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COMPARATIVE STUDIES ON THERMAL EFFICIENCY OF SINGLE AND DOUBLE GLAZED FLAT PLATE SOLAR WATER HEATER

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ABSTRACT

A Study was under taken to assess the performance of single glass flat plate solar water heater (SGFPSWH) and double glazed flat plate solar water heater (DGFPSWH) were experimentally investigated. Galvanized iron plate of 1.42 x 0.7 m^2 size was employed as Flat absorber plates. A glass plate of similar size was used as top cover for SGFPSWH and two glass plates of same size with a gap of 2cm were used for DGFPSWH the glass plates used as protection for heat loss from absorber plate to atmosphere. Performance of SGFPSWH and DGFPSWH at different mass flow rates (0.0041, 0.0083, 0.0125 kg/s) were investigated and reported. Thermal efficiency is found to be higher for DGFPSWH compared to SGFPSWH.

Keywords: flat plate solar water heater, flat absorber, galvanized iron plate, mass flow rate.

INTRODUCTION

A solar collector is a special kind of heat exchanger that transforms solar radiant energy in to heat. A solar collector differs in several aspects from more conventional heat exchangers. Flat plate solar collector can be designed for application requiring energy delivery at moderate temperatures, up to perhaps 100^0C above ambient temperature. They use both beam and diffuse solar radiation, do not use tracking of the sun and require little maintenance. They are mechanically simpler than concentrating collectors. The common application of the flat plate collectors are mostly found in domestic hot water and space heating, industrial processes, vapour absorption refrigeration and air conditioning system. Therefore, due to their various applications, there is continuing endeavour of a designer to determine thermal performance of flat plate solar collectors.

Soteris A. Kalogirou [1] performed an analysis of the environmental problems related to the use of conventional sources of energy and the benefits offered by renewable energy systems. The various types collectors including flat plate, compound parabolic, evacuated tube, Fresnel lens, parabolic trough, parabolic dish and heliostat field collectors were followed by an optical, thermal and thermodynamic analysis of the collectors and a description of the methods used to evaluate their performance. The thermal performance of the solar collector was determined by obtaining values of instantaneous efficiency for different combination of incident radiation ambient temperature and inlet fluid temperature

DavideDel Col, Andrea padovan, [2] determined the performance of prototype of glazed flat plate with roll bond absorber. Measurements of thermal efficiency are reported for two samples of the prototype, one with a black coating on the absorber and the other with a semi selective coating. The experimental results show that the roll bond absorber can provide higher performance than the normal sheet and tube type absorber.

Federico Giovanneti, Sebstian Foste [3] performed newly developed, highly transmitting and spectrally selective glass coatings can be used. Uncovered single and double glazed designs are taken in to consideration. The results show that a significant performance increase is accessible both in single glazed with low or non selective absorbers and in double glazed collectors with highly selective absorbers.

Many authors [4, 5] have concentrated on the development of effective design methods for solar collectors. For their analysis the cross sectional area of the absorber plate has been constant. However, the collector receives energy from the sun that is absorbed by the plate and is then transferred to the fluid. On this basis, energy transferred increases in the direction of flow energy in a plate. It is well known fact that for effective design, the profile shape of the absorber plate increases the collector performance.

Paul Magloire E. Koffi, Blaise K. Koua [6] determined theoretical and experimental analysis of the thermal performance of a solar water heater prototype with an internal exchanger using thermosyphon system. The results focus mainly on the levels of the heat fluxes temperatures recorded, mass flow rate and efficiency of collector. These tests are performed for a sunny day and cloudy day. Finally the results show that means daily efficiency is near 50%. This reveals a good compatibility of the system to convert solar energy to heat which can be used for heating water.

N. Ihaddadene, R. Ihaddadene [7] performed the effect of distance between double glazing on the performance of a solar thermal collector. Experiments were carried out on an active solar energy demonstration system. The results show that the efficiency of double glazing solar collector decreases with increasing the distance separating the two glasses.

Elham Hosseinzadeh and Hessam Taherian [8] performed radiative cooling system with flat plate solar collector in a humid area, Babol, Iran, is assessed both experimentally and numerically. The experiments were carried out at various mass flow rates and in different weather conditions and the results have been compared to those of the theoretical model. The results indicate that the water temperature decreases with increase in mass flow rate.

Farahat, F. Sarhaddi [9] determined the optimal performance and design parameters of solar flat plate collector. A detailed energy exergy analysis is carried out for evaluating the thermal performance and optical performance, exergy flows and losses as well as exergetic efficiency for a typical flat plate solar collector under given operating conditions. In this analysis ,the following geometric and operating parameters are considered as variables: the absorber plate area, dimensions of solar collector , pipe's diameter, mass flow rate, fluid inlet and outlet temperature, the overall loss coefficient etc. and also a simulation program is developed for the thermal and exergetic calculations.

M. M. A. Khan, A. B. M. Abdul malek [10] performed design and experimental analysis of a solar domestic water heating system. Water heating system with glazed and unglazed collectors was tested. During testing, the efficiency of the glazed collector increased by about 70.3. % when compared with the unglazed collector.

Alkhair M. Abdul Majeed, M.Y. Sulaiman [11] have determined to increase the output temperature of the water flowing inside an absorber of flat plate solar water heater, here concentrating material had been used. With this study influenced the improvement in thermal efficiency of the flat plate solar water heater by increasing the water temperature along the absorber pipe length.

Various studies reviewed above have shown the importance of performance improvement of the collector in solar water heating system. In this study SGFPSWH and DGFPSWH with flat absorber plate is designed and constructed with the aim of low cost and to bring out better efficiency.

Objective

To investigate the performance of SGFPSWH and DGFPSWH at different mass flow rates.

Experimental setup

The experimental setup made up of mild steel box and flat absorber plates. The line diagram of the experimental setup shown in Figure-1. Galvanized iron plate of 1.4 x 0.7 m^2 was employed as absorber plate for both collector. Single glass top cover used for SGFPSWH and Two glass plates of similar size were used as protection for heat loss from absorber plate to atmosphere for DGFPSWH. A gap of 2 cm maintained in between top glass cover to the bottom glass cover. The bottom of the collector was covered with heat resisting material to minimize the heat loss to the surroundings.

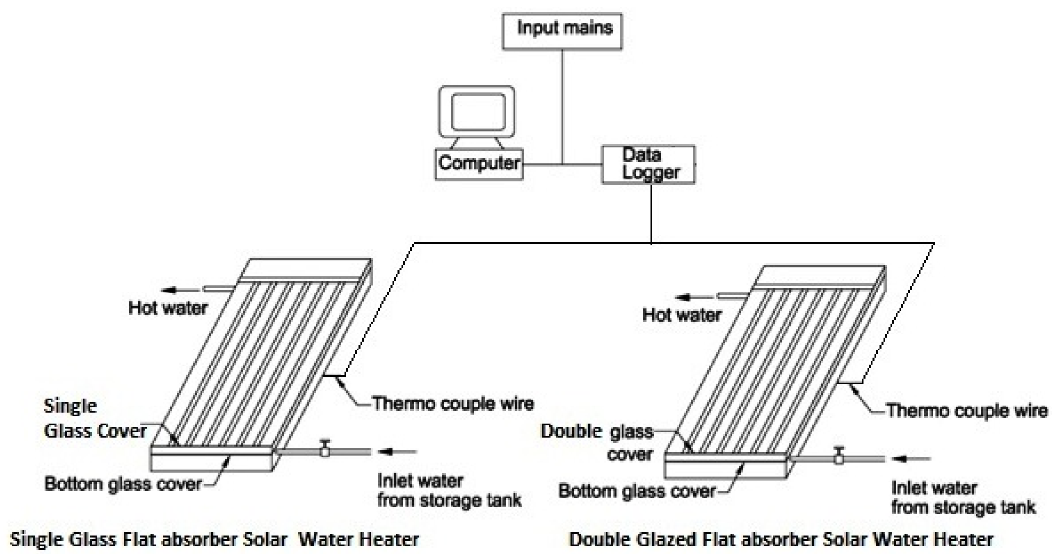

Figure-1. Line diagram of experimental setup.

Figure-2. Flat absorber plate with tube.

Figure-3. Photographic view of experimental setup.

Figure-4. Agilent Data Logger.

Table-1. Specification of the experimental setup.

Single and Double glazed solar water heater	
Length of the collector	1.42m
Width of the collector	0.7m
Area of the collector	1m^2
Diameter of the tube	0.0127m
Tube centre to centre distance	0.1m
Length of the absorber plate	0.69m
Material of the absorber plate	G.I
Glass cover emissivity	0.85
Refractive index	1.5
Diameter of the header pipe	0.019m
Insulating material	Glass wool
Density of the insulating material	200kg/m^3

Measuring equipment

Agilant Data logger has been used to acquire all the data. T-type copper constantan thermocouples have been used. Water Inlet temperature, water outlet temperature, absorber plate temperature, tube temperature and glass plate temperature were measured.

Experimental procedure

The performance of SGFPSWH and DGFPSWH is studied with flat absorber plate geometry shown in Figure-2 and SGFPSWH and DGFPSWH setup shown in Figure-3.

At the starting the data logger is switched ON 10 minutes before the commencement of experiment. Readings are recorded at a uniform interval of 10 min from 10.00 am to 3.30pm. Experiments were conducted on Flat absorber plate with uniform mass flow rate and the data were collected on the data logger. The thermal efficiency and heat gained by the water were calculated and the results are discussed.

RESULTS AND DISCUSSIONS

SGFPSWH and DGFPSWH selected for experimentation. Graphs were plotted between time vs efficiency (%), time vs inlet and outlet water temperature (^{0}C), time vs ambient temperature (^{0}C), time vs solar intensity (w/m^2) respectively as illustrated in Figures 5 to 12.

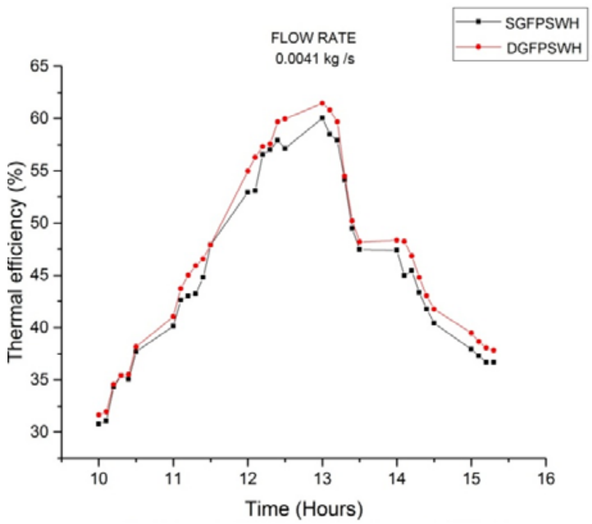

Figure-5. Thermal efficiency versus time (Flow rate 0.0041 kg/s).

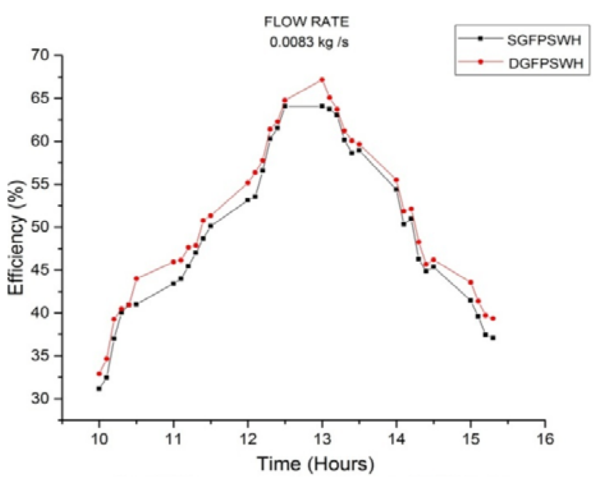

Figure-6. Efficiency versus time (Flow rate 0.0083 kg/s).

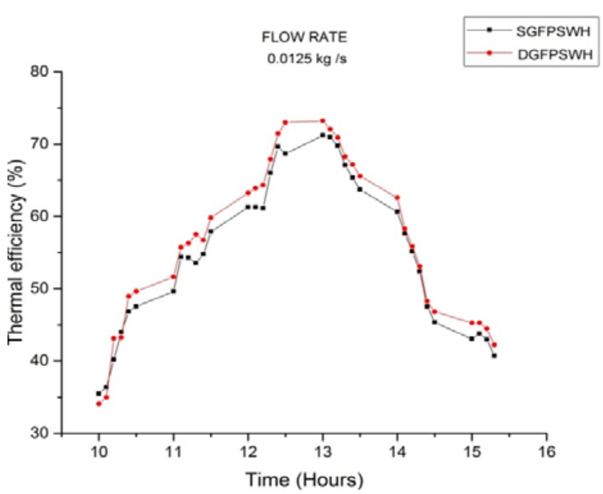

Figure-7. Thermal efficiency versus time (flow rate 0.0125kg/s).

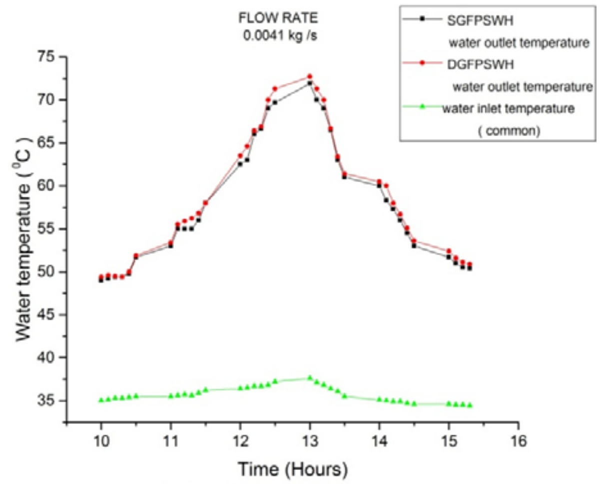

Figure-8. Water inlet and outlet temperature versus time.

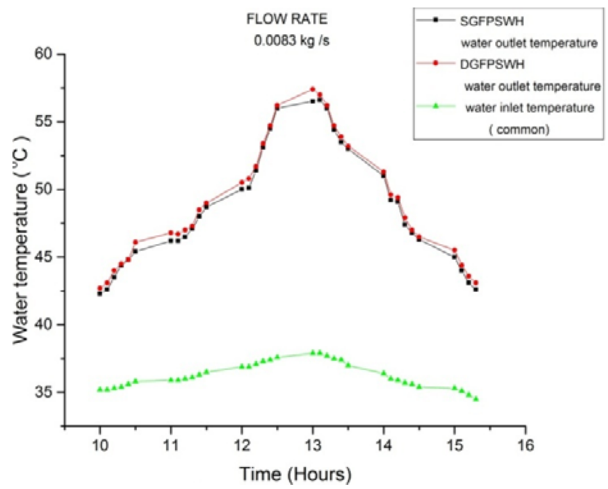

Figure-9. Water inlet and outlet temperature versus time.

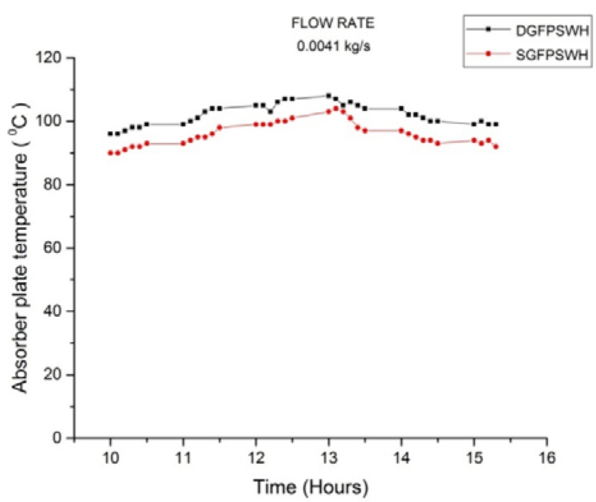

Figure-10. Time versus absorber temperature.

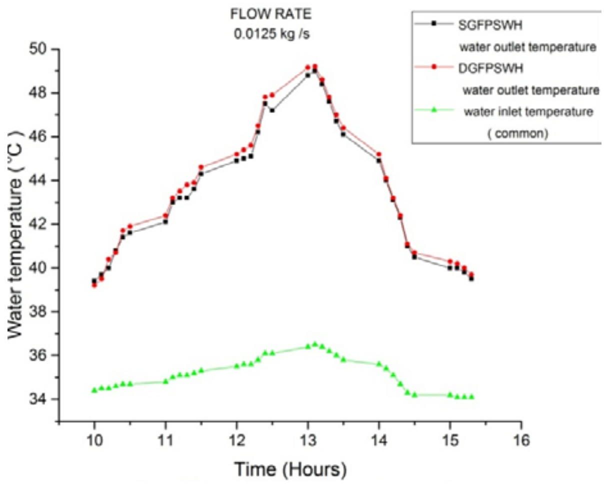

Figure-11. Water inlet and outlet temperature versus time.

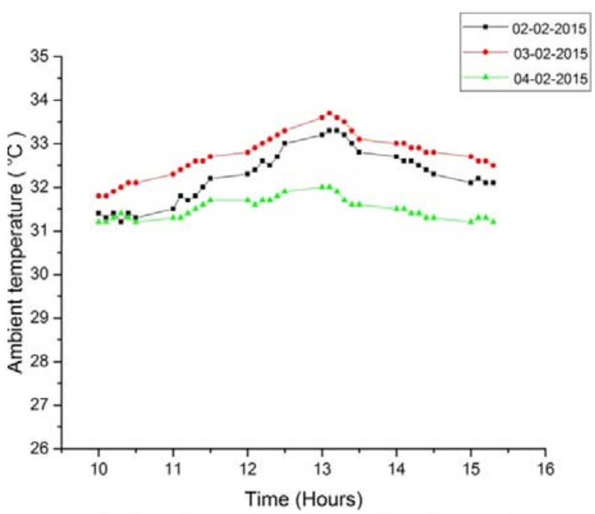

Figure-12. Ambient temperature versus time (three different dates).

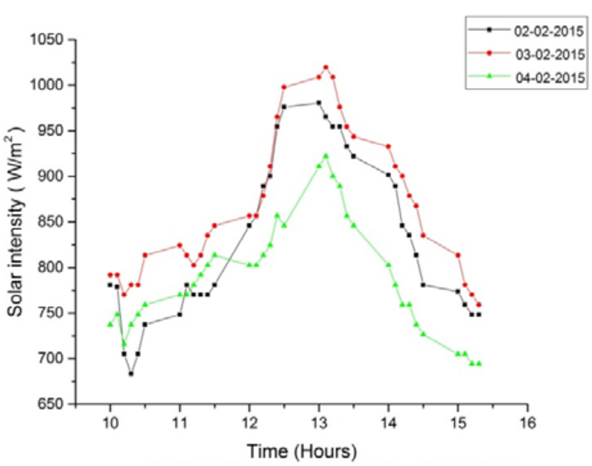

Figure-13. Solar intensity versus time (on three different dates).

Figures 5 to 8 shows that the thermal efficiency is found to be higher on DGFPSWH than SGFPSWH with the different mass flow rate (0.0041kg/s, 0.0083 and 0.0125kg/s). It is evident from fig 9 to 10 shows that water out let temperature gained by water is more at experimental conditions with DGFPSWH compared to SGFPSWH. As the mass flow rate of water increases the thermal efficiency and heat gained by the water also increases. Hence both are directly proportional to each other. Figure-11 shows that time vs. absorber plate temperature for 0.0041 kg/s. Figure-12 shows that time vs. ambient temperature for three different dates. Figure-13 shows that solar intensity for three different dates.

From the above it has been found that the DGFPSWH is performing satisfactorily than SGFPSWH with respect to thermal efficiency of the solar water heater.

CONCLUSIONS

Experiments conducted on SGFPSWH and DGFPSWH at uniform mass flow rate. The following conclusions were obtained from this study.

a) DGFPSWH temperature is higher than the SGFPSWH during experimentation.
b) Thermal efficiency is higher for DGFPSWH.
c) Heat gained by the water in DGFPSWH is comparatively higher than the SGFPSWH.
d) Thermal efficiency and heat gained by the water increases with increase in mass flow rate for both SGFPSWH and DGFPSWH.

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