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TECHNOECONOMICAL FEASIBILITY OF FLAT PLATE COLLECTOR WATER HEATING SYSTEM WITH AUTO TILTING MECHANISM.

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Abstract: India is one of the richest receivers of sunlight, being present very close to the equatorial line. Being a tropical country, it is blessed with plenty of sunlight for maximum period of the year; therefore, numerous opportunities are available in the Indian Subcontinent to fully utilize the solar energy with excellent cost economical alternatives. The developed pilot scale system in the current work tries to design and develop a prototype and pilot scale plant with and without auto tilting mechanism to carry out the experimental studies and evaluate the performance of the FPC for utilizing maximum incident solar radiation throughout the day. Index Terms—FPC, solar energy ,radiation.

1. INTRODUCTION

Two important factors which affect the efficiency of solar surfaces are angle and orientation. In some cases it possible to have a number of limitations to adjust the solar collector or panel at the excellent orientation and tilt angle. If the case is so, then tilt angle and orientation must to be adjusted to maximize solar radiation. It is known from previous studies that south is the optimum direction. Since the flat plate solar collectors are positioned at an angle to the horizontal, it is crucial to find out the optimum tilt angle in order to maximize the amount of collected energy. By utilizing maximum solar energy through the optimum tilt, we are able to harness the energy needed without polluting our environment. It reduces the CO2 emissions in the atmosphere which is a major culprit for Global warming. By reducing CO2 emissions in the atmosphere, carbon credit can also be earned which is an international issue now a day. It was revealed from the literature review, many efforts are directed towards intelligent sun tracking systems, specially designed for PV panels. However, no effort was made reflecting the utility of the same technique for thermal solar energy utilization. The concept of solar tracking is not applied to the flat plate solar water heaters. The FPC panel can be rotated according to the sun path and its performance can be assessed. If there is increase in the efficiency of the flat plate solar water heaters, it will enhance the efficiency of the system.

In this paper, an attempt is made to design and modify the existing FPC system by application of auto tilting mechanism and also to carry out performance evaluation and cost economics of the same with system without auto tilting mechanism.

The auto tilting system has been designed to rotate the FPC panel from East to West during the period from sunrise to sunset. In order to rotate the panel through 1800 (East to West), the required rotational speed of the panel is very less. To achieve this small rotational speed, it has been decided to design a gearbox. The stand supplied by the manufacturer of the solar panel has to be replaced by the new stand, so that the panel can swing through the required angle. In order to achieve free rotation of the panel, the ball bearings are required. In order to modify the existing FPC, without any mechanical damage to the panel, the panel holder plate was used in the system. Along with these mechanical accessories, electronic speed controller to vary the speed of motor was assembled.

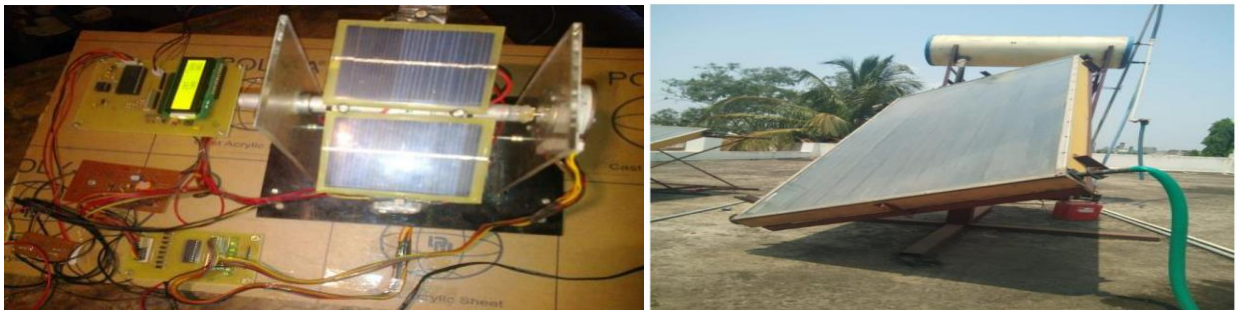

Fig 1 Prototype and experimental set up

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2. EXPERIMENTAL SETUP

Fig. above shows the experimental setup for tilting panel. At the time of sunrise, the panel was set so that it faces the East and locked in the position. This was done manually and the required rpm of the motor is set by using the electronic controller. The motor was switched on and the panel is allowed to rotate at the designed speed. In order to avoid over movement of the panel, a limit switch is provided on West side, so that the panel will stop automatically. In the next morning, the same procedure was repeated.

3. METHODOLOGY

3.1 Positioning the panel

At the time of sunrise, the tilting panel is required to be kept facing towards East. The panel is rotated manually so that it will be facing East and it is then locked in the position using the chain and sprocket arrangement. By using a plumb bob, the correct required position of the panel is permanently marked on the support stand and the panel is locked at this mark.

3.2 Setting up the speed of the motor

In order to rotate the panel according to the sun path, it is required to set the speed of the motor as per the calculations. From the data collected for sunrise and sunset timings for the study area, the required voltage for corresponding speed is noted and the voltage of the motor is set to the required value.

3.3 Recording the temperatures

The temperature of the water in both the tanks (fixed and tilting panel) is measured with the same thermometer. In order to measure the temperature of the water, a water sample is collected directly from the tank. For this, bibcock were provided at the hot water outlet of the tank. At the same time, ambient air temperature has been recorded every hour.

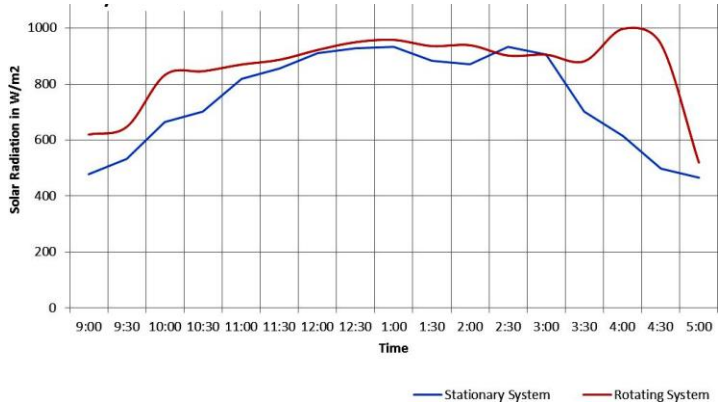
3.4 Emptying the tanks

After sunset, the hot water in both the tanks is stored in separate tank of capacity 120 lit. The hot water stored in a separate tank was used in the next morning. After emptying, both the tanks were filled with fresh cold water. In the next morning all steps were repeated.

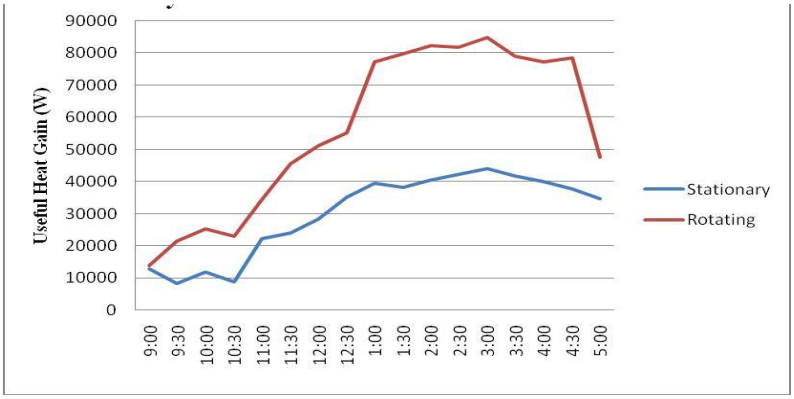
4. RESULTS AND DISCUSSIONS

4.1 Effect of Solar radiation on the performance of both collector

To study this effect, solar radiation falling on the surface of stationary and rotating flat plate collector are considered and plotted against the time.



Effects on Useful Heat Gain



These graphs show that solar radiation falling on the surface of rotating flat plate collector is more throughout the day than that of stationary collector. Therefore, more input solar energy is provided for the rotating collector and hence gain of useful heat energy is also more with this arrangement. Graphs highlight that in the morning and evening period solar radiation incident on stationary collector is much less. On the other hand, the rotating system receives radiation with more intensity on the surface. During period of 12.30 pm to 2.00 pm both system receive approximately radiation with same intensity. Therefore it is concluded that tracking system is more beneficial during morning and evening session to get more radiation. Effects on Outlet Temperature of Water

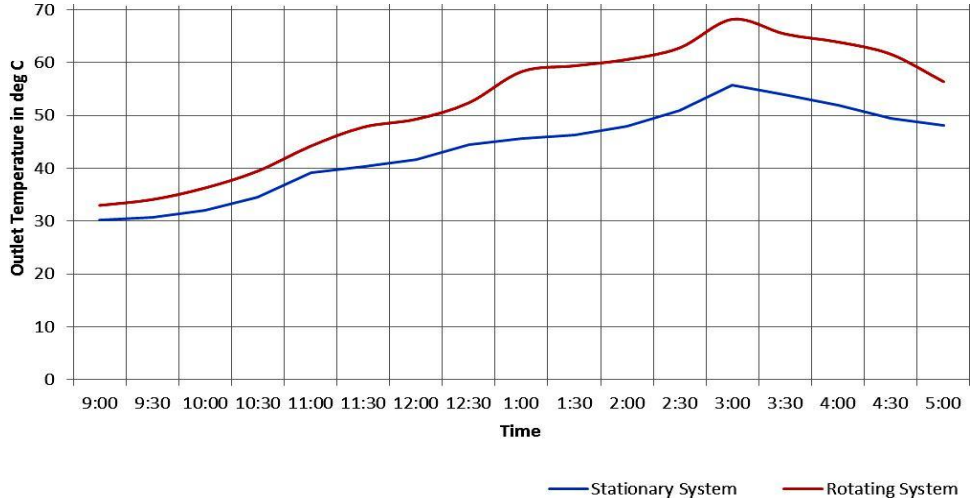


Figure shows that effect on the outlet temperature of water in both systems. It shows that the outlet temperatures are higher with proposed system of solar collector. Initially, the temperature difference between both systems is slightly lower but as time passes forward, this difference in outlet temperatures is continuously increasing. With stationary flat plate collector, maximum outlet temperature is around 54 to 56 oC while with rotating solar collector, maximum temperature is in rage of 67 to 69 oC under similar working conditions. Hence it is concluded that the rotating flat plate system provides water with higher outlet temperature on an average 10 to 13 oC than stationary system. Graph show slightly decreasing trend at the end, it is because decrease in intensity of solar radiation at the end of day.

Approximate cost for solar flat plate collector installation: 25000Rs.

The economic feasibility can only be justified for solar water heating system when it gives a considerable return on investment as compared to conventional market. Though initial investment cost is high still it is feasible due to its environmental benefits

5. CONCLUSION

1. Due to tracking system, intensity of radiation falling on the surface of collector is very large. This intensity is obtained throughout the day as system continuously tracks the sun and radiations falling in perpendicular direction on surface. Average intensity of solar radiation on rotating system over period of day is 856 W/m2 and in stationary collector, it is 746 W/m2.
2. The system with tracking arrangement gives maximum outlet temperature of water. With stationary flat plate collector, maximum outlet temperature is around 54 to 56oC and in rotating system, it is in range of 67 to 69 oC under similar working conditions. Hence it is concluded that the rotating flat plate system provides water with higher outlet temperature on an average 10 to 13 oC higher than stationary system.
3. Higher efficiency with rotating collector is 95 to 96 % and for stationary collector, it is 75 to 77 %. It means that collector with tracking system provides 18 to 20 % higher efficiency than that of conventional system.

6. REFERENCES

[1] Amin N, Yung W C and Sopian K, 2008, "Low Cost Single Axis Automated Sunlight Tracker Design for Higher PV Power Yield" ISESCO Science and Technology Vision, (4) 6, pp. 6 – 9.
[2] Greentech Knowledge Solutions Pvt. Ltd, New Delhi, 2010 "Solar Water Heaters in India: Market Assessment Studies and Surveys for Different Sectors and Demand Segments" Report submitted to Project Management Unit, Global Solar Water Heating Project, Ministry of New and Renewable energy,
[3] Joao M G Figueiredo, Jose M G Sa da Costa, 2008 "Intelligent Sun – Tracking System for Efficiency Maximization of Photovoltaic Energy Production" Paper presented at International Conference on Renewable Energies and Power Quality.
[4] Metcalf and Eddy, 2003, "Wastewater Engineering-Treatment and Reuse" Tata McGraw-Hill Publishing Company Limited, New Delhi.
[5] Peterson T, Rice J and Jeff V, 2005, "Solar Tracker" prepared for Hosfelt Electronics, Steubenville, Ohio.
[6] Rai G D, 2008 "Non-Conventional Energy Sources" Khanna Publishers, New Delhi.
[7] Roth P, Georgiev A, and Boudinov H, 2004, "Cheap Two Axis Sun Following Device" Energy Conversion and Management, Vol. 46, Issue 7-8,pp-1179-1192
[8] Sarkar M R I, Pervez Md Riaz and Beg R A, 2010, "Design, Fabrication and Experimental Study of a Novel Two – Axis Sun Tracker" International Journal of Mechanical and Mechatronics Engineering IJMME – IJENS, Vol. 10, pp.- 01 – 13.
[9] Selvraj K, 2011,"Increase In Efficiency of Solar Water Heaters Using Fine Metal powders Mixed in Heat Absorbing Coatings and Their Applications in Electrical Engineering" International Journal of Research and Review in Computer Science IJRRCS, Vol. 2, pp-61-64.