PRODUCTIVITY ENHANCEMENT OF SOLAR STILL COUPLED WITH EVACUATED GLASS TUBES USING BLACK WICK AS ABSORBER WITH SOLAR TRACKING

[1]Anand Prakash Pannusa, [2]Manish Hassani
[1]M. E. Scholar, [2]Lecturer
[1]M.E. Scholar, Department of Mechanical Engineering, M.B.M. Engineering College, J.N.V. University, Jodhpur, Rajasthan, India
[2]Lecturer, Department of Mechanical Engineering, Govt. Polytechnic College, Jodhpur, Rajasthan, India

Abstract*— The scarcity of pure drinkable water is increasing as growing population in developing countries like India. The solar water distillation proves to be best alternative water purification technique to meet the present water crisis in villages and in remote areas as well. The enhancement to total pure water in solar still is a design challenge. The wick as absorber with sun tracking system was incorporated to enhance the still productivity. A manual sun tracking system was used for rotating the solar still with the movement of the sun by drawing sun-chart. Depending upon the weather conditions the wind speed is varied from 0.13 to 1.81 m/s and the ambient temperature is varied from 27 to 45 °C at different days and solar intensity is varied from 30 to 1100 W/m^2 during day time. The experimental setup was designed and installed at solar lab MBM Engineering College. Experiments were conducted simultaneously on both stills for the same basin condition solar lab (26° 27'N, 73° 04'E) Jodhpur, Rajasthan, India during the months of May – June 2013. The sun tracking increases the productivity 35.30 % as compared to the bare basin setup.

***Index Terms*—Black Wick, Solar Tracking, Solar Still, Evacuated Glass Tube.**

I. INTRODUCTION

Water is essential for all life forms on the earth, plants, animals and humans. However, the lack of fresh water is always a trouble for humanity. The rapid industrial growth and worldwide population explosion have resulted in a huge rising demand for freshwater, both for household needs and for crops to produce adequate quantities of food. Added to this is the problem of the pollution of rivers and lakes by industrial waste and the large amounts of sewage discharge. On a global scale, man-made pollution of natural sources of water is becoming one of the greatest causes for freshwater shortage. In most places, ground water is brackish and not suitable for drinking and cooking. In arid areas, clean and potable water is extremely limited and the establishment of a human habitat in these areas strongly depends on the amount of such water which can be made accessible.

The solar still have been serving the purpose for a very long time through the history. The Arab alchemists used this technology to produce fresh water way back in 1551. At that time, it produced 23,000 l of clean water per day given the area of distillation plant was 47,000 m^2 which reduce to a calculation of 4.9 kg/m^2 of the still surface in the whole day. The still used for this purpose was of single sloped type. The commercialization of solar still has also been done earlier to provide people with fresh water. The efficiency of the solar still puts a shackle on the full-fledged commercialization of it and increased efficiency shall also be contributing to the production of fresh water on a massive scale.

Solar still is a very simple device used to convert available brackish or saline water into drinkable water by use of solar energy. Desalination is one of most humankind's primitive forms of water treatment and it is still a popular treatment solution throughout the world today. Solar still is a device which is used for desalination purpose. Solar still are of two types passive still and active still. Passive solar still employs only solar radiation to evaporate water for production of distillate output. Whereas active solar still requires the addition of some mechanical source in the form of collector with solar energy. Hence the efficiency as well as distillate output of active solar still is good compared with solar still. Solar still operates similar to natural hydrological cycle of evaporation and condensation. Both basins of solar still are filled with saline water. The sun rays absorbed by collector are passed through glass cover to heat the water in the both basins. And the water gets evaporated. As the water inside the solar still evaporates, it removes all contaminates and microbes in the basin. The purified vapour condenses on the inner side of the glass. This condenses vapour collects in the flask. Many solar systems were developed over the years using above principle for distillation. This paper reviews the technological development of active solar still distillation system developed by various researchers in detail.

II. DEVELOPMENT OF SOLAR STILL COUPLED WITH EGT

In view of geographically culture in temperate zone maximum receipt of solar insolation engineered as a boon of nature. Harnessing solar energy is paradigm to meet the contemporary energy crisis. In view to meet the present requirement of fresh, pure and non-contaminated potable water, affordable measure is needed.

Solar Still Development

The development of still involve various steps from design and construction each still component.

Still Component

The experimental setup was designed and installed at solar lab MBM Engineering College. Experiments were conducted simultaneously on both stills for the same basin condition solar lab (26° 27′N, 73° 04′E) Jodhpur, Rajasthan, India during the months of May – June 2013. The major element of the experimental setup active solar still coupled with evacuated tubes.

The experimental setup consists of:

Basin and Side Wall

The basin was made of Fiber reinforced plastic (FRP) having 1 m^2 area. The whole basin surfaces were coated with black paint from inside to increase the absorptivity. The still was insulated from the bottom to the sidewalls with polyurethane from 4 cm thick having thermal conductivity of 0.034 W/m^2 K to reduce the heat loss from the still to ambient as shown in Figure1 and 2.

Figure 1 Solar Still Basin

A Single basin double slope solar still has been fabricated with mild steel sheet as shown in Fig 4.2. Fourteen hole of 49 mm diameter were punched by the pressing operation at lower basin surface in one side of seat with equal distance between each hole.

The overall size of inner basin 1006 mm × 325 mm × 380 mm. the maximum height and that of the outer basin is 1006 mm × 536 mm × 100 mm. the brackish water feed pipe work provided at the top of upper chamber of the basin at middle double basin chamber supports were provided.

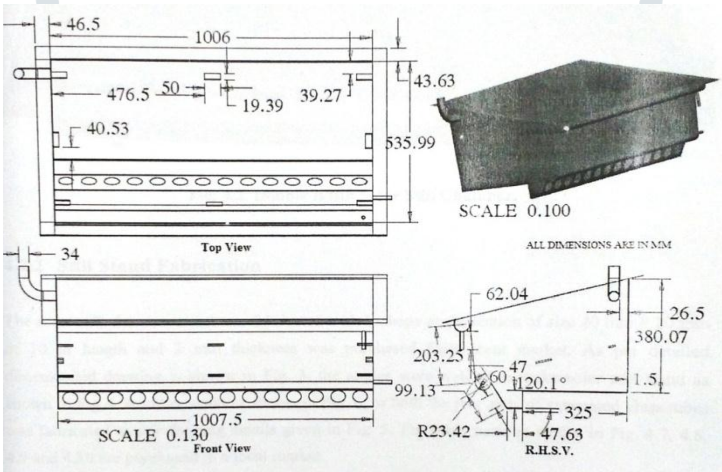

Figure 2 Detail drawing of solar still chamber

Evacuated Glass Tube

Evacuated Glass tube (EGT) works on 'Black body heat absorption principle'. The principle says, 'black colour absorbs maximum heat, more than any other colour'. Solar water heating systems using vacuum tubes made of borosilicate glass with special coating to absorb the solar energy are called as Evacuated Tube Collector system (ETC Systems).

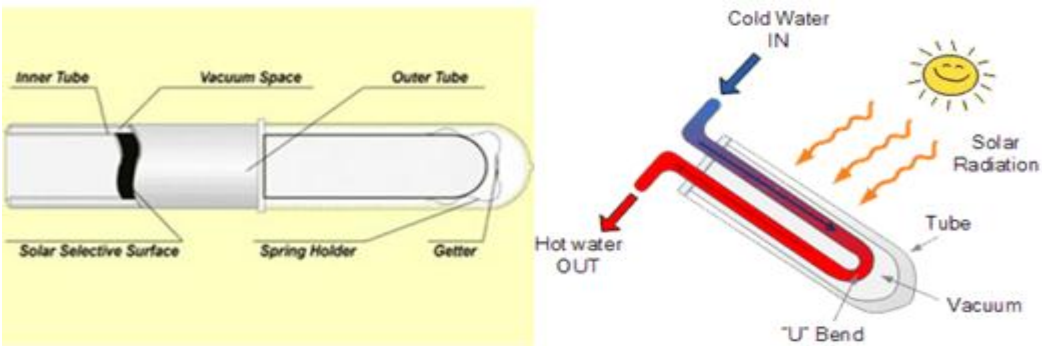

Figure 3 Evacuated Glass Tube

Figure 3 shows the main component of EGT, which absorbs solar energy. The vacuum tube is an assembly of two concentric; borosilicate glass tubes. Air between the gaps of two glass tubes is evacuated. It results in high level of vacuum, which acts as the best insulation to minimize the heat loss from inner tube. The black coating on the inner tube absorbs the solar energy and transfers it to the water. The water on upper side of Vacuum Tube becomes hot and thus lighter, so it starts moving upwards in the tank. At the same time cold water, which is heavy, comes downward from the basin and is stored at the bottom. The phenomenon is called as natural Thermosyphon circulation, which occurs in every tube.

Table 1 Evacuated glass tube parameters

Specifications of Evacuated Glass Tubes	
Material of Glass	Borosilicate Glass
Length	1800 mm and 2100 mm
Outer diameter	47 mm
Inner diameter	37 mm
Thickness of Glass Tube	Outer tube thickness: 1.8 mm, inner tube thickness: 1.6 mm
Selective coating type	AIN/AIN-SS/CU – Sputtering
Value of absorptance and emittance of the black coating	Absorptance: $\alpha \geq 93.5\%$, Emission rate: $\varepsilon \leq 5\%$
Vacuum rate	$P \leq 5.0\times10^{-4}$Pa
Coefficient of Thermal Expansion	3.3×10^{-6}/k

Insulation (polyurethane foam)

A wide range of insulation materials is available; however, few meet the requirements of still construction. Selection of insulation material should be based on initial cost, effectiveness, durability, the adaptation of its form/shape to that of the still hold and the installation methods available in each particular area. From an economic point of view, it may be better to choose an insulating material with a lower thermal conductivity rather than increase the thickness of the insulation in the still walls. Polyurethane foam is one of the best commercially available choices of insulation. It has good thermal insulating properties, low moisture-vapour permeability, and high resistance to water absorption, relatively high mechanical strength and low density. Polyurethane is formed by mixing an isocyanate, such as methylene diphenyldiisocyanate (MDI) with a polyol blend. These components are mixed to form a rigid, cellular foam matrixas shown in Figure 4. The resulting material is an extremely lightweight polymer with superior insulating properties. As a result of the high thermal resistance of the gas, polyurethane insulation typically has an initial R-value around R-5 to R-6 per inch.

Figure 4 Polyurethane Foam

Glass Cover

The water in the basin is heated by the solar energy directly received through the glass cover of the still. The solar radiation, after reflection and absorption by the glass cover, is transmitted inside the enclosure of the distiller unit. Consequently, the water is heated, leading to an increased difference of water and glass cover T temperature. There are basically three modes of heat transfer: radiation (q_{rw}), convection (q_{cw}), and evaporation (q_{ew}) from the water surface to the glass cover. The evaporated water is condensed on the inner surface of the glass cover after releasing the latent heat. Under gravity, condensed water trickles into the channels placed at the lower ends of the glass cover. The glass cover temperature was measured at node by copper-constantan thermocouples.

Frame and Stand

The solar still chamber stand was fabricated with L shape angel section of size 20 mm × 20 mm of 10 meter length and 2 mm thickness. The detailed dimensional drawing is shown in Figure 6 and 7.To hold the rear and ends of evacuated glass tubes was fabricated as per drawing shown in Fig. 5.

Figure 5 Solar Still Chamber Stand

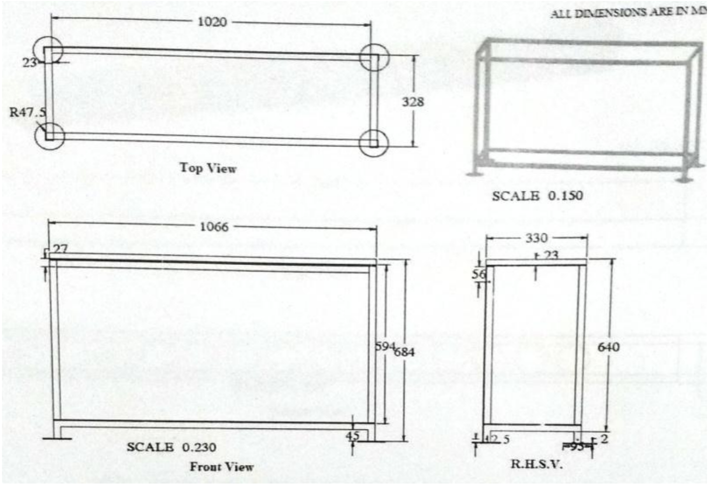

Figure 6 Detail drawing of solar still chamber stand

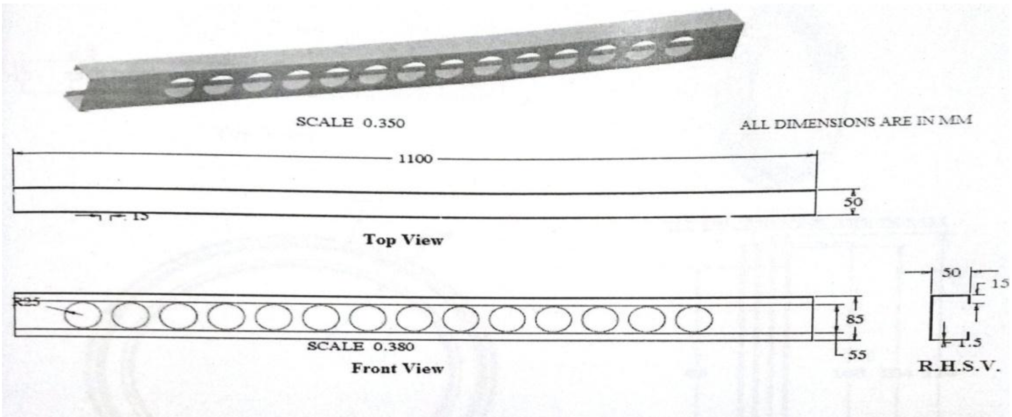

Figure 7 Detail drawing of supporting stands of EGTs

The still was coupled with rows of parallel transparent evacuated glass tubes (EGT), each of which contains an individual absorber tube covered with selective coating to warm the water additionally prior to sending it to the solar still. Evacuated glass tubes are integrated with the basin type single slope solar still. The whole basin surfaces were coated with black paint from inside to increase the absorptivity. The still was insulated from the bottom to the sidewalls with polyurethane from 4 cm thick having thermal conductivity of 0.034 W/m^2 K to reduce the heat loss from the still to ambient. The basin was covered with a glass sheet of 3 mm thickness inclined at nearly 30° horizontally to maximize the amount of incident solar radiation and sealed with silicon seal to avoid water leakage.

To maximize the productivity of the still, to increase the inner temperature basin and to increase the harness of solar radiation the still was augmented with manual solar tracking mechanism. This solar mechanism consists of four roller wheel bolted at each corner of still frame and chart reflecting hourly Sun's angular position.

Water pipes and Distillate collecting Flask

For accumulation of output of still in the form of distillate water proper arrangement of high strength and non-reactive water pipe were installed. Brackish water in flow is facilitated with similar pipe.

III. Economic Analysis

Good management consists primarily of making wise decisions; wise decisions in turn involve making a choice between alternatives. The ultimate objective of the economic analysis is to provide a decision-making tool which can be used not only for the pilot project but also for demonstration purposes. In considering solar system usefulness we must find the potential benefits and costs of the systems. Costs related to the analysis include the initial investment required to purchase the system, administrative costs and any operation and maintenance costs that may be associated with the systems. Generally there is no operation cost to the utilities associated with solar energy system because the customers do not have to pay for the energy requires running the systems. The Solar technology systems have only installation and maintenance cost but zero operational cost. The economic feasibility of any solar still can be assessed primarily on the basis of 'the unit cost of desalination of saline water' and 'payback period' of the investment made for the solar stills. Though the process of desalinating saline water – evaporating water, condensing and collecting pure water vapours – remains the same, what makes all the difference is its no-fuss, closed-loop design and the total absence of conventional fuels, thus making it totally sustainable, affordable, and eco-friendly. The payback period of the experimental setup depends on overall cost of fabrication, maintenance cost, operating cost and cost of feed water. The cost of feed water is negligible.

Overall fabrication cost to be considered = Rs.10000 (over all)
Cost per litre of distilled water = Rs.10
Productivity of the solar still = (6-7) l/m^2/day (including nocturnal yield)
Cost of water produced per day = cost of water / litre x productivity
= 10 x 7 = Rs.70
Maintenance cost = Rs.5/day (estimated)
Net earnings = Cost of water produced – maintenance cost

= 70– 5 = Rs.65
Payback period = Investment/Net earning
=10000/65 = 154 days (approx.)

Table 2 Capital cost of active solar still system

S.No.	Details of component	Quantity	@ materials	Rs
1	Mild still plate	18 kg	R_{MS}=Rs78/kg	1404
2	Evacuated Glass tubes	14	R_{EGT}= Rs 200/ pic.	2800
3	Silicon Seal	14	R_{SS}= Rs 50/ pic.	700
4	EGT Cap	14	R_{CAP}= Rs 50/ pic.	700
5	Glass cover (Glass Thickness 5 mm)	1.043 m^2	R_{GLASS} = Rs 190/ M^2.	198
6	GLASS TRAY (Glass Thickness 5 mm)	1.5 m^2	R_{GLASS}= Rs 190/ M^2.	285
7	Thermocouple wire (k-Type)	30 m	$R_{K\text{-}TYPE}$ = Rs 35/ m	1050
8	Sealant	4 m	R_{SELANT}= Rs 25/ m.	100
9	Fiber reinforced plastic	2.3 m^2	R_{FRP}=Rs 180/ m^2.	414
10	Stand	1		200
11	PU Foam	2 m^2	R_{PU}=Rs 40/ m^2	80
12	Roller Wheel	4	R_{Roller}=40	120
13	Wick		R_{Wick}=50	50
14	Manufacturing cost			1300
Total				9401

Experiment Setup and Procedure

Figure 8 Experimental Setup

Experiments were conducted at solar lab MBM Engineering College, Jodhpur (26° 270027′N, 73° 06319′E) Rajasthan, India during the months of May-June, 2013. The readings were taken from morning 08:00 AM to 06:00 PM on hourly basis.

Temperature were measured at more than one location and averaged was considered for the case of base plate temperature and basin water temperature. Thermocouples were integrated with a temperature indicator and selector switch. To measure the solar radiation a calibrated Pyranometer was used. The hourly weather data, i.e., solar radiation and wind speed were measured.

IV. Results and Discussion

The experiments were conducted on still under local climatic conditions. The system was operated during the summer month of May and June 2013. The observations of the days with the average radiation conditions were considered for analysis. Totally, 20 combinations of readings were taken in solar still by varying water depth, water sample, absorbing material and solar tracking. The proposed model can accurately predict the distillate yield for a basin type evacuated solar desalination system operating at high temperatures.

Depending upon the weather conditions the wind speed is varied from 0.13 to 1.81 m/s and the ambient temperature is varied from 27 to 45 °C at different days and solar intensity is varied from 30 to1100 W/m^2 during day time.

Hourly variation of Solar Insolation and temperature

The solar productivity is depends on the influence of climate conditions as, solar insolation and ambient temperature prevailing the experimental location. Figure 9 and Fig. 10 shows the hourly variation of the solar intensity and the ambient air temperature on the clear days of the month of May. The solar radiation gradually surges with time till 2:00 PM and declines towards evening. It can be seen that the solar intensity was maximum at the mid noon whereas, the ambient air temperature reached its maximum in the afternoon hours. This time lag of the maximum ambient air temperature and maximum solar intensity is mainly due to the thermal capacity of the atmospheric air, besides, factors like air density, humidity, quality and others may also affect.

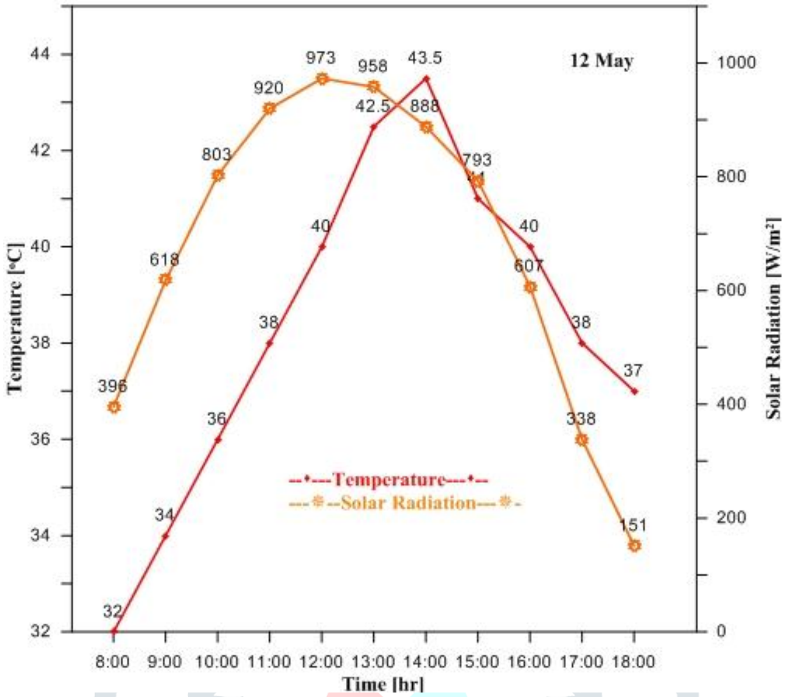

Fig. 9 Hourly temperature distribution with respect to Solar Insolation for 12 May.

The study for variation of global solar radiation and ambient temperature was conducted. The global solar radiation data was collected from pyranometer on hourly basis. The ambient temperature was measured from a thermocouple junction and thermometer, reading from both temperature probes was cross checked for accuracy. Temperature data was also collected on hourly interval.

Figure 9 represents the distribution of solar radiation and corresponding ambient temperature from 8:00 AM in the morning that from sun rising to the 6:00 PM that is sun setting time for date 12 May. The solar radiation follows parabolic pattern. In morning the value of solar radiation is 396 W/m^2 at 8:00 AM. In forenoon hour the solar radiation increases till 12:00 AM and attains its maximum value 973 W/m^2. At this time Sun is at the top. Thereafter the radiation starts decreasing and at 6:00 PM its value is 151 W/m^2. The ambient temperature correspond the radiation with the time lag of two hour approx. Temperature reaches 43.5^{o}C maximum of the day at 3:00 PM. Though the ambient temperature is also function of wind velocity, thus it does not follow the same parabolic path. At 8:00 AM ambient temperature is 32^{o}C and at 6:00 PM temperature is 37^{o}C and keep on declining with time.

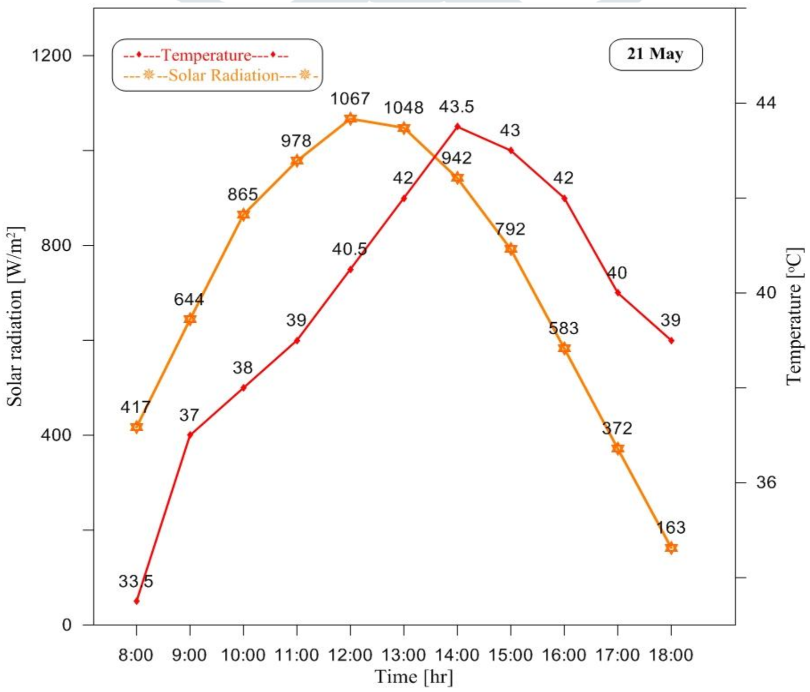

Fig. 10 Hourly temperature distribution with respect to Solar Insolation for 21 May.

Figure 10 represents the distribution of solar radiation and corresponding ambient temperature from 8:00 AM in the morning that from sun rising to the 6:00 PM that is sun setting time for date 21 May. The solar radiation follows parabolic pattern. In morning the value of solar radiation is 417 W/m^2 at 8:00 AM. In forenoon hour the solar radiation increases till 12:00 AM and attains its maximum value 1067 W/m^2. At this time Sun is at the top. Thereafter the radiation starts decreasing and at 18:00 PM its value is 163 W/m^2. The ambient temperature correspond the radiation with the time lag of two hour approx. Temperature reaches 43.5^{o}C maximum of the day at 3:00 PM. Though the ambient temperature is also function of wind velocity, thus it does not follow the same parabolic path. At 8:00 AM ambient temperature is 33.5^{o}C and at 6:00 PM temperature is 39^{o}C and keep on declining with time. The data of solar radiation and ambient temperature was collected during the complete experimental duration. The data distribution follows the similar pattern.

Water Sample

Water from three most commonly used sources are collected for better study of water quality is used. The aim of water sampling is to determine the impurities and quantity of minerals present in sample water. Samples are as mention in Table 3.

Table 3 Water sample and there location

S. No.	Sample	Source
1	Tap water	Solar Lab MBM Engg. College
2	Tube well water	Farm near UmedBhavan
3	Pond water	Mechanical Engg. Dept. MBM Engg. College

Water of all the three samples was collected from the sources in clean plastic bottles. Samples were deposited on the same day at a certified test centre district headquarters. The physico chemical test for 13 parameters and bacteriological examination for total coliform bacteria was done at the test house. Results of test house are presented.

Effects of Solar radiation distillate

The influence of climatic conditions and mainly solar radiation, on the system production is investigated. The variations of the daily solar still output and the solar radiation for 6th may is shown in Figure 11.The figure shows that the still productivity is proportional to the solar radiation intensity, which depends on climatic condition of each day.

The distillate output of the solar still varies as the total solar radiation intensity with about 2 hours delay. It increases up to a maximum value at 03:00 PM and then decreases as time passes. The maximum yield reached is about 730 ml/m^2. Variations of the accumulated distillate during the day for different days are shown in Figure 11. The accumulated water reached 4200 ml/m^2 at 06:00 PM for day 6 May 2007.

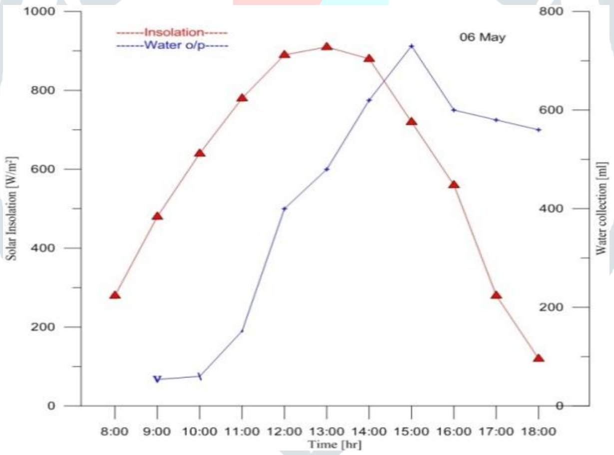

Figure 11 Hourly distillate productivity with respect to solar radiation

Effect of water depth on the solar stills productivity

The effect of water depth in the still basin on the productivity is shown in Figure 12. It is evident that as the water depth increases, the productivity will be decreased.

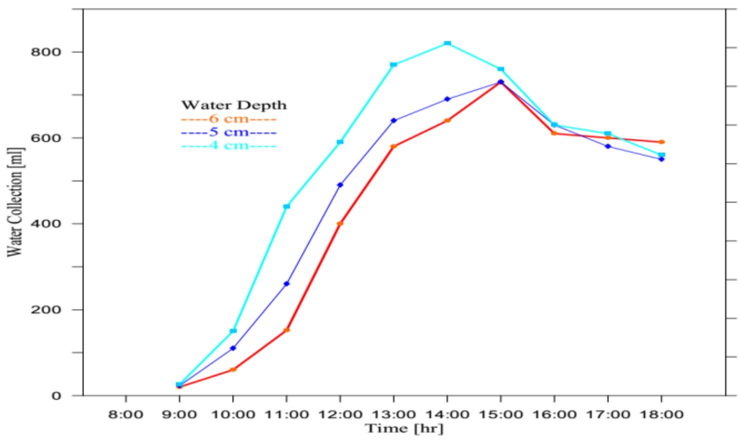

Figure 12 The effect of water depth in the basin on the productivity

This is due to the increase of the heat capacity of the water in the basin, results in lower water temperature in the basin leading to lower evaporation rate.

Table 4 Distillate collection with various water depths

S. No.	Time (h)	Ambient Temperature (^oC)			Output of water collection (ml)		
		Day 1	Day 2	Day3	6 cm	5 cm	4 cm
1	08:00	32	31	32	0	0	0
2	09:00	34	36	34	20	23	26
3	10:00	35	39	36	60	110	150
4	11:00	36	41	38	152	260	440
5	12:00	37	43	40	400	490	590
6	13:00	39	45	42.5	580	640	770
7	14:00	40.5	44	43.5	640	690	820
8	15:00	41	43	41	730	730	760
9	16:00	39	42	40	610	630	630
10	17:00	38	41	38	600	580	610
11	18:00	37	39	37	590	550	560

The experiment is conducted for three different water depth that is 6 cm, 5 cm and 4 cm on 10, 11 and 12 May respectively. Table 5.3 dictates the increase in distillate productivity with decrease in water depth. The maximum output of 820 ml/hr is accumulated at 02:00 PM with 4 cm water depth setup. There is 22.56 % productivity increment during experimental hours with 4 cm water depth as compared to 6 cm water depth. Critical analysis revels that the hourly productivity varies abrupt with higher water depth as in case of lower depth productivity variation is less.

Effect of Solar tracking on productivity

Figure 9 and 10 show that a higher solar intensity corresponds firstly to a high still productivity and secondly to a high ambient temperature. Thus, the intensity of solar radiation has the prime importance on the still productivity. It clarifies that at sunset, the productivity of the still decreases suddenly and during the period of diffuse radiation, a very low productivity is attained and little or no productivity at all when the solar intensity reaches zero.

The intensity of solar radiation reaching the earth surface varies from zero during the night to about 1067 W/m^2, on a bright afternoon. To maximize the still productivity manual solar tracking procedure was used. For tracking the still was made movable by installing four round wheels at each corner of the still setup. A solar chart is drawn for tracking the sun at latitude 26.27° N as shown in Figure 13. Solar radiation capturing is dependent on the angle of incidence of the sun to the solar still's surface and the closely perpendicular it is, the more the irradiance.

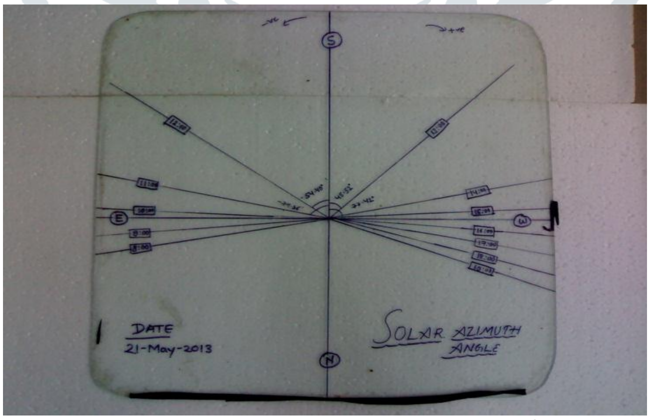

Figure 13 Solar chart for latitude 26.27^o N

As per the position mentioned in the solar chart the still is moved and turned hourly basis to that angle with the help of magnetic compass. This maximize the direct solar radiation and increases the water temperature thus enhances the water collection.

Table 5 Distillate collection with black wick as an absorbing medium.

S. No.	Time (h)	Output of water collection (ml)		
		Bare basin	Black Wick	Black wick with tracking
1	08:00	0	0	12
2	09:00	18	63	80
3	10:00	190	370	450
4	11:00	430	590	620

5	12:00	780	890	930
6	13:00	900	1032	1130
7	14:00	870	1068	1210
8	15:00	890	980	1090
9	16:00	780	910	990
10	17:00	630	870	920
11	18:00	580	630	790

Sun tracking experement were conducted with installing wick as absorber setup. It is evident that by using black wick productivity increaes and with sun tracking water collection further rieses. The water productivity was recorded for blackwick with and without sun tracking and compiled in Table 5 with the bare basin output.

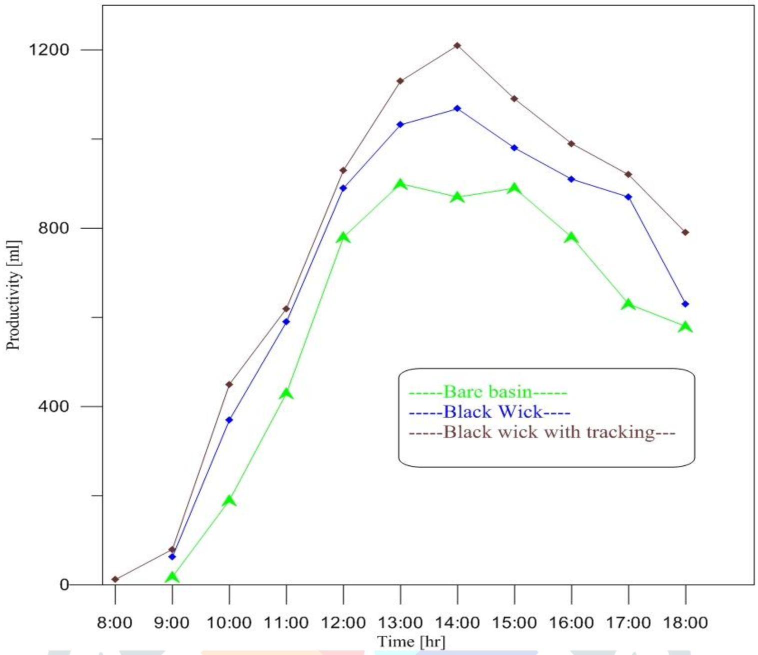

Figure 14 Effect of solar tracing with black wick as an absorbing medium

Only in this experiment the water output was collected in the first hour of operation. In first hour of operation water collection was 12 ml that is till 8:00 AM. Later onwards as the solar radiation increase the basin water temperature rises and rate of water collection increases as shown in Fig. 14. The water collection recorded maximum at 2:00 PM was 1210 ml. There after the yield accumulation was declining reaches at 790 ml at 6:00 PM. The total distillate water collection reached 8210 ml for operation from 8:00 AM to 6:00 PM for day. In Sun tracking the rate of water heating inside the basin increases and results in overall disttilate production. The sun tracking increases the productivity 35.30 % as compared to the bare basin setup as shown in Table 6

Table 6 Effect of different experimental setup on productivity

S. No.	Absorber Used	Daily productivity for 4cm depth		Productivity increase in %
		With Absorber	Bare basin	
1	Bare basin	6068	---	---
2	Black wick	7403	6068	22.00
3	Black wick with solar tracking	8210	6068	35.30

V. Conclusions

In this experimental investigation, a comprehensive study on various absorbers with solar tracking on solar still is presented. The study covers fundamentals of solar thermal system, detailed description of various types of solar water distillation systems, performance analysis and thermal modeling of solar still, different solar water distillation technologies, optimization of parameters to enhance the productivity of distilled water and efficiency of solar still.

In line to the productivity enhancement black wick were used as absorber. The water collection enhances 22.56 % with black wick as absorber.

The setup was constructed with existing setup by installing a transparent glass basin. The mid glass basin was placed inclined so that water evaporated from lower basin condense and slides in the second water accumulation line

The intensity of solar radiation has the prime importance on the still productivity. For maximum solar energy harness on fixed probe the incidence solar angle should be perpendicular. A manual sun tracking system was adopted by drawing date wise solar chat for experimental location having latitude 26.27^{o}N. There are two set of experiment with sun tracking were conducted. For tracking the still was made movable by installing four round wheels at each corner of the still setup. As per the position mentioned in the solar chart the still is moved and turned hourly basis to that angle with the help of magnetic compass. This maximise the direct solar radiation and increases the water temperature thus enhances the water collection. In Sun tracking the rate of water heating inside the basin increases and results in overall disttilate production. The sun tracking increases the productivity 35.30 % as compared to the bare basin setup.

Solar desalination proves most compatible water purification technique. The productivity enhancement from solar still augmented with evacuated glass tube results better as compared to conventional still. Installing black wick as absorber, black wick shows better results.

Solar desalination coupled with evacuated glass tubes has greater scope for further research work. Still productivity can be enhanced for further by implying following measures:

- For maximizing solar intensity automated solar tracking system will be adopted. This provides sun tracking at particular instant resulting more solar energy harnessing at same base area.
- Further for better solar radiation absorbing at basin various absorbing medium like pebbles, corrugated basin can be tested for higher productivity.
- Multi-basin solar still coupled with evacuated glass tubes can be designed for maximizing the water productivity.
- Input water to the basin can be heated by external means which will increase overall efficiency of the desalination system.
- For better condensation at inside portion of the glass cover external cooling arrangement may be adopted which will enhance the overall water collection.
- Improving the overall design making arrangement of the scheduled maintenance and cleaning ergonomics proves this system for commercial production for low cost water distillation system.

REFERENCES

[1] Karuppusamy S. , An Experimental Study on Single basin Solar Still Augmented with evacuated tubes, Thermal Science, Vol. 16 (2), 2012, pp. 573-581.

[2] Omara Z.M., Hamed M. H. and Kabeel A. E., Performance of finned and corrugated absorbers solar stills under Egyptian conditions, Desalination, Vol. 277 (3), August 2011, pp. 281–287.

[3] Patel M. I., Meena P. M. and Inkia S, Effect of dye on distillation of a single slope active solar still coupled with evacuated glass tube solar collector, International Journal of Engineering Research and Applications, Vol. 1 (3), 2011, pp. 456-460.

[4] Chittaranjan R., Drinking Water Treatment, Springer, 2011 (Chapter 6).

[5] Sengar S. H., Mohod A. G., Khandetod Y. P., Modak S. P. and Gupta D. K., Design and development of wick type solar distillation system, Journal of Soil Science and Environmental Management Vol. 2(7), 2011, pp. 125-133.

[6] Setoodeh N., Rahimi R. and Ameri A, Modeling and determination of heat transfer coefficient in a solar still using CFD, Desalination, 268, 2011, pp. 103-110.

[7] Ahmed H. M., Al Taie A. K. and Almea, Solar water distillation with a cooling tube, International Renewable Energy Congress, November 5-7, 2010, pp. 6-10.

[8] Tabrizi F. F., Dashant M, Moghaddam H. and Razzaghi K., Effect of water flow rate on internal heat and mass transfer and daily productivity of a weir-type cascade solar still, Desalination, 260, 2010, pp. 239-247.

[9] Tabrizi F. F. and Sharak A. Z., Experimental study of an integrated basin solar still with a sandy heat reservoir, Desalination, 253, 2010, pp. 195–199.

[10] Tarawneh M. S. K., Effect of water depth on the performance evaluation of solar still, Jordan Journal of Mechanical and Industrial Engineering, Vol. 1, Sep. 2007, pp. 23 – 29.

[11] Kabeel E., Performance of solar still with a wick concave evaporation surface, Twelfth International Water Technology Conference, IWTC12 ,2008, Alexandria, Egypt.

[12] Kumar K. Vinoth and KasturiBai R., Performance study on solar still with enhanced condensation, Desalination, 230, 2008, pp. 51–61.

[13] O.O. Badran, Experimental study of the enhancement parameters on a single slope solar still productivity, Desalination, 209, 2007, pp.136–143.

[14] Aybar H. S., Egelioglu F. and Atikol U., An experimental study on an inclined solar water distillation system, Desalination, 180, 2005, pp. 285-289.

[15] Naima Mona M. and Abd El KawibMervat A. Non-conventional solar stills with charcoal particles as absorber medium, Desalination, 153, 2002, pp. 55–64.

[16] Gad H. E., El-Gayar S. M. and Gad H. E., Performance of a solar still with clothes moving wick, Fifteenth International Water Technology Conference, IWTC, Alexandria, Egypt.

[17] Assadi M. K., Basin-type stepped solar still, Journal of the Solar Energy Society of India, SESI Journal 8(2), 1998, pp. 97-104.

[18] Kumar S. and Tiwari G. N., Estimation of convective mass transfer in solar distillation system, Solar Energy, Vol. 57 (6), December 1996, pp. 459–464.

[19] Mahdi J.T. and Smith B.E., Solar distillation of water using a v-trough solar concentrator with a wick-type solar still, Renewable Energy, Vol.5, Part I, 1994, pp. 520-523.

[20] Duffie J. A. and Beckman W. A., Solar Engineering of Thermal Processes, Wiley-Interscience Publication, 1980 (Chapter 1).