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Thermal performance analysis conical solar water heater

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Abstract

Solar radiation is harnessed as an alternative energy source for numerous industrial and domestic applications. Currently, apart from space heating, air-conditioning and lightning, solar water heating (SWH) systems have a widespread usage and applications in both domestic and industrial sectors. The major issue with solar energy is that the transmission efficiency is low and so heat transfer augmentation methods can be used to improve thermal performance of solar water heater and the aim of present work is to developed conical solar water heater with objective is to obtain good water outlet temperature from compact solar water heater.

Keywords: Concial Solar Water Heater; Thermal Performance; Thermocouple and Inlet/ Outlet Temperature

1. Introduction

Solar water heater is the simplest application of solar thermal energy. The solar water heater system consists of a water tank, a ducting system, and a solar collector. Solar water heaters are classified into active solar water heaters and direct and indirect solar water heaters. The active and passive classification is based on the pump requirement for the solar water heater. In a passive solar water heater, heat is transferred from the collector to the water tank on top of the collector by a natural recirculation process. In a working solar water heater, water is circulated from the solar collector to the water tank by a water pump. Solar water heater in which heat is transferred from working fluid to water through heat exchanger is called indirect solar water heater and solar water heater which does not use heat exchanger to transfer heat is called direct solar water heater. T. H. Holland et al [1] explained designing and construction of a solar water heating system. Nosa Andrew Ogie et al [2] published paper on design and construction of solar water heater based on thermo siphon principle. P. Sivakumar et al [3] conducted experiments on solar heating system for performance enhancement. M.Z.H. Khan et al [4] also conducted experiments in solar heating system for efficiency towards sustainable development. H.I. Abu-Mulaweh et al [5] et al explained designing and development of solar water heating system experimental apparatus. Besma Chekchek et al [6] constructed solar water heater from plastic bottles and evaluate its thermal performance. Sivakumar et al. [7] explored the effect of zig-zag arrangement of riser tubes from the existing collector as well as the number of riser tubes. Kulkarni et al [8] investigated the effect of tube arrangements on the overall performances of a SWH. Ramasamy et al [9] interested in SWHs with rectangular and circular absorber fin. They tried to enhance the thermal transfer by increasing the area, while maintaining the pressure reduction and the outlet velocity. Sudhakar et al. [10] utilized four types of solar cell arrays and various shapes of receiver to enhance the efficiency of trough concentrating photovoltaic SWH. Jignesh A. Patel et. al.[11] conducted a comparative thermal performance study of the straight tube solar water heater with the proposed experimental set-up of the spiral tube solar heater; it consists of a spiral-shaped copper tube, flat plate collector. Potthuru R P et al.[12] compared the performance fixed flat plate water heater with that of the heater with tracking by conducting experiments. Herrero Martin et al. [13] developed an experimental side by side solar collector test under the requirement of EN12975-2. Taherian et al [14] analyzed the performance of the shell and tube HX external to the storage tank, in which fluid flow was induced by natural convection. Smith et al.[15] studied on helical tape is inserted in the tube with a view to generate swirl flow.

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Shahidul Islam Khan et al [16] collected data of SWH performance over entire year for capacity of 100 lt and 200 lt. Zohreh Rahimi-Ahar et al [17] reviewed flat plate and concentrate-type solar collectors, integrated collector–storage systems, and solar water heaters combined with photovoltaic–thermal modules, solar-assisted heat pump solar water heaters, and solar water heaters using, phase change materials are studied based on their thermal performance, cost, energy, and exergy efficiencies. Yaser Y et al. [18] focused on the design and development of cost effective compact solar water heater. Siampour et al.[19] studied Energy policies in some countries are aimed to provide sustainable and secure energy. A novel ICS vessel design based on a pyramid shape was presented by Abdel-Rehin [20]. Davis et al. [21] developed a symmetric cusp reflector ICSSWH system designed particularly to suit Colorado's cold weather conditions, and found that the collector efficiency can reach as high has72%. G.L. Morrison et al [22] studied the thermal performance of water-in-glass evacuated tube solar water heaters and is evaluated using experimental measurements of optical and heat loss characteristics and a simulation model of the thermo syphon circulation in single-ended tubes. Y. Taheri, Behrooz et al [23] investigated new techniques for solar water heater using black coated sand and all experiments results, the collector averaging daily efficiencies achieved higher than 70%. N.M. Nahar [24] focused on effect of selective surface on the performance of solar water heater the overall efficiency of the heater is 57%. The predicted performance at various Indian stations revealed that hot water is required at most places for domestic use only during winter season and it can provide 100 ml of hot water at an average temperature of 50–70 ^{0}C, which can be retained to 40–60 ^{0}C till next day morning use. K.K. Chong et al [25] studied solar water heater using stationary V-trough collector. Integrating the solar absorber with the easily fabricated V-trough reflector can improve the performance of solar water heater system. In this paper, optical analysis, experimental study and cost analysis of the stationary V-trough solar water heater system are presented in details. Rakesh Kumar et al [26] carried out thermal performance of integrated collector storage solar water heater with corrugated absorber surface. Hashim et al.[27] focused on the main solar thermal usage scenarios in Iraq using solar water heating (SWH) in a flat plate collector. Ogueke et al. [28] reviewed different designs of solar water heaters and compared their performance. Zhang et al.[29] focused on a comparative study of the annual performance of the eye thermosiphon SWHS and conventional SWHST. Tsung-Ching Chen et al.[30] studied the collection efficiency of dual-circulation plate and tube solar water heaters with tube wall-mounted internal fins and external recirculation. Chittireddy et al. [31] An AC cooled flat panel solar collector tested as a cooling element for a water heater with dense corrugated fins attached to the tubes. Kalogirou [32] investigated different types of solar collectors and their applications. According to Al-Madani [33], thermal efficiency was fully evaluated in March and April. Sivakumar et al.[34] performed experiments with an elliptical heat pipe solar collector designed, fabricated and tested for various mass flow rates and Lc/Le ratios. Mazarrón F R et al. [35] tested the feasibility of water heating with evacuated tube collectors at different operating temperatures. Ogie et al. [36] analyzed the design and construction of a HUW where water is heated and flows through a tank as a coolant. [37, 38, 39, 40, 41, 42, 43, 44] Patel Anand et al. [45, 46, 47, 48, 49, 50, 51, 52, 53] Anand Patel et al. includes various studies of thermal performance by variation of absorber plate geometries in solar air/water heater using which the current study was able to be established on. The practical feasibility of solar heater are conceptualized using [54] Ruchi Shukla et al. [55] Patel et al. The thermal performance enhancement for solar heater is studied in [56] Hussain Al-Madani et al. Cylindrical Solar Water Heater [57] S. Vasanthaseelan et al. Different type of turbulators in solar ware heater [58] S. Sadhishkumar et al. historical solar water heating system work review paper. [59] Tengyue Wang et al. [60] Li et al. [61] Kime and Seo et al. [62] Pakdaman et al. documents thermal performance comparison between solar air heater, a conventional tube collector and transparent tube collector which is helpful to perform the in the current study. [63, 64, 65, 66, 67, 68, 69, 70, 71]] includes research studies of combination of twisted tabe within evacuated tubes of the solar water heater to enhance thermal performance of the system.

2. Material and method

2.1. Experimental Set up

In this experimental set up the copper pipe of ½" diameter is bend in conical shape using specially design die and two ends are extended for water inlet and outlet and then whole assembly is placed in the 3 mm transparent glass box having dimensions of 12" X 15" X 15" and box is made using silicon glue. The main idea behind glass box is that solar rays can easily penetrate inside the box and solar energy absorbs by copper pipe and so water flowing through gets heated. The water flow rate is measured using measuring flask and stopwatch. During experimentation work allows water to flow from downward to upward direction and so maximum heat transfer can be achieved.

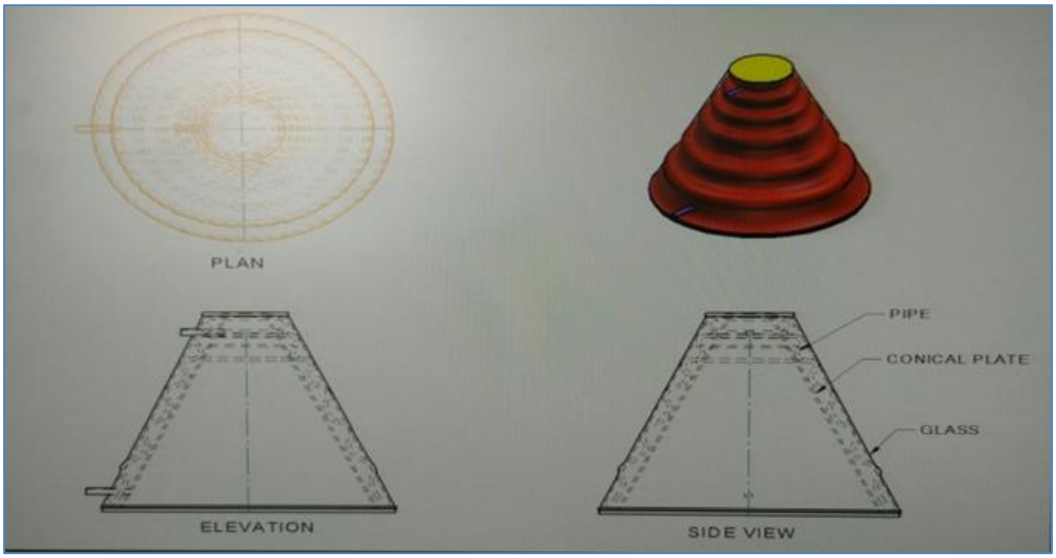

Figure 1 CAD Model of Conical Solar Water Heater

Figure 2 Measuring Flask

Figure 3 Thermocouples with Indicator

Figure 4 Conical Solar Water Heater

3. Result and Discussion

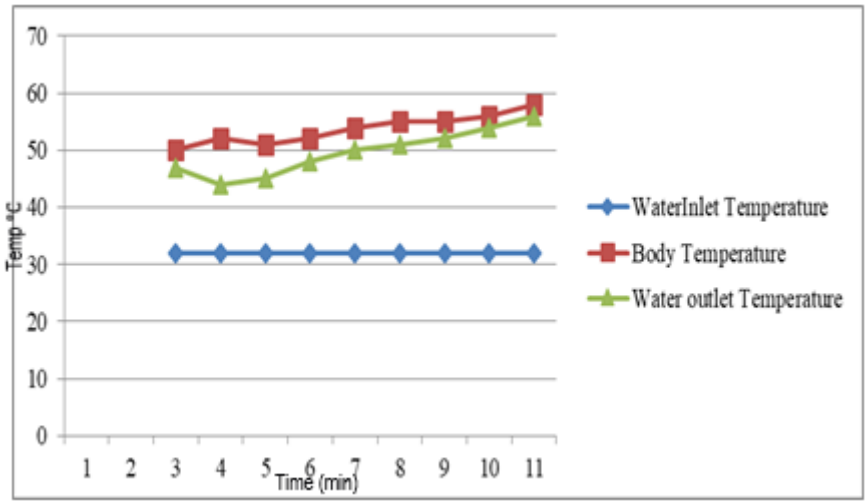

Figure 5 Temperature Variation with respect to Time for Solar Water Heater

Table 1 Result Table

Time required to fill 1000 ml tank	Mass Flow Rate	Qo	Qi	η
Second	Kg/ s	kW	kW	%
451	0.002	0.139	0.681	20.46
452	0.002	0.111	0.681	16.33
453	0.002	0.120	0.681	17.66
454	0.002	0.148	0.681	21.68
455	0.002	0.166	0.681	24.34
456	0.002	0.174	0.681	25.64
457	0.002	0.183	0.681	26.93
458	0.002	0.201	0.681	29.56
459	0.002	0.219	0.681	32.17

In the present work water is allowed to flow from bottom of solar water heater and due to conical shape more turbulence in the flow can be achieved and which leads to raise the water outlet temperature and also due to more retention time for water flow so better heat transfer can be obtained and water suppose to flow against gravity and so more heat can be received by water.

4. Conclusion

The major outcome present work is that with such compact solar water heater better results can be obtained only cost is challenging part.

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