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STUDY OF BUILT-IN-STORAGE TYPE SOLAR WATER HEATERS USING DIFFERENT TYPES OF ABSORBER PLATES

Nishith Kumar Das* and Chowdhury Md. Feroz
Department of Mechanical Engineering, Bangladesh University of Engineering and Technology
Dhaka-1000, Bangladesh.

Abstract- An equal volume of south facing trapezoidal corrugated absorber plate has been built and tested compared with a flat absorber plate collector during the month of July and August 2001 at Dhaka. The trapezoidal corrugated absorber plate collector heats water up to 61^{o} C and 66^{o} C in the month of July and August whereas flat absorber plate collector can heats up to 57^{o} C and 61.5^{o} C, respectively. The average efficiency is 73% and 62% for trapezoidal corrugated absorber plate collector and flat absorber plate collector, respectively.

INTRODUCTION

Solar water heater (SWH) combining collection and storage in one unit has been described by Tanishita, I. (1964). Solar water heating for domestic use is at present the most attractive way of utilizing solar energy. Conventional SWHs are still a costly affair. The cost of a system is 30% due to the collector itself while 70% is contributed by associated components like extra storage tank, piping, gate-valves, stand, Heat exchanger, electronic control besides installation charges [Goetzberger and Rommel, 1987]. The pioneer work on the SWH was done by many researchers [Löf and Close 1967, Richards and Chinnery 1967, Tanishita 1970, Garg *et al.,* 1997, Nayk and Amer 2000, Amer *et al.,* 1999, Amer *et al.,* 1997, Amer1998, Amer *et al.,* 1998a, Amer *et al.,* 1998b, Ecevit *et al.,* 1989]. Rönnelid *et al.* (1996) tested and compared compound parabolic concentrator collector with flat plate collector. Morad (1995) investigated the effect of corrugated absorber plate on the performance of a rectangular collector-cum-storage type solar water heater (CSWH). He used sinusoidal corrugated absorber plate, which was placed crosswise at the top of the water tank. But for better fluid flow corrugation of the absorber plate should be placed along lengthwise. So far no investigation has been carried out in a CSWH with trapezoidal corrugated absorber plate in comparison with flat absorber plate.

EXPERIMENTAL APPARATUS AND TEST PROCEDURE

Both the collectors are placed at 23.5^{o} angle of inclination due in south facing at Dhaka. The schematic diagram of the experimental set up is shown in Fig. 1.

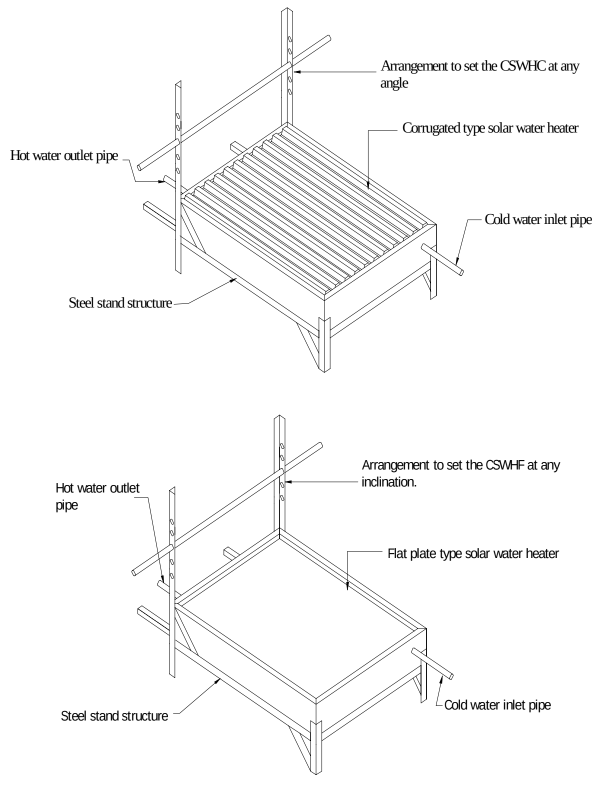
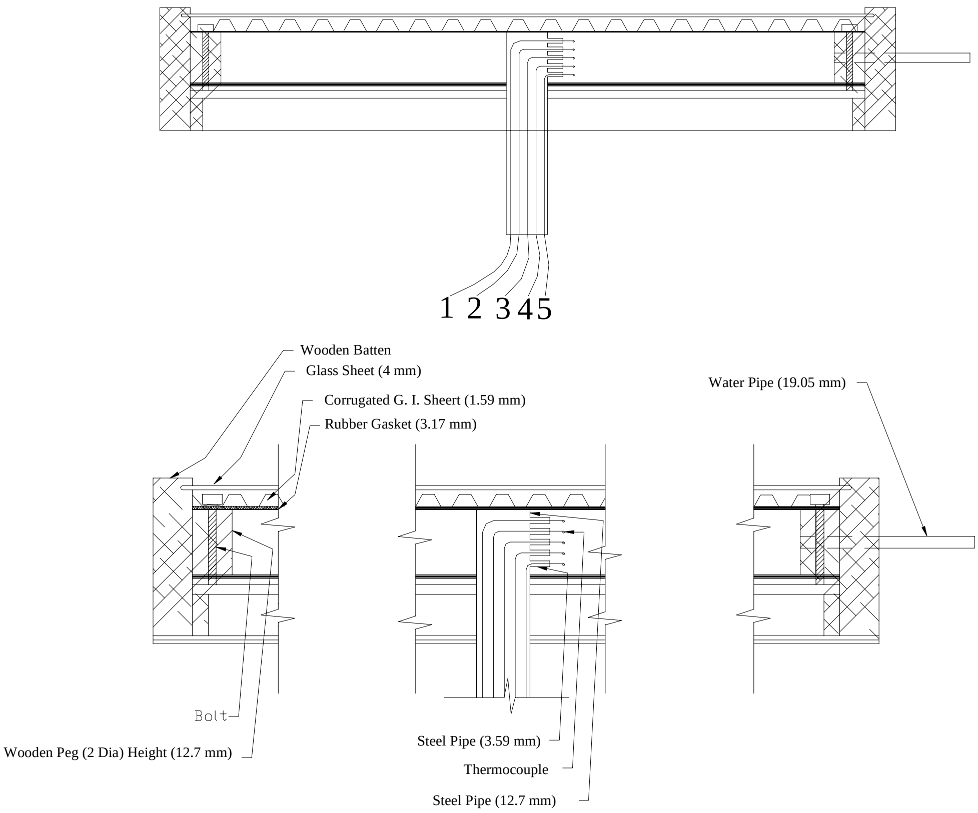


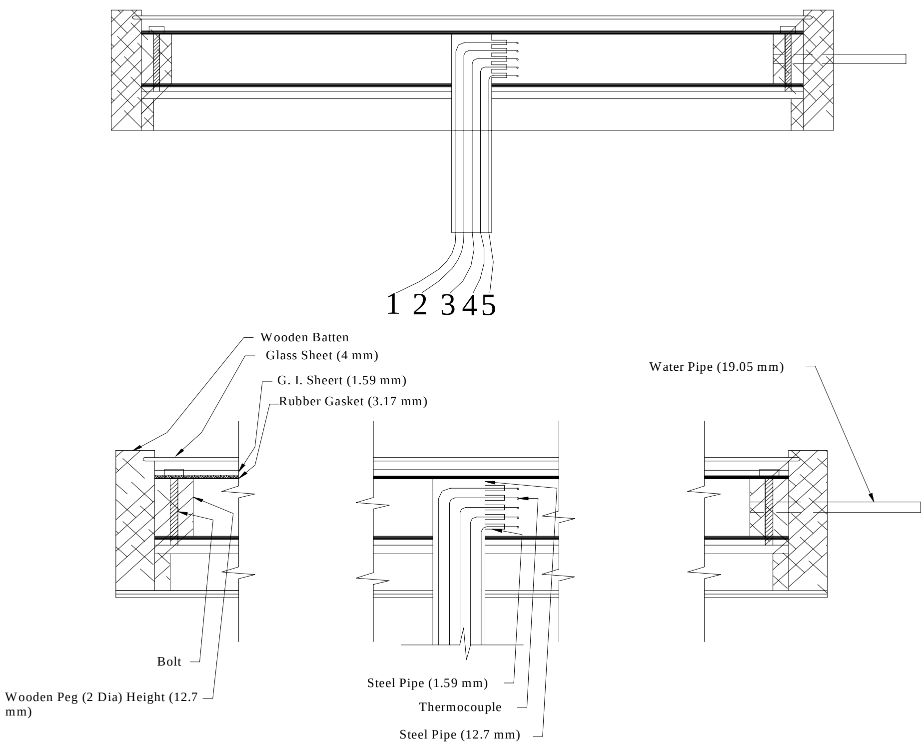
Fig. 1 Schematic diagram of the experimental set up

The storage tank and solar collector are combined and built as one unit. External dimensions of the collectors are 155.5cm X 109.5cm X 31cm and a capacity 165 liters each. Absorber plate placed at the top of the collector and bottom of the tank are made of 16-gauge G.I. sheet. Both the flat and trapezoidal corrugated

* nishith-das@hotmail.com



(a) Solar water heater having corrugated absorber plate



(b) Solar water heater having flat absorber plate

Fig. 2 Details of the test section

absorber plates are blackened with dull paint. The wooden casing supports both the plate and gaskets are used to avoid leakage and the plates are tightened with nuts and bolts. Details of the test section are shown in Fig. 2. All the collectors placed on the mild steel angle frame (3.81cm x 3.81 cm x 0.375 cm) and have the provision of setting the collectors at 17.5 to 45 degree angle of inclination. A probe containing five 35 SWG chromel-alumel thermocouples is installed in each SWH for measuring temperature at different depth of water as shown in Fig. 2. To reduce heat losses from the collector by radiation and convection to a minimum value, a glass cover with optimum air gap of 25.4 mm is used as per the work of Marsh (1994). Glass rests on a wooden casing and is secured by wooden batten and screwed with casing. The glass wool is used as insulation having a thickness of 2.86 cm at the bottom surface and 2.54 cm at the sides. Temperatures of water are recorded at each hour from 8 a.m. to 5 p.m. with a maximum error of 0.2^{o} C.

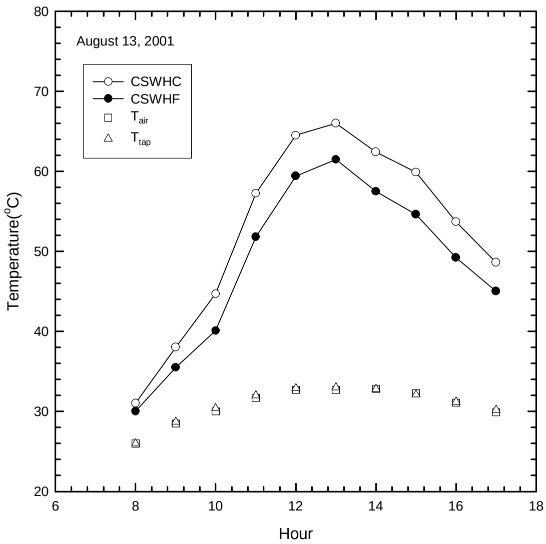


Fig. 3 Daily temperature distribution

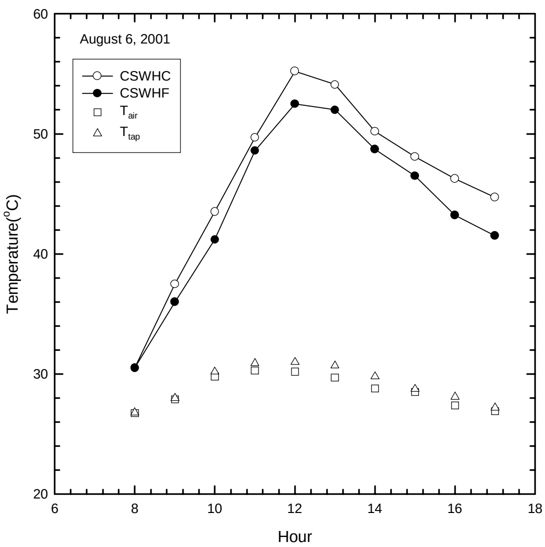


Fig. 4 Temperature distribution on a cloudy day

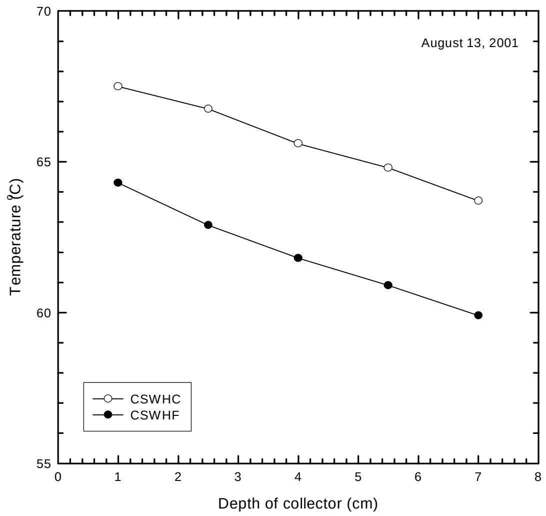


Fig. 5 Temperature distribution of water along the depth of collectors

RESULTS AND DISCUSSION

Measurements are done on July and August 2001 at Dhaka. Figure 3 shows the typical performance of the system for a sunny day in the month of August 13, 2001. The figure indicates that the system can heat the water up to 66^{o} C for the corrugated absorber plate of CSWH and 61.5^{o}C for the flat absorber plate of CSWH when the air temperature is 32.8^{o} C. The maximum temperature reached at about 13:00 PM. It also indicates that the maximum ordinary tap water temperature is 35.8^{o} C.

Fig. 4 shows the experimental performance of the system for a partially cloudy day in the month of August 6, 2001. The figure indicates that a temperature rise of about 26^{o} C can be achieved by the system for a partially cloudy day.

Typical temperature distribution of water along the depth of collector is shown in Fig. 5. The figure indicates that the temperature decreases towards the bottom of the collector.

Performance of the built-in-storage type SWHs is expressed in terms of efficiency of the collector. Efficiency of the collector is calculated by using the following equation of Marshal-Adams (1978):

$$\eta = (m_w C_p \Delta T)/AI$$

Comparison of performance between cullector-cum-storage type SWHs with corrugated and flat absorber plates is shown in Fig. 6. The figure shows the typical comparison among the daily average efficiencies of SWHs based on July 28, 2001. It indicates that the daily average efficiency of corrugated absorber plate CSWH is about 10.5% higher than that of flat absorber plate. Within our experimental range, the average efficiency of the trapezoidal corrugated absorber plate of CSWH is

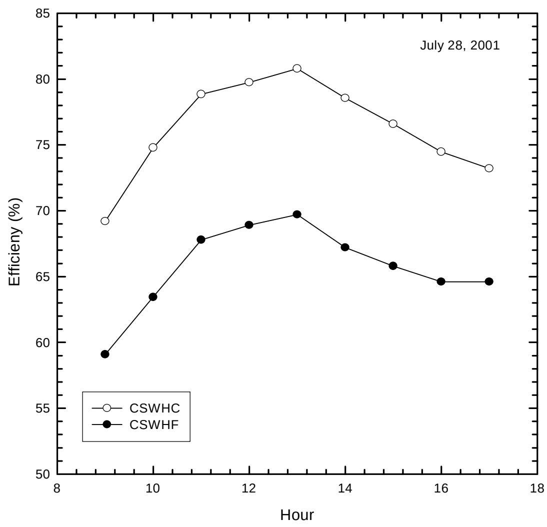


Fig. 6 Comparison of performance between collector-cum-storage type solar water heaters

about 11% higher than that of the flat absorber plate of CSWH.

CONCLUSIONS

Experimental study on the performance of built-in-storage type solar water heaters gives the following results:

1. The average maximum temperature of the corrugated absorber plate of CSWH is 4.5^oC higher than that of the flat plate.
2. The average maximum temperature of the corrugated absorber plate of CSWH at a cloudy day is found to be 2.7 ^oC higher than that of the flat plate.
3. The daily average efficiency of the corrugated absorber plate of CSWH is 11% higher than that of flat absorber plate.

NOMENCLATURE

A : projected area of the collector surface, m^2
CSWHC : collector-cum-storage type solar water heater with corrugated absorber plate
CSWHF : collector-cum-storage type solar water heater with flat absorber plate
C_p : specific heat at constant pressure, kJ/kg K
I : solar insolation, W/m^2
m_w : mass flow rate, kg/hr
q : energy absorbed, W/m^2
T : temperature, ^oC
ΔT : rise in temperature of water, ^oC
η : efficiency

Subscript

air : ambient air
tap : tap water

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