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Review on Thermal performance analysis of thermosyphon solar water heating system fitted with a spiral tube

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Introduction

Numerous researchers have looked into ways to increase the solar water heater's efficiency through experimental or numerical analysis. There are several ways to make it better, like changing the shape, using a different working fluid, changing the material of the storage tank, and more, to achieve the greatest outcomes in the flat plate collector. The extensive amount of searches examined how improvements were made using either numerical tests or research on tests using flat plat types. Study in this literature to demonstrate how you might look into innovative flat plate collector designs and concepts to improve heat transfer and increase efficiency. The flat plate is one of the better collector types because all of the surface area is exposed to solar radiation without any shadows on the tube. Energy and exergy were the fundamental equations employed in the studies, with the latter being crucial because it indicates the system's useful work. Due to the benefits of flat plates, most research focuses on improving them in one way, such as by adding additional heaters, twisted tape, more than one twisted ratio, dimple tubes, and other methods. Recent studies have concentrated on the twisted tap since it can be a more efficient method with fewer coastlines, while other research is working to enhance other designs to achieve the same purpose.

J. Ananth and S. Jaisankar [1] conducted a realization test to see if adding twisted tape will improve the thermosyphon solar water heater's heat transmission and friction factor. External power is not necessary for this procedure. In this experiment, laminar flow conditions were used with a full length helical twist with a twist ratio of 3, along with a rod and spacer with lengths of 125, 250, and 500 mm. The findings demonstrate that the Nusselt number rises as the Reynolds number rises. According to the test's findings, the Nusselt number reduces by 6% for a 125 mm spacer and by 38% for a 500 mm spacer as a result of an increase in rod and spacer length, while pressure drop increases for a decrease in rod and spacer length. Lowering friction factor in the length range of 125 to 250 mm11% and (250 – 500) mm is 40%.

Helical and Left Right twist taps of twist ratio 3in riser tap were explored experimentally by S. Jaisankar et al. [2] [2] to improve heat transfer, friction factor, and thermal performance of thermosyphon SWH system. The riser tubes were filled with the twisted tape depicted in fig (1).

They can draw the conclusion that one benefit of adding a left_right twisted tap is to increase the surface area where fluid contacts the surface more, causing more heat to flow to the fluid and resulting in greater frictio n factors than plain tubes of 3.75 (375%) and 1.42 (142%). 1.58% Nusselt number

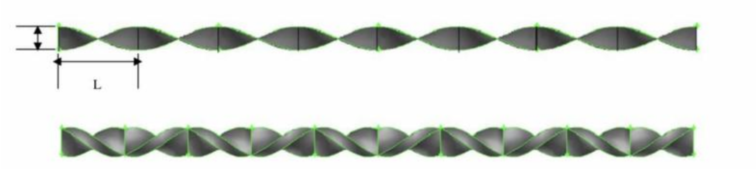


Fig (1)

To demonstrate how to improve the heat transmission and friction factor properties of thermosyphon SW H, **S. Jaisankar et al. [3] [3]** studied whole length Left_Right twist tap, twist fitted with rod and spacer at the tr ailing edge for lengths of 100, 200, and 300 mm for twist ratios 3 and 5. The experiment was conducted outdoor s under obverse south conditions with an 18° tilt angle. The test was completed after several phases, and results were taken every 15 minutes. These findings reveal that Nusselt number decreases by 11% and 19% for twists fi tted with rods and twists with spacers, respectively, and that friction factor also decreases by 11% and 19% for t he twists fitted with rods and twists with spacers.

Experimentally, **A. Kumar and B.N. Prasad [4]** investigated the use of twisted tape to improve heat transfer from a solar water heater. The outcome showed that twisted-tape solar water heaters' thermal performance increased with decreasing values of the tape twist pitch ratio Y. Due to lower heat losses, thermal performance increases by around 30% over conventional solar water heaters.

Gao et al. [3] [5] conducted analytical and experimental testing to improve the efficiency of solar air heaters by using cross-corrugated heaters that consist of wavelike absorption plate and wavelike bottom plate.

These heaters can be divided into two categories.In contrasts to the type 1 heater, which has a bottom plate with a wavelike shape perpendicular to the flow direction and an absorbing plate with a wavelike shape parallel to the flow direction, the type 2 heaters has a bottom plate with a wavelike shape parallel to the flow direction. The results showed that the type 2 heaters' thermal performance was slightly better than the type 1 heater's, but both were still superior to flatplate solar air heaters, with respective attainable efficiencies of 58.9%, 60.3%, and 48.6%.

By using numerical analysis, **R. B. Manoram et al. [2] [6]** investigated the impact of the dimples employed in fig(2) below to enhance SWH. The thermal efficiency and friction factor of the solar collector are improved by these dimples' role as heat transfer enhancers. Pitch-to-dimple diameter ratio can be changed to conduct emulation. Dimple count and mass flow rate The findings indicated that tube dimples disrupt fluid flow and reduce hydraulic diameter, improving the collector's ability to transfer heat quickly and efficiently. A maximum increase of 2.5 times in the Nusselt number was noted for the dimpled tube with a P/Dd ratio of 3 and six dimples between two pitches compared to a plain tube at a mass flow rate of 2.5 kg min1. Comparing the friction factor to the standard tub, it rose by 11.1%

In order to discuss the Nusselt number, heat transfer coefficient, and Reynolds number of SWH, **K. Sivakumar and K. Rajan [7]** conducted an experimental study. For the study of laminar flow, a concentric tube with a triangular cut twisted tape (TCTT) insert with a twist ratio of 5.4 and 1.2 cm of depth of the triangular cut was used.According to the findings, Reynolds numbers varied between (5710 – 18366) , and Reynolds numbers with Nusselt numbers were improved by 1.1 to 1.3 times in comparison to those of simple twisted tape tubs. In comparison to conventional twisted inserts, the configuration of TCTT inserts had a higher friction factor and heat transfer.

By using whole length Left-Right twist, twist equipped with rod and spacer at the trailing edge for lengths of 100, 200, and 300 mm for twist ratios 3 and 5**, S. Jaisankara et al. [3][8]** highlighted by experimental inquiry how to improve the heat transfer and friction factor of SWH.The results reveal that for twists fitted with rods and twists with spacers, the Nusselt number reduces by 11% and 19%, and the friction factor decreases by 18% and 29%. When compared to twist fitted with space, the heat enhancement in twist fitted with rod at the trailing edge is largest because swirl flow is maintained along the entire length of rod.

M. Mehrali, et al. [2] [9] studied the effect of used hybrid Nano fluids to improve the absorber efficiencies of solar thermal energy collector. They concentrated on application of hybrid nano fluids containing reduced graphene oxides decorated with silver nanoparticles in volumetric solar absorbers.The parameters that could affect the thermal and optical characteristics of the nano fluids employed in this test were the concentration of grapheme nano sheets and the amount of gold used for decorating in this investigation.The outcomes demonstrated that Nano fluids, even at low light intensity, can be employed for direct absorption solar collectors for a brief length of time. Efficiency of 77% is possible at low concentrations of 40 ppm, according to improved light absorption of graphene at the excitation wave length.

Iranmanesh et al. [5] [10] Experimental research was done to determine how varying mass percentages of graphenenanoplatelets (GNP) at (0.025, 0.5, 0.075, and 0.1wt%) affected the thermal performance of an evacuated tube solar collector (ETSC) water heater. They tested the solar collector's thermal efficiency with varied volumetric flow rates of (0.5, 0. 1 and 1.5 L/min). The experimental findings demonstrated that adding 0.1 weight percent of GNP Nano fluid, which is 35.8% more than DW at a flow rate of 1.5 L/min in weight percent, increased the thermal efficiency of the system to roughly 90.7%.

In this work, **M.E. Zayed et al. [6] 11]** concentrated on the various advances of phase change materials (PCMs) and cascaded thermal storage phase change materials (CTSPCMs) and how they were used in SWC stor age tanks. They went over and talked about packed bed storage units, various heat exchanger storage unit config urations, multi_storage tanks with cascaded PCM, and other cutting-edge storage tank designs.The test's findings demonstrated that CTSPCM improved PCM heat transfer and stored rates of energy and exergy, increasing storage energy and exergy efficiency in comparison to the single stage PCM system.

By utilizing different V-corrugated reflectors and booster reflectors in front of solar collectors, **Ronnelid Mats and Karlsson Bjorn[12]** tested ways to improve the yearly irradiance onto the collecting plane. The results of a ray tracing program showed that the annual reflected direct radiation on the collector increased by

10% as a result of the use of a corrugated reflector at the top of the reflector, which increased the effective reflectance and allowed for an annual increase of about 3% in collector output.

To increase thermal efficiency and thermo hydraulic performance, **Rajesh Kumar and Prabha Chand [13]** employed MATLAB codes to analyze numerically the model of an air heating collector with twisted tape inserts. The MATLAB design resulted in an 8.3% increase in the thermal efficiency of the collector with twist ratio Y = 2. They discovered that the tape with the smallest twist ratio produced the most augmentation, making twist ratio Y = 2 the most effective.

By creating turbulent flow caused by the use of twisted taps, **A. Kumar and B. N. Prasad [14]** conducted experimental research to improve heat transmission in a solar water heater. They used different mass flow rates and twisted tape with a twist pitch to tube diameter ratio ranging from 3 to 12 in their test. They discovered through this test that the pressure drop increased by 87–132% while the heat transfer in the twisted tape insert collectors increased by 18–70%. Due to use of twisted taps, the thermal performance increased by roughly 30% above that of plane solar water heaters when running under the same conditions. It has been discovered that twisted-tape collectors perform more effectively in the lower range of Reynolds number (Re 1 12,000)

The performance of the collector was tested in China by **Jinbao Huang, et al. [3] [15]** to determine the impact of the employed heat exchanger between the collector and the tank. The employed heat exchanger's objectives were to increase friction resistance to thermosyphon circulation and maintain the system's simplicity. The thermosyphon flat plate solar water heater's efficiency has increased by 50%, according to test data, compared to the all-glass evacuated tubular solar water heater**.**

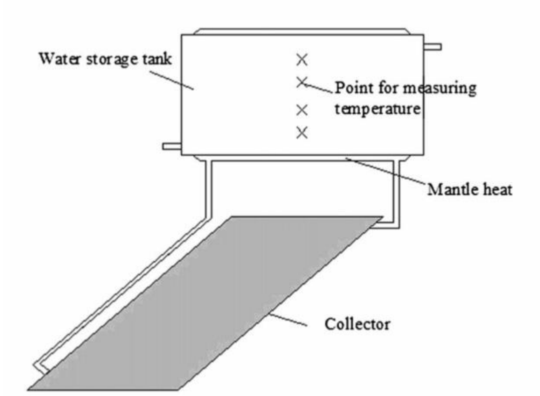


Fig (3) thermosyphon solar water heater with a mantle heat exchanger

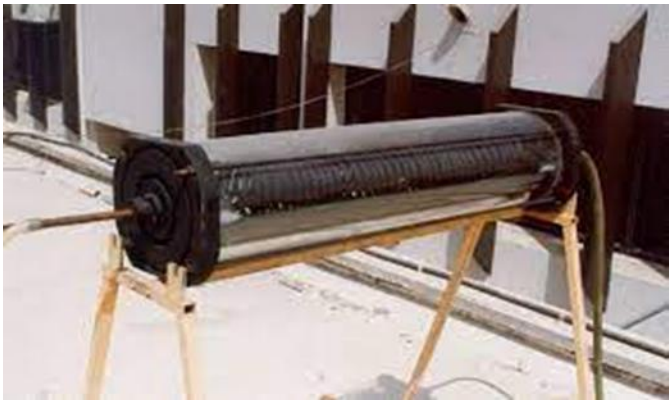
By altering the collector's design, **MojtabaMoravej, et al. [4] [16**] improved the solar water heater. They employed spiral tubes that flow into the collector from the side and exit from the center, without risers, and a symmetrical flat-panel solar collector with circular geometry. The experimental results indicate that this collector's efficiency increases more quickly than rectangular collectors, with a maximum efficiency of about 75.3% at temperatures ranging from 19 to C.

Fig (4) circular collector

Al2O3 nano fluids and twisted tape inserts were examined by **L. Syam Sundar et al. [3] [17**] to improve the heat transfer of SWH. They investigated tubes with or without twisted tapes that were filled with water or nano fluids and had a Reynolds number of 13000. The findings demonstrate that using a twisted tape ratio of 5 increased the heat transfer enhancement for 0.3% with Al2O3 from 21% for the plain tube to 49.75%. When compared to water in a plain collector, 0.3% Al2O3 has a maximum friction penalty of 1.25 times with twisted ratio 5. The plain collector's thermal efficiency was also increased to 58% when the 0.3% Nano- fluid and increased to 76% with a twisted tape of atat a mass flow rate of 0.083 kg.

By using a solar pump, **Roonprasang et al. [2] [18]** improved the SWH system. The pump in this arrangement was driven by the steam generated by a flat plate collector. As a result, the hot water storage tank transfers heat from the collector downward. Test conditions included discharge heads of 1, 1.5, and 2 meters. Pumps work best when the collector is between 70 and 90 °C and the vapor gage pressure is between 7 and 14 kPa. According to the findings, the system's daily thermal efficiency is between 7 and 13 percent, and the average daily pump efficiency is between 0.0014 and 0.0019%.

Hussain Al-Madani [19] testing an experimental cylindrical SWH at the University of Bahrain's Mechanical Engineering department. employed a spiral ring made of copper coil that was painted black as a solar energy collector and a cylindrical tube made of premium glass, as seen in fig 5 The testing was conducted from March to April 2002 under the following conditions: a maximum temperature difference of (27.8 1C) between the SWH's input and output, a mass flow rate of 9 kg/h, and these conditions. The results indicated that the efficiency reached a maximum of 41.8%. An economic analysis shows that the cylindrical SWH is more cost-effective than the flat plate collector.



Cylindrical SWH fig (5)

H. Bhowmik, R. Amin[20]

Concentrated on the significance of solar collectors and how to maximize incident radiation intensity to p roduce the highest heat transfer to working fluid. In order to concentrate both direct and diffuse solar radiation t oward the collection by changing the angle during the day, they employed a solar reflector in conjunction with a solar collector, as illustrated in fig6 by doing this; they may increase efficiency by 10%.

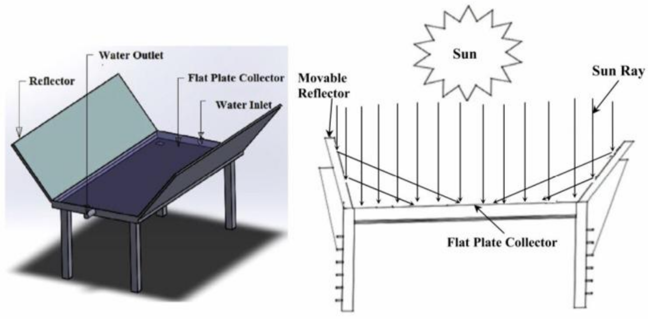


Fig (6) flat plate collector with reflector

P.M.E. Koffi et al. [4][21] By using theoretical and experimental analyses, a collector could obtain a heat flux peak of 989 W/m2, water temperatures over 85.5 C, and a thermal efficiency of about 58%. In the storage tank, they installed a copper heat exchanger. The hot fluid therefore navigates a sizable volume of water that has been stored. The outcomes demonstrate that this approach is among the finest..

M.R. Assaria et al. [2] [22] In order to increase the solar system's efficiency, it was investigated computationally and experimentally how to arrive at the best thermal stratification by changing the fluid's input and outlet locations in a horizontal cylindrical storage tank.

Using the energy balance, the test comprised adjusting the intake, switching the outlet, and then switchin g it back. The findings demonstrate that they could improve SWH performance by selecting the best site for the hot water input, which led to improved thermal stratification in the storage tank, and by selecting the best locatio n for the cold water outflow, which led to a higher collector efficiency. the difference in temperature between th e experimental and numerical results is 1.9 °C, with a 3.9% error. The three average temperatures on the vertical line in the middle of the tank were 49.9, 48.7, and 48.4 °C, with an average of 49 °C, while the simulation result was 47.1 °C.

C. C. Chien et al. [5][23]studied experimentally and theoretically tow phase thermosyphon SWH. The test parameters include the different heating powers ranged from 50 W to 600 W with an increment of 50 W, and the tilt angles of the heater, ranged from 0 to 30 with an increment of 5. The experimental results show that 82% was the best charge efficiency of the two-phase thermosyphon SWH on the other hand the charge efficiency decreases no more than 5% when the tilt angle of the system is less than 15. In theoretical model raise 3% and 4% when used double fin tubes and nano particle.

Kh. Zelzouli et al. [2][24] A glassed flat plate collector with a selective black chrome coated absorber and a low wall conductance horizontal storage were employed in a studied experiment and numerically designed high performance thermosyphon system. They tested how varied inlet water temperatures affected the performance of the collector. The findings demonstrated that a flat plate collector used in conjunction with a well-insulated storage tank may achieve high efficiency, high output water temperature, and selective absorber performance of 39% annually.

Y. Taheri et al. [2][25] enhance heat transfer by used CSWH as shown in fig (7.) .The water storage tank was manufactured from galvanized sheet of 0.0015 m in thickness and the volume of 1.45 0.56 0.17 m^3 and main portion of the collector absorber section was the black colored sands immersed into the water storage tank established. The results show they could achieve higher than 70% efficiency**.**

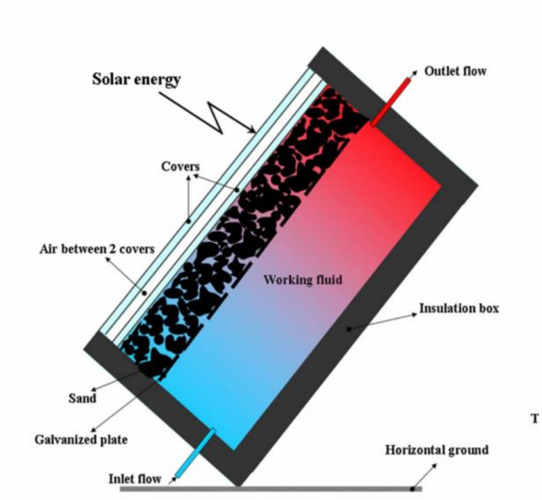


Fig (7**)** compact solar water heater

The main contribution of this study is an experimental investigation of three development shapes of (NT, TT, TTTT)to estimate which model of tube receives and absorbs more heat from sun than the other shapes under same operation conditions, such as same wind speed and clear sun shine . The contribution or the novelty of this thesis is that:

1- The three different design (normal, spiral, and spiral tube with twisted tap) were made them from copper with the additional of a copper extra plate . To the knowledge of the researcher, the using of spiral tube fitted with twisted tap had not been proposed previously in the studies of this subject.
2- The twisted tube was used to ensure that the HTF circulates during its flow inside the solar tube. This ensures maximum absorption of the possible solar energy and converts it into heat energy. So when used the spiral tube inside it twisted tap we can achieve largest amount of water particular be attach with heated tube.

3- The heated water retune to the storage tank by Self-circulation, not need pump to make circulation or any other force so less coast than when we need electric power.

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