The Performance Investigation of Square Tube Solar Water Heater

Anand Patel

Mechanical Engineer
Mechanical Engineering Department,
LDRP- Institute of Technology and Research of Anand Patel
Gandhinagar, India

***Abstract*- The energy availability plays a vital role in economic activity because production and manufacturing can be fulfilled by energy consumption only. The solar energy having one the best domestic and industrial application is solar water heater which can be used for water heating purpose. The hot water can be used for cooking, cleaning, washing and such other purposes also; and the design of such solar water heater (SWH) is highly influence by, orientation of set up toward sun, dimensions of set up, active or passive type solar water heater, material of collector plate, thickness of absorber plate and shape, surface finish and material of water pipes and shape of water pipe also. The solar water in the present work is of square shape pipe with dimension of 0.5" X 0.5 "cross section and 1 m meter in length and K type thermocouple is used to measured temperature of water outlet and pipe body temperature. The maximum temperature of obtained is 49 ^{0} C.**

***Index Terms*- Square Tube, Solar Water Heater, Solar Energy, K-type thermocouple.**

I. INTRODUCTION

To be useful in a heating or cooling system, the solar energy that travels from the sun to Earth via electromagnetic radiation must first be transformed to heat. A feasible device for converting solar energy to heat must be vast since sunlight energy is diffuse when it reaches Earth. Devices used to convert solar radiation into heat, known as solar collectors, typically feature a surface that effectively absorbs sunlight and turns this incident flux into heat, hence increasing the operating temperature of the absorbent material. A liquid or gaseous heat transfer fluid then removes some of this energy from the absorbing surface. The flat-plate collector is a type of solar power collectors that is relatively easy to construct. In contrast to focusing systems, flat-plate collectors are optimised for applications that can accept energy supply at moderate temperatures, maybe up to 80 °C above ambient. Similar to conventional water heaters, solar water heating devices collect solar radiation and transform it into thermal energy. The next step is to use this heat to warm some water.

The two main components of a solar water heater are a storage tank for the heated water and heat collectors. Inside the collector, a black absorbent surface (a selective chemically coating surface) soaks up the sun's rays and sends that energy to the water in the pipes.

The thermal efficiency of serpentine solar water was the primary area of research for Hardik A. Parmar et al. [1], who also determined the efficiency value's temporal variability. Solar water heaters made from recycled plastic bottles were built and tested for efficiency by BesmaChekchek et al. [2]. The number and configuration of riser tubes emanating from the current collector were investigated by Sivakumar et al. [3]. The impact of tube configurations on SWH performance was studied by Kulkarni et al. [4]. SWHs with either a square or a circle for an absorber fin piqued the interest of Ramasamy et al [5]. They increased the surface area in an effort to improve heat transfer, but kept the pressure drop and output speed constant. Four different solar cell array types and three different receiver shapes were used by Sudhakar et al. [6] to improve the performance of trough concentrated photovoltaic systems. SWH. Mangesh.Solar water heaters were created by A.Pachkawade et al. [7] using nontraditional materials such as plastic lateral tubes, HDPE pipe, old glass wool, thermocol, plastic drums, etc., and their thermal performance was assessed. Based on research by Prakash Kumar Sen et al. [8], which looked at how satisfied customers were with solar water heaters, we know that these systems are superior since they use no power and are safe for the environment. Several strategies for boosting the performance of solar-powered water heaters were discussed by J.P. Kesari et al. [9]. Al2O3-H2O nanofluid particles were utilised by Somasekhar T et al. [10] to improve the solar water heater's thermal performance in comparison to CuOnanofluid. Sanjay Kumar Sharma et al. [11] conducted an experimental study on the V-Through Flat Plate Collector and found that it enhances the SWH's thermal performance in the hot climate of Rajasthan. For their study on the efficiency of solar flat collectors, Ismail.N.R et al. [12] zeroed down on zigzagging grooves and employed an absorber panel made of three layers of glass. KrthikMunisamy et al. [13] investigated the effect of a variety of tube configurations on solar water heater performance. To boost the efficiency of solar water heaters, Y.R.Shivarkar et al [14] reviewed the work of numerous scholars. P.Shivkumar et al. [15] found that using a zigzag pattern and a greater number of rising tubes improved efficiency. Jayesh V. Bute et al. [16] found that the heating effectiveness of solar water heaters might be increased by experimenting with different tube forms. By adjusting the solar water heater's tube design and material, Anshali S. Bhabutkar et al [17] were able to boost its efficiency. Kumar sourav et al. [18] looked explored how using copper piping might affect a solar water heater's efficiency. A flat surface water heater equipped with a mechanism that follows the sun was the subject of an experiment by Prasad et al. [19]. Fluid flow and heat transfer in a collector with a wavy absorber plate were numerically analysed by Oztop et al. [20]. Natural convection heat transport inside the inclining wavy solar collectors and

the flat-plate solar collectors was analyzed using a computational fluid dynamics (CFD) model by Varol et al. [21]. Gertzos et al. [22] validated a 3D CFD model through experimental and numerical study of a collector storage solar system with recirculation. The flat-panel solar water heater CFD model performed by Selmi et al. [23] has been validated. Ho et al. [24] conducted an experimental and theoretical investigation of a flat-plate solar water heater that recycles its heat via rectangular pipes. According to research by Kumar and Prasad [25], a pressure drop of 87-132% is acceptable in exchange for an increase in efficiency of 18-70% compared to conventional collectors. ManishaJouhri et al. [26] compiled a summary of the studies conducted by a wide range of scientists on solar water heaters. The efficacy of heat transfer from the absorber pipe wall to the working fluid was investigated by Mohamed Abu Waseem et al. [27] using a variety of inserts and inner caps. D Prakash et al. [28] focused on making the most of solar energy by developing a novel solar water heating technique, and good ceiling insulation prevents heat from escaping within the building. Phase Change Materials (PCMs) were first investigated by S. Sadhishkumar et al. [29] as a means to store solar energy for use later, such as heating water for household usage at night. Parabolic Trough Collector (PTC) models were attempted in Ansys 15.0 Workbench by Ankit S. Gujrathi et al. [30], who noted that the PTC was designed at a concentration ratio of 25. In their study [30], Arun K. Raj et al. compared the performance of a raiser pipe for a flat-table solar water heater with and without fine. Different sizes and forms for the absorber plate pipes can have different effects on heat efficiency, as K. VasudevaKaranth et al. [31] investigated. In a March 2016 study, Mohammed Abdul Junaid et al. [32] used computer-aided design (CAD) software to conduct thermal analysis at 11 a.m., 12 p.m., and 2 p.m. while maintaining a constant mass stream frequency. Using CFD analysis using an evacuated tube heat pipe to convert radiation energy into useful heat, V. Y. Chaudhary et al. [33] concentrated on the application of solar power. Battery performance was investigated by M. Dinesh Babu et al. [34] for a solar water heater with fins attached externally to the riser pipe. The energy that is lost between the collector and the receiver as a result of convection and radiation was investigated by Shrikant G. Pise et al. [35]. The thermal performance of a straight tube solar water heater and a spiral tube solar water heater, which uses a copper tube and flat plate collector, was compared and contrasted by Jignesh A. Patel et al. [36]. Using a flat panel solar receiver, [37] [38] [39] examined how pipe design variations affected performance. Anand Patel et al [40] focused on comparative thermal performance of serpentine solar water heater with straight tube solar water heater. Anand Patel et al [41] concentrated on thermal performance of helical solar water heater and also discussed about manufacturing process of solar water heater. Anand Patel et al [42] obtained experimental results in case of solar water heater using phase change material (PCM). The thermal performance of a fin-covered solar air heater was the primary focus of Patel Anand et al. [43]. Patel Anand et al [44] centered their attention on developing and testing a spiral solar air heater. [46] Anand Patel et al [45] HD Chaudhary et al. thermal performance evaluation due to different geometries and dimension changes within a solar heater. [47] [48] [49] Anand Patel et al. [50] SK Singh et al. [51] Prakashkumar Prajapati et al. [52] Nikul K. Patel et al. defines the concept of heat exchange in an application beyond solar heater. Solar Heater heat transfer enhancement methodology and practical feasibility are conceptualized using [53] S. Jaisankar et al. [54] Ruchi Shukla et al. [55] [56] Patel et al. The thermal performance enhancement for solar heater is studied in [57] Hussain Al-Madani et al. Cylindrical Solar Water Heater [58] S. Vasanthaseelan et al. Different type of turbulators in solar ware heater [59] S. Sadhishkumar et al. historical solar water heating system work review paper.

II. EXPERIMENTAL SET UP

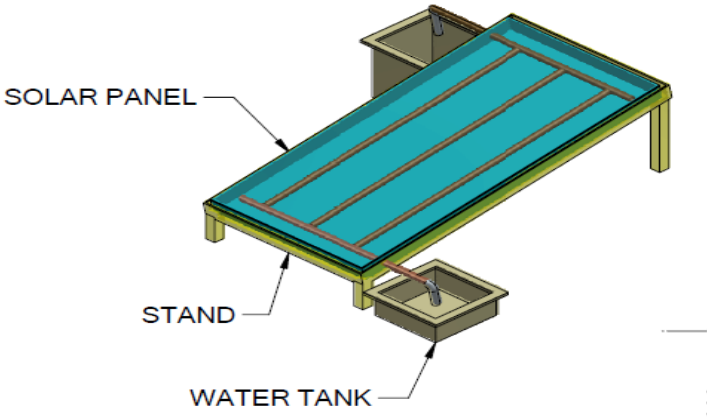

Fig 1 CAD Model of Experimental Set up

Plate 1 L shape copper sheet

Plate 2 Square Tube

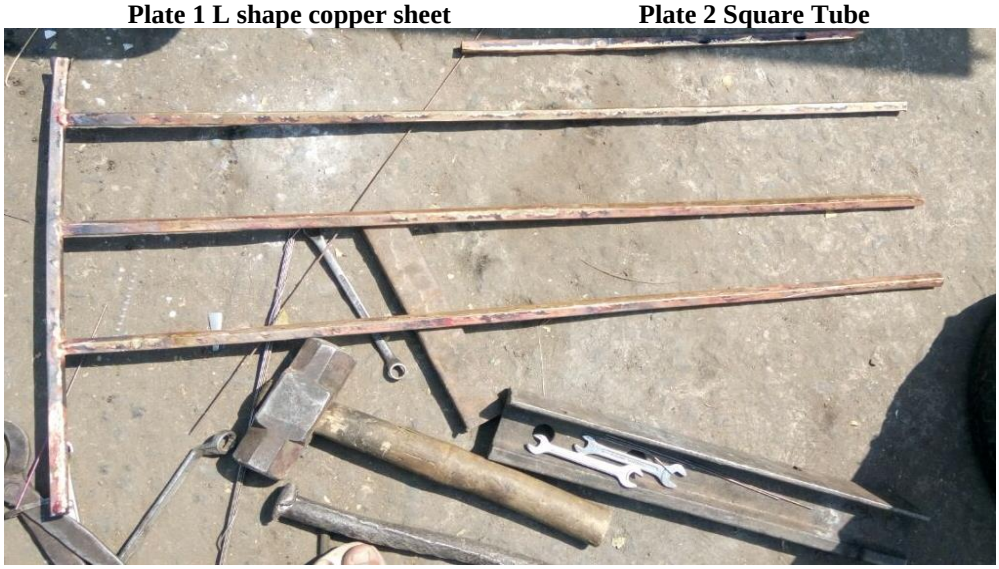

Plate 3 Assembly of Solar water Heater Pipe

Plate 4 End Connection of Solar Water Heater

Plate 5 Experimental Set up

In the present work ½ "copper tube is fabricated from two L section of ½ " cross section with 1 m length and such three pipes are fabricated using brazing as shown in plate 1 and plate 2. After this all three pipes are fabricated with same type of square pipe with 0.5 m length at top and bottom and these two pipes are connected with ½" copper circular pipe with which can be connected with PVC pipe t is connected. The PVC pipe is connected with water Tank. To absorb more heat the pipe assembly is painted with black color. The whole pipe assembly is placed in the wood box which is covered absorber plate of 0.1 mm galvanized sheet which is black color coated and top is covered with 2 mm transparent glass sheet.

III. EXPERIMENTAL METHODOLOGY

In the first phase the experimental set up is placed in north south position with respect to sun's position in east and initially after interval of 15 minute measure the water outlet temperature with K type thermocouple after adjusting flow of water initially.

IV. RESULT AND DISCUSSION

Table 1 Observation Table

TIME (hh:mm)	$T_{w_{in}}$ (°C)	T_b (°C)	$T_{w_{out}}$ (°C)
11:20	32	50	45
11:35	33	52	42
11:50	34	51	42
12:00	35	52	41
12:30	35	54	42
1:05	35	55	44
1:20	37	55	44
1:30	36	56	45
1:40	37	58	49

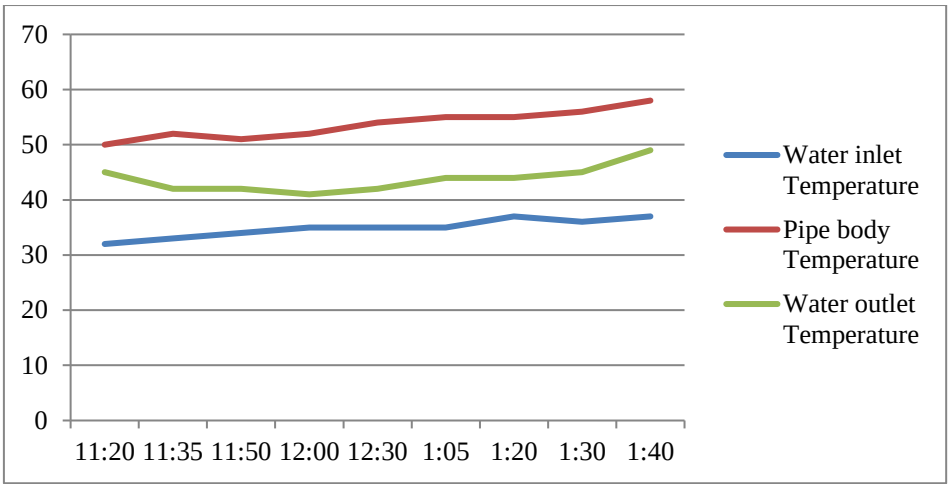

Fig 2 Various Temperature Distribution w.r.t time

Table 1 and Fig. 2 indicate the temperature variation values with respect time of water inlet and outlet temperature as well as body temperature of pipe material. In this work the temperature value of outlet water temperature continuously rises because of heat accumulation inside solar water heater it is due to glass sheet and collector plate as collector plate reflected back the incident solar energy partly and partly absorbed and glass sheet does not allow the reflected radiation to go outside the system; and ultimately copper pipe which have wide surface are at top and bottom through which water is flowing absorbs the heat and which leads to increases the temperature of water.

Table 2 Result Table of Solar Water Heater

Mass flow rate Kg/s	Heat absorbed by Water Qw kW	Heat incident on SWH Oi kW	Efficiency
0.0048	0.259	0.825	31.42
0.0048	0.179	0.825	21.75
0.0048	0.160	0.825	19.33
0.0048	0.120	0.825	14.50
0.0048	0.140	0.825	16.92
0.0048	0.179	0.825	21.75
0.0048	0.140	0.825	16.92
0.0048	0.179	0.825	21.75
0.0048	0.239	0.825	29.00

Table 2 shows the heat gains by water with respect to incident heat upon the solar water heater

V. CONCLUSION

The square tube solar water provides good results but as manufacturing cost is the major concern and so to find appropriate and low cost manufacturing option is necessary.

VI. FUTURE SCOPE

Thermal performance square tube solar water can be compared with same dimension of conventional circular tube solar water heater and on the basis of which possible way of modification can be made.

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