

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 8, Issue 6, June 2019

Experimental Investigation on Solar Still System Integrated with Parabolic Concentrator and Phase Change Material

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ABSTRACT: This paper introduces an adaptation of illustrative parabolic concentrator– sun powered still with nonstop water flow utilizing a capacity tank to improve the efficiency. Four methods of activity were considered tentatively: (I) Parabolic Concentrator -sun based still without top widen cooling; (ii) Parabolic Concentrator -sun based still with top widen cooling, Parabolic Concentrator -sunlight based still incorporated with phase change material without top spread cooling and Parabolic Concentrator -sun based still synchronized Phase Change Material with cooling. The analyses were completed for the cooling water stream rates of 120 ml/min; 140 ml/min, 160 ml/min, 180 ml/min and 200 ml/min. Diurnal varieties of water temperature (T_w), air temperature (T_a), top spread temperature (T_{oc}) and creation rate are estimated with continuous time interims. Inclusion of Phase Change Material was practical, whereas water cooling was not practical.

KEYWORDS: Parabolic concentrator, Solar still, Phase change material

I. INTRODUCTION

By 2040, the interest for vitality could twofold or even triple, as the worldwide populace rises and creating nations grow their economy. All life on Earth relies upon vitality and the cycling of carbon. Vitality is fundamental for financial and social advancement yet in addition represents a natural test. We should investigate all parts of vitality generation and utilization including vitality proficiency, sustainable power source, atomic vitality, carbon catch and capacity, and the worldwide carbon cycle, just as their relationship to atmosphere and characteristic asset issues. Today the world is tested to give adequate unadulterated water assets to human needs. An ongoing report demonstrates that the ground water levels and precipitation are in decrease. Later on, with populace and per capita utilization development, the circumstance will turn out to be significantly progressively troublesome.

In any case, desalinization is one class of arrangements that holds critical guarantee. A case of refining is a sunlight based still, which is a basic gadget that can be utilized to change over saline or bitter water into drinking water [1]. Karimi Estahbanati et al. [2] examined the impact of number phases of dissipation and buildup on the presentation of multi-impact sun oriented stills and their consequences for efficiency. They inferred that with more stages, the generation improvement is more in the ceaseless mode contrasted with the non-constant mode. Ahsan et al. [3] considered the minimal effort triangular sun based still to be utilized in country and seaside zones for changing over saline water into consumable water utilizing sun oriented vitality.

Numerous scientists have dissected the effect of cooling of the buildup surface of sun oriented stills. Somwanshi and Tiwari [4] found that the distillate yield increments somewhat with an expansion in water stream rate over the top

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spread. Arunkumar et al. [5] investigated the impact of water stream over a cylindrical sun based still. They presumed that the water stream over the spread expands the distillate efficiency. Suneesh et al. [6] explored a 'V' type sun oriented still with cotton cloth cooling. They presumed that water streaming over the buildup surface expands the profitability. Tiwari et al assessed the exhibition of a sun based still with water stream over the glass spread. Tiwari et al. [7 &8] consolidated the progression of waste boiling water in the bowl alongside water stream over the glass spread and got an expansion in distillate yield comparable with the increment in gulf water temperature in the bowl.

Lawrence et al. [9] approved their model by fusing the impacts of water stream over the spread and warmth limit of water in the bowl. They found an expansion of 7–10% in proficiency of the sun oriented still because of water stream over the glass spread. Abu-Hijleh [10] if your paper is proposed for a gathering, if it's not too much trouble contact your meeting editorial manager concerning satisfactory word processor. Hypothetically explored the viability of film cooling under various working attributes; his outcomes showed that the best possible utilization of the film cooling parameters can build the still proficiency by 6% yet poor parameters can lessen still productivity. Abu-Hijleh and Mousa [11] expanded the previous work and incorporated the dissipation impact of a water film streaming over the glass spread.

Water streaming over the gathering spread has been examined by numerous writers working in the field of desalination. These days' concentrators are utilized in different applications. Numerous creative research exercises have been performed on concentrator frameworks, for example photovoltaic frameworks, structures, air conditionings and cooling-warming. Concentrator fueled sun oriented refining frameworks assume a critical job in creating desalted water. By and by numerous analysts are engaged with these exercises to collect top notch de-salted water through concentrator-helped frameworks.

The exploratory and hypothetical examination finished up with a normal relative blunder of 42% for the distillate stream rate. Numerous creators have played out the refining procedure with concentrator-helped methods. El-Sebaai [12,13] contemplated the presentation of single slant sun powered still with stage change material. Gude [14] investigated vitality stockpiling for desalination forms with waste warmth sources. A solitary bowl twofold slant sun based still with various vitality putting away materials has been examined by Kalidasa Murugavel et al. [15]. They found that quartzite shake is the more viable in expanding creation every day. Sodha et al. [16] introduced the impact of color on the sun based still execution. They inferred that dark and violet colors were discovered more compelling than different colors.

A stage type sun based still with inherent idle warmth warm vitality stockpiling has been researched by Radhwan [17]. They inferred that the still's productivity is 57% contrasted with 61% for the still without stage change material. An exploratory examination on a regenerative sun powered still with warm vitality stockpiling medium has been considered by Sakthivel et al. [18]. This change was ease as the jute material is extremely modest and promptly accessible. Arjunan et al. [19] explored the presentation of a basic sun powered still with various vitality stockpiling materials like dark rock, rocks, blue stone, and paraffin wax.

A straightforward sun powered still with various shaded wipe liners on the internal divider surfaces was examined by Arjunan et al. [20]. They inferred that the 5 mm thickness wipe liner gives 35.2% higher yield than the traditional still and a dark wipe gives more yield than the others, which is 43.5% higher than the customary still. The impacts of warmth stockpiling bed and water profundity are examined by Omara and Kabeel [21]. They demonstrated that capacity bed (sandy layer) improved the sunlight based still profitability. Test investigation of a sun oriented still with stage change material has been contemplated by Sathyamurthy et al. [22]. They found that the effectiveness of the sun based still improved by 14% with PCM.

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A sun oriented still with a semi-round trough safeguard has been broke down they reasoned that bewilders upgraded the profitability by 16.7%. Sathyamurthy et al. [22] displayed a pyramid formed sun oriented still with stage change material. They found that the distillate efficiency was improved by 35% with the inert warmth warm vitality stockpiling framework. A multistage dynamic sun powered still with sun based vitality authorities have been dissected by Feilzadeh et al. They found that the profitability expanded by 48% with the impact of gatherers. El-Sebaai et al. contemplated the impact of a balance on the sun based still execution.

The general refining expanded by 13.7% with the impact of the balance in the sun based still. El-Agouz et al. [72] considered the impact of a blade in a slanted sun based still. They found that the everyday distillate yield improved by 57.2% with top spread cooling over the consolidating spread. Tiwari and Suneja [12] built up an upset reflector sun oriented still for refining. They inferred that the profitability new sun based desalting framework. The exploratory outcomes demonstrated that the effectiveness of the framework expanded by 29%. El-Sebaai et al. [13] examined the impact of astound safeguards in the single slant sun based still. They presumed that the day by day distillate yield improved by 20% in respect to a regular sunlight based still.

A sun based still with implicit inside and outer reflectors has been examined by Omara et al. [21]. They found that the profitability improvement was 125% because of the impact of reflectors. El-Agouz [28] considered the water stream over a ventured sunlight based still. The creator inferred that the proficiency of the proposed sun powered still was 20% more noteworthy than regular sun powered stills.

II. MATERIALS AND METHODS

The parabolic concentrator sun based still comprises of a round area gatherer (generally explanatory) and a hemispherical safeguard. The hemispherical part was independently structured and appended to the bowl base piece of the still. This whole hemispherical safeguard volume goes about as water stockpiling for the still. The safeguard is made out of copper with 4 mm thickness. The measurement of the hemispherical base is 0.22 m. The internal and external surfaces were painted dark and a $\frac{1}{4}$ in. channel pipe filled in as a water delta. The six copper balls are empty. The paraffin wax is loaded up with the opening gave at the top. 25 g of Phase Change material was utilized in the balls. In the event that more were utilized, since the volume of the phase change material increments after dissolving, it would cause spillage. A Pyranometer is utilized to screen the sunlight based radiation. The water temperature, air temperature, surrounding temperature, inward spread temperature and phase change material ball temperatures are estimated by K-type thermocouples. The vulnerability of the estimating gadgets are in Table 1. Table 2 abridges the thermo-physical properties of business grade paraffin wax phase change material. The warmth extricated water was gathered and it is utilized in the equivalent sun powered still for refining reason for the following day.

The top surface of the still is a front of region 0.25 m x 0.25 m. The top spread is made out of straightforward glass 2 mm thick. The top spread was put over the notches with uniform resting slant of 110 from the flat. A water gathering portion was likewise given at the fitting spot. The fragment has a length of 0.27 m and a width of 0.025 m. This whole setup was mounted at the point of convergence of the concentrator underneath. A capacity tank mounted on a steel structure provided crude water and cooling water. The water tank produces weight head. Prior to initiation of the trial, the required stream rate from water tank to the PC still was ceaselessly tried and afterward water was permitted to stream over the glass spread. The schematic perspective on the parabolic concentrator sunlight based still with the cooling framework is appeared in Figs. 1 and 2. The phase change material-stacked balls in the bowl are appeared in Fig. 3

In this work, an explanatory concentrator-sunlight based still has been manufactured that is not the same as every past work since it couples an allegorical concentrator with top spread cooling. Testing for the present investigation was completed for Pune India climatic conditions amid March–May, 2019. Additionally, the bowl of the sunlight based still is made as hemispherical bowl, where the sun based radiation is engaged to a point to build the temperature of the water inside the still. To build the buildup of water on the internal surface, spread cooling is conjured. The trial

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included diverse stream rates over the top spread. So as to improve the medium-term efficiency, paraffin wax stage change material stacked copper balls were put in the still bowl.

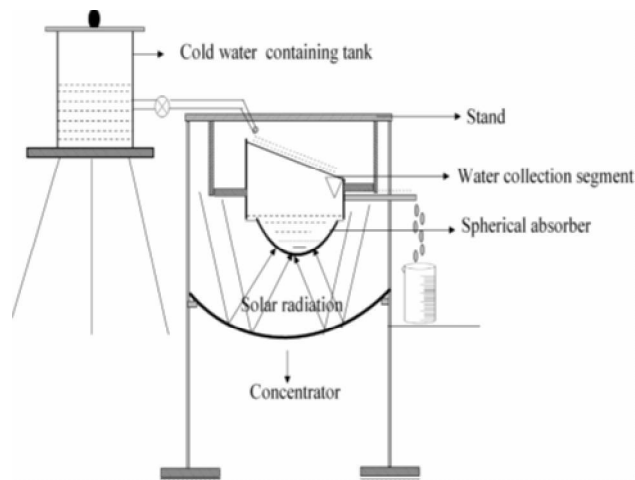


Fig. 1. Schematic diagram of parabolic concentrator solar still with top cover cooling unit.

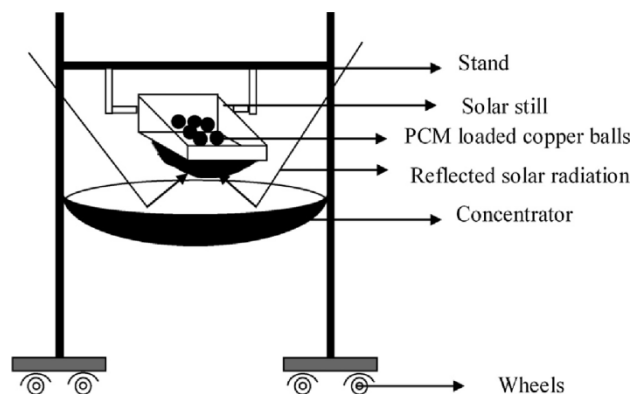


Fig. 2. Schematic diagram of parabolic concentrator solar still with phase change material

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Fig. 3. Pictographic view of PC solar still model for experimental work.

III. MECHANISM

The sun based radiation is transmitted through the single incline sun powered still spread and is consumed by the phase change material and water; henceforth, these temperatures increment. Some portion of the vitality consumed by the bowl is exchanged by convection to the water and part is exchanged by conduction to the cooler phase change material laying on the bowl. As the balls are warmed, heat is first put away as reasonable warmth until the phase change material achieves its liquefying point. As of now, the phase change material begins to dissolve and after complete softening of the phase change material, the warmth will be put away in the liquefied phase change material as further reasonable warmth. Evening, when the sun based radiation diminishes, the still parts begin to chill off and the fluid phase change material exchanges warmth to the bowl liner and from the last to the bowl water until the phase change material is totally set. The phase change material will go about as a warmth hotspot for the bowl water amid low force sun powered radiation periods just as amid the night; thus, the still keeps on delivering crisp water after dusk even with slight layers of bowl water.

IV. RESULTS

Fig. 4 & 5 demonstrates the variety of sun oriented radiation and surrounding temperature as for time. Respectively Sunlight based insolation and encompassing air calm are the two most significant ecological parameters to the exhibition of any sun oriented desalination framework. It very well may be seen from assume that the greatest recorded encompassing temperature is 370C at 1.30 PM. Correspondingly the most extreme recorded sunlight based radiation is 1050 W/m². Two parabolic concentrator-sun based still frameworks were manufactured to analyze the outcomes. This is the best way to foresee the definite outcomes in the equivalent climatic conditions. Fig. 6 (a–f) demonstrates the variety of temperatures without PCM in the PC-sun oriented still for various cooling water stream rates. Fig. 7(a–f) demonstrates the variety of temperature with cooling water and PCM in the PC-sun powered still.

The bowl water temperature isn't greatly influenced by the cooling water due to the concentrator impact. In the meantime, the glass temperature step by step diminishes with expanding cooling water stream rate from 120 ml/min to 200 ml/min. The consolidated impacts of top spread cooling and PCM improve the efficiency of the PC-sun oriented still. The all out creation of the framework is outlined in Table. 1 that the impact of cooling spread improves the yield by 6% with an expansion in the stream rate of water. Because of the expanded driving temperature inclination between the bowl water and glass, the buildup of water inside the spread is expanded.

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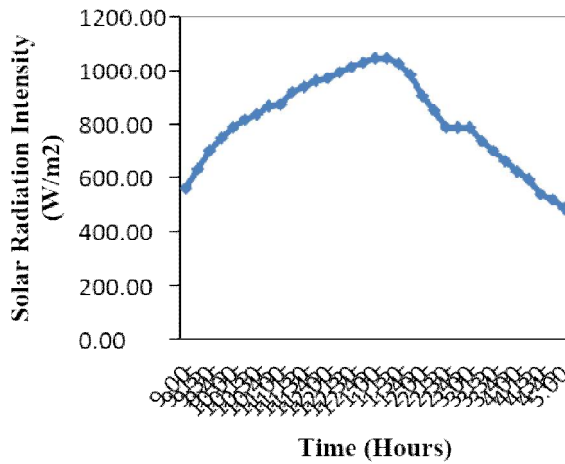


Fig. 4. Variation of solar radiation intensity with time

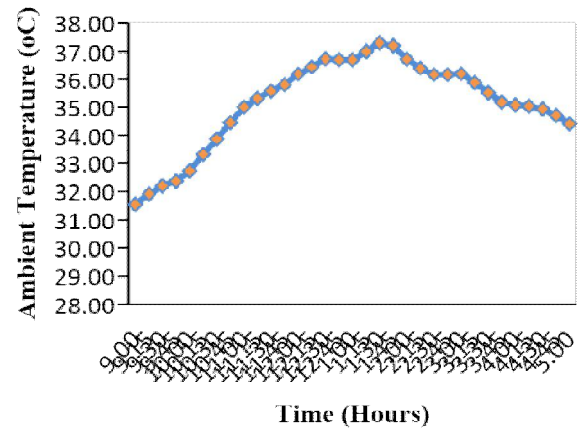


Fig. 5. Variation of ambient temperature with time

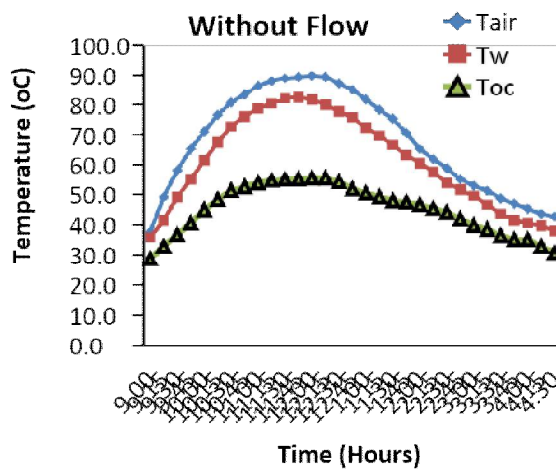


Fig. 6(a)

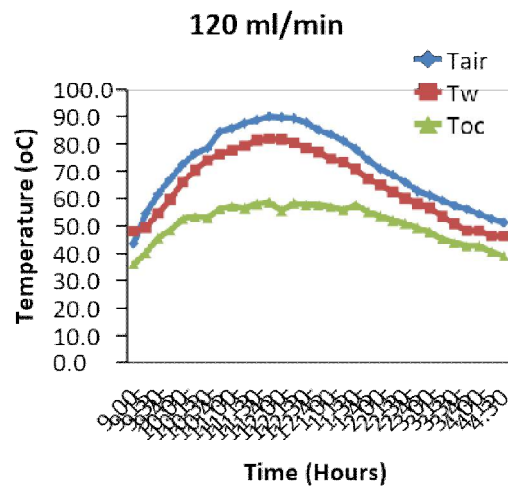


Fig. 6(b)

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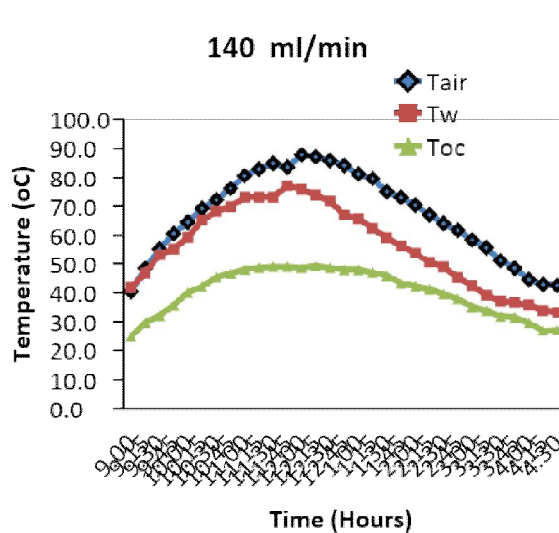


Fig. 6(c)

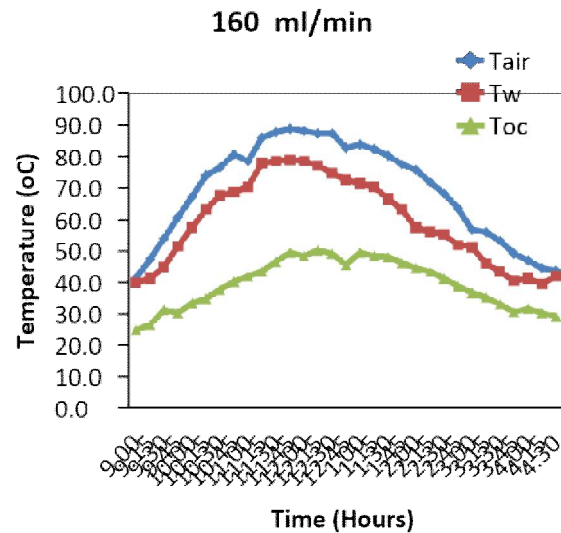


Fig. 6(d)

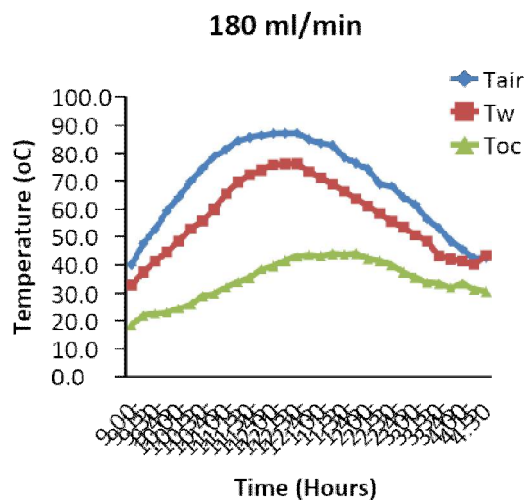


Fig. 6(e)

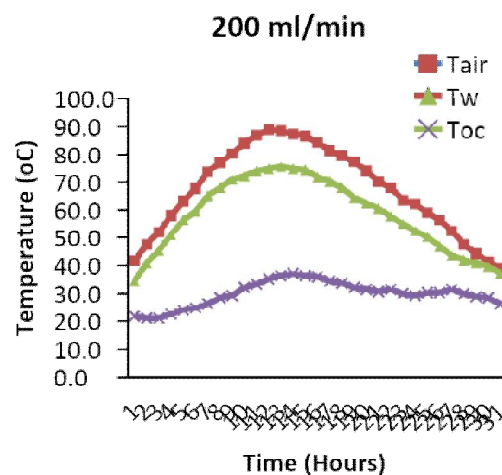


Fig. 6(f)

Fig. 6. (a-f) Hourly variation of temperature with respect to time without PCM for top cover cooling different flow rates (including zero).

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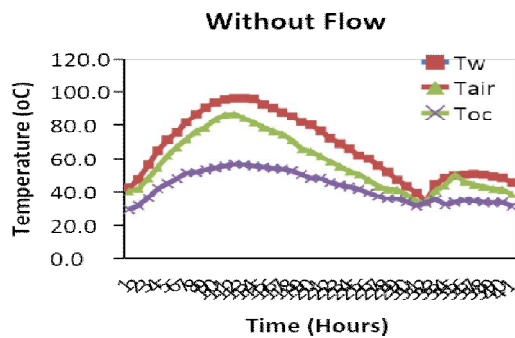


Fig. 7(a)

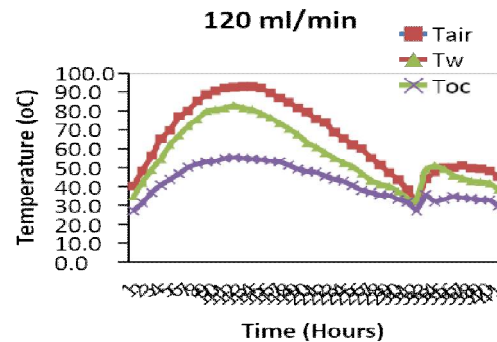


Fig. 7(b)

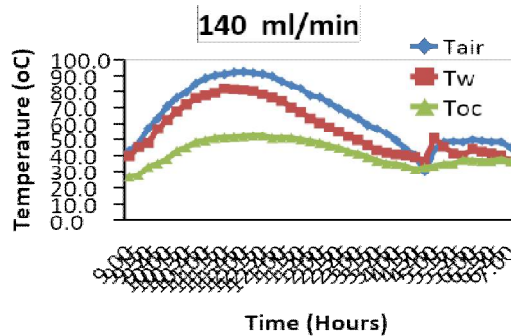


Fig. 7(c)

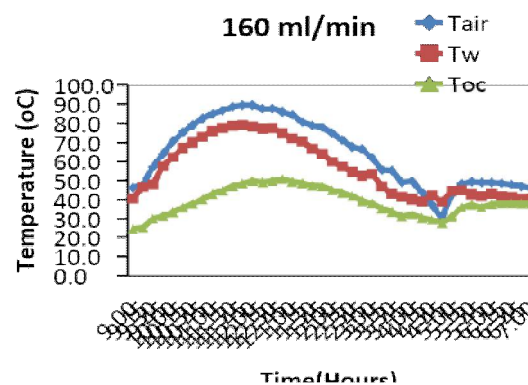


Fig. 7(d)

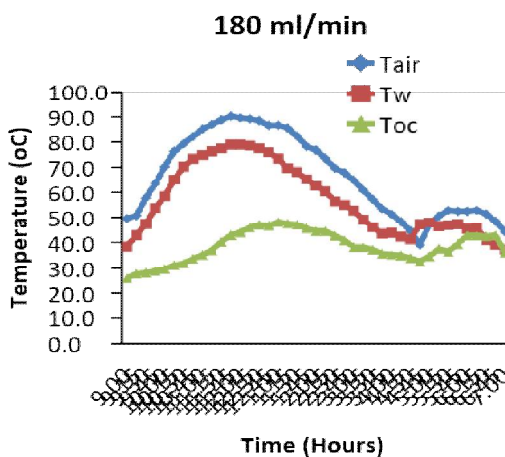


Fig. 7(e)

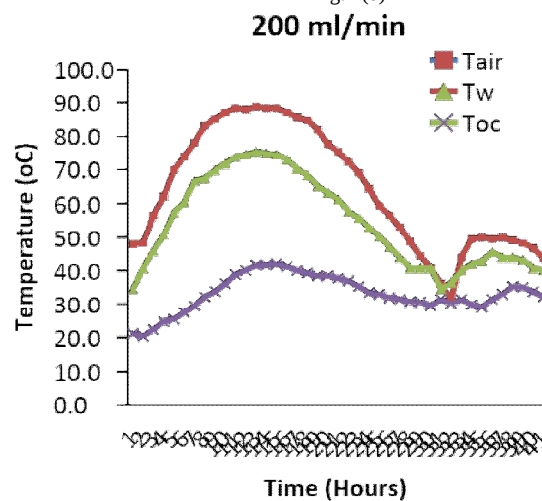


Fig. 7(f)

Fig. 7. (a-f) Hourly variation of temperature with respect to time with PCM and different flow rates (including zero).

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Sr.No	Cooling Water Flow Rate (ml/min)	Output of Distilled Water without Phase Change Material (ml/day)	Output of Distilled Water with Phase Change Material (ml/day)
1	0	3540	3920
2	120 ml/min	3620	4010
3	140 ml/min	3840	4130
4	160 ml/min	4050	4450
5	180 ml/min	4220	4570
6	200 ml/min	4450	4650

Table:1 Productivity of Solar Still with and without incorporation of phase change material.

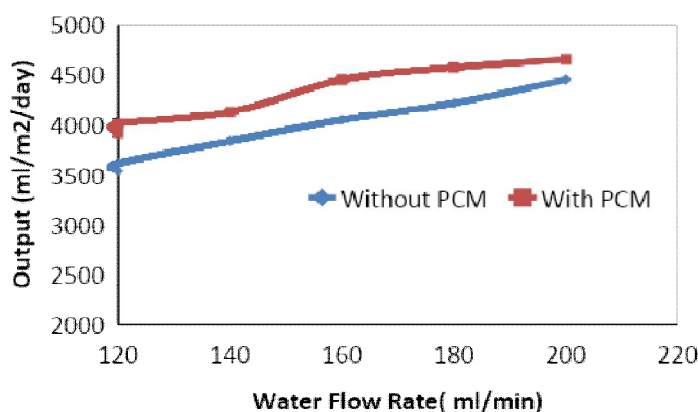


Fig. 8. Variation of solar still output with and without incorporation of phase change material

V. CONCLUSION

An parabolic concentrator attached single slope, sun slanting still (PC sun oriented still) has been manufactured and tentatively tried with various cooling water flow rates. To improve the conception further, balls of PCM-stacking are included the bowl. In this assessment article, four individual stream rates over the top glass spread are contemplated. The concentrator persistently supplies the radiation, which is changed into warmth vitality on the base of the sun powered still round safeguard in the meantime the stream water separates the warmth from the glass spread. The accompanying ends are drawn from the exploratory outcomes:

- Productivity increments with expanding the stream rate of the cooling water over the top spread, however this isn't financially savvy. The efficiency is additionally improved by including the PCM in the bowl of the still, and this is practical.
- The cooling water stream is legitimately corresponding to the efficiency and contrarily relative to the spread temperature. Because of this impact, the temperature distinction between the top spread and the bowl water temperature increments.

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- In this sort of PC-sun powered still, the bowl water temperature isn't influenced by the cooling water. This occurs because of the impact of the concentrator.

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