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An Experimental Investigation of the Performance of a Solar Heater under Climate Conditions of South of Iraq

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***Abstract*—In general, solar water heating system can be described as a beneficial device for heating water by the utility of incident solar radiation. In the present study, an experimental solar water heater was constructed in Misan City, south of Iraq. The constructed experimental unit is a box of glass with a width of 40 cm. To measure temperatures of the experimental unit 7 K-type thermocouples were used. Three different inclination angles were investigated. The results showed that in the month of January, temperature of the solar water heater reached around 70 °C with an inclination angle of 37°. Furthermore, it was conducted that for the investigated period (January), temperatures reached the maximum at around 14 p.m. and then there was a decrease in the temperature. Moreover, it was concluded that the height of the solar water heater has a significant influence on the temperature.**

***Keywords*—solar heater, solar energy, Sustainable energy, Renewables, solar radiation.**

I. Introduction

Due to the increasing demand for energy and levels of greenhouse gases (GHG), it is significant to seek new clean and sustainable energy resources. The utilisation of fossil fuels for the power generation causes more GHG emissions, and consequently, more pollution challenges. Renewables are likely to be the best alternative to the conventional fuels. These energy resources are sustainable and have the potential to meet the growing demand for energy without adding negative impact on the environment [1].

Solar energy is a sustainable and clean energy with no GHG emissions, and consequently, its exploitation has no negative influence on the environment. Solar power-based technologies might be the most natural types of energy offering unlimited power generation for as long as the sun shines on the globe. These technologies could be capable of providing unlimited power generation [2-12]. The utility of solar energy applications has increased substantially in recent years; these applications vary from supplying electrical power by the exploitation of solar panels or solar towers to providing thermal heat to residential and industrial buildings via using the flat plate and vacuum tubes solar collectors [13,14]

A solar collector can be defined as a device which gathered collecting and converting the incident solar radiation into a useful energy (thermal energy). Commonly, solar collectors are divided into three common types: flat plate, evacuated tubes and concentrating collectors [15,16].

The present study is an endeavour to conduct experimental results related to the utility of solar water heater in an area with a promising opportunity of using solar energy. These results would be beneficial for more future investigations.

Solar water heater is a cost-effective method to supply hot water for many applications such as buildings and some industries requiring temperatures below 100 °C. It could be characterised by its performance; the performance essentially and vitally depends on the transmittance of its cover, and physical properties of the working fluid. Moreover, the incident solar radiation is the main parameter affecting the performance of the solar water heater [17,18]. Based on the mode of operation, solar water heating system can be divided as an active or passive operation. The active operation has a pump to circulate the working fluid between the collector and the storage tank or any end use. On the other hand, the passive system works without a pump [15]. In this paper, it is focused on the passive solar water heater.

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For the purposes of this study, to generate data from solar water heater sited in Iraq, a small experimental solar water heater was constructed in the south of the country. This is to enabling the potential of this technology to be fully explored and to investigate the performance of a passive solar water heater in this area.

II. Experimental Work and Materials

The experimental study was carried out in the month of January. A small solar heater with dimensions of 73×40×5 cm was constructed in the city of Misan, which is located in the south of Iraq (Latitude: 31.48°, Longitude: 47.14°). The temperature in the experimental unit was monitored during the working time. The experimental unit was a small container made of glass sheets of 6 mm thickness, and covered with a 4 mm glass cover. The side walls and base of the glass container were surrounded by a frame with a thickness of 2 mm made from aluminium. In between the glass and aluminium layers a 5 cm layer of glass wool was inserted. This layer of glass wool acted as an insulator, to reduce heat loss from the base and walls of the experimental unit. The inner sides of the glass were painted black to improve the solar radiation absorptivity of the experimental unit. Figure 1 shows a schematic of the experimental unit.

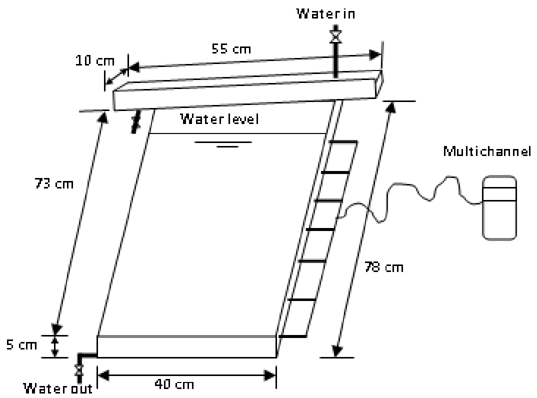
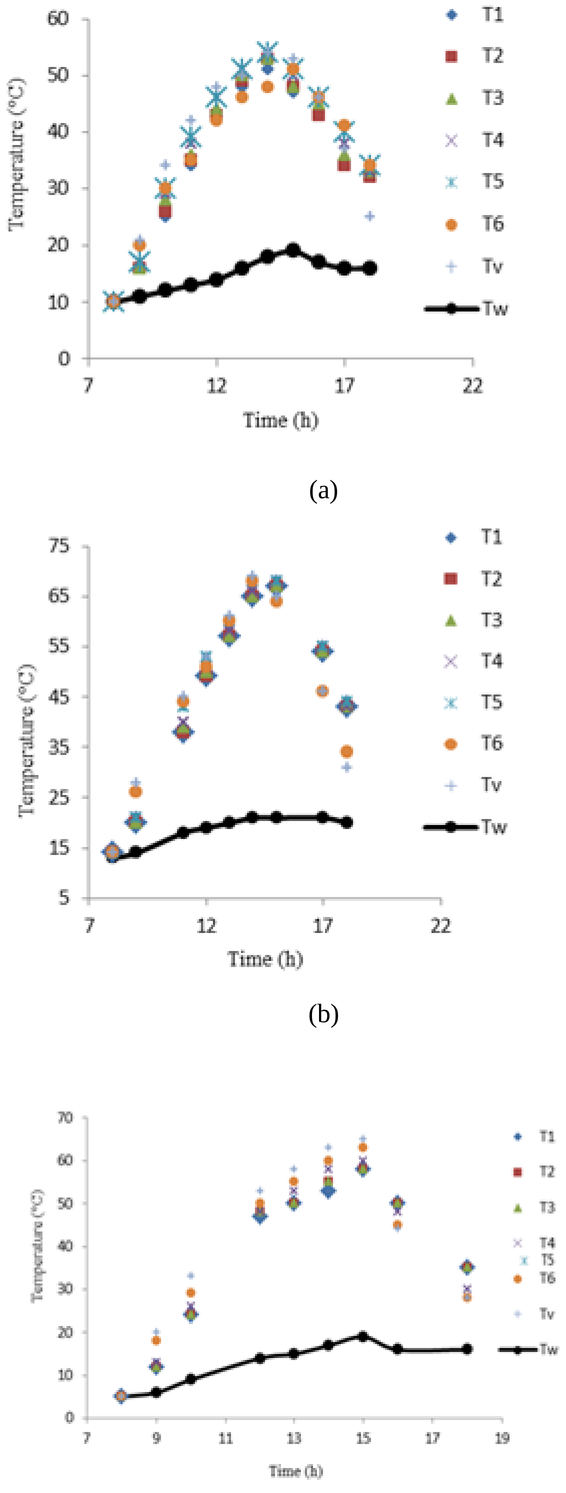


Figure 1: A schematic diagram showing the experimental solar water heater and the distribution of thermocouples which monitor the temperature in the solar heater.

Temperature was measured by the use of 7 calibrated K-type thermocouples. As shown in Figure 1, the used thermocouples were fixed along the vertical right side of the unit, to measure the vertical temperatures. The aim of the utility of 7 thermocouples was to investigate if there is any variation in the temperature with the altitude during the time of experiment. All thermocouples were connected to a multichannel digital reader by 1 m extension wires. To examine the impact of the inclination on the temperature of the storage; three different angles were investigated, and different temperatures were measured.

III. Results and Discussion

Figure 2 illustrates the change in temperatures measured by all thermocouples fixed on the experimental unit.



(c)

Figure 2: Temperature variation along the solar heater with the daytime for H = 60 cm and inclination, (a) angle ϴ=41.5°, (b) angle ϴ=37°, (c) angle ϴ=30°

It can be observed from Figure 2(b) that the best inclination is when ϴ=37°. Vapour temperature (Tv) reaches more than 65 °C. This means more water evaporation and in other words more heat absorption in the unit. Moreover, it can also be seen from Figure 2 (a,b, and c) that temperatures have similar profiles for all investigated inclination angles. It is clear that temperature increases steadily to hit the maximum at about 14 p.m. and remains around this value until 15 p.m. Then the temperature decreases gradually to reach the lowest value at 18 p.m. (Figure 2).

For the same angles of inclination (41.5, 37 and 30°), the temperature measurements for different times from morning to afternoon are shown in figures 3-5.

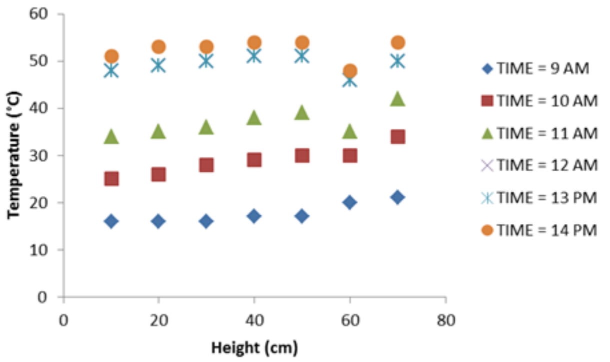


Figure 3: Temperature variation with solar heater height along heating period for H = 60 cm and inclination angle ϴ=41.5°

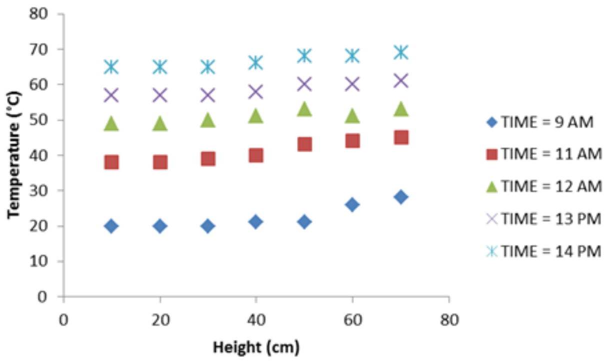


Figure 4: Temperature variation with solar heater height along heating period for H = 60 cm and inclination angle ϴ=37°

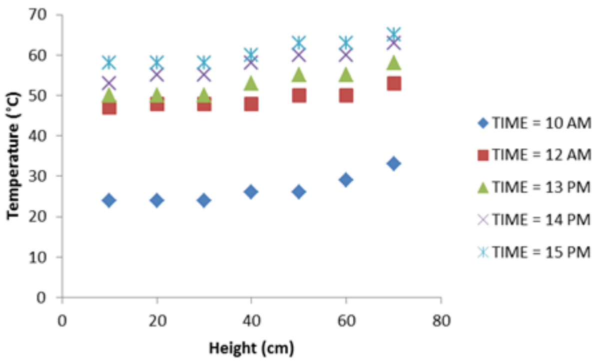


Figure 5: Temperature variation with solar heater height along heating period for H = 60 cm and inclination angle ϴ=30°

It is evident from figures 3-5 that for the three studied inclination angles, the increase in the temperature with the height of the experimental unit is gradual from the morning time to the evening. Furthermore, temperatures reach around 70 °C with the angle of 37° at the top of the unit and this was at 15 p.m. The maximum temperature was at 15 pm and this was shown in Figure 2.

Temperatures of the heater bottom and top were considered for the three considered angles. These temperatures are shown in figures 6 and 7 for the bottom and the top respectively.

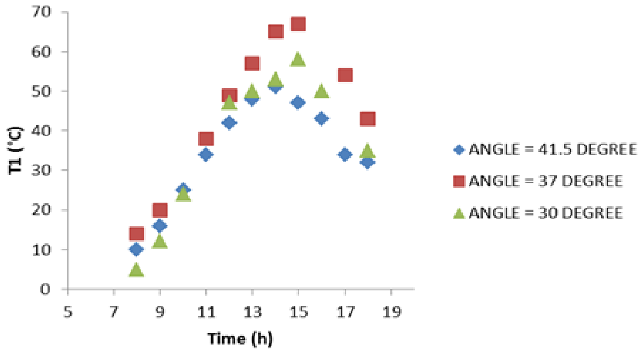


Figure 6: comparison of temperature at the heater bottom with time for H = 60 cm and for three different inclination angles

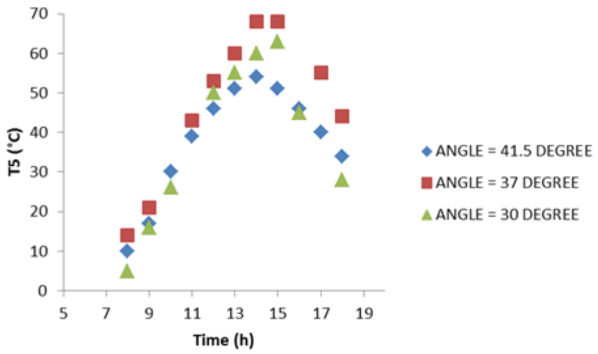


Figure 7: comparison of temperature at the heater top with time for H = 60 cm and for three different inclination angles

It is clear from figures 6 and 7 that with the inclination angle of 37°, the temperature is the highest. Meanwhile, for the three inclination angles, the temperature behaviour is similar. The development of temperature with height of the solar heater was considered for two different times of the day. These times were 14 and 18 p.m., and the measured temperatures are illustrated in figures 8 and 9.

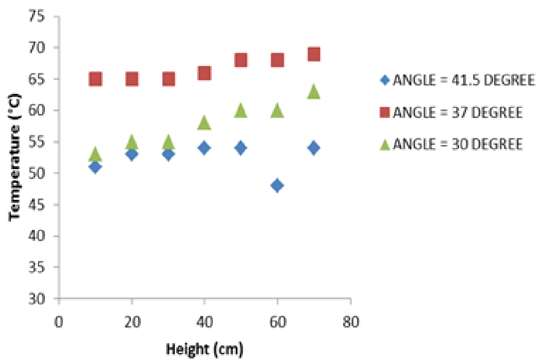


Figure 8: Comparison of temperature with the heater height at time = 14 PM and for three different angle of inclination

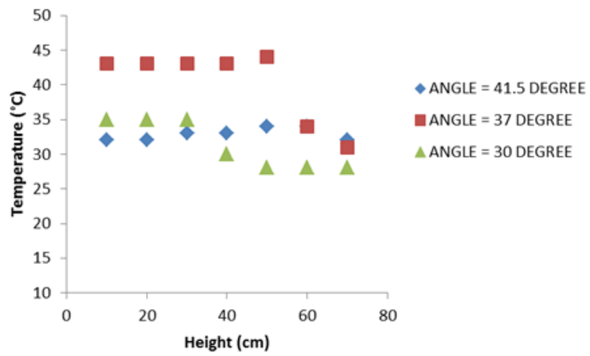


Figure 9: Comparison of temperature with the heater height at time = 18 PM and for three different angle of inclination

It is clear form Figure 8 and Figure 9 that in the time of 14 p.m, the temperature was higher than the temperature at 18 p.m. It can be said that even at 18 p.m. temperatures decreased to around 40 °C, it remained approximately suitable for some uses such as domestics and industries require low temperatures.

The change in temperature with the height of the solar water heater was investigated. Three different heights were selected and investigated. Temperature measurements are shown in Figure 10.

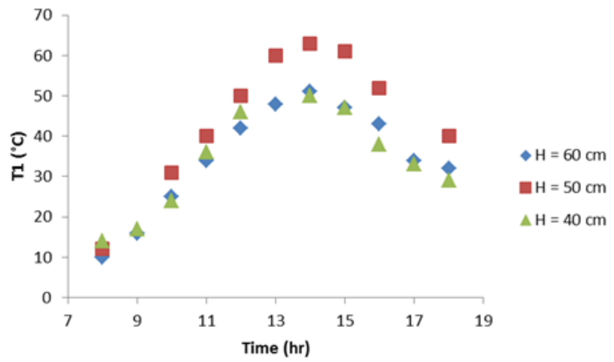


Figure 10: Comparison of the temperature at the heater bottom with time for three different water levels in the heater

Figure 10 illustrates clearly that the height of solar water heater has a significant effect on the temperature. As shown in Figure 10 the measurements of one thermocouple were selected and the measurements show the clear effect of the height. It is clear from the figure that the best height is 50 cm.

Conflict of Interest

Authors declare that they have no conflict of interest.

IV. Conclusions

In this investigation, a small experimental solar water heater was constructed in Misan City, south of Iraq. The aim of the construction was to collect experimental measurements for the solar water heater in this area of the country. To accomplish the temperature measurements, 7 K-type thermocouples were used. Moreover, the impact of inclination on the temperatures of the solar heater was studied; for this purpose, three different angles were tested. The results illustrated that in the area of the study, temperature can reach around 70 °C in the month of January. Furthermore, the results demonstrated that the angle of inclination has a remarkable impact on the temperature of the investigated solar water heater. Additionally, the results showed that height of the solar water heater has an impact on the calculated temperature.

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