An Experimental investigation and comparison of a Solar water heater

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Abstract: An experimental set-up of Solar water heater has been fabricated to see the effect of various parameters on outlet water temperature. The impact of mass flow rate has been taken into account to see the variations in outlet water temperature. The solar flux has been taken between the range of 700-900 W/m^2. Tilt angle has been taken as 45˚ for all the readings. A graph has been plotted between outlet water temperature in y-axis and mass flow rate in x-axis keeping the tilt angle constant.

Keywords: Solar water heater, outlet water temperature, mass flow rate.

Introduction:

Water heaters are one of the most basic and extensively used device used for household purposes. But they all works upon electricity or use fossil fuels like coal to work upon for heating water. But by looking at the present trends of consumption of fossil fuels, there is a need to focus our attention from conventional fuels to non-conventional energy sources. One such renewable energy source is solar energy which is in plenty and full harnessing of this energy has not been achieved yet. So many attempts have been made to use this abundant solar energy. One such method is to use it for heating water in solar water heater. So, this paper presents the findings of using solar energy to heat water in solar water heater. Many researchers have done their work in this field. Some of the findings has been given below.

Zhao et al. [1] investigated on a solar water which uses a phase change material and have a bigger set up since it is having a combination of two tanks one for the water and one for the phase change material. They concluded that due to the PCM material, there is a good increase in the thermal conductivity which makes it more effective in the heating of water.

Hossain et al. [2] investigated and examined the low-cost, flat plate solar water heater for financial analysis and thermal efficiency. This device has two sides flow which is parallel. This system is having improved overall thermal efficiency when compared to other systems, and it has low fabrication cost.

Urban et al. [3], did their study in different solar technologies used in photovoltaic and solar water heaters. They focused their attention towards low carbon emissions and their constructions primarily based on smaller villages or towns due to space requirements.

Khan et al. [4], fabricated a system coupled with glazed and unglazed collectors in Bangladesh. He found that, the effectiveness of the glazed collector got improved by around 70% than the unglazed collector.

Yoo [5] did his work on the operation of Solar water heater for three years that is installed in the housing complex. He concluded that the accumulated heat gain from the three-year operation was 52%.

Oliy & Ramayya [6] did their work on Serpentine Flat Plate SWH. The primary goal was to improve the thermal performance of collectors. They use a new mechanism on the absorber plate to diminish thermal fusion in the plate.

Experimental Set-up:

Schematic diagram of SWH has been shown in figure 1. It has two storage tanks. The capacity for cold water storage is 20 litres and for storing hot water is 25 litres. Both are made of copper. A heating source is provided to give heat flux of the range of 700-900 W/m^2. For this halogen bulbs are used for having 500 W each intensity. These were measured with the help of pyranometer.

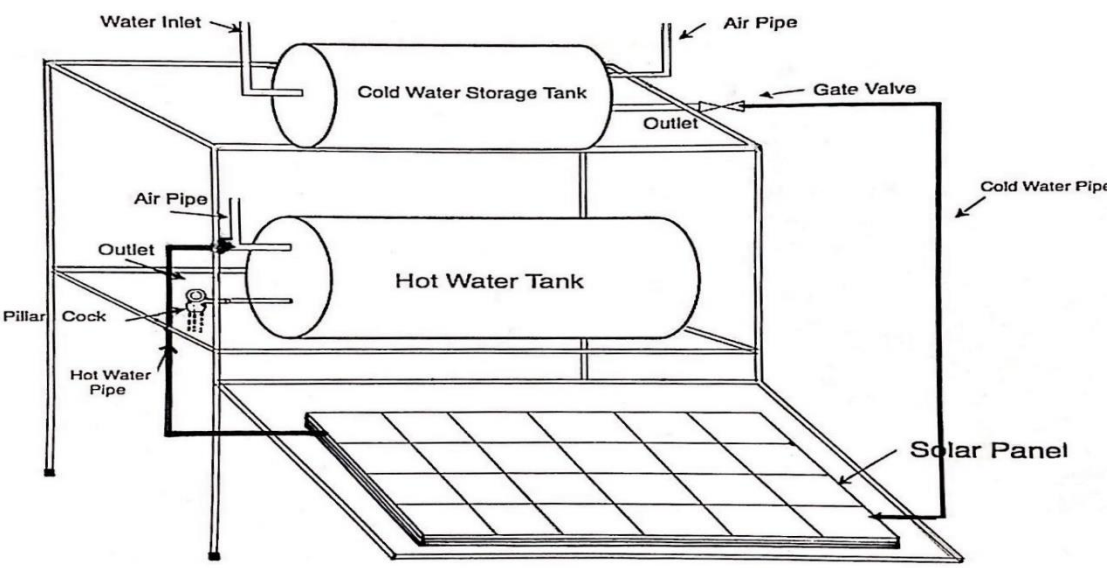

Figure.1. Schematic view of solar water heater

Results and Discussions:

Results have been shown to see the effect of varying intensity on the outlet water temperature.

Parameters taken are:

a) Mass flow rate ($\dot{m}$)(kg/s)
b) Outlet temperature (T_o)
c) Solar radiation intensity (w/m^2)
d) Tilt angle (α)

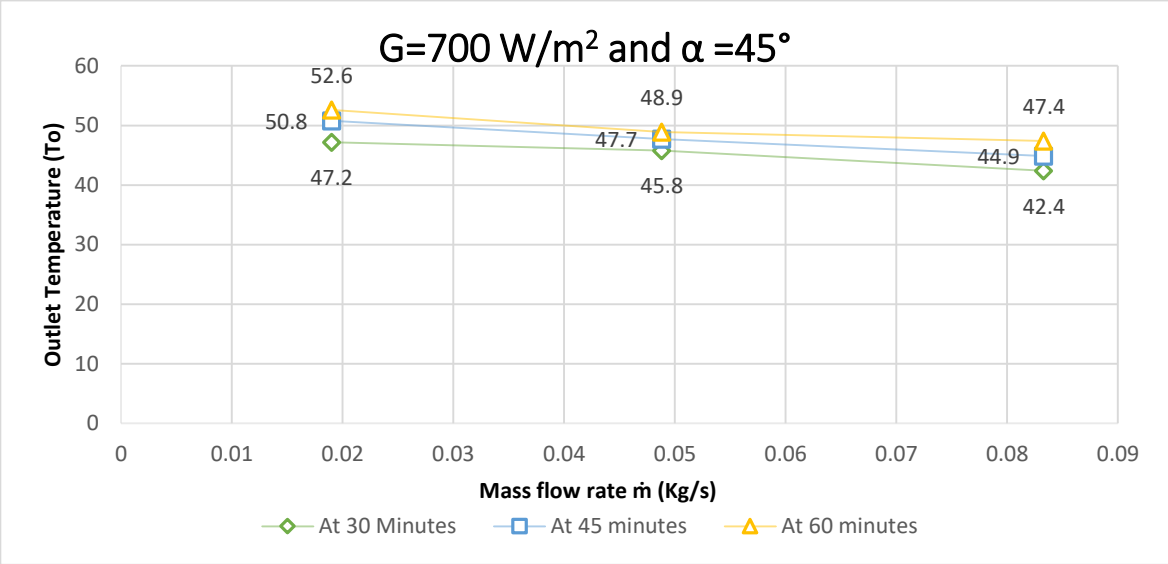

Figure. 2. The effect of ṁ (Kg/s) on T_o at G= 700 W/m^2 and α = 45°.

Figure 2 illustrates the effect of mass flow rate on the outlet temperature with Solar Radiations (G)=700 W/m^2 and Tilt Angle (α) = 45°. According to this T_o decreases with an increase in the mass flow rate ṁ (Kg/s). The outlet water temperature (T_o) decreases significantly to 1.4°C with changing flow rate from 1.9x10^{-2} to 4.88x10^{-2} and more at 8.33x10^{-2} Kg/s with a decrement of 3.4°C for 30 minutes. For all other cases of flow rate, T_o decreases more with increasing mass flow rate from 1.90x10^{-2} to 4.88x10^{-2} and decreases less with increasing mass flow rate from 4.88x10^{-2} to 8.33x10^{-2} Kg/s.

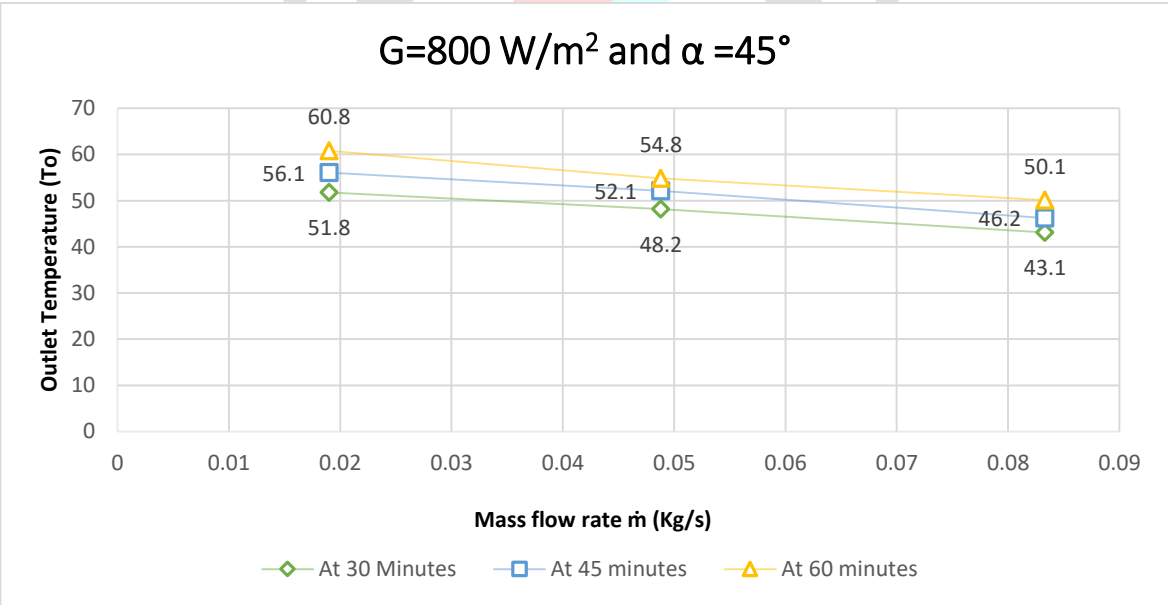

Figure. 3. The effect of ṁ (Kg/s) on T_o at G= 800 W/m^2 and α = 45°.

Figure 3 shows the effect of ṁ (Kg/s) on the outlet temperature with Solar Radiations (G)=800 W/m^2 and Tilt Angle (α) = 45°. It shows that T_o decreases with an increase in ṁ (Kg/s). T_o decreases significantly to 3.6°C with changing flow rate from 1.9x10^{-2} to 4.88x10^{-2} and more at 8.33x10^{-2} Kg/s with a decrement of 5.1°C for 30 minutes. For all other cases of flow rate, T_o decreases more with increasing ṁ (Kg/s) from 1.90x10^{-2} to 4.88x10^{-2} and decreases less with increasing ṁ (Kg/s) from 4.88x10^{-2} to 8.33x10^{-2} Kg/s.

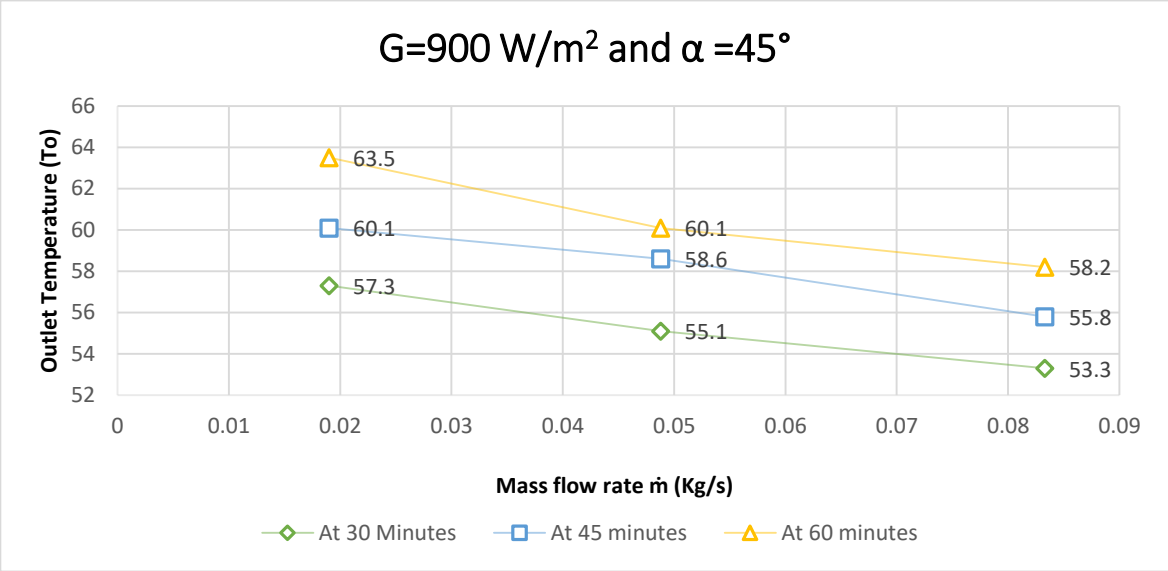

Figure. 4. The effect of ṁ (Kg/s) on T_o at G= 900 W/m^2 and α = 45°.

Figure 4 shows the effect of mass flow rate on the outlet temperature with Solar Radiations (G)=900 W/m^2 and Tilt Angle (α) = 45°. The graph shows that T_o decreases with an increase in the ṁ (Kg/s). The outlet water temperature (T_o) decreases significantly to 2.2°C with changing flow rate from 1.9x10^{-2} to 4.88x10^{-2} and less at 8.33x10^{-2} Kg/s with a decrement of 1.8°C for 30 minutes. For all other cases of flow rate, T_o decreases more with increasing ṁ (Kg/s) from 1.90x10^{-2} to 4.88x10^{-2} and decreases less with increasing ṁ (Kg/s) from 4.88x10^{-2} to 8.33x10^{-2} Kg/s.

Conclusion:

It has been concluded from the above results that for a constant tilt angle of 45˚ and solar radiations ranging from 700-900 W/m^2, the maximum outlet water temperature comes out to be 63.5˚C for intensity of radiations 900 W/m^2 which is close to 17% higher than what we get when the intensity is on the lower side that is 700 W/m^2. So, by placing collectors at right location we can get maximum efficiency and enhanced output.

References:

[1] Zhao, Juan, Ji Yasheng, Yanping Yuan, Zhaoli Zhang, and Jun lu. "Energy-Saving Analysis of Solar Heating System with PCM Storage Tank." *Energies* 11, no. 1 (2018): 1-18.

[2] Hossain, Md, Dr A. Pandey, Mohsin Ali Tunio, Jeyraj Selvaraj, Kazi Enamul Hoque, and Nasrudin Abd Rahim. "Thermal and Economic Analysis of Low-Cost Modified Flat-Plate Solar Water Heater with Parallel Two-Side Serpentine Flow." *Journal of Thermal Analysis and Calorimetry* 123 (2015): 1-14.

[3] Urban, Frauke, Yu Wang, and Sam Geall. "Prospects, Politics, and Practices of Solar Energy Innovation in China." *The Journal of Environment & Development* 27, no. 1 (2018): 74-98.

[4] Khan, M. M. A., A. B. M. Abdul Malek, M. A. H. Mithu, and D. K. Das. "Design, Fabrication and Performance Evaluation of Natural Circulation Rectangular Box-Type Solar Domestic Water Heating System." *International Journal of Sustainable Energy* 29, no. 3 (2010): 164-77.

[5] Yoo, Jung-Hyun. "Evaluation of Solar Hot Water Heating System Applications to High- Rise Multi-Family Housing Complex Based on Three Years of System Operation." *Energy and Buildings* 101 (2015): 54-63.

[6] Gutu Birhanu Oliy, Auch Venkata Ramayya. "Experimental Testing of a Serpentine Flat Plate Solar Water Heater." *International Journal of Energy and Power Engineering* 6 (2017): 61-67