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Comparative Thermal Performance Evaluation of U Tube and Straight Tube Solar Water Heater

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Abstract
The sun is the life force behind all terrestrial organisms. Since society is progressing, it makes use of numerous kinds of energy at each stage. Simply said, solar energy is sunlight that has been captured from another location, most commonly Earth. Solar energy is most sustainable source of energy and environment friendly too. Solar water heating having wide domestic and commercial application and to achieve better performance of solar water heater in terms of either in the shape of tubes, tube material, modification in absorber plate and using thermal energy storage systems are various available options. In this study, a U-shaped salaried water heater was proposed, and its thermal performance was compared to that of a conventional straight-tabbed solar water heater and K typed thermocouples are used to measure the temperature and maximum temperature is achieved as 56^{0}C.
Keywords: *Solar water heater, U-shaped salaried water heater*

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I. INTRODUCTION

Collecting Radiation with Flat Plates However, the very straightforward flat plated collector for solar power has seen the most widespread use thus far. Because of its well-understood properties, this collector design is the most straightforward and affordable to manufacture, set up, and keep in working order. Additionally, it can harness solar energy in both its diffuse and direct beam forms. Flat plate collectors, whether used for home or commercial purposes, can generate heat at temperatures high enough to heat swimming lakes, household hot water, and buildings, and can even run a cooling unit, especially when combined with a reflector to maximize incidence sunlight. Temperatures in the 40–70°C range can be easily achieved with flat plate collectors. Careful engineering using heat-resistant materials and unique surfaces that reflect more of the incident radiation makes greater working temperatures possible.In order to assess the efficiency of water-in-glass evacuated tube solar-powered water heaters, Budihardjoet al. [1] used a computational model of the thermo syphon flow in single-ended tubes in addition to experimental observations of optical and heat loss parameters. Using black coated sand, Y. Taheri et al. [2] researched novel methods for solar water heating, and found that the collector averaged daily efficiencies of greater than 70%. The overall efficiency of the heater is 57%, according to research conducted by N.M. Nahar [3], who investigated the impact of selective surface on the performance of solar water heaters. Solar water heaters with a stationary V-trough collector were the focus of research by K.K. Chong et al. [4]. The efficiency of a solar water heater can be increased by combining the solar absorber with a V-trough reflector, which can be made with minimal effort. The efficiency of a cylindrical solar water heater was determined thanks to experiments conducted by Hussain Al-Madani [5]. R. Thundil RajSandwich-type solar water heaters, in which the absorber plates are sandwiched between two pipes carrying water, have been the focus of research by Karuppa R. et al [6]. The PCM solar water heater was the subject of research by M.V. Kulkarni et al. [7]. There are two heat sinks in the system, and they work together. CFD findings for were obtained by R. Sivakumar et al. [8]. Important geometric characteristics that affect the greatest rise in temperature during peak solar radiation include the depth to which the collector's fins are submerged in water and whether or not the surface of the absorber is grooved or dimpled. Eze J. I. et al [9] looked into how effective a passive solar water heater is in generating heat. P.Selvakumar et al [10] looked into how a solar water heater's tilt affected its heating capacity. The thermal efficiency of the evacuated tube was designed, developed, and experimentally evaluated by V.S.P.Vamsi [11]. K. Vasudeva Karanth, et al [12] used intensive numerical analysis to assess solar water heater performance. Kumar et al. [13] investigated the efficiency of a solar water heater that used a corrugated absorber plate. A flat plated hot water heater equipped with a mechanism that follows the sun was the subject of an experiment by Prasad et al. [14]. Fluid flow and heat transmission in a collector with a wavy absorber plate were numerically analyzed by Oztop [15]. The V-groove air heating system was the subject of experimental investigation by Karim et al. [16].

A computational fluid dynamics (CFD) investigation of natural convective heat transfer within inclined wavy sun collectors and solar collectors with flat plates was investigated by Varol et al [17]. An empirical and numerical study by Gertzos et al. [18] created a verified three-dimensional CFD model for an integrating collector storage solar system with recirculation. The flat-panel solar water heater CFD model performed by Selmi et al. [19] has been validated. In addition, M.Z.H. Khan [20] experimented with solar heating systems to improve their efficiency and contribute to long-term sustainable development. The experimental setup for a solar water heater was described by H.I. Abu-Mulaweh [21]. In order to evaluate the performance of various collection types and to choose the most appropriate tools, a standardized testing protocol is necessary. The strategies proposed by many researchers to improve the efficiency of solar water heaters were analyzed by Sushil Tiwari et al [22]. An practical and theoretical study of a flat-plate solar water heater that recycles its heat was conducted by Ho et al. [23]. Using a novel solar water heating technique, D Prakash et al. [24] focused on making the most of the sun's energy, and good attic insulation prevented heat from escaping inside the building. The investigation into the use of Phase Change Materials (PCMs) for storing solar energy and utilize this energy at night to heat water for residential uses was begun by S. Sadhishkumar et al. [25]. Parabolic Trough Collector (PTC) models were attempted in Ansys 15.0 Workbench by Ankit S. Gujrathi et al. [26], who noted that the PTC was designed at a concentration ratio of 25. The flat table with solar water heater raise pipe either with or without fine was studied by Arun K. Raj et al. [27]. K. Vasudeva Karanth et al. [28] examined the effects on heat efficiency of using absorber plate pipes of varying diameters and forms. With the mass stream frequency held constant, Mohammed Abdul Junaid et al. [29] conducted thermal analysis at 11 a.m., 12 p.m., and 2 p.m. on March 31 using CAD software to build a solar flat plate collector. Use of solar energy was the main emphasis of V. Y. Chaudhary et al.'s [30] CFD analysis, which included an evacuated tube heat pipe that converted radiation energy into useful heat. down their investigation of serpentine solar water, Hardik A. Parmar et al. [31] zeroed down on its thermal performance and derived its time-dependent efficiency value change. Besma Chekchek et al. [32] built a solar water heater out of recycled soda bottles and tested its efficiency. The number and configuration of riser tubes emanating from the current collector were investigated by Sivakumar et al. [33]. Kulkarni et al. [34] looked into how different tube configurations affected the overall SWH performance. The absorber fin of both rectangular and circular SWHs piqued the curiosity of Ramasamy et al. To improve heat transfer, they increased the surface area, but kept the pressure drop and the outlet speed constant. To improve the efficiency of troughs concentrating photovoltaic SWH, Sudhakar et al. [36] used four different solar cell array types and different shaped receivers. The thermal performance of a spiral tube solar water heater, which comprises of a copper tube and a flat plate collector, was compared to that of a conventional straight tube solar water heater by Jignesh A. Patel et al. [37]. [38 – 44] Anand Patel et al. [45] HD Chaudhary, et al. [46] Anand Patel et al. evaluates thermal efficiency with a different geometrical condition of solar collector in solar heater. [47-48] Patel Anand et al. documents various methodology of heat transfer in similar applications to Solar Hear for understanding the phenomenon in the current study of work of "Comparative Thermal Performance Evaluation of U Tube and Straight Tube Solar Water Heater". [49] SK Singh et al. [50] Nikul K. Patel et al. document the review of an alternative fuel energy which is similar to solar heater applications. [52] D.J. Morrison et. al thermal performance of effects of phase change for air and liquid based solar heating systems. [53] Wei Wu et al. [54] Abokersh et al. [55] Feliński and Sekret et. al. [56] Ji et al. [57] Kürklü et al. evaluate thermal performance PCM of solar collector in solar heater.

II. EXPERIMENTAL SET UP

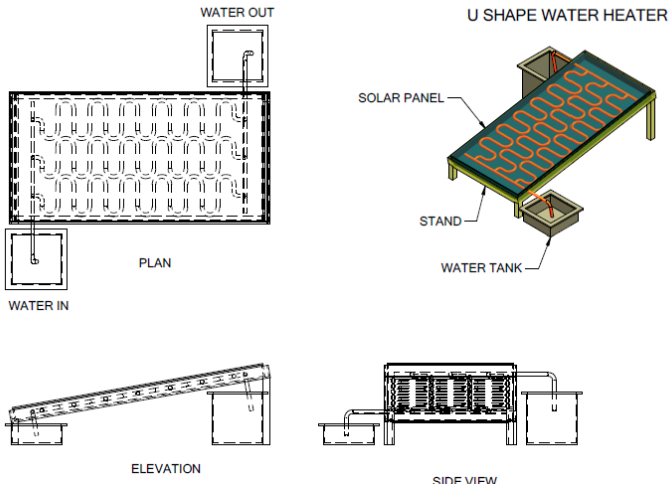

Figure 1 CAD Model of Experimental Set up

In the present work two solar water heaters of same size having overall dimensions of 1m X 0.5 m X 0.05 m box made of wooden sheet and in straight tube solar water heater set up and with 0.5 m X 0.5 m X 0.05 m in case of U-shaped solar water heater and the top of wooden box is enclosed with 2 mm transparent glass sheet and bottom is covered with 0.2 mm galvanized sheet painted with black color. The three copper tubes with 0.9 m length and ½" diameter and fabricated with 0..6 m copper pipe with same diameter at top and bottom; only in one solar water heater tubes are straight and in other tubes ate bend in U shape using pipe bender. To measure the water flow 1 lt measuring flask and stop watch is used and water is supplied through 20 lt tank in both experimental set up. Fig 1 indicates CAD model of U shaped solar water heater.

Plate 1 Temperature Indicator

Plate 2 Measuring Flask

Plate 3 Copper Pipes

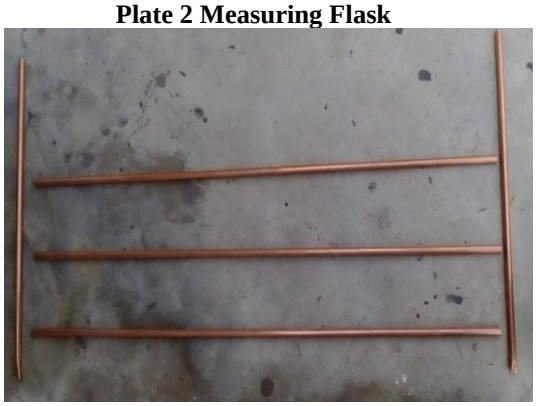

Plate 4 Pipe Assembly of Solar water Heater

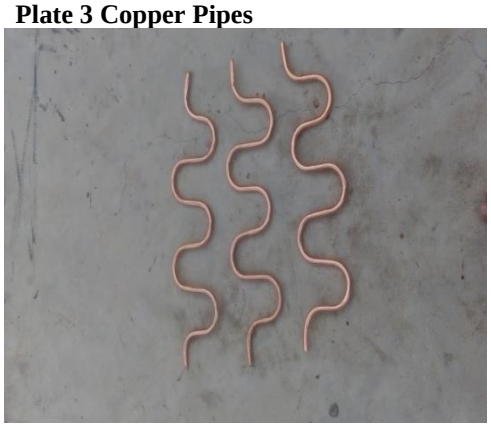

Plate 5 U bend Pipe

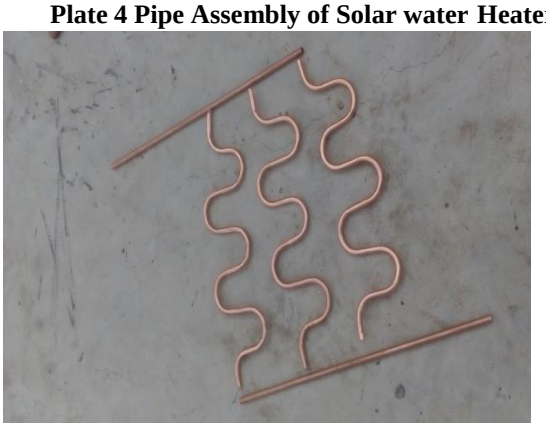

Plate 6 U bend solar Water Heater

III. EXPERIMENTATION:

In the first phase both set up are orient in north south position and then allow the water to flow through both set up using ½ " PVC flexible pipe from 20 lt water tank and after interval of 30 minutes measure the body and water outlet temperature.

IV. RESULT AND DISCUSSION

Table 1 Observation Table

	U Shaped			Straight		
TIME (hh:mm)	**$T1_{in}$ (°C)**	**$T2_b$ (°C)**	**$T3_{out}$ (°C)**	**$T4_{in}$ (°C)**	**$T5_b$ (°C)**	**$T6_{out}$ (°C)**
11:00	38	62	42	38	60	40
11:30	38	65	46	38	63	43
12:00	38	68	49	38	67	48
12:30	38	71	52	38	70	50
13:00	38	73	56	38	71	53

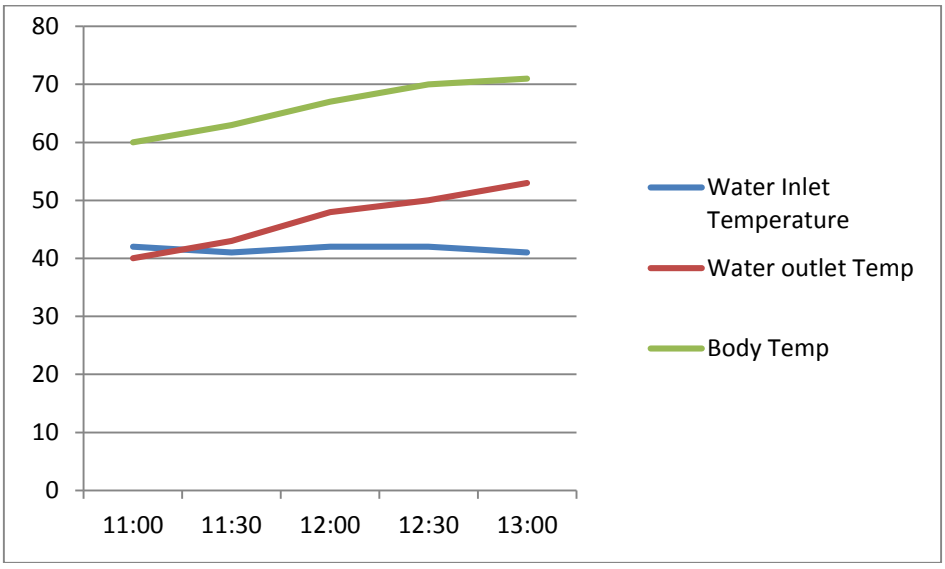

Figure 2 Temperature variation in Straight Tube Solar Water Heater

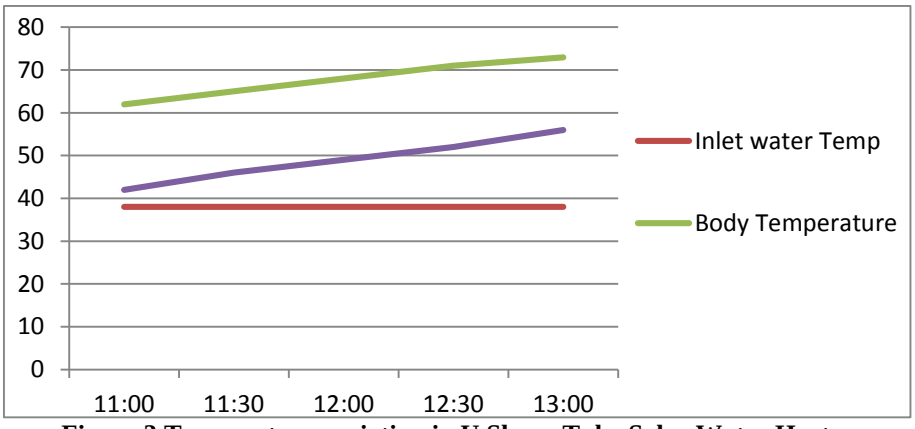

Figure 3 Temperature variation in U Shape Tube Solar Water Heater

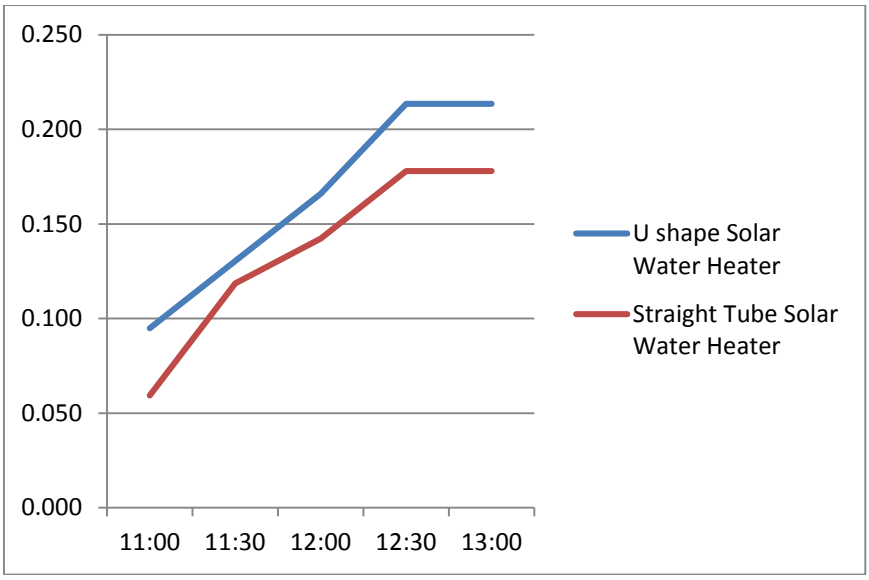

Figure 4 Heat Gain by Water in both Solar Water Heaters

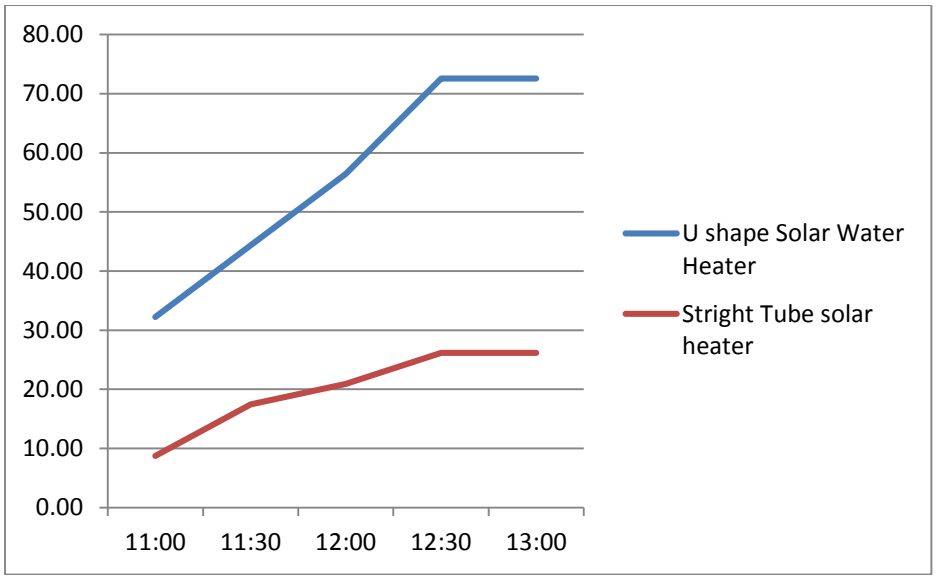

Figure. 5 Efficiency in Both Solar Water Heaters

Here Fig. 2 and Fig. 3 show Temperature variation with respect to time in case of straight and U shaped solar hot water heater, while Fig. 5 and Fig 6 represent heat gain by water and efficiency in case of both solar hot water heater respectively. From Fig 2 and Fig 3 it is clear that outlet water temperature will be higher in case of U shaped solar hot water heater may be because of pipe shape allow turbulence in the flow and more retention time is available which allow water to absorb more heat. The heat gain by water is more in case of U shape water heater as higher water outlet temperature and small area of U shape solar water heater which leads to higher efficiency value in case of U shape water heater.

V. CONCLUSION:

The most significant take away from this study is though U shape solar water heater is better option and it s compact in size but the manufacturing cost of making U shape pipe is comparatively increases the overall cost of the U shape solar water heater.

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