Performance enhancement of Solar water heater using reflective white sheet

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Abstract: - Nowadays, hot water is used for commercial, domestic and industrial uses. Various resources like diesel, coal, gas, petrol etc. are used for producing steam and to heat water. Solar energy is the alternative to replace the Non-renewable energy sources. The solar water heating system is the technology to trap the free available solar energy emitting from Sun. The solar energy system is designed to meet the energy demands. The size of the systems are according to solar radiation available, temperature, customer requirement, condition of geographical location and solar system arrangement, etc. Therefore, it is necessary to design the solar water heater as per above given parameters. Solar water heater proves to be an effective technology for converting solar energy from sun into thermal energy. The efficiency of solar heat conversion is around 69% when compared to solar electrical direct conversion system which has an efficiency of just 18%.So providing reflectors below evacuated tubes can improve energy harnessing. So solar water heaters hold a vital role in industrial as well as domestic Works due to its easy operation and easy maintenance. Providing reflective white sheets(GI sheets) will be increasing the efficiency and heat harnessing much better than the usual setup which is without any reflective sheet.

1. Introduction

The planet Earth gets an enormous amount of solar energy**.** The sun, an average star, is a fusion reactor that has been burning nearly 4 billion years. It provides sufficient energy in one minute to supply the world's energy needs for annum. In one day, it provides more energy than world population would consume in 27 years. In fact, The total amount of solar energy received by land over a 72 hour period is equal to the energy collected in all non renewable energy sources. Solar energy is a cost free**,** inexhaustible resource, yet trapping it is a very new plan. The ability to use solar power for heat was the very first invention. A famous Swiss scientist named Horace de Saussure, built the first solar collector thermally in later 1700, which was later used to water heating and cooking. The first commercial patent for a solar water heater went to Clarence Kemp from USA in the year 1891. This system was bought by two executives of California and installed in one-third of the homes of city of Pasadena by early 1900. Producing electricity from solar energy was the second invention. In the later 1839 a French physicist by the name Edmund Becquerel realized that the sun's energy may be producing a "photovoltaic effect". In the early 1880s, selenium photovoltaic (PV) cells were manufactured that can convert light into electricity with 1-2% efficiency (the efficiency of a solar cell is the percentage of current solar power from sun converted to domestic electricity for usage), but how the conversion happened was not known to them. Photovoltaic power therefore "remained a curious mystery for coming years, since it was not efficient at turning sunlight into electricity." It was not until Albert Einstein gave an explanation for the "effect of photo electricity" in the early 1900s, for which he was given Nobel Prize, that people began to know the importance the photovoltaic effect.

Principle of solar water heater

There are numerous ways of creating a solar system. Some methods are proposed in the

literature, others are based on computer simulations. Both of them are complex processes which should begin with introductory measurements and a detailed analysis of diagrams, construction projects and the financial planning and economic analysis. It is necessary to guess the costs and uses of the tedious planned investment. The basic data which are required at the beginning stage are: the amount of solar energy (insulation), the location of the solar energy collectors (inclination) and to analyze the requirement of hot water. To determine the basic Solar energy condition in the region the parameters like solar radiation flux density W/m2, insulation kWh/m2 the energy of solar energy radiation reaching the unit area at a unit time and the numbers of sunshine hours of direct solar operation, visible operations are very needed

2. Objectives

The objectives of the present project work are listed below

1. To study the performance of solar water heater.

2. To study the performance of solar water heater with the help of reflective white sheet.

3. To study the performance of solar water heater throughout the day at different position of sun for multiple days.

4. To study the performance of solar water heater at diverse climate.

3. Materials and Methodology

3.1. Materials

The following materials are required to build solar water heater:

1. Infrared digital thermometer: The infrared thermometer is a device which gives temperature from a portion of the thermal radiation sometimes called black body radiation emitted by the object being measured.. By finding the amount of infrared light emitted back from the subject and subject's emissivity, the subject temperature can usually be calculated in a particular range of distance of its original temperature. Infrared thermometers are a derivatives of devices known as thermal laser thermometers.

2. Evacuating Tube collector: Evacuated tube collectors are flat devises which consist of cylindrical absorbing surfaces or tubes with internal fins installed in an evacuated tube to reduce the convection losses.

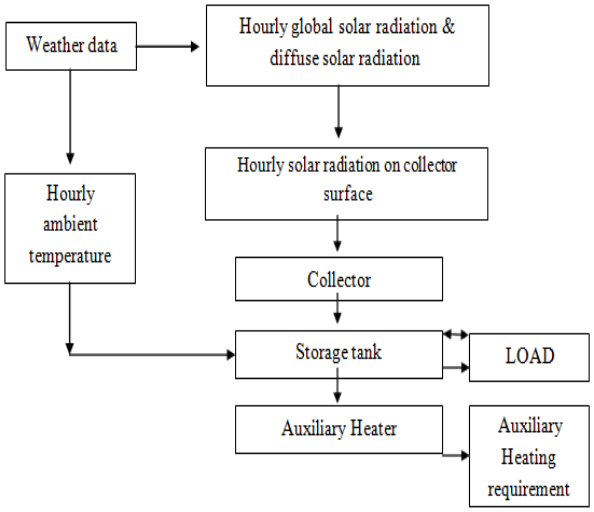
3. Tube Ring: The tube caps are majorly used to avoid any leakage of heated water from the collecting tank which is heated through the solar energy received from the sun. The tube rings may be of different dimensions.

4. Reflective white sheet: Reflective white sheet is common, such as light reflector, solar heat reflector materials, decoration, decoration of wall, signs, logo for brands, bags and so on. Aluminum bright grinded mirror sheet of coil is manufactured from intensive line of rolling, which rolled from pure quality of Aluminum, which is usually used as reflectors.

5. Frame: The frame helps in holding the evacuated tubes and withstands the weight of the system and this frame is made to place the tubes in a certain inclination angle to extract maximum energy.

6. Pyranometer :It is used for measuring solar radiance on a planar surface and it is fabricated to measure the solar radiation flux from the hemisphere above within a wavelength. range 0.3µm to 3µm.which is an essential device in measuring the intensity of the solar light coming from sun.

3.2 Methodology

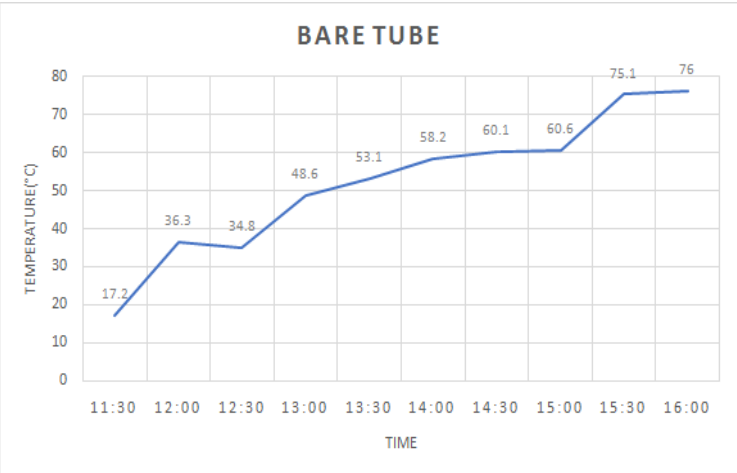


There are several methods for designing a solar water heater .we made the solar water heater with the help of a few L shaped bar for the supporting the parts of solar water heater, evacuated tubes to trap solar heat and heat the water, rubber to create a cushion for the evacuated tube as its in direct contact with iron support, Pyranometer to measure the brightness of sun for the comparison with temperature ,GI sheets to provide them as reflective white sheet which helps in heating the water much faster and finally infra red thermometer to measure the temperature of water which is getting heated up in the evacuated tube. The process of our experiment begins with measuring initial temperature of water in evacuated tubes and setting up the pyranometer setup at the same time so that the comparison can be synced later process of calculation. The setup contains evacuated tubes provided with different angle of reflective white sheets. The same process of recording the temperature is done per every one hour till the evening and the results are recorded for further research and the pyranometer readings of corresponding time is recorded and graphs are plotted accordingly. Based on the results better angle of inclination of the reflective white sheet is identified and they can be helpful in commercial installation thus reducing its cost of installation for household purposes.

placing reflective white sheets below the evacuated solar tubes at different angles and the temperature is measured with the help of Infrared digital Thermometer. The resulted temperature varies from time to time as the position of sun changes every minute in the sky. The below are the results of the conducted experiment.

Case I: Without any reflective white sheet (Bare)

Time	Date	Water Temperature (◦c)	Tube Temperature (◦c)		Intensity (W/m^2)
			Top	Bottom	
11:30	07/03/2020	17.2	18.5	13	666
12:00	07/03/2020	36.3	27.8	24.8	684
12:30	07/03/2020	34.8	28.2	23.5	865
13:00	07/03/2020	48.6	20.1	21.6	884
13:30	07/03/2020	53.1	20.3	19.5	782
14:00	07/03/2020	58.2	17.2	19.5	263
14:30	07/03/2020	60.1	24.4	22.4	207
15:00	07/03/2020	60.6	20	20.2	120
15:30	07/03/2020	75.1	32	34.2	107
16:00	07/03/2020	76	31.4	32.5	430



4.Results and Discusssion

4.1.Results

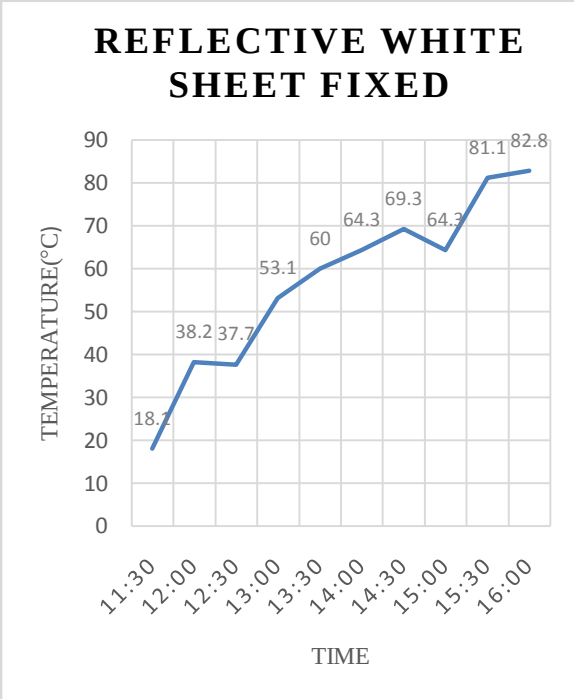
The Experiment is conducted by

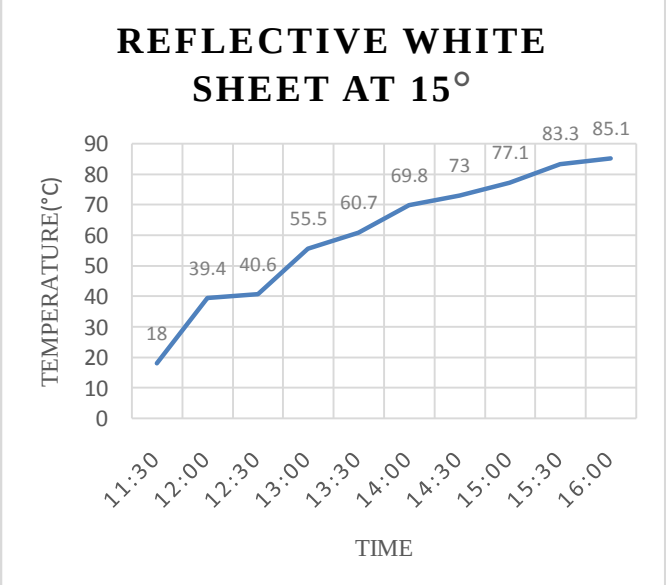
Case II: Tube with reflective white sheet (Fixed)

Time	Date	Water Temperature (◦c)	Tube Temperature (◦c)		Intensity (W/m^2)
			Top	Bottom	
11:30	07/03/2020	18.1	19.3	13.8	666
12:00	07/03/2020	38.2	27.7	24.7	684
12:30	07/03/2020	37.7	28.7	24.0	865
13:00	07/03/2020	53.1	21.4	20.4	884
13:30	07/03/2020	60	18.8	17.1	782
14:00	07/03/2020	64.3	16.9	19.8	263
14:30	07/03/2020	69.3	23.4	23.4	207
15:00	07/03/2020	64.3	19.9	20.3	120
15:30	07/03/2020	81.1	30.9	32.1	107
16:00	07/03/2020	82.8	31	32.4	430

Case III: Tube with reflective white sheet (15^0)

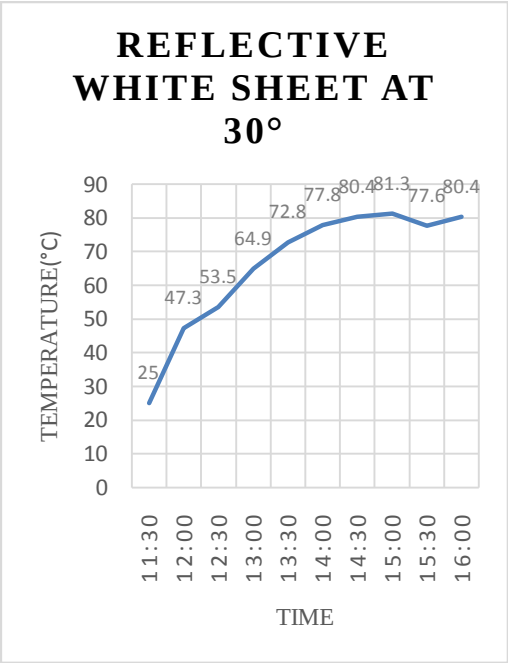
Time	Date	Water Temperature (◦c)	Tube Temperature (◦c)		Intensity (W/m^2)
			Top	Bottom	
11:30	07/03/2020	18.0	21.5	14.9	666
12:00	07/03/2020	39.4	27.8	24.4	684
12:30	07/03/2020	40.6	23.5	26.8	865
13:00	07/03/2020	55.5	19.8	21.3	884
13:30	07/03/2020	60.7	21.1	22.4	782
14:00	07/03/2020	69.8	22.9	22.5	263
14:30	07/03/2020	73	28.8	23.5	207
15:00	07/03/2020	77.1	28	21.0	120
15:30	07/03/2020	83.3	36.4	38.5	107
16:00	07/03/2020	85.1	32.9	32	430





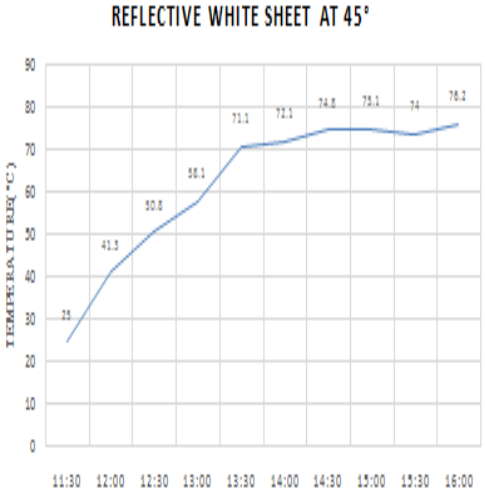
Case IV: Tube with reflective white sheet (30^0)

Time	Date	Water Temperature (◦c)	Tube Temperature (◦c)		Intensity (W/m^2)
			Top	Bottom	
11:30	07/03/2020	25	12.5	19.1	652
12:00	07/03/2020	47.3	17.6	21	680
12:30	07/03/2020	53.5	21.3	18	847
13:00	07/03/2020	64.9	26.1	27.6	881
13:30	07/03/2020	72.8	28.1	29.4	782
14:00	07/03/2020	77.8	36.6	36.2	263
14:30	07/03/2020	80.4	46	40.7	207
15:00	07/03/2020	81.3	47	40	170
15:30	07/03/2020	77.6	28.1	30.2	107
16:00	07/03/2020	80.4	39.1	38.2	406



Case V: Tube with reflective white sheet (45^0)

Time	Date	Water Temperature (◦c)	Tube Temperature (◦c)		Intensity (W/m^2)
			Top	Bottom	
11:30	07/03/2020	25	11.5	17	656
12:00	07/03/2020	41.3	19.3	22.3	689
12:30	07/03/2020	50.8	22	23.7	228
13:00	07/03/2020	58.1	21.9	26.6	981
13:30	07/03/2020	71.1	33.5	32.3	927
14:00	07/03/2020	72.1	33.7	34.5	202
14:30	07/03/2020	74.8	43.6	41.2	205
15:00	07/03/2020	75.1	42.2	40	120
15:30	07/03/2020	74	31.3	31.5	86
16:00	07/03/2020	76.2	31	31.9	467



4.2. Discussion

1. By tilting the solar setup to the north 8 degree we can extract more energy.
2. With the help of reflective white sheet we can observe more than 20-30% compare to the domestic setup.
3. The part of evacuated tube which doesn't face sunlight will be used in order to heat up the water.
4. It yields better result than the setup with no reflective sheet, which is inferred from the results recorded.
5. The evacuated tube is better utilized when the reflective white sheet is at 15 degrees when compared to 30 and 45 degrees.

6. Conclusion

Evacuated tube solar collectors are more efficient than flat plate collector in the application of high temperature used domestic and industrial application. Because advantage of vacuum created between tube is type of collector very common and effective in cooled climate. Since it can harvest both beam and diffuse radiations more efficient than concentric types of solar collector. Since the tube is independent in every damage only efficiency of system is decreased but the other types of collector totally system damage.

1. Heating efficiency of the solar water heater with reflective white sheet is far better than the solar water heater without reflective white sheet.
2. Water gets heated up faster and the efficiency increases when the reflective white sheet is at 45^{o}
3. Placing reflective white sheets at certain angles may help us reduce thw number of evacuated tubes in the solar water heater as the efficiency rises by 30%.

7. References

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