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Article

Thermal Performance Analysis Of a Solar Still Coupled With An Evacuated Glass Tube (Egt) System

Winners Parekh[1], Pina Bhatt[2]

[1]Silver Oak University, Gujarat, India
Email: winners.parekh@gmail.com
[2]GTU Innovation and Technology Research (GTU- ITR), Gujarat Technological University, Ahmedabad. Guiarat. India. Silver Oak University, Gujarat, India.

Abstract: The lack of drinking water is a significant global issue, especially in places that rely on salty or brackish water. Solar desalination is a long-term solution, but conventional solar stills don't work very well, so they can't be used on a large scale. This study looks at how a solar static by an (EGT) system behaves when heated and how much distillate it produces when forced air flows through it. A comprehensive thermal model was created to measure how heat moves between the EGT, absorber tubes, annulus air flow, and still basin. There were experiments over three days while measuring solar insolation, basin Climate, covering glass humidity and temperatures of water. The results show that the EGT coupling greatly improved heat absorption and water temperature, which led to better evaporation and freshwater yield. Solar insolation reached its highest point at noon, when it was between 911 and 935 W/m². This caused the degree Celsius of the water in the basin to upturn on all days. Changes in temperature on the inside and outside glass surfaces showed that heat was successfully moved to the basin. In general, the solar still with EGT assistance greatly improved thermal performance and showed great promise for high-efficiency desalination in sunny areas. This shows that EGT-assisted stills greatly increase freshwater yield by speeding up the overall heat transfer rate. This study helps make hybrid solar distillation systems work better and shows that they can be used to make freshwater in a sustainable way.

Keywords - Evacuated Glass Tube (EGT); Heat transfer; Solar desalination; Solar still; Thermal performance.

1. INTRODUCTION

Contents Fresh water is basic necessity used for all social life on planet. world's supplies of clean water are very limited, and they are not evenly distributed based on nation population. People in many nations throughout the globe, including Africa, lack a supply of potable water. Another issue in America is that there are much too many bases of fresh water for the populations [1],[2]. Contaminated water induces several health complications; medical studies indicate that each individual need just 5 litres of potable water for consumption. Clean water is essential in several sectors, including agriculture, industry, and domestic consumption. To fulfil the need for potable water for consumption and other purposes, other sources such as saltwater must be considered. However, it is not immediately beneficial for drinking and has other applications. To utilise saltwater directly, it must first be salt-free. The technique of eliminating salt from water is called desorption.

Solar desalination uses solar energy extract fresh water commencing saline sources, including brackish or brine water. This method emulates the organic water cycle, which includes transpiration and condensation. Sunlight impinges onto the upper surface of a cover plate in this configuration, which aims to maximise light transmission to the saline water reservoir underneath. Convective and radiative heat transport are both necessary for this procedure. sink's darkening external lowers reflection onto surrounding environment by efficiently absorbing incoming radiation [3].

The operation and energy use of altered remains had been studied through experiments. This research looked at three setups: a standard still unit, a standard continuing device equipped by a displaced pipe collector, beside a conventional still unit using an expanded tube extraction and parabolic trough reflectors. utilising both adjustments together is more efficient than utilising them individually. The findings show an 82.26% production increase with the still and displaced pipe accumulators, also 112.57% with together upgrades. Using simultaneous mechanisms improves solar still performance, efficiency, and pond manufacture costs, allowing to rate assessment. [4] compared the performance of the Plain-Still and EGT-Still at a fixed water level of 2.0 cm. Results show that adding an displaced pipe to a standard solar still boosts production by 13.73 %. Nougriaya et al.,[5] discovered that a A solar still, with a water depth of one to two.cm performs well compared to other water depths; moreover, the use of drive loading resources such as paraffin also PCM may boost day and night output. Compared to just one slope, a double slope solar still generates more distillation. Vigneswaran et al. [6] conducted experiments utilising various absorbing materials with basins to determine the influence of phase-change solid. They discovered that effectiveness of low heat-conductivity material is better than the galvanized material. Kamal et al.[7] used an external heater for water heating and storage energy materials for increasing the efficiency of water heating. This improved the water temperature by 15%. Panchal et al [8]. They stated that the time for the peak values of DO changes from 1 to 3 p.m. for a representative day in six months, and the experiment took place in February 2019. Further, the value of the temperature measurement of MSS at the peaks and averages is raised by 43 °C and 19 °C, individually, associated to CSS. Additionally, the value of the total DO present in one day changes from 2.515 to 6.662 L and during the night changes from 0.057 to 0.872 L. In addition, the average value of DO rises from 2.88 to 7.03 L incrementing by 144.1% in six months. An experiment aimed at improving the competence of a simple solar still through 1 m^2 external zone and using 8 vacuum tubes is carried out by [9]. Various cooling methods are implemented on glass plates: pulse and continuous methods for glass plates. The productivity raised sharply to 2653 ml/day; therefore, it recorded a 237.5% increment. In pulse cooling cycles of (1min/15min) output rose to 3510 ml/day; (1min/10min) yielded 3587 ml/day; and the continuous method elevated it to 4980 ml/day. These expressed additional percent increments of 332%, 386%, and 656.8%, respectively. Furthermore, its efficiency surpassed the normal ones. The study delivered by Angappan et al., [10] intended to exploring effectiveness also analytical criteria of ETC-assisted solar distillation structures and heat transfer fluid. The literature of the last 30 years has been discussed and reviewed carefully. One of the most important findings is that the solar still and ETC can produce 3.5 to 4 l of fresh water for the area of 1 m2 with depth of 0.01 to 0.03 m. The mean energy efficiency of ETC-assisted solar still is 33% countless that of a predictable solar still. ETC solar still has 4% greater exergy efficiency than that of conventional still. The experimental work has been conducted by[11], which compared the economical and performance viabilities of the evacuated tube enhanced solar still and conventional still for a year at Kurukshetra City, India. daily invention of additional water and efficiency of the enhanced still have been enlarged through 149 and 1.7%, individually. price of invention of new water per liter is $0.0098 for conventional still and $0.022 for enhanced still. The thermal efficiency of conventional and enhanced Evacuated Tube Solar Stills of 30 and 50 l of water. The study carried out by [12], for instance, involved thermal parameters such as distillate yield and interior tube temps for glass tubes. The Modified Evacuated Tubes operated effectively at water depths of 0.03m and 0.05m relative to water depth, compared to others, showing that the Modified Evacuated Tube was yielding 242% and 246% more distillate than a conventional still. Mehta et al.[13] clarified that pcm and heat storage could improve solar still performance. The efficiency of distillation and heat utilization have proved to improve its greener and more economical performance. The designs can coordinate the utilization of water resources and energy resources; therefore, the production of water becomes environmentally sustaining for arid climatic regions. The level of present detailed analysis has been carried out to improve the acceptance level of SS regarding water security/availability for environmental sustainability worldwide. The study carried out on SS involving fins, condensers, and evaporation tubes is précised in table 1 below.

Table 1. Summary of Previous Studies

Reference	**Varieties of Solar Still**	**Modified still**	**Productivity Enhancement (%)**
Farghaly et al., [14]	solo slope still	Modified Evacuated tube collector solar still	82.26%
Mohammad Akram et al., [4]	Traditional solar still	Modified Evacuated glass tube (EGT) solar still	13.73%.

Najaf et al., [15]	Traditional solar still	Modified vacuum tubes solar still	656.8%
Taqi et al., [16]	single slope solar still	Modified evacuated tube solar collector solar still	35.63 %
Panchal et al., [17]	double basin solar still	Modified solid fins solar still.	25%
Alshqirate et al., [18]	semi-cylindrical tent-shaped solar still	Modified evacuated tubes solar still	45.7 %
Eswaran et al., [19]	single slope solar still	Modified nanoparticles solar still	66.6%
Mevada et al., [20]	Conventional solar still	condenser and fins with solar still	73.45%
Jaafar& Hameed, [21]	single slope solar still	a basin fabricated from a galvanized iron	90.09%
Bhargva& Yadav, [22]	single-slope solar still	with an evacuated tube collector	33.4%
Kabeelet al.,[23]	single-slope solar still	With electric water heater	31.3%

Many researchers have upgraded solar stills employing fins, external heaters, nanoparticles, evacuated tube collectors (ETC), and reflector-assisted systems. Despite various proposals to improve solar still performance, including evacuated tube collectors, reflectors, fins, PCM, and condensers, EGT-based stills are not yet fully evaluated. Traditional stills, EGT-assisted stills, and EGT with auxiliary reflectors have been examined under comparable operating circumstances in few investigations. Furthermore, EGT-assisted stills' water-depth-based performance, integrated thermal modelling, nocturnal behaviour, seasonal evaluation, and economic viability are understudied. A complete investigational as well as analytical exploration of solar stills by expatriate glass pipes is needed to optimize freshwater output.

2. OBJECTIVE OF THE STUDY

The investigational research focusses on design, building, and presentation evaluation of solar still connected through an evacuated glass tube (EGT) system, intended to enhance freshwater production. It examines several parameters affecting the thermal behaviour and heat transmission characteristics of the system, along with the improvements in productivity relative to conventional solar stills. The primary factors examined are sun intensity, basin water depth, ambient temperature, all essential for ascertaining distillate production. The results highlight a significant improvement in thermal performance attributable to the EGT coupling, aiming to boost overall system efficiency and freshwater production.

3. EXPERIMENTAL SET UP

Two prototypes of energetic solar stills, integrated through expatriate pipe collectors and using mandatory air exchange via a serpentine route, were conceived, constructed, and evaluated under various working circumstances. The solar still has primarily binary constituents: a solar still through a winding duct or channel also an evacuated tube collector (ETC), which are now discussed upon in the following sections.

3.1 Evacuated Tube Collector

Ten evacuated tubes were incorporated in the evacuated tube collector. To enable air circulation, an MS metal pipe of 32 mm in external width also 1.6 mm in breadth henceforth referred to as the air tube was placed concentrically within internal crystal tube of displaced pipe. The intake header, a square mild steel pipe measuring 50.8 mm by 50.8 mm in cross-section, was joined to the 10 air tubes by welding. A rectangular mild steel pipe measuring 38.1 mm by 76.2 mm in cross-section served as the output header. A silicone gasket was used to attach the evacuated tubes' open end to the outlet header. Rockwool (k = 0.05 W/m K) was used in a 20 mm thick layer as protection to decrease heat defeat since collector's headers also joints. While Figure 2 shows a portion of the ETC and how it connects to the solar still, Figure 1 shows how the intake header, output header, and air tubes are installed. Air was circulated through the active solar still and evacuated tube collector (ETC) using a centrifugal blower powered by a 3-phase, 1-hp, 2800 rpm electric motor. The blower was used to pull in ambient air, and an orifice meter connected the blower's output to the ETC's inner header.

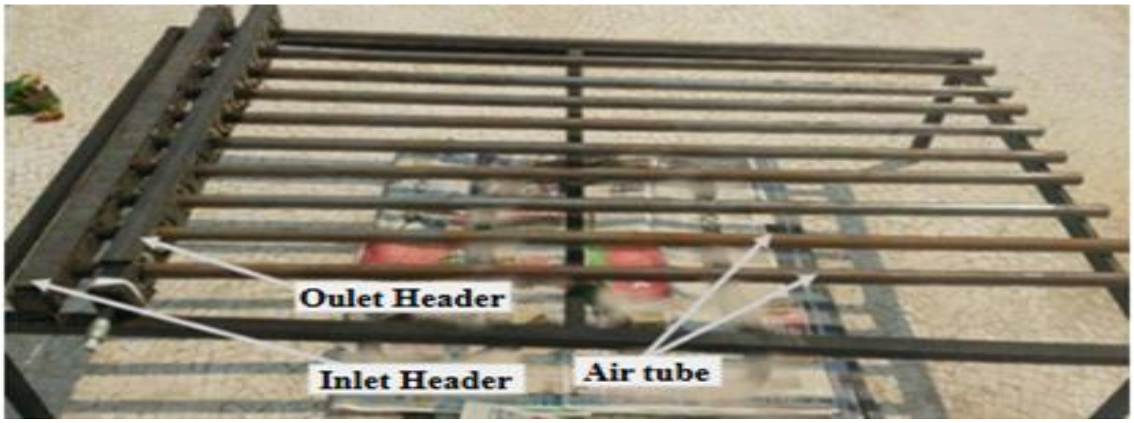

Fig. 1 Air tubes, inlet header, and outlet header

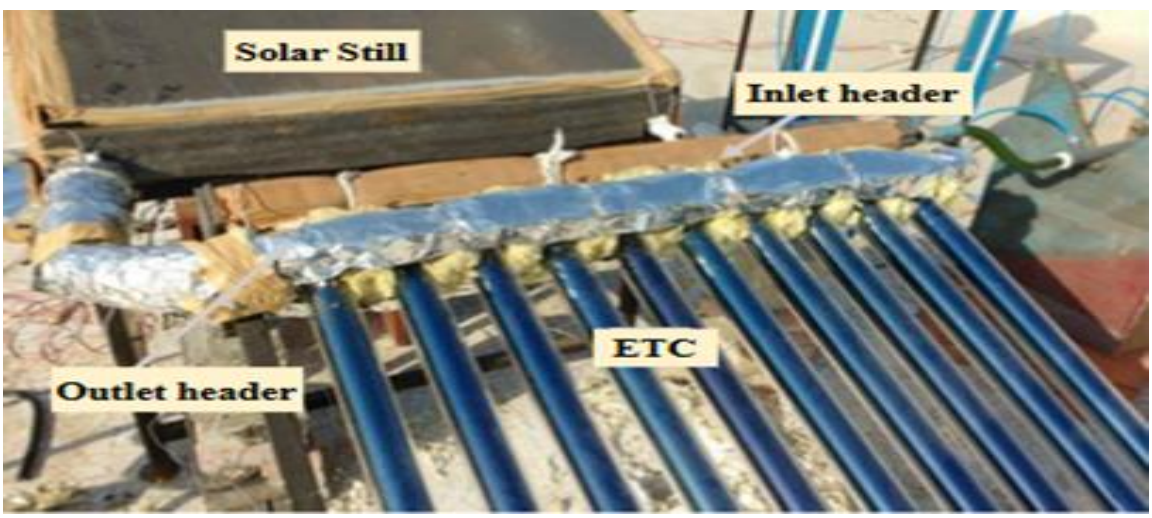

Fig. 2 Solar Still -connected ETC

3.2 Solar Still Using a Serpentine Tube Configuration

The Solar Still consisted of a serpentine tube, which is to be welded to the top of the basin. The boundaries also end of the solar still remained protected through a 20mm heavy Heatlon insulation substantial, with a k value of 0.49 W/mK. The stainless-steel tube with a 9mm inner and 12mm outer diameter, twisted to make a serpentine form, later painted black to enhance light absorption properties after the welding process for the basin. inlet of serpentine tube is linked to exit header of ETC, and exit of the serpentine tube is left open to air to enable the open-loop system. Aluminum trench installation is done in the Solar Still for distilled water harvesting, as exposed in figure 4.

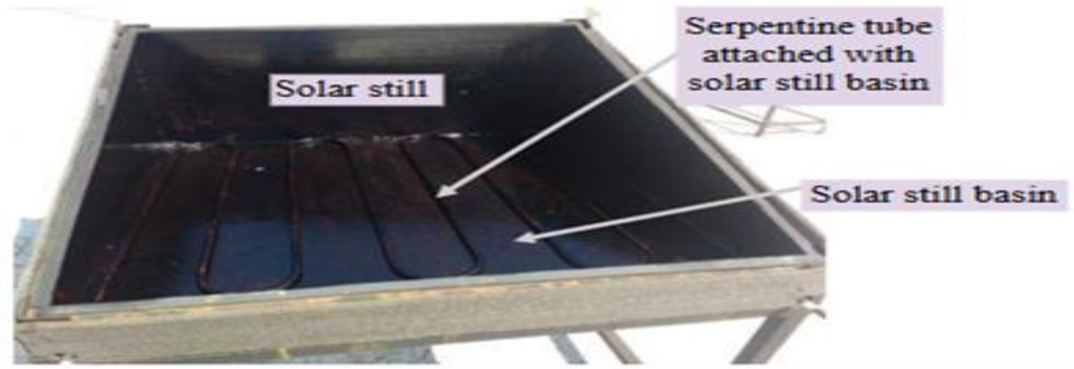

Fig. 3 Fabrication of Solar Still Using Serpentine Tube Configuration

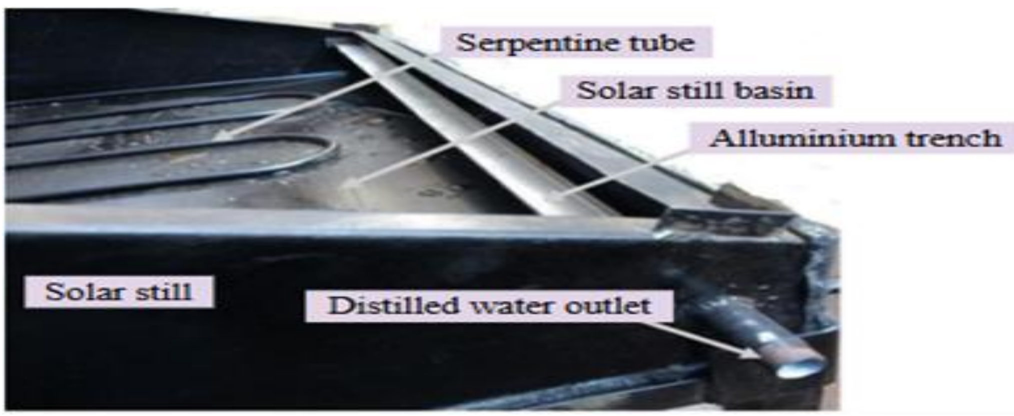

Fig. 4 Distilled water collection using an aluminum trench

A solar still with a serpentine channel was built below the basin. The side walls also lowest of the still remained protected through 20 mm heavy Heatlon insulation boards by a thermal conductivity k = 0.49W/m K. A total of ten equal portions was made at a distance of 100 mm with nine vertically placed plates. The nine vertically placed plates by breadth of 1 mm also a whole length of 900 mm were welded underneath the basin to form a serpentine route, as shown in Figure 5. The entrance point of the serpentine route was connected to the ETC's output header, while its exit point was left to the outside environment for free-flow circulation, as shown in Figure 6. The larger cross-sectional area in the serpentine route significantly reduced pressure loss rather than the serpentine tube.

Fig. 5 Fabrication of solar still with serpentine passage beneath the basin

Fig. 6 Outlet and Inlet of Serpentine Passage Beneath the Basin of Solar Still

The energy equilibrium for the outside crystal tube of the ETC is delineated by equations 1 to 5.

3.3 Thermal Model

A thermal model for both kinds of active solar stills, integrated with evacuated tube collectors and using forced air circulation, has been developed to forecast their performance.

3.3.1 Thermal model for ETC under forced circulation

Thermal Model of the ETC based on natural air circulation: In this kind of approach, the heat obtained from the ETC is transferred by natural air circulation. For forced air circulation, a concentric air pipe is provided inside the absorber pipe of an evacuated tube of the ETC. The air is forced through an evacuated tube collector to the serpentine pipe or channel. A thermal model is proposed for determining the thermal efficiency of the ETC for various operating conditions. Figure 7 illustrates the diverse heat fluxes among the various components of the ETC, air, and the surrounding environment.

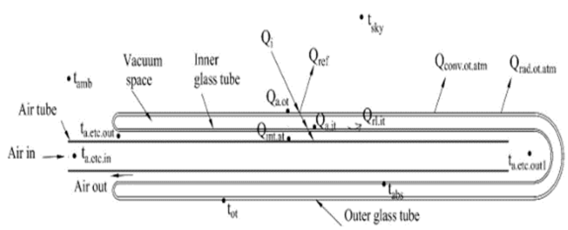

Fig. 7 Heat Transfer Between Different ETC Components

Thermal efficiency of ETC can be written

$$\eta_{sc} = \frac{Q_u}{Q_i}\eta_{sc} = \frac{Q_u}{Q_i} \quad (1)$$

Solar radiation falling on the ETC is given by

$$Q_i = I_c A_{ap} Q_i = I_c A_{ap} \quad (2)$$

Where, aperture zone of ETC is

$$A_{ap} = n_{ET} d_{it.o} l_u A_{ap} = n_{ET} d_{it.o} l_u \quad (3)$$

Heat engaged through outside crystal tube and heat reflected from outer crystal cover is given by the equations (3.4) and (3.5) respectively

$$Q_{a.it} = \alpha_{ot} I_c d_{ot.o} l_u Q_{a.it} = \alpha_{ot} I_c d_{ot.o} l_u \quad (4)$$

$$Q_{ref} = \gamma_{ot} I_c d_{ot.o} l_u Q_{ref} = \gamma_{ot} I_c d_{ot.o} l_u \quad (5)$$

The energy balance for the internal crystal tube of the ETC and the air tube is now shown.

The beneficial heat obtained from the ETC is expressed as

$$Q_u h_{a.av} A_{it.i} dt_{av} n_{ET} Q_u h_{a.av} A_{it.i} dt_{av} n_{ET} \quad (6)$$

The mean hotness among the absorber and the air in the annulus is

$$dt_{av} = t_{abs} - \frac{(t_{a.etc.out} + t_{a.etc.out.1})}{2} dt_{av} = t_{abs} - \frac{(t_{a.etc.out} + t_{a.etc.out.1})}{2} \quad (7)$$

Air makes its way into the ETC, moving from the exposed end of displaced pipe towards the closed end of the air tube. As air goes after the closed end of displaced pipe to the open end, it removes heat from the inside of the absorber tube. This happens via the space between internal crystal pipe and the air tube. As air moves through the collector, an internal heat exchange happens via the air tube's walls. The internal heat transfer may be simplified by treating the system as a counterflow hotness exchanger.

Internal heat exchange and overall heat transfer coefficient are defined as follows:

$$\text{s}Q_{int.at} = U_i . A_{at.i} . LMTD_{at} Q_{int.at} = U_i . A_{at.i} . LMTD_{at} \quad (8)$$

$$U_i = \left[\frac{1}{h_{a.i} . A_{at.i}} + \frac{1}{h_{a.av*} A_{at.o}} + R_{m.at}\right]^{-1} . A_{at.i}^{-1} U_i = \left[\frac{1}{h_{a.i} . A_{at.i}} + \frac{1}{h_{a.av*} A_{at.o}} + R_{m.at}\right]^{-1} . A_{at.i}^{-1} \quad (9)$$

The convective heat transfer coefficient for the air moving by the air pipe (heavy) also the annulus among the inner crystal pipe and the air tube (heavy) depend on the nature of the airflow. In the case of laminar flow, the coefficient can be approximated to be constant at 4.36, since the characteristics of the heat flux process remain steady. For turbulent flow, the correlation can be obtained using the Dittus-Boelter relation Nu_a=0. 023.Re_a^ (0.8). Pr_a^n. The value of n for the air moving through the air tube is 0.4, and for the air moving through the annulus region, it is 0.3. The air properties for both instances are to be rated at the mean temperature. The solid resistance for the air tube can be given by

$$R_{m.at} = \frac{\ln\left(\frac{d_{at.o}}{d_{at.i}}\right)}{2\pi . k_{at} . l_u} R_{m.at} = \frac{\ln\left(\frac{d_{at.o}}{d_{at.i}}\right)}{2\pi . k_{at} . l_u} \quad (10)$$

The logarithmic mean high temperature difference can be computed as

$$LMTD_{at} = [(t_{a.etc.out} - t_{a.etc.in}) - 0.1] . \left(\ln\left(\frac{t_{a.etc.out} - t_{a.etc.in}}{0.1}\right)\right)^{-1}$$
$$LMTD_{at} = [(t_{a.etc.out} - t_{a.etc.in}) - 0.1] . \left(\ln\left(\frac{t_{a.etc.out} - t_{a.etc.in}}{0.1}\right)\right)^{-1} \quad (11)$$

The temperature differential is assumed at the closed end of the evacuated tube to prevent an uncertain solution. The temperature at the closed end may be determined as

$$t_{a.etc.out.1} = Q_{int.at}.\left(m_a.C_{pa}\right)^{-1} + t_{a.etc.in}t_{a.etc.out.1} = Q_{int.at}.\left(m_a.C_{pa}\right)^{-1} + t_{a.etc.in} \quad (12)$$

3.4 Thermal model for serpentine tube configuration inside a basin

The ETC's hot air flows into a serpentine tube, which is nestled inside the basin. Heat is before transmitted after the air to the saline water, with the tube's wall acting as the conduit. The assumption is that there is no heat loss in the connections between the electrochemical cell (ETC) and the serpentine tube. Therefore, the heat absorbed by the evaporative cooling tower (ETC) before conveyed to saline water in the sink.

$$Q_u = A_{st}U_{st}LMSD_{st}Q_u = A_{st}U_{st}LMSD_{st} \quad (13)$$

The complete heat transmission constant for a serpentine tube configuration is expressed as

$$U_{st} = \left[\frac{1}{h_{a.st}} + \frac{d_{i.st}}{h_w d_{o.st}} + R_{m.st}\right]U_{st} = \left[\frac{1}{h_{a.st}} + \frac{d_{i.st}}{h_w d_{o.st}} + R_{m.st}\right] \quad (14)$$

value of convective heat transfer constant used for air passing inside a serpentine tube can be evaluated by utilizing the Dittus-Boelter equation: Nu_(a.st) =0. 023.Re_a^0.8. Pr_(a.st) ^0.3 The value of all qualities for air should be evaluated at mean temperature. value of natural convective heat transmission parameter at external edge of the serpentine tube and sea water can be evaluated by utilizing:

$$Nu_w = 0.36 + \frac{\left(0.518Ra_w^{0.25}\right)}{\left[1+\left[\frac{0.559}{Pr_w}\right]^{0.56}\right]^{0.44}}Nu_w = 0.36 + \frac{\left(0.518Ra_w^{0.25}\right)}{\left[1+\left[\frac{0.559}{Pr_w}\right]^{0.56}\right]^{0.44}} \quad (15)$$

The Rayleigh number, Prandtl number, also Grasshof number for saline water are computed as:

$$Ra = Gr_w.Pr_wRa = Gr_w.Pr_w \qquad Pr_w = \frac{\mu_w.cp_w}{k_w}Pr_w = \frac{\mu_w.cp_w}{k_w}$$ and

$$Gr_w = \left[\beta_w.g.\rho_w^2.d_{o.st}^3.\left(t_{a.avg.st} - t_w\right)\right]\mu_w^{-2}Gr_w = \left[\beta_w.g.\rho_w^2.d_{o.st}^3.\left(t_{a.avg.st} - t_w\right)\right]\mu_w^{-2} \quad (16)$$

Substantial resistance of serpentine pipe is written as

$$R_{m.st} = \frac{\left(\frac{d_{o.st}}{d_{i.st}}\right)}{2\pi k_{st}1_{st}}R_{m.st} = \frac{\left(\frac{d_{o.st}}{d_{i.st}}\right)}{2\pi k_{st}1_{st}} \quad (17)$$

The logarithmic mean temperature for heat transmission may be expressed as

$$LMTD_{st} = \frac{(t_{a.in.st}-t_w)-(t_{a.out.st}-t_w)}{\ln\left[\frac{(t_{a.in.st}-t_w)}{t_{a.out.st}-t_w}\right]}LMTD_{st} = \frac{(t_{a.in.st}-t_w)-(t_{a.out.st}-t_w)}{\ln\left[\frac{(t_{a.in.st}-t_w)}{t_{a.out.st}-t_w}\right]} \quad (18)$$

3.5 Thermal model of the serpentine tunnel under the basin

The hot air released from ETC moves into a serpentine tunnel positioned below the solar still basin, helping in conducting the heat to salty water in sink. The cross-section dimensions of this tunnel are 92 mm high and 100 mm wide, and the heat from ETC is conducted to the salty water in this tunnel with the help of forced air circulation., It expected that is no heat defeat in between ETC and the serpentine route.

$$Q_u = A_{sp}U_{sp}LMTD_{sp}Q_u = A_{sp}U_{sp}LMTD_{sp} \quad (19)$$

Asp, which is equivalent to basin area, represents the surface area of serpentine path that interacts with saline water.

The total heat transfer coefficient among saline water as well as air moving through the channel may stay written equally

$$U_{sp} = \left(\frac{1}{h_w} + \frac{1}{h_{a.sp}\eta_{f.o}} + R_{mat.sp}\right)U_{sp} = \left(\frac{1}{h_w} + \frac{1}{h_{a.sp}\eta_{f.o}} + R_{mat.sp}\right) \quad (20)$$

Substantial resistance of serpentine passage/basin is

$$R_{mat.sp} = \frac{th_b}{k_{sp}} R_{mat.sp} = \frac{th_b}{k_{sp}} \quad (21)$$

The perpendicular plates of serpentine channel purpose of fins, improving the area needed for heat transmission on the air side.

The complete fin competence is defined as

$$\eta_{f.o} = \left(1 - \left(1 - \eta_f\right)\frac{A_{uf}}{A_t}\right)\eta_{f.o} = \left(1 - \left(1 - \eta_f\right)\frac{A_{uf}}{A_t}\right) \quad (22)$$

4. RESULTS AND DISCUSSION

The setting for the study was set up as seen in Figs. 8 and 11, and measurements were obtained starting at 13 p.m. on average. for all experimental days.

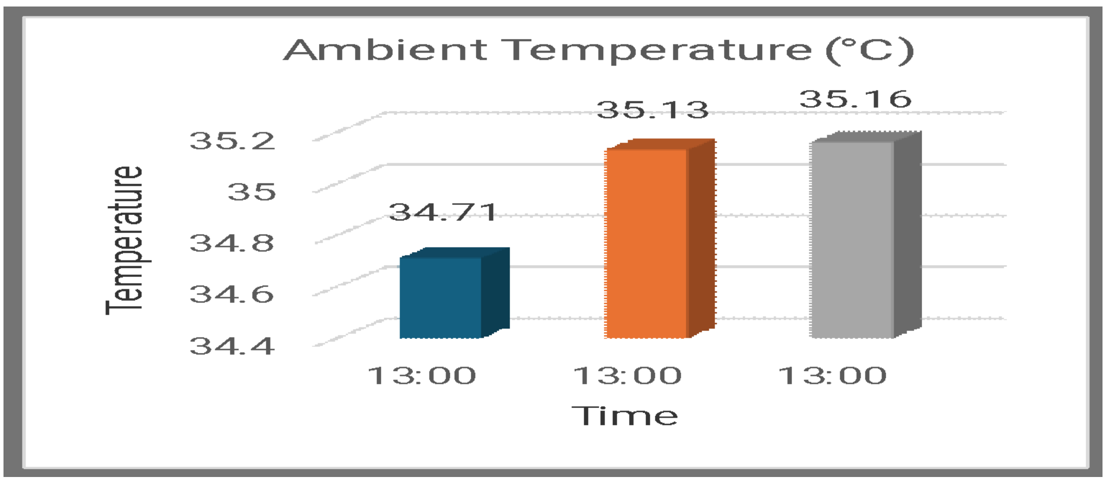

Fig. 8 Ambient Temperature (Tamb-°C) Vs Time

The figure 8 displays three measurements of ambient temperature in °C taken at the same recorded Time of 13:00. The total range of variation across the three points is small, approximately $0.45 °C, but the distinct difference between the first and subsequent readings, the first two differ by about 0.4 °C indicates that the environmental conditions were changing or heterogeneous at the time of measurement. This visualization compares three distinct ambient temperature readings, all purportedly taken at the same time stamp.

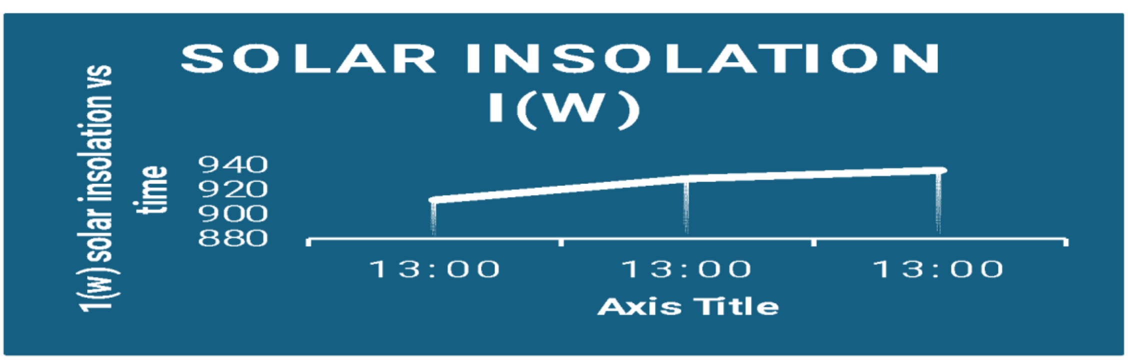

Fig. 9 I(W) I-Solar Insolation vs. Time

The graph 9 shows that solar insolation has been steadily rising at all three measured points: 911.67, 928.89, and 935.56. This shows that the amount of solar energy received at 1:00 PM grew steadily from the first measurement to the third. More sunlight in the middle of the day raises hotness of water, speeds up transfer of heat through evacuated tubes, and then makes more vapour inside the still. This visualization compares three distinct solar insolation readings, all purportedly taken at the same time stamp.

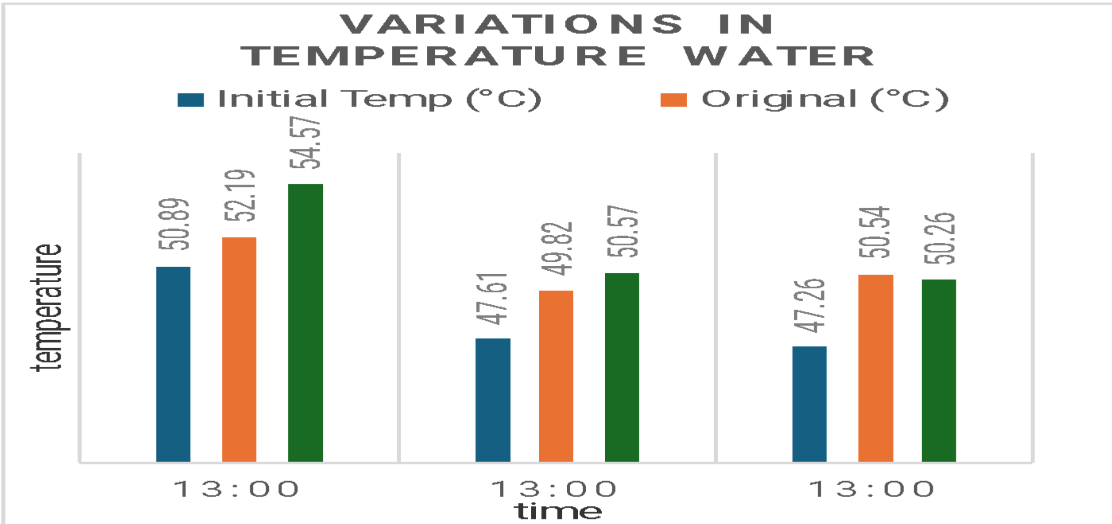

Fig. 10 Variations in Temperature of Water

Figure 10 shows three different sets of water temperature measurements taken at the same time, 13:00, over all experimental days. The most important thing to notice about all three measured temperatures over the three periods is that they are all clearly getting warmer. The first temperature (tw1,) goes down a lot from 50.89 °C in the first period to 47.61 °C in the second, and then reaches slightly low at 47.26 °C in the third period. The last temperature (tw2) also goes down a lot, from 54.51 °C to 50.26 °C. In the first and third periods, tw1 (initial temperature) is the moderate value in its group. In the original (tw1) value (52.19 °C) is higher than both days the tw1 (49.82 C) and tw1 (50.54 C) values in that all experimental days. The figure shows how these three specific water temperature readings change in a predictable way over the three measurement periods at noon**.**

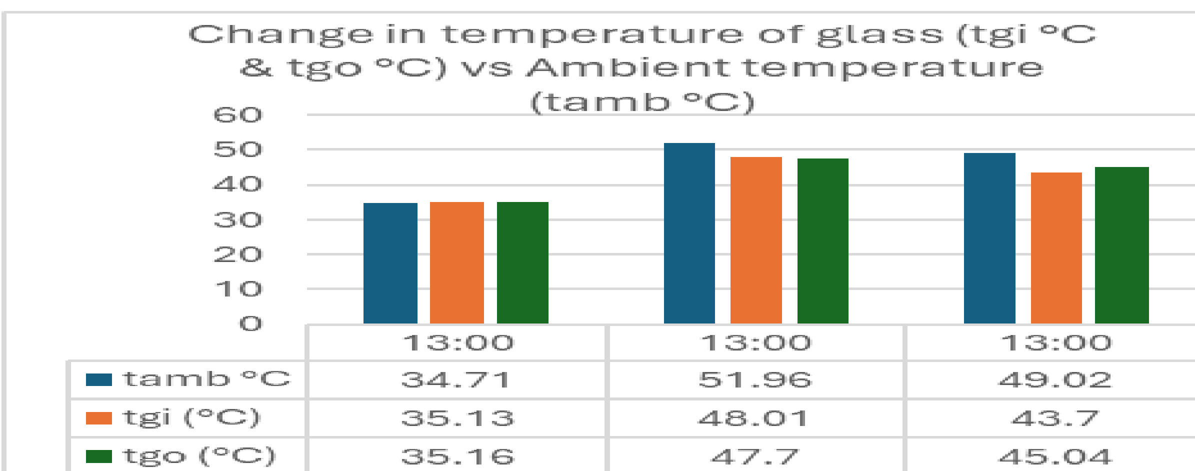

Fig. 11 Changes in temperature of glass (tgi-°C & tgo-°C)) vs Ambient temperature (tamb-°C)

The figure 11 shows three sets of temperature readings Ambient humidity, internal glass Celsius, the and external glass climate taken at 13:00 PM on three consecutive experimental days. The figure shows the values for each parameter. The overall trend shows that the temperatures changed a lot from day to day, with tgi, the highest temperatures for all three parameters. On Day 1, all three temperatures are very close together 35°C, with the highest tgo being 35.16 °C. On Day 2, there is a clear peak, with the number going up tamb sharply to 51.96°C, then down tgi to 48.01°C and then tgo with 47.7°C. Day 3 shows a sharp drop from the peak on Day 2, with tamb 49.02°C, tgo with 45.04 being a little higher than tgi 43.7°C. The data shows that Day 2 had the most intense thermal loading, especially in the surrounding area. On Day 3, the glass temperatures started to cool down noticeably.

5. CONCLUSION

This study looked closely at solar stills combined with an evacuated glass tube (EGT) system to see how they could make desalination work better. We tested two different modified solar still designs, each paired with a forced-circulation ETC that was made to maximise heat absorption and transfer to the sink water. experimental outcomes presented that thermal performance got a lot better. This was shown by higher basin water temperatures, better temperature gradients in the glass cover, and better evaporative heat transmission. Looking at temperature of air, the amount of sunlight that hit the system, and the temperature inside the system over three experimental days showed that the system behaved consistently and that the EGT coupling consistently improved thermal performance. The thermal model made in this study did a good job of showing how heat moved between the evacuated tube, air channel, absorber surface, and basin water. The model correctly predicted how solar insolation would affect system efficiency, internal heat exchange, and beneficial heat gain. The rise in insolation (up to 935 W/m²) directly caused the rise in water temperature and made evaporation more likely. In general, combining an evacuated glass tube collector with active air circulation made the distillation process much better than using traditional passive stills, which is in line with previous research that found a 13–112% increase in productivity. The results show that solar stills with EGT are a good and energy-efficient means to make freshwater in places through a proportion of sun. Future work may include optimising the water depth, adding thermal storage materials, and doing yearly performance and cost analyses to make these systems even more useful and scalable.

Conflicts of Interest

The authors declare that there are no conflicts of interest

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References

1. R. Rajagopal, M. Wichman, and E. Brands, "Water: drinking," *Int. Encycl. Geogr.*, pp. 7587–7599, 2017.
2. H. Panchal, D. K. Patel, and P. Patel, "Theoretical and experimental performance analysis of sandstones and marble pieces as thermal energy storage materials inside solar stills," *Int. J. Ambient Energy*, vol. 39, no. 3, pp. 221–229, 2018.
3. H. Thakkar, A. Sankhala, P. V Ramana, and H. Panchal, "A detailed review on solar desalination techniques," *Int. J. Ambient Energy*, vol. 41, no. 9, pp. 1066–1087, 2020.
4. C. H. Mohammad Akram, G. Saritha, A. Sharma, H. K. Singh, M. L. Rinawa, and S. Ashwin Kannan, "Improving the yield of a solar still with the aid of an evacuated tube," *J. Phys. Conf. Ser.*, vol. 2272, no. 1, 2022, doi: 10.1088/1742-6596/2272/1/012009.
5. S. K. Nougriaya, M. K. Chopra, B. Gupta, P. Baredar, and H. Parmar, "Influence of basin water depth and energy storage materials on productivity of solar still: a review," *Mater. Today Proc.*, vol. 44, pp. 1589–1603, 2021.
6. V. S. Vigneswaran *et al.*, "Energy, Exergy, and Economic analysis of low thermal conductivity basin solar still integrated with Phase Change Material for energy storage," *J. Energy Storage*, vol. 34, p. 102194, 2021.
7. M. D. R. Kamal, B. Parandhaman, B. Madhu, D. M. Babu, and R. Sathyamurthy, "Experimental analysis on single and double basin single slope solar still with energy storage material and external heater," *Mater. Today Proc.*, vol. 46, pp. 10288–10292, 2021.

8. H. Panchal *et al.*, "Performance evaluation of using evacuated tubes solar collector, perforated fins, and pebbles in a solar still–experimental study and CO2 mitigation analysis," *Environ. Sci. Pollut. Res.*, vol. 30, no. 5, pp. 11769–11784, 2023.
9. B. Patıl, J. Hole, and S. Wankhede, "Performance enhancement of stepped solar still coupled with evacuated tube collector," *J. Therm. Eng.*, vol. 9, no. 5, pp. 1177–1188, 2023.
10. G. Angappan, S. Pandiaraj, R. Rathanasamy, and T. Ayyasamy, "Distillate yield improvement techniques for solar still coupled with evacuated tube collector: a review," *Environ. Sci. Pollut. Res.*, vol. 32, no. 42, pp. 23792–23809, 2025.
11. M. Bhargva and A. Yadav, "Annual thermal performance analysis and economic assessment of an evacuated tube coupled solar still for Indian climatic conditions," *Environ. Sci. Pollut. Res.*, vol. 30, no. 11, pp. 31268–31280, 2023.
12. S. More and J. Daniel, "Productivity enhancement of Evacuated Tubes solar still of different water depth: Thermal modelling and an Experimental analysis.," in *IOP Conference Series: Materials Science and Engineering*, IOP Publishing, 2021, p. 12013.
13. V. K. Mehta, H. Panchal, B. Singh, and L. Kumar, "Revolutionizing solar water distillation: maximizing efficiency with pyramid solar stills enhanced by fins, evacuated tubes, nanomaterial, and phase change materials—a comprehensive review," *Int. J. Low-Carbon Technol.*, vol. 19, pp. 1996–2009, 2024.
14. M. B. Farghaly, R. N. Alahmadi, H. H. Sarhan, and E. S. Abdelghany, "Experimental study of simultaneous effect of evacuated tube collectors coupled with parabolic reflectors on traditional single slope solar still efficiency," *Case Stud. Therm. Eng.*, vol. 49, no. April, p. 103304, 2023, doi: 10.1016/j.csite.2023.103304.
15. F. Najaf, S. R. Aslan, and Z. A. Mohammed, "Experimental Investigation of the Effect of Evacuated Tubes and Glass Cover Cooling on the Performance of the Solar Still," *J. homepage http//iieta. org/journals/ijht*, vol. 42, no. 3, pp. 917–923, 2024.
16. R. N. Taqi, Z. A. Abdul Redha, and F. I. Mustafa, "Experimental Investigation of a Single Basin -Single Slope Solar Still Coupled with Evacuated Tube Solar Collector," *J. Eng.*, vol. 27, no. 6, pp. 16–34, 2021, doi: 10.31026/j.eng.2021.06.02.
17. H. Panchal, K. Kumar Sadasivuni, M. Suresh, S. Yadav, and S. Brahmbhatt, "Performance analysis of evacuated tubes coupled solar still with double basin solar still and solid fins," *Int. J. Ambient Energy*, vol. 41, no. 9, pp. 1031–1037, Jul. 2020, doi: 10.1080/01430750.2018.1501745.
18. A. A. Alshqirate *et al.*, "Enhanced distilled water productivity using an innovative semi-cylindrical tent-shaped solar still coupled with evacuated tubes," *Int. J. Thermofluids*, vol. 24, p. 100880, 2024, doi: https://doi.org/10.1016/j.ijft.2024.100880.
19. V. Eswaran, B. S. K. Subrananiam, and M. M. Athikesavan, "Performance evaluation of solar still using evacuated tube collector with and without nanoparticles," *Environ. Sci. Pollut. Res.*, vol. 30, no. 52, pp. 113002–113014, 2023, doi: 10.1007/s11356-023-30305-1.
20. D. Mevada, H. Panchal, and K. K. Sadasivuni, "Investigation on evacuated tubes coupled solar still with condenser and fins: Experimental, exergo-economic and exergo-environment analysis," *Case Stud. Therm. Eng.*, vol. 27, p. 101217, 2021.
21. Z. A. Jaafar and H. G. Hameed, "Experimental Investigation of a Single Slope Solar Still Performance-Evaporation Process Enhancement Using Evacuated Pipes," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 877, no. 1, 2021, doi: 10.1088/1755-1315/877/1/012041.
22. M. Bhargva and A. Yadav, "Productivity augmentation of single-slope solar still using evacuated tubes, heat exchanger, internal reflectors and external condenser," *Energy Sources, Part A Recover. Util. Environ. Eff.*, vol. 46, no. 1, pp. 2646–2666, 2024, doi: 10.1080/15567036.2019.1691291.
23. A. E. Kabeel, M. Abdelgaied, and G. M. Mahmoud, "Performance evaluation of continuous solar still water desalination system.," *J. Therm. Anal. Calorim.*, vol. 144, no. 3, 2021.