpose. Most of the water heaters are of Chinese origin and of Indian origin. As the water heaters are installed for 14 months on a building so data of 1 year (12 months) have been collected and analyzed. However, the data collected in the winter time contains some useful information.

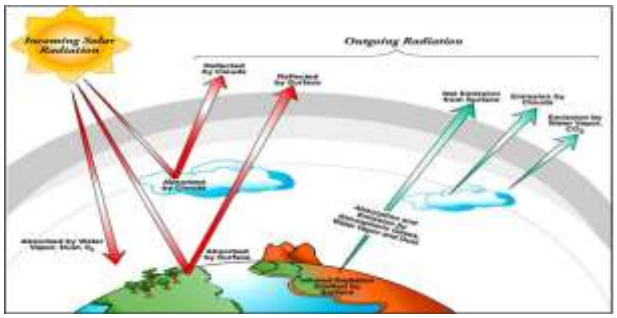

Figure – 1.1 Natural solar radiation on earth {source : [1]}

2. SOLAR ENERGY USES
Just like wind power , solar power is a virtually unlimited and inexhaustible resource (unlike power produced from expendable fossil fuels) Most of the solar energy uses [8] are concerned with trapping sunlight as photovoltaic (PV) heat. Because of the low energy density of sunlight, the higher the temperature needed the more complicated and expensive [9] the system will be. Depending on the range of temperature use, solar thermal uses [10] are divided into the three broad categories:

1. Low temperature applications (below 100˚C), such as solar drying, hot water supplies, cooking .

2. Medium temperature applications (below 150˚C), such as refrigeration, industrial process heat, etc.
3. High temperature (above 150˚C) applications, such as electricity generation ,power plants.

3. SOLAR WATER HEATER
As In any collection device, the principle usually followed is to expose a dark surface to solar radiation so that the radiation is absorbed. A part of the absorbed radiation is then transferred to a fluid like air or water. When no optical concentration is done, the device in which the collection is achieved is called a flat-plate collector.

Figure – 3.1 Inner section of flat plate collector

collector is the most important type of solar collector because it is simple in design, has no moving parts and requires little maintenance. It can be used for a variety of applications in which temperatures ranging from 40˚C to about 100˚C are required.

4. THERMOSYPHONE

The principle of thermosyphone [11] is just like boiling the water. In a flat bed collector cold water flows to the collector, it gets warm by sunshine and flows upward due to buoyancy and stored in the tank which can be used directly.

A collector essentially consists of the following components:
1. A coated flat plate which absorbs solar radiation and transforms it into thermal energy

2. An insulated storage tank used to reduce thermal losses of heated water glass or plastic

3. Cover to reduce upward thermal losses of the collector
4. Bottom insulation to reduce downward thermal losses
5. Tubes and channels for circulating water to collect thermal energy
6. Wooden or metallic frame to house the collector assembly
Solar water heater is basically a flat plate [9] collector in which heat transfer fluid is water. In Figure 5.1, the working principle of solar water heater has been shown.

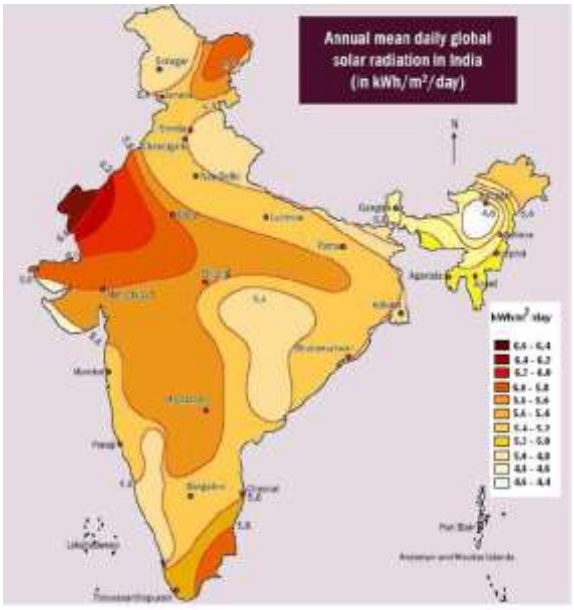

Figure – 4.1 India annual solar radiation map (source : www.mnre.gov.in)

5. DATA ANALYSIS

The reading collection of the room & tap water temperature of 100 Liter and 200 Liter solar water heater was started from 10 May 2014. Data has been collected up to 30 April 2015. So a full cycle data of complete one year has been collected successively.There was some drop in temperature as the pipes were long between water heater tank and the tap in the wash basin.

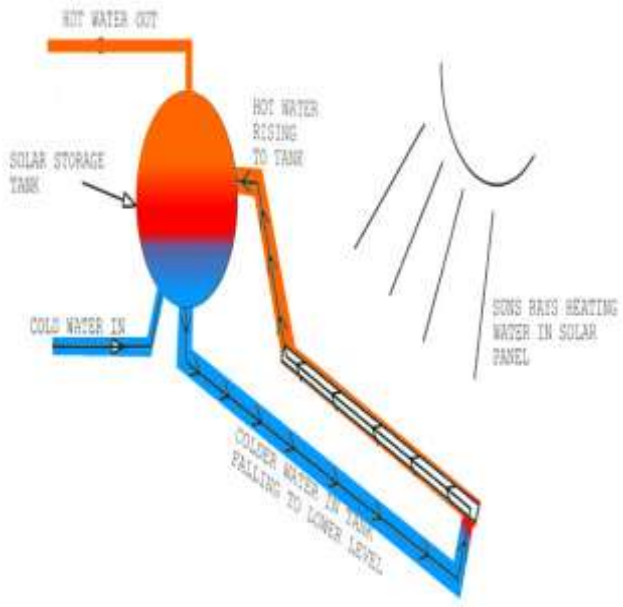

Figure – 5.1 Natural thermosyphone type flat plate collector water heater flow process (source : www.mnre.gov.in)

Moreover, 200 Liter pipes are not insulated. Although 100 Liter heater piping was insulated but rats and birds destroyed it in two weeks after installation. So there is also loss of temperature in 200 Liter heater. A solution could be to paint the piping with black color. The temperature retaining capability of 200 liter heater is better than 100 liter heater.

100 Liter 1ST Table Readings

S.NO	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP	TEMP. OUT – TEMP. IN	AMB. TEMP	TIME
1	32°C	36°C	0.45 bar	0.32	34°C	36.7°C	36°C-32°C = 4°C	33.8°C	12.00 pm
2	35°C	40°C	0.45 bar	0.33	38°C	40.2°C	40°C-35°C = 5°C	33.90° C	12.15 pm
3	39°C	43°C	0.46 bar	0.33	40°C	43.2°C	43°C -39°C = 4°C	34.50° C	12.30 pm
4	42°C	46°C	0.46 bar	0.34	42°C	46.4°C	46°C	35.0°C	12.45

Table – 1.1 100 liter ist table readings

100 Liter 2nd Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	45°C	49°C	0.33 bar	0.47 bar	45°C	49.2°C	49°C -45°C = 4°C	33.8°C	1.00 pm
2	48°C	53°C	0.33 bar	0.47 bar	47°C	52.3°C	53°C-48°C = 5°C	33.90° C	1.15 pm
3	50°C	55°C	0.33 bar	0.47 bar	49°C	54.7°C	55°C -50°C = 5°C	34.50° C	1.30 pm

Table – 1.2 100 liter ist table readings

100 Liter 3rd Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	55°C	60°C	0.47 bar	0.33 bar	53°C	59.2°C	60°C -55°C =5°C	33.8°C	2.00pm
2	58°C	63°C	0.47 bar	0.33 bar	55°C	61.5°C	63°C-58°C =5°C	33.90° C	2.15 pm
3	60°C	64°C	0.47 bar	0.33 bar	57°C	63.5°C	64°C -60°C =4°C	34.50° C	2.30 pm

Table – 1.3 100 liter ist table readings

100 Liter 4th Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	63°C	68°C	0.47 bar	0.33 bar	59°C	67°C	68°C - 63°C= 5°C	33.8°C	3.00 pm
2	65°C	70°C	0.47 bar	0.33 bar	61°C	68.4°C	70°C -65°C =5°C	33.90° C	3.15 pm
3	66°C	72°C	0.47 bar	0.33 bar	62°C	70°C	72°C -66°C =4°C	34.50° C	3.30 pm

Table – 1.4 100 liter ist table readings

100 Liter 5th Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	67°C	79°C	0.46 bar	0.31 bar	67°C	72.2°C	79°C -67°C =12°C	33.8°C	4.00 pm
2	66°C	85°C	0.46 bar	0.31 bar	72°C	73.2°C	85°C -66°C =19°C	33.90° C	4.15 pm
3	66°C	87°C	0.44 bar	0.31 bar	74°C	74.3°C	87°C -66°C =21°C	34.50° C	4.30 pm
4	66°C	89°C	0.44	0.31	75°C	75.1°C	89°C	35.0°C	4.45 pm

Table – 1.5 100 liter ist table readings

200 Liter 1ST Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	39°C	44°C	0.46 bar	0.34	41°C	44.1°C	44°C-39°C = 5°C	33.8°C	10.40 am
2	43°C	47°C	0.46 bar	0.34	44°C	47.8°C	47°C-43°C = 4°C	33.90° C	10.55 am
3	46°C	51°C	0.47 bar	0.35	46°C	50.7°C	51°C -46°C = 5°C	34.50° C	11.10 am

Table – 2.1 100 liter ist table readings

200 Liter 2nd Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	51°C	57°C	0.34 bar	0.47 bar	51°C	56.6°C	57°C -51°C = 6°C	33.8°C	11.40 am
2	55°C	60°C	0.34 bar	0.47 bar	54°C	59.5°C	60°C-55°C = 5°C	33.90° C	11.55 am
3	57°C	62°C	0.34 bar	0.47 bar	55°C	61.4°C	62°C -57°C = 5°C	34.50° C	12.10 pm

Table – 2.2 100 liter ist table readings

200 Liter 3rd Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	62°C	67°C	0.47 bar	0.34 bar	59°C	66.1°C	67°C -62°C =5°C	33.8°C	12.10 pm
2	64°C	69°C	0.47 bar	0.34 bar	61°C	67.8°C	69°C-64°C =5°C	33.90° C	12.55 pm
3	66°C	71°C	0.47 bar	0.34 bar	62°C	69.9°C	71°C -66°C =5°C	34.50° C	1.10 pm
4	68°C	72°C	0.47	0.34	63°C	71.5°C	72°C	35.0°C	1.25 pm

Table – 2.3 100 liter ist table readings

200 Liter 4th Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	69°C	74°C	0.47 bar	0.34 bar	64°C	72.5°C	74°C -69°C = 5°C	33.8°C	1.35 pm
2	70°C	75°C	0.47 bar	0.34 bar	65°C	73.9°C	75°C -70°C =5°C	33.90° C	1.50 pm
3	71°C	76°C	0.47 bar	0.35 bar	66°C	75.2°C	76°C -71°C =5°C	34.50° C	2.05 pm

Table – 2.4 100 liter ist table readings

200 Liter 5th Table Readings

S.NO.	TEMP. IN	TEMP. OUT	PRESSURE IN	PRESSURE OUT	PLATE TEMP	STORAGE TANK WATER TEMP.	TEMP. OUT – TEMP. IN	AMB. TEMP.	TIME
1	73°C	81°C	0.46 bar	0.34 bar	70°C	77.4°C	81°C -73°C =8°C	33.8°C	2.35 pm
2	73°C	82°C	0.46 bar	0.34 bar	71°C	78.5°C	82°C -73°C =9°C	33.90° C	2.50 pm
3	70°C	90°C	0.44 bar	0.31 bar	77°C	78.7°C	90°C -70°C =20°C	34.50° C	3.05 pm
4	70°C	90°C	0.44	0.30	78°C	79.4°C	90°C	35.0°C	3.20 pm

Table – 2.5 100 liter ist table readings

Temperature variation in the curve is due to foggy days during winter months in November and December. The comfortable temperature during winter month for household purpose is about 42˚C - 7˚C, which can easily be attained.

6. CONCLUSIONS

It is found from the data that the solar water heaters are working without disturbance. The tap water temperature is about 26.5˚C to 32.5˚C higher than room temperature during day time. It is expected that during evening hours it should be around 22˚C higher than room temperature. This hot tap water when mixed with cold tap water can be used comfortable according to comfort level of the user. Data for one year has been collected to analyze fully the performance of the solar water heaters over the whole year.

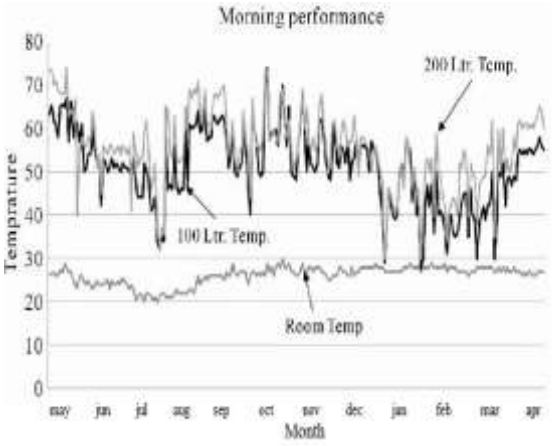

Figure 6.1 - Solar water heater performance (morning).

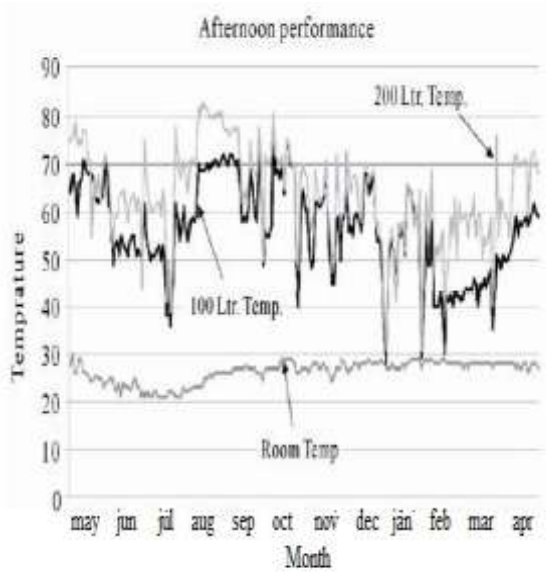

Figure 6.2 - Solar water heater performance (afternoon).

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