PERFORMANCE ANALYSIS OF SOLAR WATER HEATER USING V-GROOVED ABSORBER PLATE

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Abstract
An investigation was carried out to assess the performance of double glazed solar water heater (DGSWH) with V-grooved absorber plate was tested experimentally. Mild steel plate of 1.42 x 0.7 m^2 size was employed as an absorber plate. Glass plate of similar size has been used to protect the absorber plate from heat loss due to atmosphere. Performance of solar water heater for different mass flow rates (0.0041, 0.0083, 0.0125 kg/s) were investigated and the test results are reported. The Thermal efficiency is found to be higher for V-grooved absorber plate when compared to square pulse absorber plate.**Keywords: Solar water heater, V-grooved absorber plate, Mild steel plate, Square pulse absorber plate.**

1. Introduction

Solar Collectors are the key component of active solar-heating system. They gather the sun's energy, transform its radiation into heat, and then transfer that heat to a fluid (usually water or air). The solar thermal energy can be used in solar water-heating systems, solar pool heaters, and solar space-heating systems. There are a large number of solar collector designs, which has shown to be functional. These designs are classified in two general types of solar collectors: Flat-plate collectors – the absorbing surface is approximately as large as the overall collector area that intercepts the sun's rays. Concentrating collectors – large areas of mirrors or lenses focus the sunlight onto a smaller absorber. Flat-plate collectors are the most common solar collector for solar water-heating systems in homes and solar space heating. A typical flat-plate collector is an insulated metal box with a glass or plastic cover (called the glazing) and a dark-colored absorber plate. These collectors heat liquid or air at temperatures less than 80°C.

K.K. Chong [1] performed a study of solar water heater using stationary V-trough collector .The result shown was cost effective cum easy fabricated V-trough solar collector can improve the overall performance of solar water heater.

Paul Magloire E. Koffi, Blaise K. Koua [2] determined, theoretical and experimental analysis of thermal performance of a solar water heater prototype with an internal exchanger using thermo syphon system. The results focus mainly on the levels of the heat fluxes temperatures recorded, mass flow rate and efficiency of the collector. These tests are performed for a sunny day and cloudy day. Finally the results show that daily efficiency is near to 50%. This reveals that a good compatibility of the system to convert solar energy to heat which can be used for heating water.

Farahat, F. Sarhaddi [3] determined the optimal performance and design parameters of solar flat plate collector. A detailed exergy analysis is carried out for valuating the thermal performance and optical performance, energy 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.

Alkhair M. Abdul Majeed, M.Y. Sulaiman [4] finding out to increase the output temperature of the water flowing inside of an absorber flat plate solar water heater. Here concentrating material had been used. 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.

Duffie, J.A and W.A Beckman [5] performed annual simulation to monitor the thermal performance of a direct solar domestic water heating system operated under several controlled strategies. According to authors results higher flow rate leads to higher collector efficiency factor. However, it also leads to higher mixing tank and therefore, a reduction in the overall solar water heating system efficiency.

Many authors [6, 7] have concentrated on the development of effective design methods for solar collectors. The cross sectional area of the absorber plate has been constant in the tests conducted by them. 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 a well known fact that for effective design, the profile shape of the absorber plate increases the collector performance.

Ihaddadene and Ihaddadene [8] stated the effect of distance between double glazings 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 intensity.

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Kajavali and Sivaraman [9] have analyzed the single tube and a modified absorber plate in a parabolic trough collector. The solar energy recovery efficiency of the modified absorber plate was found to be higher than the single tube in the form of increased water temperature.

Sae-jung and Krittayanawach [10] have derived the mathematical model and the experimental study for prediction of the temperature of hot water produced from thermo syphon solar water heater. Results are presented of storage temperature, collector temperature and thermal efficiency of the solar water heater.

Various studies reviewed above have confirmed the importance of performance improvement of the collector in solar water heating system. In this study the different geometries of absorber plates namely V-grooved and Square pulse is designed and constructed with the aim of the cost and to bring out better efficiency.

2. Objectives

The main objective of this test is to investigate the performance of flat plate solar water heater subjected to various absorber plate geometries. The V-grooved and Square pulse absorber plate is used at different mass flow rates.

3. Experimental setup

The experimental setup made up of mild steel box and different shape of absorber plates. The line diagram of the experimental setup is shown in Fig.1, and the different geometries of the absorber plates are shown in Figs. 2 & 3. Mild steel flat plate of 1.4 x 0.7 m^2 was employed as absorber plate. A glass plate of similar size is used as a protection layer for heat loss from absorber plate to atmosphere and the bottom of the collector was covered with heat resisting material to minimize the heat loss to the surroundings.

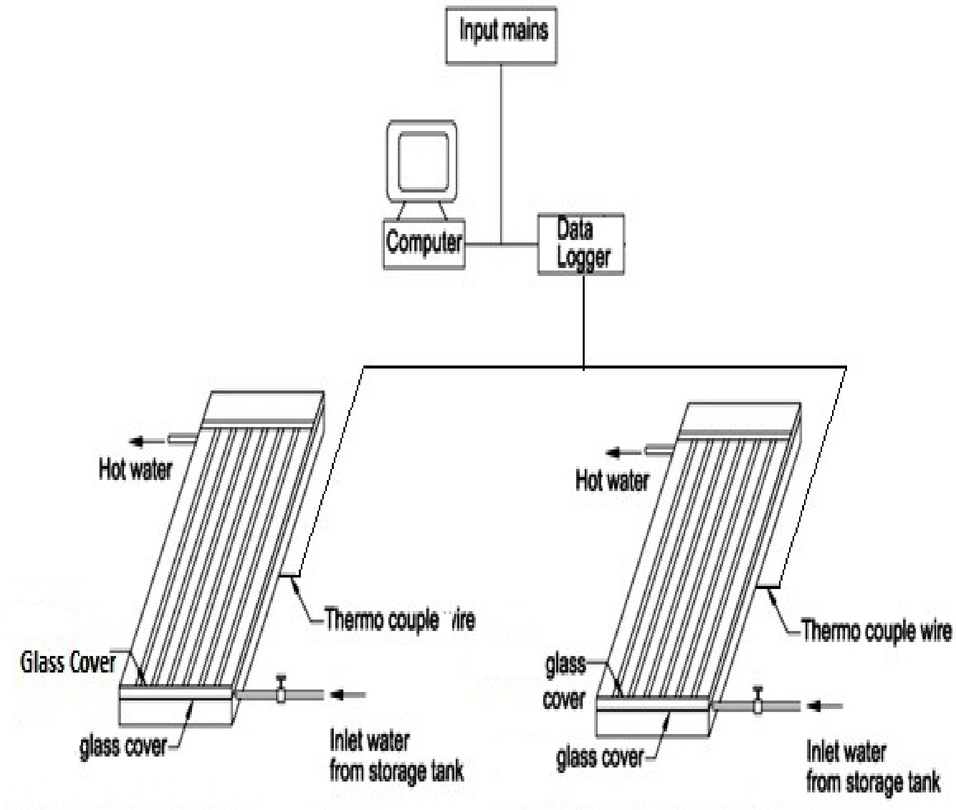

Figure 1. Line diagram of experimental setup

Figure 2. V-Grooved Absorber Plate Solar Water Heater

Figure 3. Square Pulse Absorber Plate Solar Water Heater

Figure 4. Agilent Data Logger

Table 1. Specification of the experimental setup

V-grooved and square pulse absorber plate solar water heater

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

3.1. Measuring Equipment

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

3.2. Experimental procedure

The performance of solar water heater is studied with different geometries of absorber plates. Two types solar water heater setup shown in Figs 2 and 3 having V-grooved and square pulse were fabricated and tested. 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 3.30 pm. Experiments were conducted on V-grooved and Square pulse with uniform solar intensity 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.

4. Results and Discussion

Different absorber plate geometries selected for experimentation namely V-grooved and square pulse respectively. Graphs were plotted between Time Vs efficiency (%), heat gained by the water (W), water outlet temperature (°C) and solar intensity (W/m^2) respectively as illustrated in Fig. 5 to 10 for the different mass flow rates.

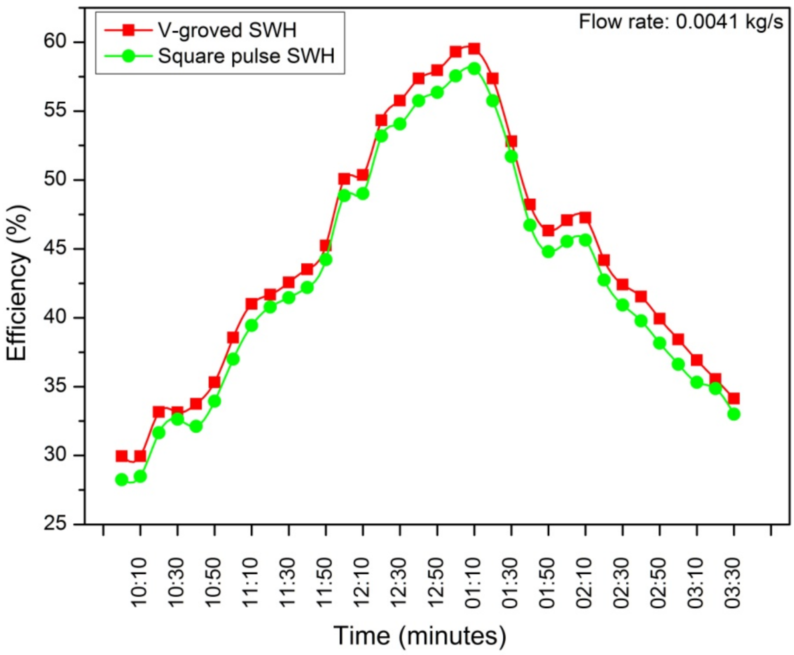

Figure 5. Thermal efficiency Vs time (flow rate 0.0041 kg/s)

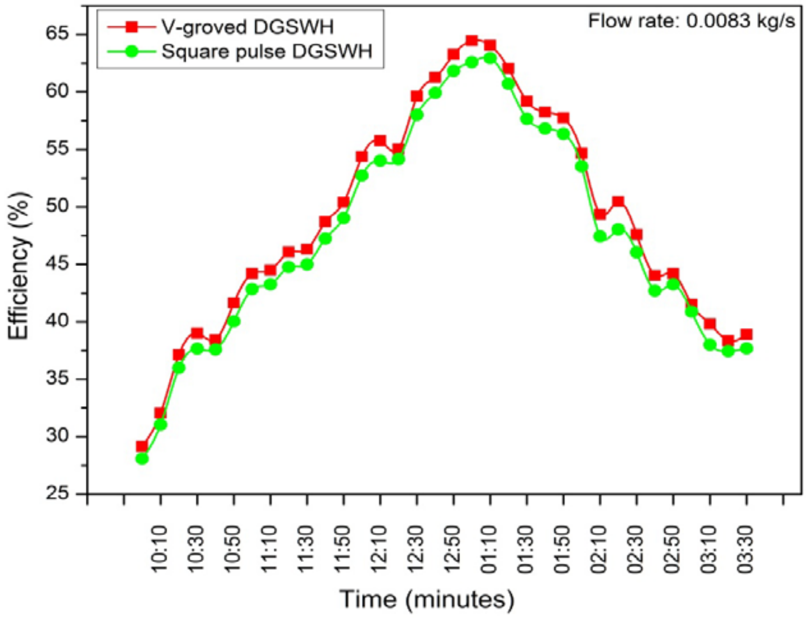

Figure 6. Thermal efficiency Vs time (flow rate 0.0083 kg/s)

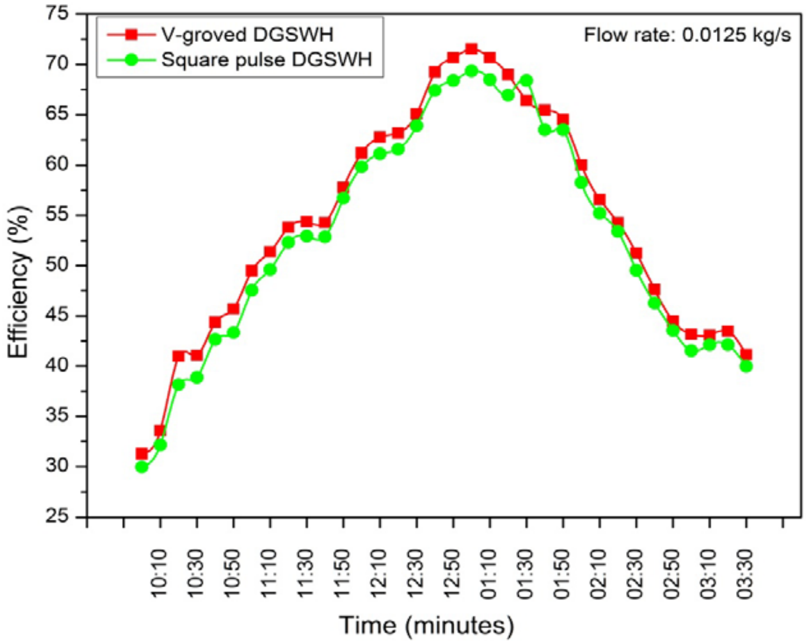

Figure 7. Thermal efficiency Vs time (flow rate 0.0125 kg/s)

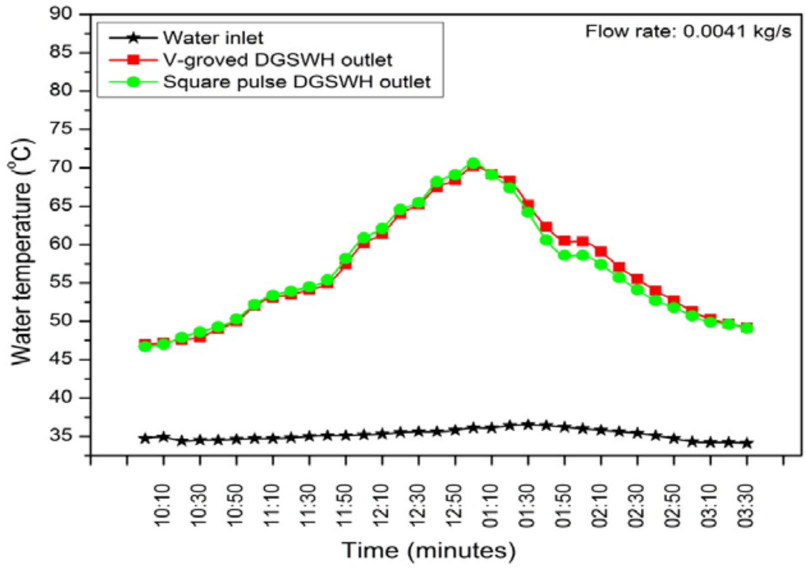

Figure 8. Water temperature Vs time (flow rate 0.0041 kg/s)

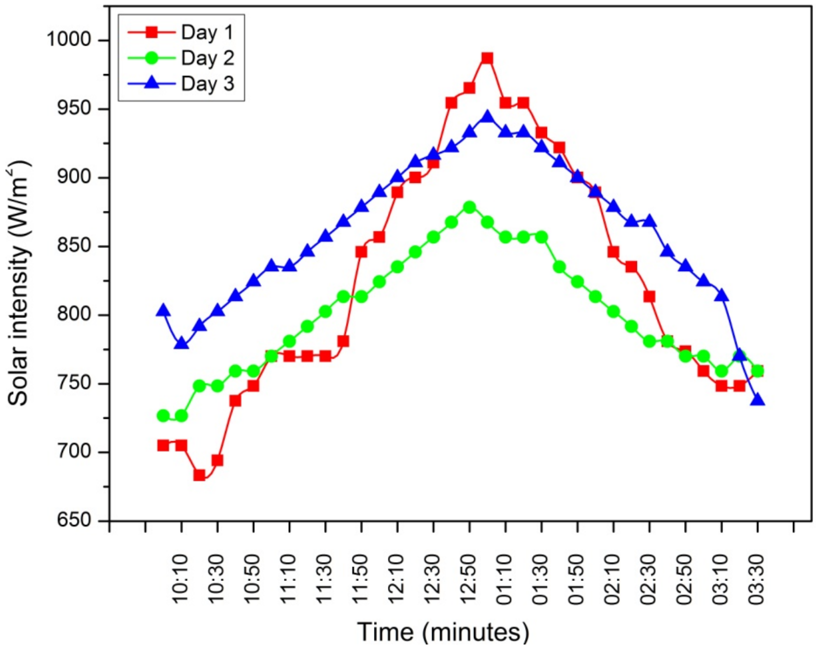

Figure 9. Solar intensity Vs time

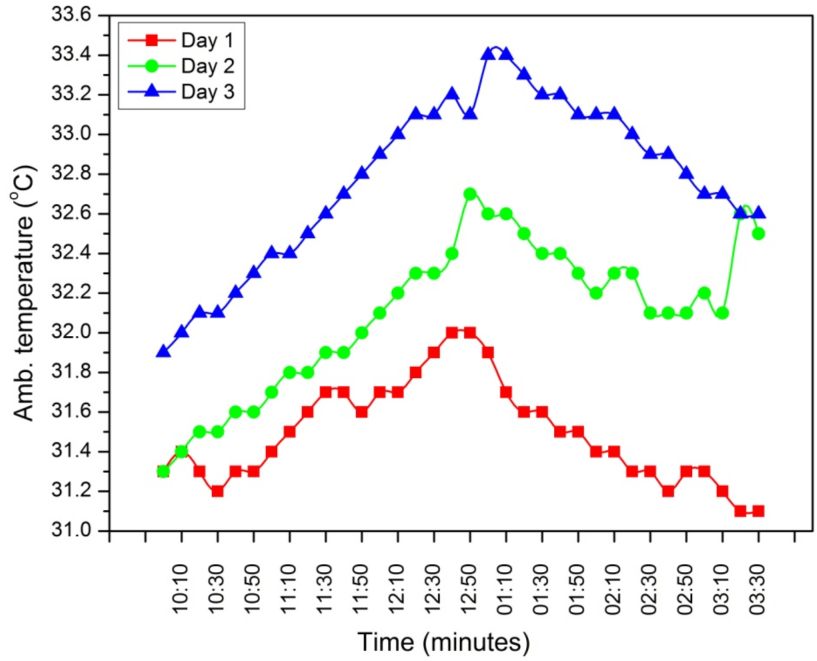

Figure 10. Ambient temperature Vs time

5. Conclusion

Experiments were conducted with double glazed solar water heater for the V-grooved and square pulse absorber plates subjected to uniform mass flow rate to find the performance of the set-up. The following conclusions were obtained from this study.

1. The V-grooved absorber geometry temperature is higher than the Square pulse absorber plater geometry during experimentation.
2. Thermal efficiency is higher for V-grooved absorber geometry.
3. Heat gained by the water in V-grooved absorber geometry is comparatively higher than other Square pulse absorber geometry.

4. Thermal efficiency and heat gained by the water increases with increase in mass flow rate.

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