ARTICLE IN PRESS

Desalination xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Desalination

journal homepage: www.elsevier.com/locate/desal

Productivity enhancement of solar still by PCM and Nanoparticles miscellaneous basin absorbing materials

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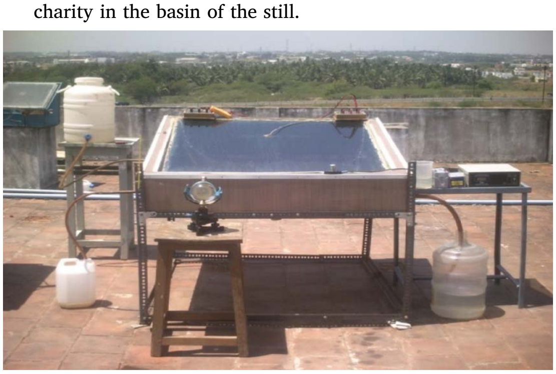
GRAPHICAL ABSTRACT

- Al_2O_3 and $C_{18}H_{36}O_2$ used in the basin of techniques by a drip button to pour saline water drop by drop on absorbing materials in the basin.
- The usual efficiency of the still through 59.14% (summer) and 27.13% (winter) and henceforth it is established that FWCW is the superlative material to be charity in the basin of the still.



ARTICLE INFO

Keywords:
Basin solar still
Phase change materials
Nanoparticles
Improve efficiency

ABSTRACT

Belongings of incorporating (Al_2O_3) Nanoparticles of wick materials in the solar still of a PCM charity in the basin for TES organization have been probed in this study. It is an innovative organization of techniques by a drip button to decant saline water drop by drop on absorbing materials in the basin. It (summer and winter) has been established with the dripping of saline water on altered absorbing materials like CW, FWCW, JW and FWJW as the basin liner. Diurnal variations of drip button temperature, T_g, T_b, T_w and mass of the output have been verified. Vitality equilibrium equations for the moist air inside the still, glass cover and wick material have been solved to get the analytical expressions for the instantaneous efficiency of the anticipated structure. The numerical calculations have been authenticated with the experimental annotations for a (S & W) few typical days from January 2016 to January 2017. With the heat extraction performance, the yield of wick materials with a single basin solar still by a PCM and Nanoparticles (S & W) as FWCW is 7.460 & 4.120 kg/m^2 day, respectively. The theoretical and experimental results have been substantiated a good covenant structure with the tiniest inaccuracy.

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https://doi.org/10.1016/j.desal.2017.11.045
Received 28 March 2017; Received in revised form 29 October 2017; Accepted 27 November 2017

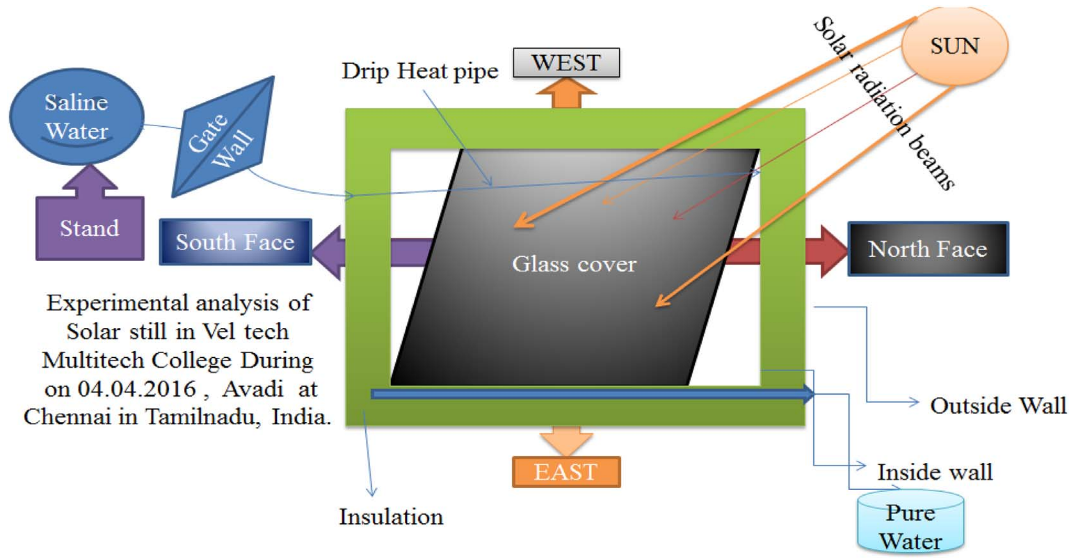


Fig. 2.1. Photograph of the experimental analysis of single basin still with different fin wick absorbing materials data collection on 04.04.2016.
(A) – Without fin arrangement work by a still
(B) – Focus on different fin wick materials use to still
(C) – Inside fixed on fin wick materials through a still
(D) – Solar intensity per second absorb to a still and measured by a multimeter
(a) Schematic diagram of an experimental setup of (wick materials) solar still.
(b), Photograph of a single basin still made of copper sheet, Drip heat pipes button arranged and coil with PCM
(c) Photograph of fixed with place in directing of a (wick materials) solar still.

1. Introduction

The human life energy memory to except is desired in instruction to brand sure energy safety, competence and environmental superiority. The behaviors of the two are: 1. Store thermal energy 2. Heating and cooling: sensible and latent. Numerous researchers have established in numerous types of solar still configurations. Sathyamurthy et al. [1] have premeditated experiments with a pyramid solar still. It is found that the wind speed increasing from 1.5 to 3 m/s and to 4.5 m/s is a consequence of swelling the still yield by 8 and 15.5% respectively. Srivastava and Agrawal [2] adapted a twin reflector booster single slope solar still with floating absorbers. It established that the designs of solar still enhanced the recital by 68%. Federalize et al. [3] have premeditated a new radiation classical for single slope solar still. Sandeep et al. [4] anticipated the reformed single slope single basin active solar still with enhanced condensation procedure. It is found that the yield increment of 14.5% associated with the ordinary design. Shanmugan et al. [5] thermal model industrialized for an energy and exergy analysis of a single slope, single basin solar still. Arunkumar et al. [6] experimentally settled a concentric tubular solar still by water and air as a coolant. It was decided that coldwater flow the tubular solar still and the then sophisticated act of the air. Rahmani et al. [7] was urbanized for a natural circulation in a solar still and established the distillate yield of 3.72 L/m2/day by 45.15% efficiency. Ibrahim and Elshamarka [8] was amended basin type solar still and accomplished that the maximum freshwater productivity of 2.93 L/m2/day. Single slope solar still was urbanized to integration for the systems to progress the efficiency. Numerous researchers have adapted to the usage of PCM, integrating solar water heater and nanofluids are also documented by [9–11]. Rativa and Gomez-Malago [12] was premeditated solar radiation absorption of metallic in nanofluids to comprising gold and silver nanoellipsoids. It was found that the Plasmon resonance absorption band of metallic is a transversal and a longitudinal oscillation mode had been tuned modifying the NEs aspect ratio. Sahota and Tiwari [13] were advanced for a double slope solar still used (Al_2O_3) Nanoparticles in the basin. They clinched without and with nanofluids for three different concentrations are 0.04%, 0.08% and 0.12%. Al_2O_3 Nanoparticles efficiency in the system is 0.12%. It is the charity for the system in 35 kg and 80 kg base fluid equaled to the efficiency of 12.2% and 8.4% in the system. Shanmugan et al. [14] was premeditated in the experimental analysis of a double Slope – Tribasin solar still. It established that the associate with and without Nanofluids enhanced the performance of first, second and third basin contributes were 35.71%, 35.7% and 28.5%.

Rajaseenivasan et al. [15] have experimental investigated in disparity basin height (0.45 m to 0.15 m) using solar still. They have charity in saline water in four stirrers; motors function with a solar photovoltaic panel by placing the paraffin wax and charcoal in the basin and distillate equated 30% escalation in the structure and diurnal harvest is 5.23 kg/m^2 day. Panchal and Mohan [16] have premeditated in innumerable methods applied to solar still fruitage. It is charity in the fin, energy storage materials and multi-basin solar still for enhancement in distillate yield. Three approaches were urbanized in water secret the basin for even distribution of water for increment in distillate construction.

Sellamia et al. [17] have enriched in solar still exploration of altered thickness besmirched layers of sponge absorber in more energy saving to recover presentation. It is charity in altered sponge liner thickness like that on 0.5 cm, 1.0 cm and 1.5 cm and harvest sponge liner are 58%, 23.03% and 30%, respectively.

Sharshir [18] was twisted in belongings of flake graphite Nanoparticles, PCM and the film cooling on the solar still enactment. It is amended of a solar still in FGN and PCM, film cooling high yield on 73.8% and matched to conventional still, the upshot of intensifications on 13% and water depth are 2 cm to 0.5 cm. The classified a heat transfer if the structure is extensive time and extra energy rise to temperature formed at pick time.

In this drudgery has been invented with like cotton wick (CW), fin with the cotton wick (FWCW), jute wick (JW) and fin with jute wick (FWJW) materials in the basin superficial. It have been supported obtainable for a number of days in both summer and winter to the invention the best wick material to be charity in the basin. Analytical lexes have also been consequential based on the vigor equilibrium equations for the moist air, water, glass cover temperature, distillate

Fig. 2.2. Photograph of the different fin wick absorbing materials on 04/04/2016 solar still, Accumulation in mass of the water to glass at various for (A) 7.00 am (B) 7.30 am (C) 8.00 am (D) 11.59 am (E) 13.00 pm (F) 15.00 pm (G) 17.00 pm.

yield and proficiency. Demonstrating has been vexed to the heat abstraction technique, the yield of wick materials with a single basin solar still by a PCM and Nanoparticles with a solar still. The analytical grades have been paralleled with the experimental annotations to detect the covenant of the theoretical grades.

2. Materials and methods

2.1. Methodology analysis of techniques; experimental setup and instrumentation

An experimental investigation of the organization by Fig. 2.1 has been equipped with the inner and outer enclosure of plywood with a facet of 1.25 m × 1.25 m and 1.3 m × 1.3 m. In among the chitchat of the plywood's are occupied with the benefit of glass wool having the wideness of 0.05 m. The back wall elevation is 0.03 m and front wall stature is 0.10 m. The viscosity of the glass cover is 4 mm and the slope of the glass cover is stationary as 11° which is equivalent to the latitude of the position and with the benefit of the metal putty charity of the arrangement no vapour escape. Accumulate of the concentration harvest are charity the j-shaped drainage channel is stable proximate the front wall. The yield trickled water down to the measuring jar. The basin area is made a copper sheet in a black paint mixed Al_2O_3 Nanoparticles coating by surface area with absorbing wick materials to absorb more solar radiation. The solar radiation communicated through the glass cover and fascinated by a wick & fin wick materials seeming – Al_2O_3 to comportment by the copper coil and then shadows the phase change materials – $C_{18}H_{36}O_2$. The solar radiation has been engrossed by Al_2O_3 Nano particles ascends esoteric the basin area escalation extra heat transfer style within near to visible and IR spectrum. The saline water through a special preparation has been completed to pour saline water drop by drop over the wick material kept in the basin. The drip heat transfer pipes full coating Nano particles mixed back paint to the lengthwise dripping arrangement is made of drip button fixed at regular intervals of 0.10 m and heat pipe stationary in amid the gap is 0.10 m horizontally in the basin.

The investigational engaged classical has been established for single basin solar still follow the schematic plan Fig. 2.1 (a). The notorious classes of PCMs in footings of melting temperature and energy extend in a wide range [14,19]. Numerous reviews have been accompanied [20–22] and a full organization of the latest advances in PCMs with their thermo physical properties can be found in the literature. Fig. 2.1 (b) present these developments, based on the above reviews, with polymeric and solid-solid PCMs included.

Fig. 2.1 (b), experimental setup in the basin area by still is copper coil arrangement and is fixed drip heat pipes. The effect of the still is fixed in ten drip heat pipes and buttons are each a distance of 0.10 m × 0.10 m by a placed horizontally in the basin with south to north orientation. A new model emerging for single slope single basin solar still have been made in the basin secure copper coil in one dia, intervals of 0.10 m and total coil 10 m fixed in the basin. The coil occupied mad black painted and mixed Al_2O_3 - Nano particles more absorb solar radiation and heat extraction supplementary progress the still is the charity for $C_{18}H_{36}O_2$ - PCM for 8 kg inside the coil secure basin area. The PCM melting point increase has been debauched evaporation of the solar still. The saline water tank is providing with a gate valve and is associated with the fjord of the dripping organization. The water temperature in the absorbing materials is to condensing cover temperature quantity by fixing copper-constantan thermocouples which have been calibrated originally. Solar radiation intensity and ambient temperature have been restrained with solar radiation monitor and digital thermometer.

An experimental work is stationary occupied classical which that the arrangement in the place and more absorb energy to this direction as shown in the Fig. 2.1 (c). The experiment has been accepted available from 6 am to 6 am of 24 h duration with wick materials of different types (cotton wick, Jute wick, Fin cotton wick, Fin jute wick) at the Research Center for Physics, Vel Tech Multitech Dr.Rangarajan Dr.Sakunthala Engineering College, Avadi at Chennai in Tamil Nadu, India, during January 2016 to January 2017. Fig. 2.2, Photograph of the different fin type absorbing materials during on 04/04/2016 is to accumulation of the water to glass at numerous for (A) 7.00 am (B) 7.30 am (C) 8.00 am (D) 11.59 am (E) 13.00 pm (F) 15.00 pm (G) 17.00 pm.

2.2. Experimental analysis of techniques by a PCM ($C_{18}H_{36}O_2$) and Nanoparticles (Al_2O_3)

Associate to Shalabyet [23] Single basin solar still by a PCM and Nanoparticles (Al_2O_3) have been fashioned far a high thermal performance of the structure. Al_2O_3 has numerous phases such as gamma, delta, theta, and alpha. However, the alpha Al_2O_3 phase is the most thermodynamically stable phase. In universal, Al_2O_3 has numerous stimulating properties, for instance, high hardness, high stability, high insulation and transparency Hart [24]. The basin solar still has been absorbed of the energy to wick materials by saline water absorption with a solar spectrum of mad black paint mixed Al_2O_3 at respectively. The basin surface area mad black point and Nanoparticles are mixed absorbing solar energy to heavy absorb use of Nano particle sizes on 50 nm internal heat transfer mode to a structure. The association to PCM of liquid fraction is in versus time between the present work and Al-Abidi et al. [25]

2.3. Paint coatings

A single slope single basin solar still with various absorber wick materials have been industrialized a copper sheet occupied miscellaneous a black paint & Nano particles (Al_2O_3) with aid of PCM their progress the great efficiency survey is Naimmona et al. [26], and layers in a copper is low-temperature with spectrally penetrating α/ε(100 °C) = 0.92/0.

A single slope single basin solar still has been amended to absorbing materials of productivity in equate to passive solar still expending Nanoparticles (CUO) by Bhupendra Gupta et al. [27].

The Stability of Nanoparticle (Al_2O_3) and PCM ($C_{18}H_{36}O_2$) used in a solar still:

The Nano particles have been secondhand in this structure the investigation on stability which that influences the properties of Nanoparticle for tender are necessary to analyze influencing factors to the dispersion stability of Nanoparticle (Al_2O_3). They have evolving Nanoparticle (Al_2O_3) stability, enhance and mechanisms. The mad black paint to mix a Nanoparticle (Al_2O_3) of accumulation in the basin area of a solar still have been added energy to inside heat transfer mode through a PCM (striaic acid) interaction from additional energy to harvest of high way heat form to conduced a water and thus water is evaporations fast to gutter to storage tank.

Local available in both materials in Nano particles & PCM ($C_{18}H_{36}O_2$ - Latent heat storage) techniques spontaneously and is paramount absorbing a solar radiation into effectual (72 °C) of a structure. The Nanoparticle (Al_2O_3) to optical properties is occupied largely higher sunlight absorption to transfer to water over a glass cover. Together this belonging in possible to a solar still is increasing the overall efficiency.

2.4. Thermal analysis

Haddad et al. [28] was functioned to progress of basin type solar still using in the vertical rotating wick and Sharon et al. [29] was premeditated in the experimental analysis of tilted wick- basin solar still. Recently performance of basin wick soar still is higher efficiency by absorbing materials. The innovative design has been emergent for an inside basin area black paint to mixed Nanoparticle and by a PCM more energy protected for a single slope single basin solar still plays are accelerated the working of inside heat transfer mode usage of solar radiation vital role. The solar radiation is absorbed by glass cover transmitted through the absorbing materials, Nanoparticles & PCM with working of obtainable in the structure as shown in Figs. 2.1 and 2.2.

The vigor equilibrium equation has been fashioned for single slope single basin solar still of subsequent to expectations:

- It is actually good in quasi-stable state and movement of water in the wick materials is equivalent.
- It is nope temperature gradient on the glass cover surface.
- The absorbing materials of heat transfer modes have been industrialized for occupied tight of insulation in the structure and glass cover is negligible.
- Single slope single basin solar still is glass cover, absorbing materials and distillate water segment.
- It has been finished full tight of experimental work evidence of single slope single basin solar still is given as:

Glass cover

$$H_s \alpha_g A_g + h_1(T_m - T_g) = h_2(T_g - T_a) \tag{A.1}$$

Moist Air

$$h_3(T_w - T_m) = h_1(T_m - T_g) + h_4(T_m - T_a) \tag{A.2}$$

Wick materials

$$\tau_g H_s \alpha_w A_w = M_w C_w \frac{dT_w}{dt} + h_3(T_w - T_m) + h_5(T_w - T_g) \tag{A.3}$$

where

$$T_w = T_{PCM+Nanoparticles} + T_{b+nanoparticles}$$

$$h_1 = h_{cmg} + h_{rmg}$$

$$h_2 = h_{cga} + h_{rga}$$

$$h_{cmg} = 0.884 \times \left[(T_m - T_g) + \frac{(P_m - P_g)(T_m + 273)}{268900 - P_m}\right]^{1/3}$$

$$h_{rmg} = \frac{\varepsilon\sigma[(T_m + 273)^4 - (T_g + 273)^4]}{(T_m - T_g)}$$

$$h_{cga} = 5.7 + 3.8V$$

Where V is the wind velocity

$$h_{rga} = \varepsilon_g \sigma[(T_g + 273)^4 - (T_a + 261)^4]$$

where

$$\alpha_w = \mathrm{d} \times \alpha_b$$

$$h_3 = h_{cwm} + h_{rwm}$$

$$h_4 = \frac{x}{K}$$

$$h_5 = h_{cwg} + h_{ewg} + h_{rwg}$$

$$h_{cwg} = 0.884 \times \left[(T_w - T_g) + \frac{(P_w - P_g)(T_w + 273)}{268900 - P_w}\right]^{1/3}$$

$$h_{ewg} = 0.016273 \times h_{cwg}\left(\frac{P_w - P_g}{T_w - T_g}\right)$$

$$h_{rwg} = \frac{\varepsilon\sigma[(T_w + 273)^4 - (T_g + 273)^4]}{(T_w - T_g)}$$

$$h_{cwm} = 0.884 \times \left[(T_w - T_m) + \frac{(P_w - P_m)(T_w + 273)}{268900 - P_w}\right]^{1/3}$$

$$h_{rwm} = \frac{\varepsilon\sigma[(T_w + 273)^4 - (T_m + 273)^4]}{(T_w - T_m)}$$

Dunkle [30] and Baum [31] are ensuing convective, evaporation and radiative total heat transfer mode secondhand to Eqs. (1) and (2) can be written in the form as

$$A_1 T_m + B_1 T_g = k_1 \tag{A.4}$$

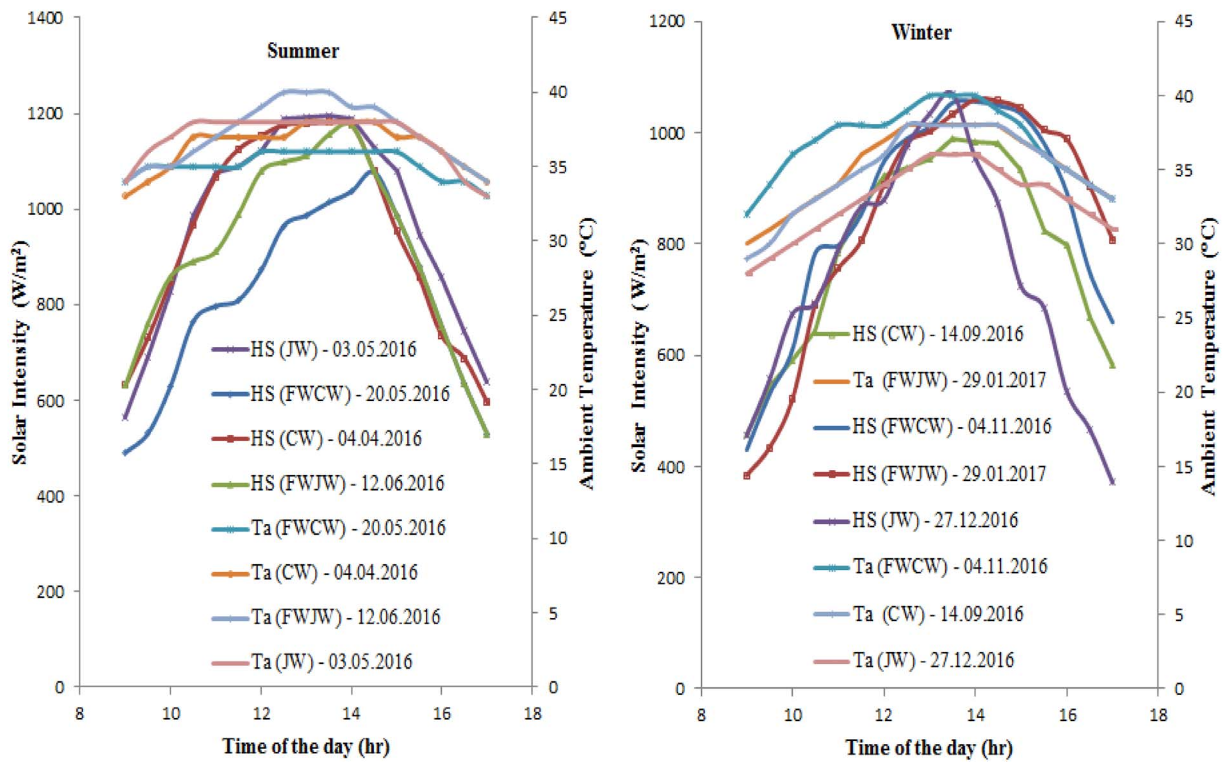


Fig. 3.1. Photograph of summer and winter with hourly variation of Hs & Ta during in four days in wick materials.

$$A_2 T_m + B_2 T_g = k_2 \tag{A.5}$$

where

$A_1 = h_1$

$B_1 = h_1 - h_2$

$A_2 = -(h_1 + h_3 + h_4)$

$B_2 = h_1$

$k_1 = -(h_2 T_a + \alpha_g H_s A_g)$

$k_2 = -(h_4 T_a + h_3 T_w)$

Eqs. (4) and (5) can be articulated form as

$$\begin{bmatrix} A_1 & B_1 \\ A_2 & B_2 \end{bmatrix} \begin{bmatrix} T_m \\ T_g \end{bmatrix} = \begin{bmatrix} k_1 \\ k_2 \end{bmatrix} \tag{A.6}$$

The Eq. (6) resembles the form

$$[A][X] = [B] \tag{A.7}$$

Then

$$[X] = [A^{-1}][\mathrm{B}] \tag{A.8}$$

That is

$$[X] = \begin{bmatrix} T_m \\ T_g \end{bmatrix} \tag{A.9}$$

$$A^{-1} = \frac{1}{2h_1^2 + h_1 h_3 + h_1 h_4 - h_1 h_2 - h_2 h_3 - h_2 h_4} \begin{bmatrix} h_1 & -(h_1 + h_3 + h_4) \\ h_1 - h_2 & h_1 \end{bmatrix} \tag{A.10}$$

On substituting Eq. (10) on (8), we get

$$X = \frac{1}{Z} \times \begin{bmatrix} h_1 & -(h_1 + h_3 + h_4) \\ h_1 - h_2 & h_1 \end{bmatrix} \times \begin{bmatrix} k_1 \\ k_2 \end{bmatrix} \tag{A.11}$$

Therefore, the equation for moist air inside the still and glass cover temperature can be written as

$$T_m = \frac{T_a(-h_1 h_2 - h_1 h_4 - h_3 h_4 - h_4^2) + T_w(-h_1 h_3 - h_3^2 - h_4 h_3) - h_1 \alpha_g H_s A_g}{Z} \tag{A.12}$$

$$T_g = \frac{T_a(-h_1 h_2 + h_1 h_4 + h_2^2) + h_1 h_3 T_w + \alpha_g H_s A_g(-h_1 + h_2)}{Z} \tag{A.13}$$

Where

$Z = 2h_1^2 + h_1 h_3 + h_1 h_4 - h_1 h_2 - h_2 h_3 - h_2 h_4$

Substituting the Eqs. (12) and (13) for T_g and T_m in Eq. (3) and reorganizing, the equation can be written in the procedure

$$\frac{dT_w}{dt} + aT_w = f(t) \tag{A.14}$$

Where

$$a = \frac{h_3 + h_5}{M_w C_w} + \frac{h_3^2(h_1 + h_4) - (h_1 h_3 h_4)}{Z(M_w C_w)}$$

$$f(t) = \frac{H_s(\tau_g \alpha_w A_w + \alpha_g h_5 A_g(-h_1 + h_2))}{M_w C_w} - \frac{\alpha_g H_s A_g h_1 h_3}{Z(M_w C_w)} + \left[\frac{(-h_1 h_2(h_3 + h_5) - h_1 h_2^2 h_3 h_4 h_5 - h_1 h_3^2 h_5(h_4 + h_5) - h_3 h_4^2}{Z(M_w C_w)}\right] T_a$$

The solution of the Eq. (14) is given by

$$T_w = \frac{f(t)}{a} + c.\ e^{-at} \tag{A.15}$$

Eq. (15) subject to the personalize circumstance

When t = 0, $T_w = T_{wi}$

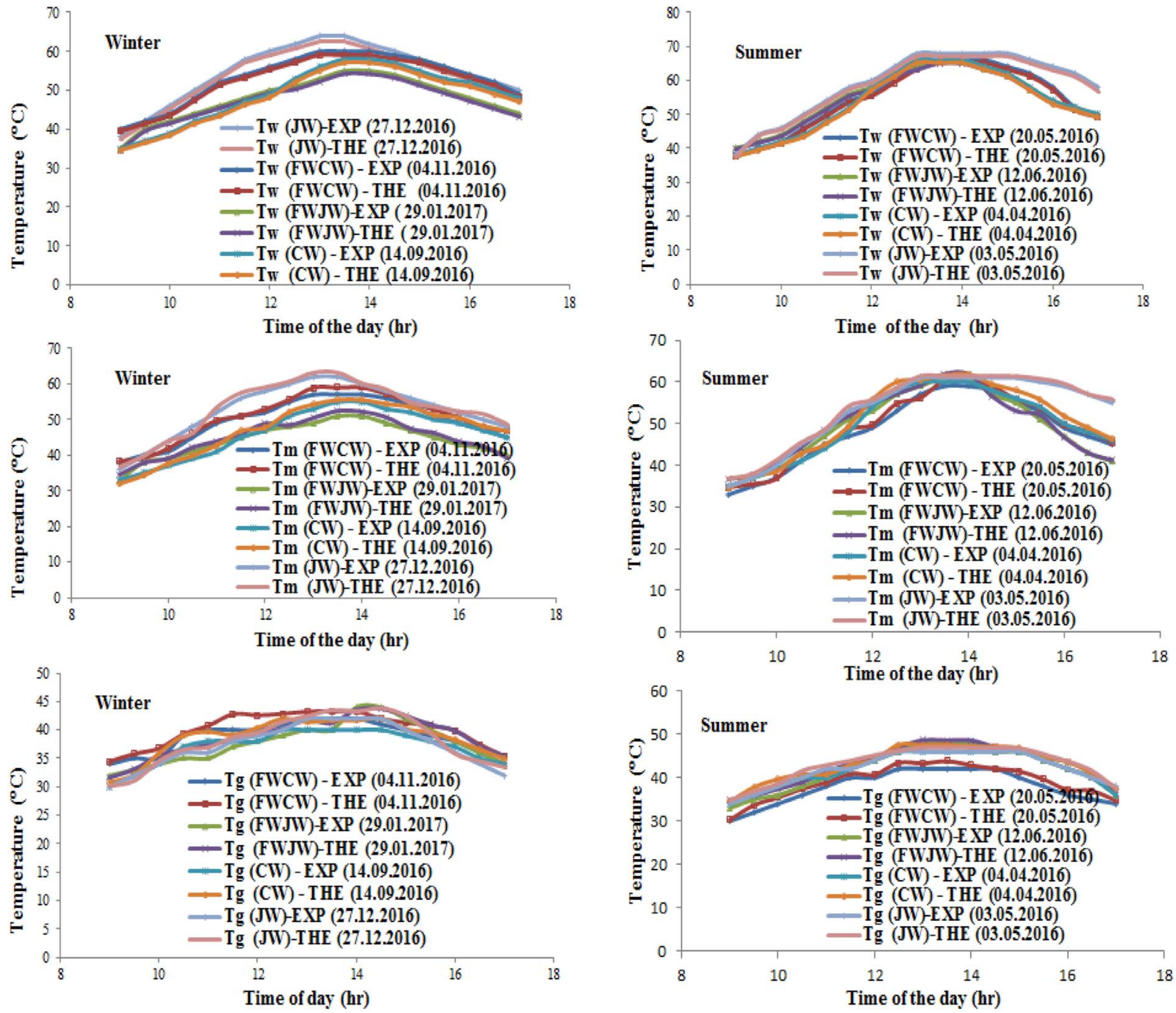


Fig. 3.2. Photograph of summer and winter with hourly variation of T_w, T_g & T_m in various temperature testing in four days with wick materials.

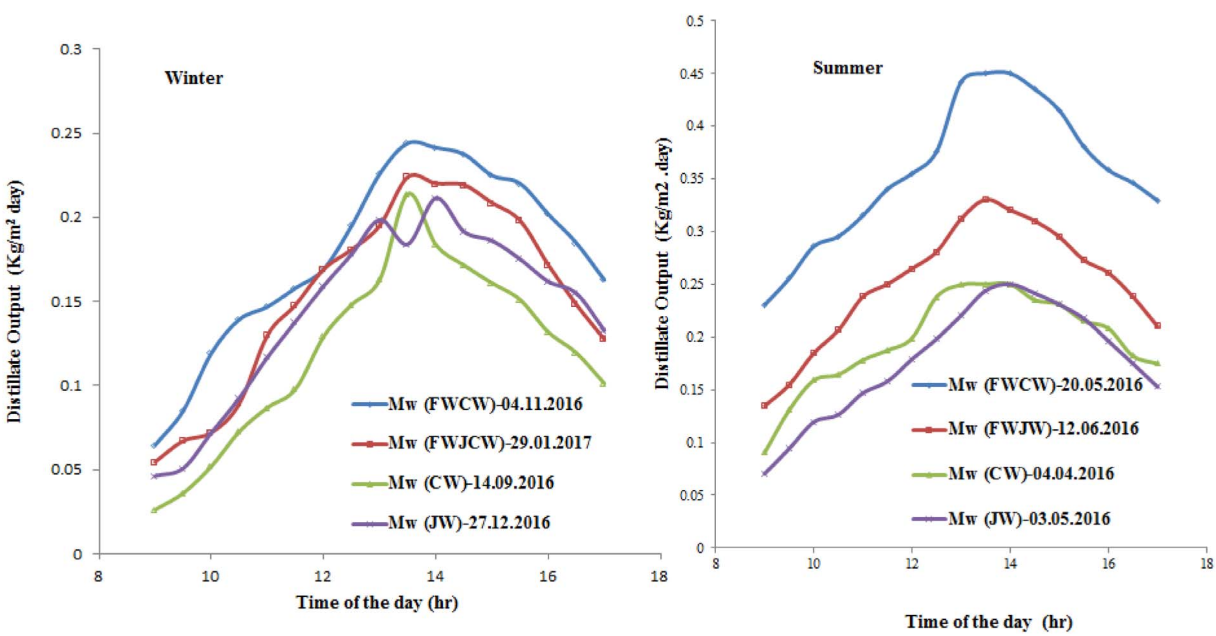
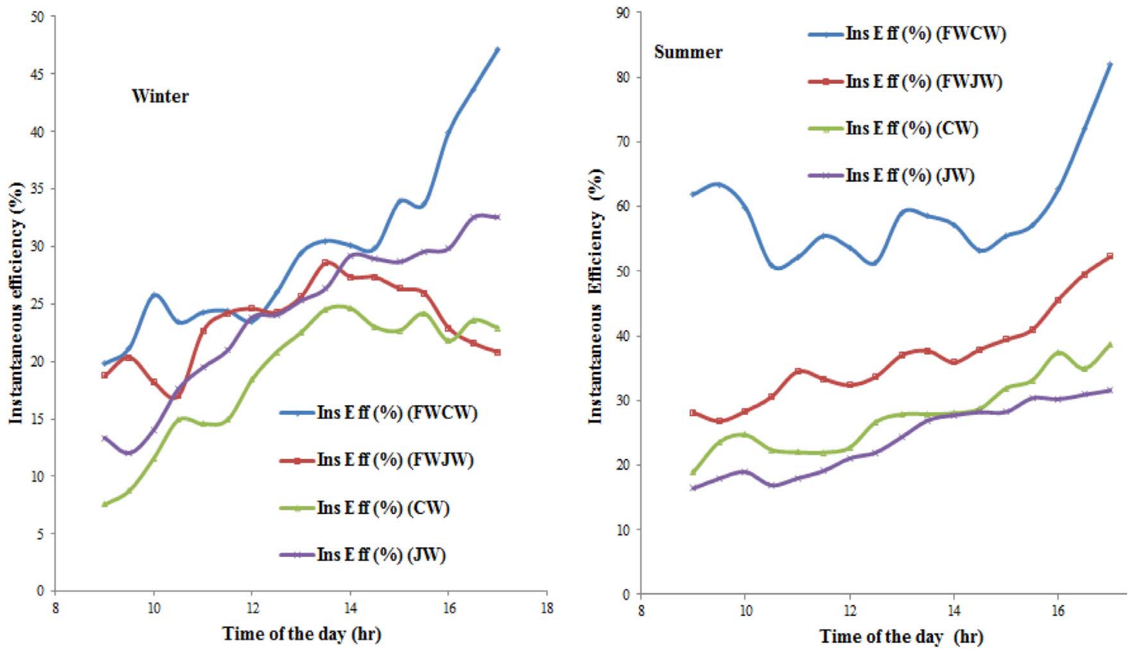


Fig. 3.3. Photograph of summer and winter with hourly variation of distillate output testing with wick materials in four days.



Figs. 3.4. Photograph of summer and winter with hourly variation of wick materials are testing in four days for efficiency of system.

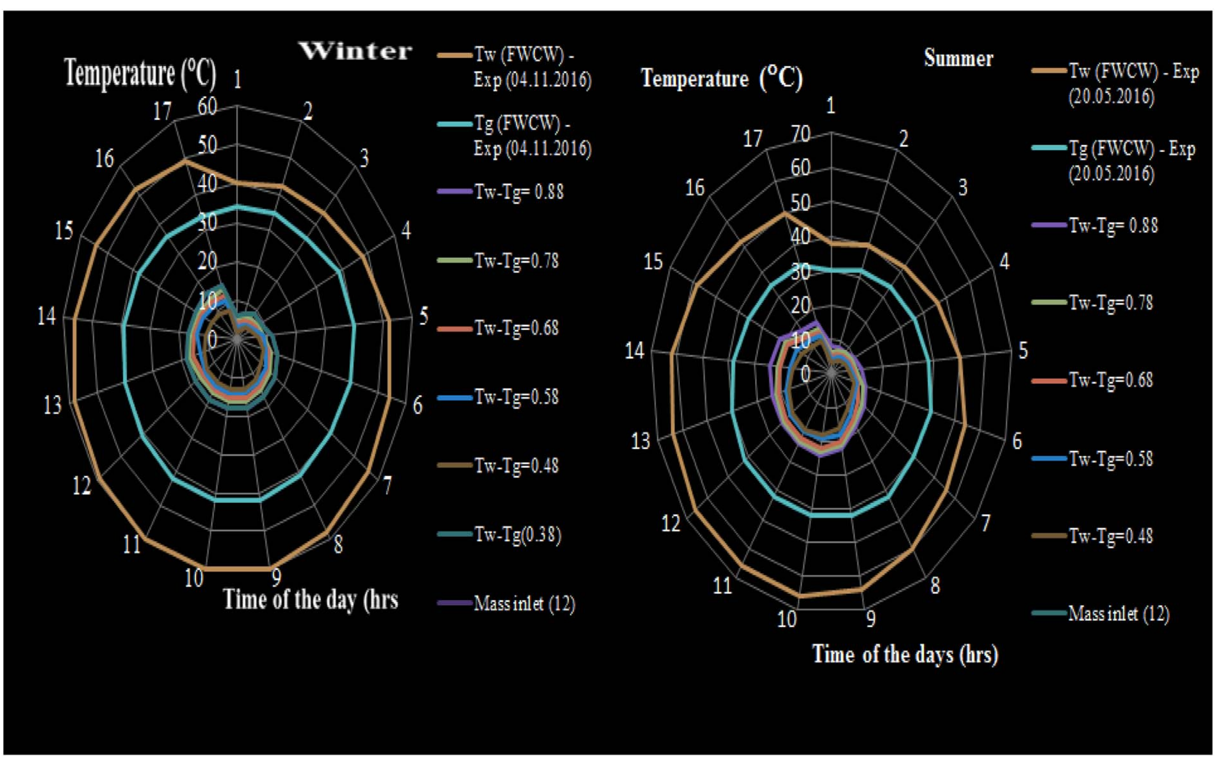


Fig. 3.5. Photograph of summer and winter with hourly variation of (FWCW) Tw, Tg absorbs energy in wick materials for 12 kg inlet of a system.

$$c = T_{wi} - \frac{f(t)}{a} \tag{A.16}$$

Substituting the value for c in Eq. (15), we get

$$T_w = \frac{f(t)}{a}(1 - e^{-at}) + T_{wi}.\ e^{-at} \tag{A.17}$$

Eqs. (12), (13) and (17) are the mandatory explicit expressions for the temperatures of the absorbing materials i.e., water, moist air and glass cover of the still, respectively.

The instantaneous hourly distillate output per unit basin area of the still is premeditated by Singh and Tiwari [32].

$$m_e = \left(\frac{h_{ewg}(T_w - T_g)}{L}\right) \times 3600\,\text{Kg/m2 hr} \tag{A.18}$$

The instantaneous efficiency of the still is articulated as Kumar et al. [33]

$$\eta\% = \frac{m_e L}{A_w H_s t} \times 100 \tag{A.19}$$

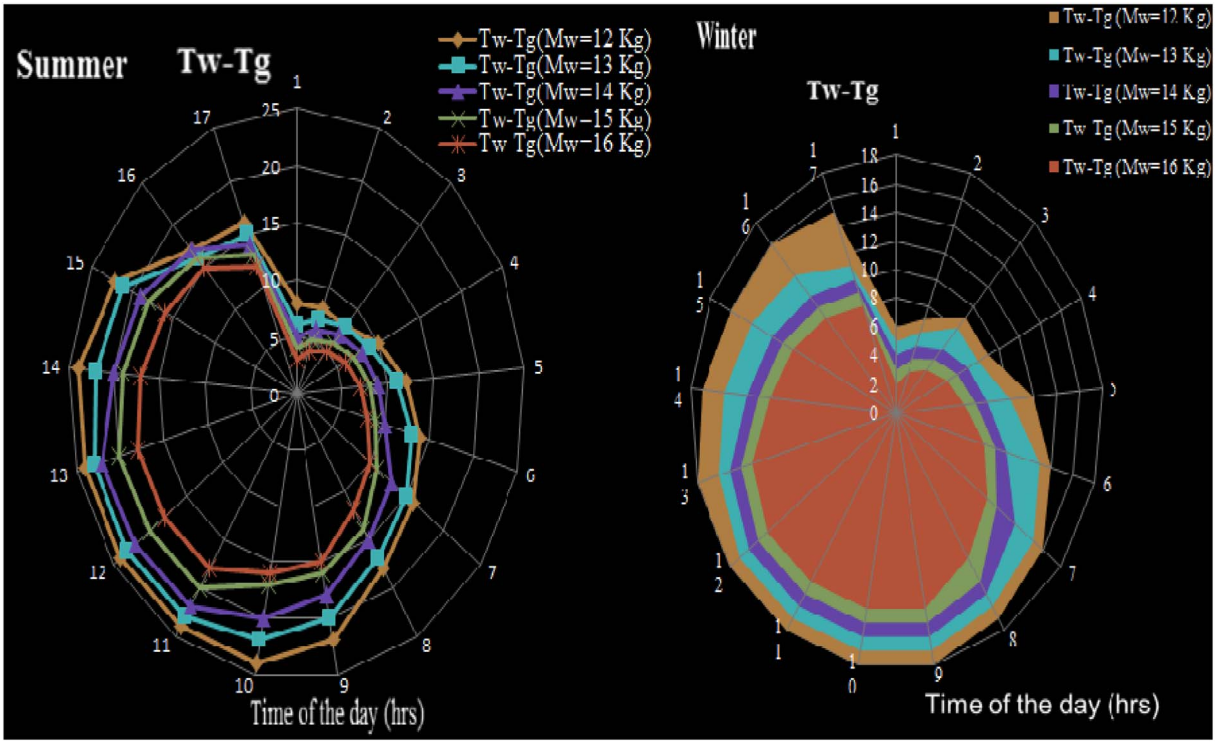


Fig. 3.6. Photograph of wick materials absorb in summer and winter with hourly variation of Mw inlet of a system.

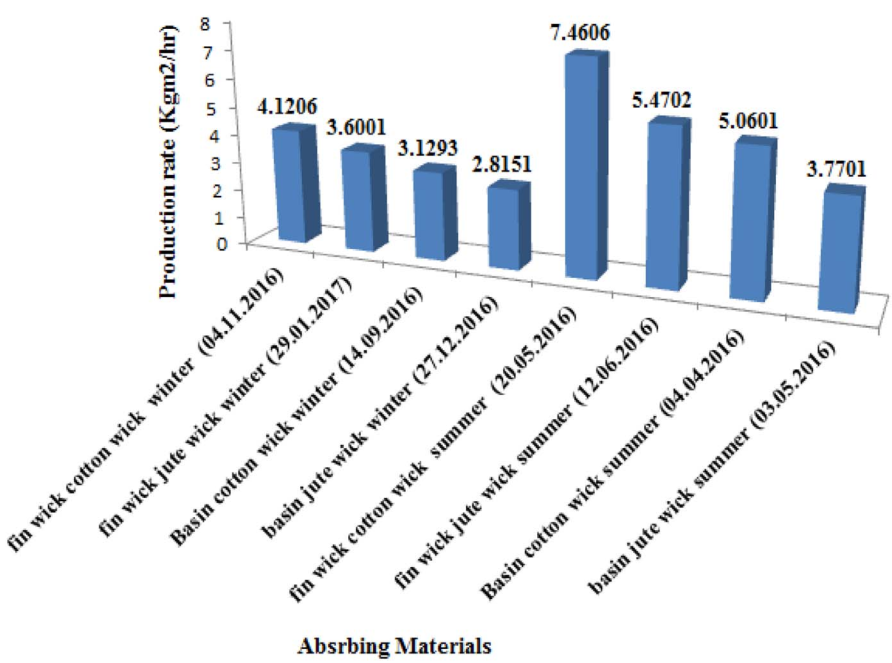


Fig. 3.7. Photograph of production various wick materials during efficiency of the solar still in summer & winter.

3. Results and discussion

In instruction to appreciate the analytical upshots of the still, computations have been finished for four typical days in summer and winter with a cotton wick (CW), fin with cotton wick (FWCW), jute wick (JW) and fin with jute wick (FWJW) in the basin area. The parameters are secondhand to appraise the instantaneous thermal efficiency of the anticipated solar still.

$A_g = 1.69\ m^2$, $\tau_g = 0.75$, $\alpha_w = 0.88$, $A_w = 1.69\ m^2$, $M_w = 12Kg$, $\varepsilon_g = 0.88$, $\sigma = 5.66 \times 10^{-8} W/m^2K^4$, $\alpha_g = 0.05$, $C_w = 4190\ J/kg$, $V = 1.4m/K = 0.038\ W/mK$

It have been fashioned for high thermal energy accumulation with the benefit of PCM & Nanoparticles engrossed by the solar intensity and ambient temperature for four days with wick materials i.e., FWCW, CW, FWJW and JW in together summer and winter typical days have been exposed in Fig. 3.1. It is found that the (Hs) solar intensity fluctuates as the (T_a) ambient temperature intensifications through the operational hours of the structure. The absorbing materials had been stowed to Hs

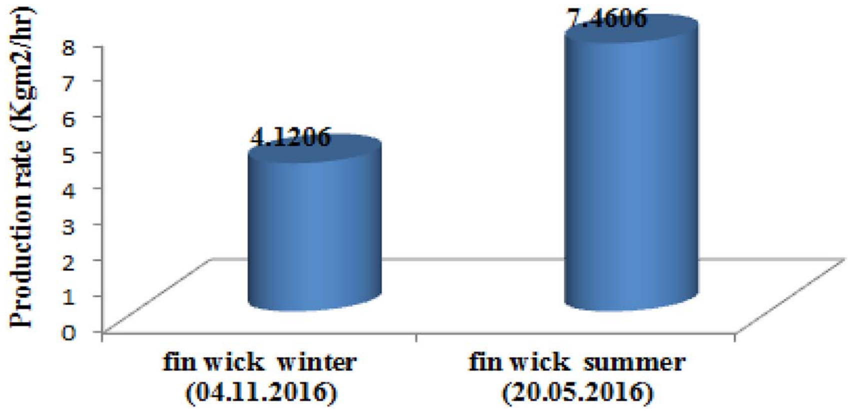


Fig. 3.8. Photograph of summer& winter high output of the still.

Table 1
The hourly version of solar radiations is measurement of monitors.

S.No	Instrument	Range	Accuracy (%)
1	RTD sensors (PT100)	− 267 to 260 °C	± 0.1 °C
2	Signal Range (SR01 Pyranometers)	0 to 2000 W/m^2	± 0.05 W/m^2
3	Collecting Jar	0–1000 mL	± 10 mL
4	Anemometer	0 to 50 m/s	± 0.2 m/s

and T_a gradually proliferations in morning and diminutions in evening. Electromagnetic waves in absorbing wick materials have been industrialized for interior transmission mode high performance fashioned by a solar still. In summer and winter in occupied a solar still, parameters are a pick time high radiation energy absorb to wick materials at dissimilar days on ambient Temperature (T_a) (°C), Solar Intensity (Hs) (W/m^2) succeeding in Table 4. The city of Avadi, Chennai, Tamilnadu, in India, is blessed with a tropical climate that often comes with a good quantity of consistent sunshine in summer and winter. The solar radiation intensity of sunlight for an assumed unit area is clear in Watts per meter square. The ordinary (T_a) characterizes the boundary condition of the solar still is condensation of water vapour trapped inside the solar still depends on the temperature gradient between ambient temperatures. On an ordinary sunny day, the solar radiation and ambient temperature are at hour could start from as high as value in Table 4 in summer and winter absorb by a solar still. Fig. 3.1 illustrations the ordinary hourly in solar radiation of sunny days verified at the experimental site by using in solar radiation monitor and thermometer to record the standard local time at the end of the day. Experiments have been approved available with the absorbing materials during summer and winter in four typical days for computation.

In summer & winter absorb energy have been accompanied with the lengthwise fin organization and without fin preparation by absorbing materials spread over the fin and without fin distillate yield is witnessed. Among the experimental working days to witness for the fin with Cotton wick (FWCW), fin with Jute wick (FWJW), Cotton wick (CW) and Jute wick (JW) have been secondhand for computation. Numerical calculations have been done to determine with a wick, moist air and glass cover temperature, summer and winter annotations result has been depicted in the Fig. 3.2.

Fig. 3.2 illustrates the comparison of theoretical and experimental analysis of glass cover, moist air and water temperature on a typical day in predictions of the analytical model to accomplish for usage in basin area of PCM and Nanoparticles to high energy artifact of a structure. The theoretical model closely predicted the average glass cover temperatures for the first 3 h. However, from the fourth hour onwards an over predicted result with ever increasing deviation by each hour. Table 5, illustrations FWCW, FWJW, CW, and JW mention the wick, moist air and glass cover temperature heavy engross values to the still. It has been perceived that theoretical results are in close agreement with the experimental observations. The wick, glass cover and moist air temperature of the structure with FWCW & CW in summer & winter has a significant impact on the fabrication of distillate yield.

The hourly variation in distillate yielded to FWCW, FWJW, CW and JW has been depicted in the Fig. 3.3. It is perceived that still with FWCW & CW in summer and winter of providing higher distillate yield than other wick materials in the basin usage of PCM & Nanoparticles. The purpose of lengthwise fin organization is to intensification the evaporating surface area. Cotton wick on the fin association has been fashioned higher distillate yield due to the augmented evaporating surface and amplified a capillary exploit. It is also seen that the production of the still in summer and winter use of PCM & Nanoparticles with cotton wicks alone is lesser than the still through FWCW. The evaporating surface area for cotton wick alone is lighter than that of the cotton wick along with fins. The evaporative high heat transfer improves the use of PCM & Nanoparticles are larger in case of the still with cotton wicks over the fins. Moreover, the moist air temperature inside the still also had exposed to a both hike during the working hours of the structure.

Numerous wick materials have been fashioned of pick time output of high values illustration that in Table 6. The PCM & Nanoparticles use of the structure of summer and winter harvest in maximum distillate yielded is achieved during 13 h to 14 h and it is found to be 0.450 & 0.244 kg/m^2 hr. for still with FWCW and total daily distillate yield in during 9.00 am to 17 pm for FWCW is 7.460 & 4.120 kg/m^2 day, 5.470 & 3.600 kg/m^2 day for FWJW, 5.060 & 3.129 kg/m^2 day for CW and 3.770 & 2.815 kg/m^2 day for JW respectively. Tables 7 & 8 show that

Table 2
Corporeal assets of Al_2O_3 Nanoparticles & PCM.

S.No.	Nano particles	Concentration/size of particles (%)	Specific surface (m^2/g)	Density (Kg/m^3)	Thermal conductivity (W/mK)	Enhancement (%)
1	Al_2O_3	50 nm	1 ∗ 1	3890	30	99.99
	Compound	Melting temperature (°C)	Heat of fusion (kJ/kg)	Density (kg/m^3)	Thermal conductivity (W/m K)	Application (%)
2	Stearic acid	72	208	853	0.178	Solar still (FWCW) 59.14

Table 3
Compare to with and without solar still using in PCM & Nanoparticles.

Conventional solar still					Modified solar still with Nanoparticles& PCM			
Solar Still	Cotton wick (CW)	Jute wick (JW)	Fin with jute wick (FWJW)	Fin with cotton wick (FWCW)	Fin with cotton wick (FWCW)	Fin with jute wick (FWJW)	Jute wick (JW)	Cotton wick (CW)
Winter days					Winter days			
Yield (mL)	0.10245	0.11687	0.11891	0.136354	0.244011	0.224011	0.214011	0.184011
Overall thermal efficiency (%)	10.2858	14.7563	13.2546	16.5476	27.1375	23.33269	26.68159	18.91069
Summer days					Summer days			
Yield (mL)	0.178208	0.146821	0.238208	0.295429	0.450114	0.330416	0.244011	0.250114
Overall thermal Efficiency (%)	22.36505	16.89705	30.56485	42.89011	59.14168	36.69403	24.03934	27.72613

Table 4
Hs, Ta are written in four days high value.

Summer segment						Winter segment			
Elite stint various absorbing wick materials in the system									
S.No	Various Date	Times	Wick materials	HS (W/m^2)	Ta (°C)	Various Date	Times	HS (W/m^2)	Ta (°C)
1	20.05.2016	14.5	FWCW	1078	36	04.11.2016	14.0	1056	40
2	04.04.2016	14.5	CW	1078	38	14.09.2016	13.5	988	38
3	12.06.2016	14.5	FWJW	1078	40	29.01.2017	14.0	1060	38
4	03.05.2016	13.5	JW	1194	38	27.12.2016	13.5	1070	36

Table 5
FWCW, FWJW, CW, JW mention the wick, moist air and glass cover temperature heavy absorb to the still.

Summer segment							Winter segment				
Elite stint various absorbing wick materials in the system											
S.No	Various date	Times (sec.)	Wick materials	T_w (°C)	T_m (°C)	T_g (°C)	Various date	Times (Sec.)	T_w (°C)	T_m (°C)	T_g (°C)
1	20.05.2016	13.0	FWCW	66	59	42	04.11.2016	13.0	60	57	42
2	04.04.2016	13.5	CW	66	60	46	14.09.2016	13.5	58	55	40
3	12.06.2016	13.5	FWJW	66	61	48	29.01.2017	13.5	55	51	44
4	03.05.2016	13.5	JW	68	60	46	27.12.2016	13.0	64	62	42

Table 6
FWCW, FWJW, CW and JW are increases high values distillate yield in the system.

Summer segment					Winter segment		
Elite stint various absorbing wick materials in the system							
S.No	Various date	Times (Sec.)	Wick materials	Mass of output	Various Date	Times (Sec.)	Mass of output
1	20.05.2016	13.0	FWCW	0.450114	04.11.2016	13.0	0.244011
2	04.04.2016	13.5	CW	0.249511	14.09.2016	13.5	0.214011
3	12.06.2016	13.5	FWJW	0.330416	29.01.2017	13.5	0.224011
4	03.05.2016	13.5	JW	0.250114	27.12.2016	13.0	0.211375

the value of summer and winter produce in distillate yields is obtained during 13 h to 14 h of a solar still. Hence, summer & winter during of the still with FWCW has been provided with a higher daytime distillate yield as well as nighttime output in 1.900 & 1.100 kg/m^2 night distillate yield. It is seen that the still in summer and winter use of FWCW provided better yield that other wick materials in the basin. Numerical results from moist air, wick materials and glass cover temperature are in close agreement with the experimental observations.

The PCM & Nanoparticles secondhand in the still with FWCW is the best arrangement to be charity to get better results. The instantaneous efficiency has been evaluated for typical days in summer and winter with the absorbing materials illustrated in Fig. 3.4. Tables 9 & 10 illustration that the value of summer and winter produce in overall efficiency is achieved during 13 h to 14 h of the structure. The absorptive of the evaporating surface and water mass in the wick surface are significant operational parameter of the still and should be stationary optimum to afford better productivity. Moreover during summer and winter days, the overall efficiency of the still with FWCW is 59.14% and 27.13%, 36.69% and 23.33% for FWJW, 27.72% and 18.91% for CW, 26.68% and 24.03% for JW, respectively. It is clear that in summer and winter provided in still (FWCW) of better efficiency associated to other materials in the basin by Shalabyet & Bhupendra et al. [23,34]. Show the Table 11 comparisons of learning and various works about solar still with had Nanoparticles & PCM.

Numerical results have been accomplished for the FWCW in the basin of constant water flow through the wick i.e., M_w = 12 kg and is

Table 7
FWCW, FWJW, CW and JW winter values of distillate yield in the system.

S. No	Time of the day (hr)	Mw (FWCW)-04.11.2016	Mw (FWJCW)-29.01.2017	Mw (CW)-14.09.2016	Mw (JW)-27.12.2016
1	9	0.064621768	0.054621768	0.026217676	0.046217676
2	9.5	0.08507652	0.06707652	0.03607652	0.050765195
3	10	0.119193148	0.071931477	0.051931477	0.071931477
4	10.5	0.139264287	0.089264287	0.072642869	0.092642869
5	11	0.146820829	0.129916821	0.086820829	0.116820829
6	11.5	0.157942105	0.147942105	0.097942105	0.137942105
7	12	0.169100707	0.169100707	0.129100707	0.159100707
8	12.5	0.195084671	0.180846707	0.148084671	0.178084671
9	13	0.225851138	0.19511375	0.162851138	0.198511375
10	13.5	0.244011375	0.224011375	0.214011375	0.184011375
11	14	0.241375025	0.220137503	0.183750252	0.211375025
12	14.5	0.237508467	0.219250847	0.171508467	0.191508467
13	15	0.224860847	0.208608467	0.160846707	0.186084671
14	15.5	0.220100707	0.198025101	0.15100707	0.175100707
15	16	0.201918214	0.171821355	0.131821355	0.161821355
16	16.5	0.184820829	0.148208291	0.119482083	0.154820829
17	17	0.162748209	0.127482088	0.101274821	0.132748209

Table 8
FWCW, FWJW, CW and JW summer values of distillate yield in the system.

S.No	Time of the day (hr)	Mw (FWCW)-20.05.2016	Mw (FWJW)-12.06.2016	Mw (CW)-04.04.2016	Mw (JW)-03.05.2016
1	9	0.230585	0.134762	0.090462	0.070462
2	9.5	0.25552	0.154765	0.130765	0.094077
3	10	0.285931	0.184768	0.158931	0.119315
4	10.5	0.295429	0.206429	0.164287	0.126429
5	11	0.315208	0.238208	0.178208	0.146821
6	11.5	0.340421	0.250094	0.187421	0.157942
7	12	0.355007	0.26501	0.199007	0.179101
8	12.5	0.375847	0.280847	0.238085	0.198085
9	13	0.442138	0.312092	0.249511	0.220511
10	13.5	0.450114	0.330416	0.250114	0.244011
11	14	0.450114	0.320416	0.250114	0.250114
12	14.5	0.435085	0.310149	0.235085	0.241508
13	15	0.415085	0.295085	0.230847	0.230847
14	15.5	0.380551	0.27301	0.215101	0.21751
15	16	0.358214	0.260821	0.208214	0.196182
16	16.5	0.346208	0.238208	0.182083	0.174821
17	17	0.329482	0.210075	0.174821	0.152748

Table 9
FWCW, FWJW, CW and JW winter values of efficiency in the system.

S. No	Time of the day (hr)	Ins Eff (%) (FWCW) 20.05.2016	Ins Eff (%) (FWJW) 12.06.2016	Ins Eff (%) (CW) 04.04.2016	Ins Eff (%) (JW) 03.05.2016
1	9	19.80398	18.74462	7.559972	13.35628
2	9.5	21.1532	20.36681	8.739124	12.03188
3	10	25.74919	18.1938	11.57938	14.06375
4	10.5	23.40808	17.02323	14.91077	17.61655
5	11	24.27569	22.6457	14.57459	19.48657
6	11.5	24.40007	24.21799	14.92092	20.96621
7	12	23.50603	24.59571	18.43186	23.85203
8	12.5	25.99376	24.26841	20.82633	24.04467
9	13	29.46749	25.66034	22.54219	25.29921
10	13.5	30.50785	28.57669	24.54313	26.35696
11	14	30.12108	27.3672	24.63296	29.19762
12	14.5	29.83636	27.33433	23.01528	28.94101
13	15	33.91677	26.35663	22.69381	28.65731
14	15.5	33.68523	25.96548	24.17907	29.56614
15	16	39.93344	22.91724	21.79564	29.82997
16	16.5	43.68725	21.6046	23.60582	32.51706
17	17	47.15165	20.81698	22.93088	32.54415

Table 10
FWCW, FWJW, CW and JW summer values of efficiency in the system.

S. No	Time of the day (hr)	Ins Eff (%) (FWCW) 20.05.2016	Ins Eff (%) (FWJW) 12.06.2016	Ins Eff (%) (CW) 04.04.2016	Ins Eff (%) (JW) 03.05.2016
1	9	61.88595	28.14368	18.89208	16.40521
2	9.5	63.41204	26.79975	23.57311	17.94095
3	10	59.80859	28.34499	24.66859	18.94342
4	10.5	50.89011	30.56485	22.36505	16.89705
5	11	52.11725	34.45725	21.98866	17.98115
6	11.5	55.45109	33.32342	21.95372	19.11227
7	12	53.64913	32.36556	22.72505	21.05396
8	12.5	51.32461	33.67548	26.6788	21.95388
9	13	59.0313	36.98458	27.86445	24.3575
10	13.5	58.49605	37.66562	27.90807	26.93072
11	14	57.19864	35.90449	28.02673	27.7203
12	14.5	53.18598	37.91347	28.73742	28.18906
13	15	55.41939	39.39777	31.88728	28.21936
14	15.5	57.05138	40.92908	33.11389	30.33121
15	16	62.60555	45.58416	37.38136	30.20146
16	16.5	71.95987	49.51192	34.92647	30.88137
17	17	81.92154	52.23244	38.65354	31.54987

Table 11
Comparisons of a study and various works about solar still with have Nanoparticles & PCM.

S.No	Reference	Modification of a solar still	Productivity of a still
1	Sharshir et al. [36] 2017	A: FGN B: PCM & FGN C:FGN &Film cooling D:FGN, PCM & Film cooling	50.28% 65.00% 56.15% 73.80%
2	Nijmeh et al. [37]	$KMnO_4$ $K_2Cr_2O_7$	26% 17%
3	Elango et al. [38]	Al_2O_3 Fe_2O_3 ZnO	29.95% 18.63% 12.67%
4	Kabeel et al. [39]	Al_2O_3	11.6%
5	Sahota & Tiwari [40]	Al_2O_3	12.2%
6	Present work	PCM & Al_2O_3	59.14% (summer) & 27.13%(winter)

varying absorptance of the cotton wick material in both summer and winter. The variances in wicks and glass cover temperature are found that to in both summer and winter days and are depicted in Fig. 3.5. It is perceived that, when the absorptive of the wick diminutions, the modification in temperature between wicks and glass cover reductions. This reduces the evaporation rate from wick to glass cover i.e., condensing surface significantly.

The absorptive of the wick of 0.88 are optimum beyond which the evaporation diminutions. Fig. 3.6 has shown the variation on transformation in temperature amid wick and condensing surface for varying water mass in the wick in both summer and winter. It is perceived that the saline water mass of about 12 kg is optimum for the structure to form into energy with greater efficiency.

When the water mass proliferation beyond 12 kg, the thermal capacity of the still is increasing thereby decreases the temperature difference between the wicks and condensing surface. Hence to maintain a large temperature difference between the wick and condensing surface, the water mass in the wick should be optimum and should be maintained to 12 kg higher total fashioned in 7.460 kg/m^2 day for FWCW in shown Fig. 3.7.

Fig. 3.8 of summer & winter in various wick materials absorbed by Shalabyet & Bhupendra et al. [23,34] have been associated with high efficiency in the solar still with various wick materials have been distillate and efficiency following in Table 3 the solar radiations

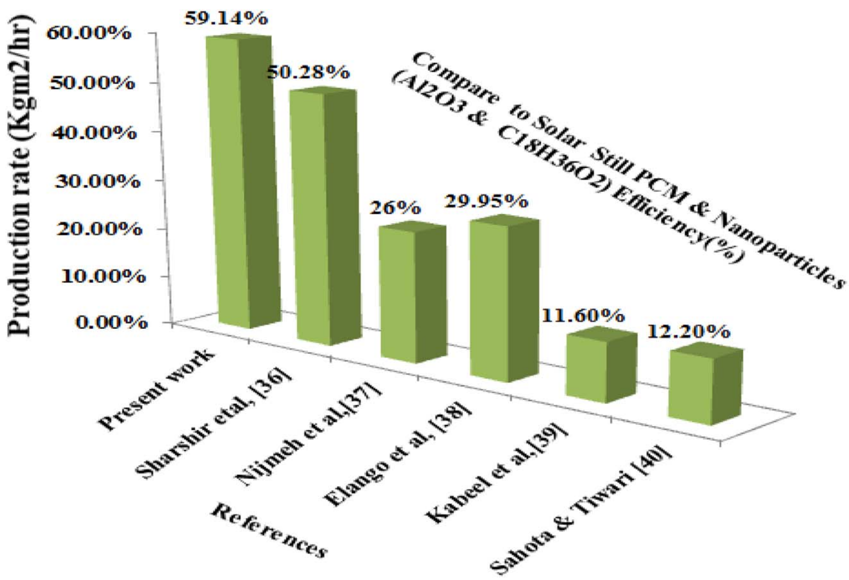


Fig. 3.9. Photograph of compare to PCM & Nanoparticles of overall (wick materials) efficiency of the solar still.

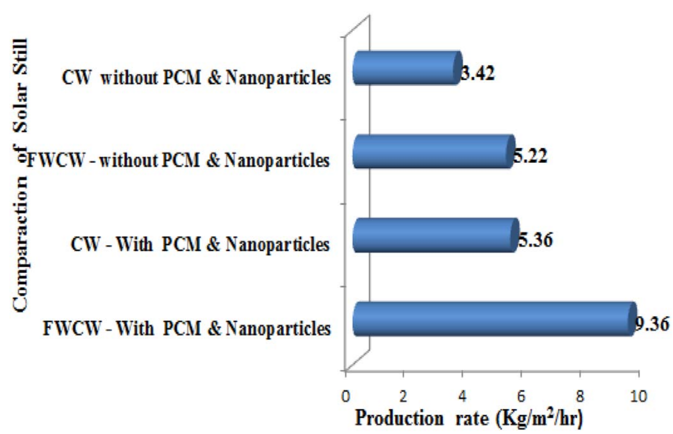


Fig. 4.0. Modulation of wick materials absorb a solar still in Summer & Winter for 24 h output with and without PCM & Nanoparticles.

measurement of monitors Table 1 and the principle of thermodynamic temperature scale is water freezes at 0 °C to boils at 100 °C and SI unit is kelvin have been occupied by under solar still atmospheric pressure range at Chennai, Tamilnadu, in India. Nanoparticles (Al_2O_3) enhancement thermal conductivity Table 2.

A single slope single basin solar still is observed energy to form into heat to force of a higher productivity and compare to the increase in saturated vapour pressure is verified by Huang et al. [35] enhancement is affected for a Nanoparticle and found that to be hydrophobic Nanoparticles used to the fast evaporation to vapour pressure of output water to the enhancement. Table 11 comparisons between present learning and various works about solar still with have Nanoparticles & PCM and Fig. 3.9, Photograph of [36–40] compare to PCM & Nanoparticles of overall high efficiency of the solar still. Fig. 4.0, Modulation of a single basin solar still in compare to with and without PCM & Nanoparticles total output (24 h) have been fashioned on 9.36 kg/m^2 day & night.

4. Conclusion

The subsequent inferences have been acquired from the modeling of single slope single basins solar still.

(i) The solar still have been charity in PCM & Nanoparticles for dissimilar heat progresses slightly sophisticated storage density and the isothermal nature process of whole efficiency of the structure.
(ii) The yield of the anticipated still is found to be great when Fin with Cotton Wick (FWCW) is charity.
(iii) The usual efficiency of the still through 59.14% (summer) and 27.13% (winter) and henceforth it is established that FWCW is the superlative material to be charity in the basin of the still.
(iv) The water mass in the wick and absorptive of the wick surface is the vital significant parameters that inspiration the act of the still.
(v) Additionally, if the water mass in the wick intensifications and absorptive of the wick diminutions, the yield of the still reductions significantly.
(vi) The absorptive of the wick surface can be maintained by numerous amputations of salt deposition and preserving whole moisture of the wick through peak sunny hours.
(vii) The absolute consequence exhibited that, summer and winter the whole yield of the augmented PCM and Nanoparticles with a solar still is whole circadian concentrate yield in through 9.00 am to 17 pm for FWCW is 7.460 & 4.120 kg/m^2 day, respectively.

Nomenclatures

A_g	Area of the glass covers (m^2)
A_w	Area of the wick surface (m^2)
C_w	Specific heat capacity of absorbing materials (J/kg K)
H_s	Tilted solar radiation (W/m^2)
h_1	Total heat transfer coefficient from moist air to glass cover (W/m^2)
h_2	Total heat transfer coefficient from glass cover to ambient (W/m^2)
h_3	Total heat transfer coefficient from absorbing materials to moist air (W/m^2)
h_4	Total heat transfer coefficient from moist air to ambient (W/m^2)
h_5	Total heat transfer coefficient from absorbing materials to glass cover (W/m^2)
M_w	Mass of the water in the wick surface (kg)
T_m	Temperature of moist air (°C)
T_g	Temperature of glass cover (°C)
T_a	Temperature of ambient (°C)
T_w	Temperature of the wick surface (°C)
K	Thermal conductivity of glass wool insulation (W/mK)
L	Latent heat of vaporization of water (°C)
x	Thickness of glass wool insulation (m)

Greek letters

α_g Absorptivity of glass cover
α_w Absorptivity of the wick surface
τ_g Transmittance of glass cover
ε_g Emissivity of glass cover
σ Stefen-Boltzman constant
η Instantaneous thermal efficiency (%)

Abbreviations

FWCW Fin with Cotton Wick
FWJW Fin with Jute Wick
CW Cotton Wick
JW Jute Wick

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