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Retraction

Retraction: Experimental Analysis on the Inactive region of Evacuated tube Solar Collector using Twisted Tapes (*IOP Conf. Ser.: Mater. Sci. Eng.* **1145** 012033)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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Experimental Analysis on the Inactive region of Evacuated tube Solar Collector using Twisted Tapes

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Abstract. The evacuated tube type solar collector is used predominantly for water heating application in both residential and industrial scales. They found superior in thermal efficiency compared to other kind of solar collectors. All-glass evacuated solar collector is the simplest form of evacuated collector which found its major applications as passive flow solar water heaters for residential and industrial purposes. However, they have been affected with an inherent issue which is due to the inactive region formed at the bottom of the tubes. This paper addresses this issue with the help of twisted tubes, made-up of aluminum. The experimental results proved that the existence of twisted tapes accelerated the heat transfer within the inactive region and helped to maintain the uniform temperature inside the tube. The results proved that the water temperature at the inactive region was augmented up to 73ºC with the help of twisted tapes, which was 31ºC more than tubes without twisted tapes. Also, the twisted tapes enhanced the average temperature of tube water by the maximum of 10ºC.

Keywords: evacuated tube solar collector; twisted tape; heat transfer; inactive region

1. Introduction

The world energy generation is majorly depending on the conventional fossil fuels which are not only continuously depleting but also damaging the eco-sphere adversely through their emission [1, 2]. Further, the end-use of electrical energy as heat contributes more than one-third of global energy contribution [3, 4]. Importantly, the energy expenditure for water heating in residences, commercial buildings, and industries is sky-scraping. Hence, the use of suitable renewable source for water heating alone save a substantial amount of conventional energy and reduce the demand from those source, considerably [5, 6]. Solar water heaters are one such recent invention which is widely spreading across the globe in the last two decades for water heating applications. They can be used from small scale residential applications to large scale industrial needs [7, 8]. They heat the water by the solar radiation heat through some suitable collectors [9, 10]. Flat plate, evacuated tube, parabolic trough and parabolic dish collectors are the few examples of presently used solar collectors [11, 12]. Among the diversified types of solar collectors, evacuated tube based solar collectors are getting their attention in recent past due to their simple construction and improved thermal efficiency [13, 14].

A wide variety of evacuated tube collectors are in use namely, simple all-glass evacuated tubes, evacuated tube with heat pipe and U-tube evacuated tube solar collectors. However, all-glass evacuated tube based collectors are extensively used in passive flow solar water heaters for their ease of erection and cost [15, 16]. A lot of improvements have been incorporated in the contemporary solar collectors with the help of phase change materials [17, 18, 19] and design modifications [20, 21] to address their inborn setbacks such as poor off-sunshine performance and losses.

The experimental results of the recent researches proved that the all-glass tubes are suffered with an inactive region at its bottom where the liquid velocity is zero and temperature difference is high [22]. Due to this issue, the water at the bottom of the tubes remains stagnant without properly mixing with the other part of the tube and hence, reduces the overall performance of the evacuated tubes. This problem can be addressed by suitably changing the slope of the tubes and reducing the length of the tubes, however, the above such modification are having their own limitations with respect to location of the collector installation and heat removal factor of the solar collector. Earlier researches evidenced that the twisted tapes in flat plate collectors proved to be the effective solution to advance the heat flow between collector and fluid. Generally, the twisted tapes are made with a certain twist angle and pitch which improves the heat transfer area [23, 24].

In this experimentation, an effort was taken to activate the aforementioned inactive region with the help of twisted tapes. Beforehand, the twisted tapes with the suitable dimensions were fabricated using aluminum and tests were performed by incorporating twisted tapes inside the evacuated tubes.

2. Experimental set-up

A commercial all-glass evacuated type solar water heater was indigenously fabricated for conducting the experiments. This fabricated water heater was a passive flow type collector having ten evacuated tubes with an integrated water tank of 100 liters storage capacity. The collector tank was fabricated from the stainless steel for avoiding the corrosion and longer life, and the evacuated tubes were inserted inside the tank using silicone rubber gaskets to ensure the leakage free operation. Then, the water heater was erected in such a way that it was facing south to get utmost solar radiation during all the seasons [25, 26] as shown in Figure 1.

Figure 1. Experimental set-up

The experiments were performed in Coimbatore, Tamilnadu which lies at 11° North Latitude and 77°East Longitude and having an annual mean maximum temperature of 32.2°C [27]. The specification of the experimented all-glass evacuated tube collector is given in Table 1.

Table 1. Specification of the experimented evacuated tubes

Description	Specification
Inner diameter	47 mm
Outer diameter	58 mm
Length of the evacuated tube	1800 mm
Tube material	Borosilicate glass
Transmittance of evacuated tube	0.90
Emissivity of evacuated tube	0.045
Absorptivity of evacuated tube	0.94

The twisted tapes are made-up of aluminum sheets with 0.5 mm thick, 15 mm width and 1650 mm length. The aluminium was chosen, because it is less in cost and weight, but it is having a very good thermal conductivity. The aluminum tapes are twisted by 180º with the twist ratio of 3 as shown in Figure 2.

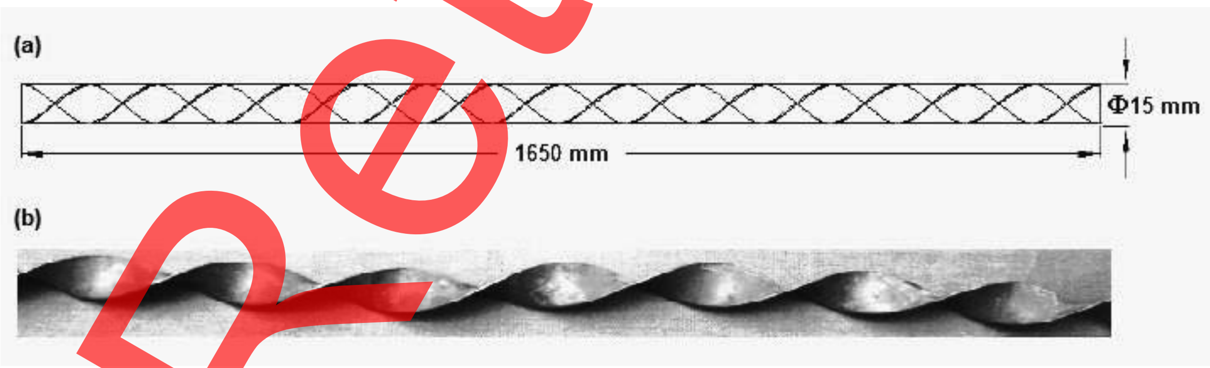

Figure 2. Experimented twisted tape (a) Diagram (b) Photograph

3. Instrumentation

The proper instrumentations were made to attain the essential data during the investigation. A solar meter [28] was utilized to measure the solar radiation during the experimentation. K-type thermocouples [29] were employed to appraise the atmospheric temperature and temperature of the water at different locations of the evacuated tube. The thermocouples were joined to the multipoint digital temperature indicator to gauge the real time temperature at different locations as shown in Figure 3.

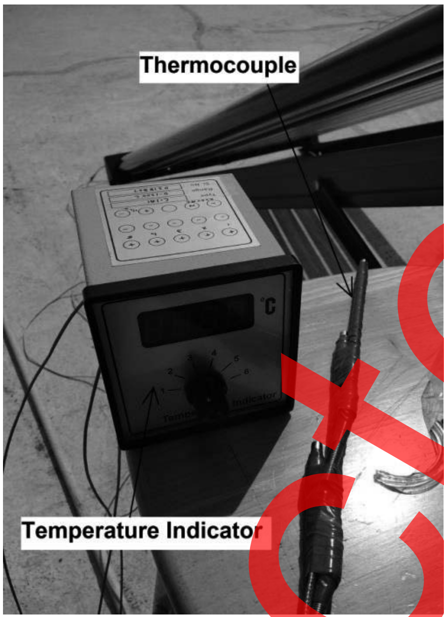

Figure 3. Thermocouple and temperature indicator used in the experimentation

4. Experimental procedure

The experiments were accomplished between 8.00 a.m and 6.00 p.m. on a clear sunny day in the month of April, 2020. Three thermocouples were used in each evacuated tube in such a way that one at the top (near the tank), one at the center of the tube and one at the bottom end of the tube. In this manner, four evacuated tubes were used for the experiment. Two tubes (tubes 2 and 6 from left) without twisted tapes and two tubes (tubes 4 and 8 from left) with twisted tapes. The solar radiation, atmospheric temperature and the temperature at the different location of the tubes were noted down once in every half an hour. The mean tube water temperature was taken at the required points by averaging the above said two tubes for each respective category. Then, the results are compared to examine the effect of using twisted tapes on the temperature of water at the inactive region of the evacuated tubes.

5. Results and discussion

The experiments were carried-out on a solar day with an average solar radiation of 660 W/m^2 and the mean atmospheric temperature of 31ºC. The disparity in solar radiation and the atmospheric temperature are shown in Figure 4.

As mentioned, four evacuated tubes were taken for the observation. Two tubes without twisted tapes and two other tubes with twisted tapes were considered for the experimentation. Figure 5 presents the average temperature of water inside two tubes at top, middle and bottom portions, without incorporation of twisted tapes. It can be clearly seen that the temperature of water at the foot of the tube remains low throughout the day compared top and middle of the tube. It visibly indicates that the water at the bottom of the tubes was not heated due to the poor buoyancy and this portion remained inactive throughout the day. The temperature difference between bottom and other parts of the tube was high and went up to 35ºC during the late afternoon.

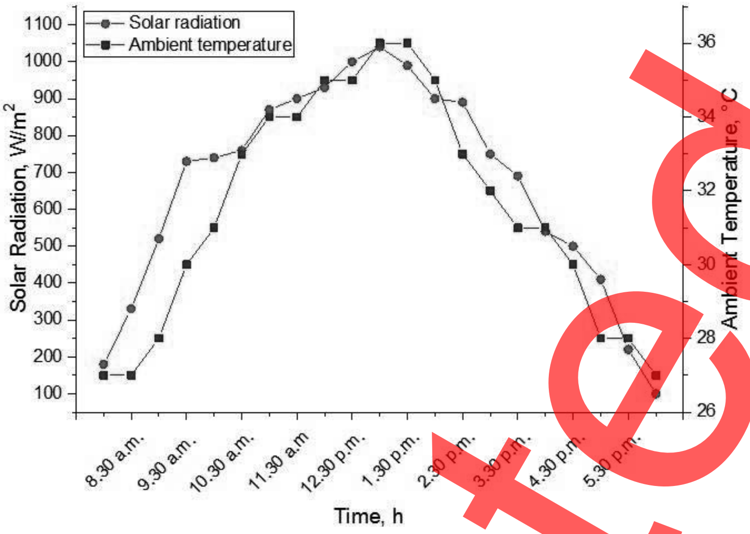

Figure 4. Solar insolation and atmospheric temperature during the experimentation

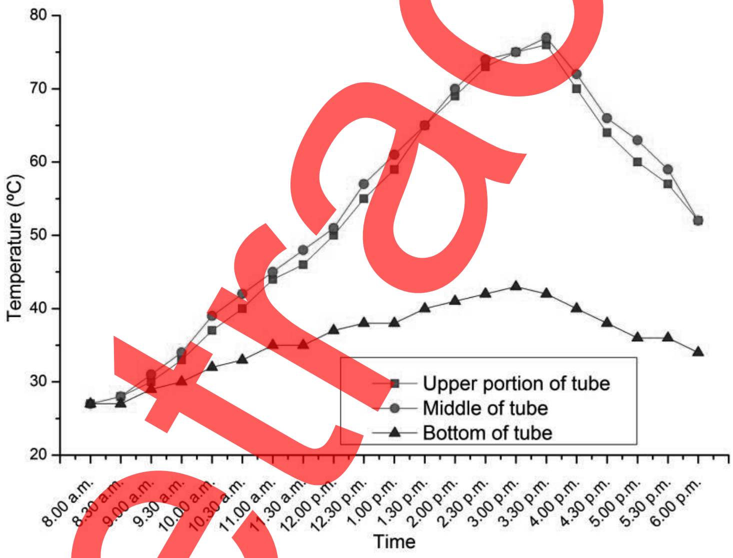

Figure 5. Temperature of water at different parts of the evacuated tubes without twisted tapes

Figure 6 presents the average temperature of water inside two tubes at top, middle and bottom portions, after the incorporation of twisted tapes. It shows that the water temperature at the bottom of the tubes increased greatly and it became nearly equal to other parts of the tubes while they were integrated with the twisted tapes. It is clear that the twisted tapes improved the bottom tube temperature through the mixing of the water with other parts of the tubes and activated the inactive region of the tubes significantly. In general, compared to the tubes without twisted tapes, the bottom temperature of the tubes with twisted tapes increased up to 31ºC.

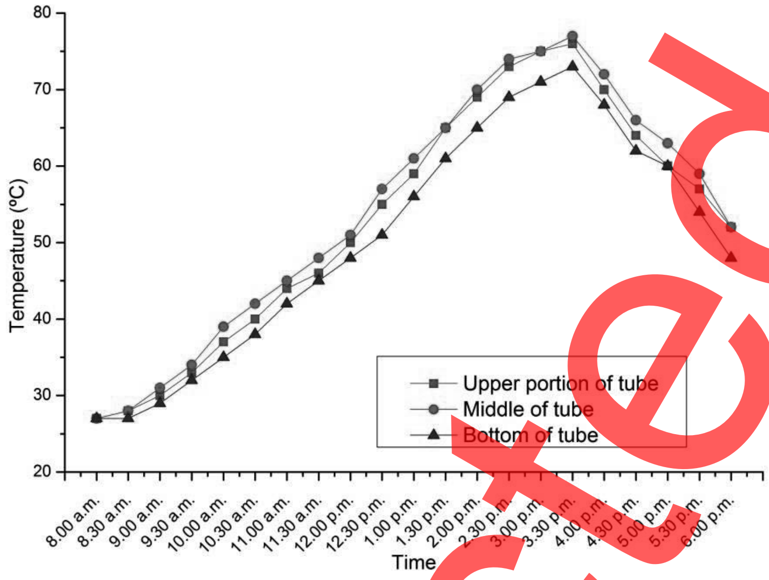

Figure 6. Temperature of water at different parts of the evacuated tubes with twisted tapes

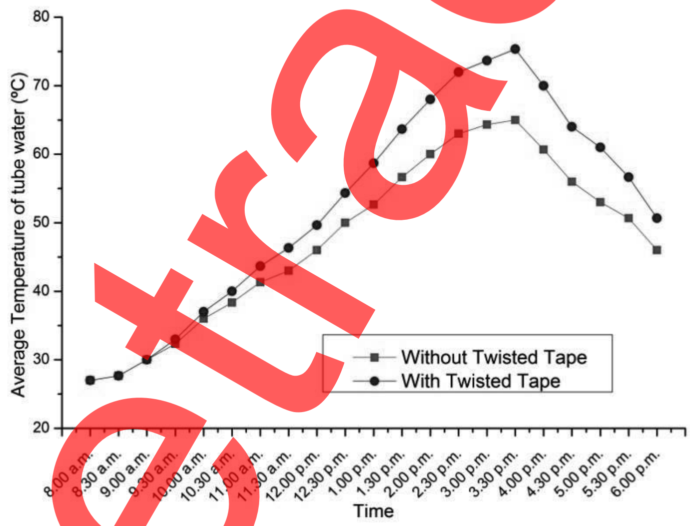

Figure 7. Mean temperature of water within the evacuated tubes with and without twisted tapes

Figure 7 indicates the mean temperature of water within the evacuated tubes with and without twisted tapes. The mean temperature of the water was increased by 10ºC while the tubes were inserted with the twisted tapes. The twisted tapes augmented the heat transfer inside the evacuated tubes through their swirling motion during the density driven flow across the tubes [30]. In this way, they activated the bottom inactive region to a great extent and facilitated to attain the uniform temperature across the evacuated tubes.

6. Conclusion

The experiment was conducted on all-glass evacuated tubes of the solar water heater to activate the inactive region at the foot of the tubes with the help of twisted tapes. The water heater was fabricated and suitable instrumentation was introduced within the water heater. The aluminium twisted tapes of length 1650 mm, width 15 mm with the twist ratio 3 were fabricated. Totally four tubes (two without twisted tapes and two with twisted tapes) were considered for the experimentation. The results proved that the twisted tapes improved the temperature at the bottom of the evacuated tubes through their swirling motion during the fluid movement and activated the inactive region through proper mixing of water. The bottom water temperature was increased up to 73ºC with the help of twisted tapes, which was 31ºC more than tubes without twisted tapes. Further, the average temperature of water was enhanced by the maximum of 10ºC, using the twisted tapes.

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