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# Solar Still Coupled with Evacuated Tube Collector

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***Abstract:*** ***World population is increasing day by day at a very fast rate. There is a high need of fresh water for mankind. There are many regions in the world where people are forced to consume polluted water due to lack of availability of fresh water. In this article, the performance of passive solar still is investigated. Single slope solar still integrated with evacuated tube is fabricated with the basin area of 0.48m$^2$. This solar still is efficient than the traditional one due to the integration of evacuated tube which provides supplementary thermal energy.***

***Keywords:*** ***Brackish water, solar desalination unit, solar still, evacuated tube, glass cover***

## I. INTRODUCTION

Water is a basic necessity for human mankind. But most of the accessible water is seawater or iceberg in the polar region. This contributes to approximately 97% water which is salty and not useful for drinking purpose. Out of which only 1% fresh water is within reach of mankind. Due to the rapid growth of population and industries, its availability and portability is decreasing day by day that's why more than 1.2 billion people still have no access to safe drinking water. Due to this, there are many health issues such as human disease, waterborne disease, etc. Nearly 70% of infectious diseases in India are waterborne. So there is a need of fresh water from available salty resource. There are various water treatment techniques which can be used for water treatment. Desalination is one of them. Many desalination techniques have a harmful effect on the environment due to their dependency on the conventional source of energy. Conventional source of energy leads to an increase in worldwide average temperatures, rising sea level and melting of glaciers, etc. All these problems could be resolved by the organized exploitation of renewable energy resources (solar energy, wind energy, geothermal energy, etc). The energy from the sun is available at every place free of cost. Hence the use of solar energy in the form of solar still is the best solution for rural and urban areas. Numerous researchers has performed experimental and numerical studies well organized in review articles (Chandrashekara M , Avadhesh Yadav, 2017) [1], (Kuldeep H. Nayi , Kalpesh V. Modi, 2018) [2], (K.S. Reddy, K. Ravi Kumar, Tadhg S. O'Donovan , T.K. Mallick, 2012) [3], (H. Sharon, K.S. Reddy 2015) [4].

(L. J. Shah & S. Furbo, 2004) [5] made a comparison of flat plate collector and evacuated tube collector. It was found that ETC is best for solar radiation collection because it utilize solar radiation from all direction. (Reddy, et al, 2012) [3] studied the performance of multistage solar still with evacuated tube collector. They explained various parameters such as the number of stages, the gap between stages, supplied mass flow rate which comes 4,100mm, 55 kg/m$^2$d$^{-1}$ respectively. Maximum distillate yield of 53.2 kg/m$^2$d$^{-1}$ is obtained at acting pressure of 0.03bar. Keeping the above studies in consideration the objectives of the present work is to evaluate the solar still productivity by:

1- Coupling the Solar Still with Evacuated tube and evaluating its performance.

## II. EXPERIMENTAL SETUP

A water desalination unit was designed and fabricated at DEPARTMENT OF MECHANICAL ENGINEERING, IMSEC GHAZIABAD (Latitude 28.6692$^0$ N, Longitude 77.4538$^0$ E) and experiments were performed in April 2019. A simple solar still was fabricated and coupled with evacuated tubes. Four evacuated tubes were used.

The solar still was made of aluminum sheet and was insulated from the environment with the help of glass wool. The basin area of the solar still is 0.48 m$^2$ (0.6 m width × .8 m Length). High-side wall depth is 660 mm and the low-side wall height is 200 mm. A schematic diagram of the setup is shown in Fig 1 Basin of solar still is coated with black paint for better absorptivity. Evacuated tubes are coupled with solar still.

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Fig. 1 Diagram of experimental setup

A seal is also provided in order to prevent leakage. Solar cover fitted in frame tilted of at $28.5^0$ angle. Evacuated tube also tilted at $28.5^0$. Solar still coupled with evacuated tube was placed on a movable wooden stand. Inlet port is given to solar still for the supply of brackish water. A collector was attached at the low side of solar still so that water vapors slide on the glass cover and after condensation could be collected in collector. This distillation yield was collected in the measuring jar with the help of pipe through provided outlet. Firstly basin and evacuated tubes were filled with brackish water up to the required water depth. The evacuated tubes consist of two concentrating borosilicate glass tube with evacuated space between them. The water inside the inner tube gets heated and moves toward the basin and cold water comes inside the tube. Due to this thermo-siphon process water in solar still gets heated and evaporation rate in solar still get increased. The main advantage of evacuated tube over other collector is zero convective loss and no requirement of the tracking system. The details are given in Table I and Table II :

| Solar still | |
|---|---|
| Area of basin | 0.48m2 |
| Material | Aluminum |
| Thickness | 0.0015m |
| High side: low side | 3.3:1 |
| Glass cover | |
| Thickness | 0.0035m |
| Inclination | $28.5^0$ |
| Insulation | |
| Material | Thermocol |
| Thickness | 1inch |

Table I design parameter of solar still

| Evacuated tubes | |
|---|---|
| Outer diameter | 4.5cm |
| Inner diameter | 3cm |
| Length | 150cm |
| Number of tubes | 4 |
| Inclination | $28.5^0$ |
| Center to center spacing | 12cm |

Table II design parameter of evacuated tube collector

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## III. RESULT AND DISCUSSION

At the beginning of the experiment, tap water is filled in the basin up to 5 cm height through the inlet pipe. The experiment is performed after 24 hours of assembling the glass cover, so as to enable the setup to reach the steady state condition. For each experiment, the glass cover is cleaned in the morning to avoid the dust deposition over the outer layer of the glass. The extensive experiments were conducted on the month of APRIL 2019. The readings were taken from 10 AM in the morning till 5 PM in the evening at hourly intervals.

Date: 12/04/2019 Time: 10.00 AM to 5.00 PM
On the basis of observation taken, the following graphs is drawn:

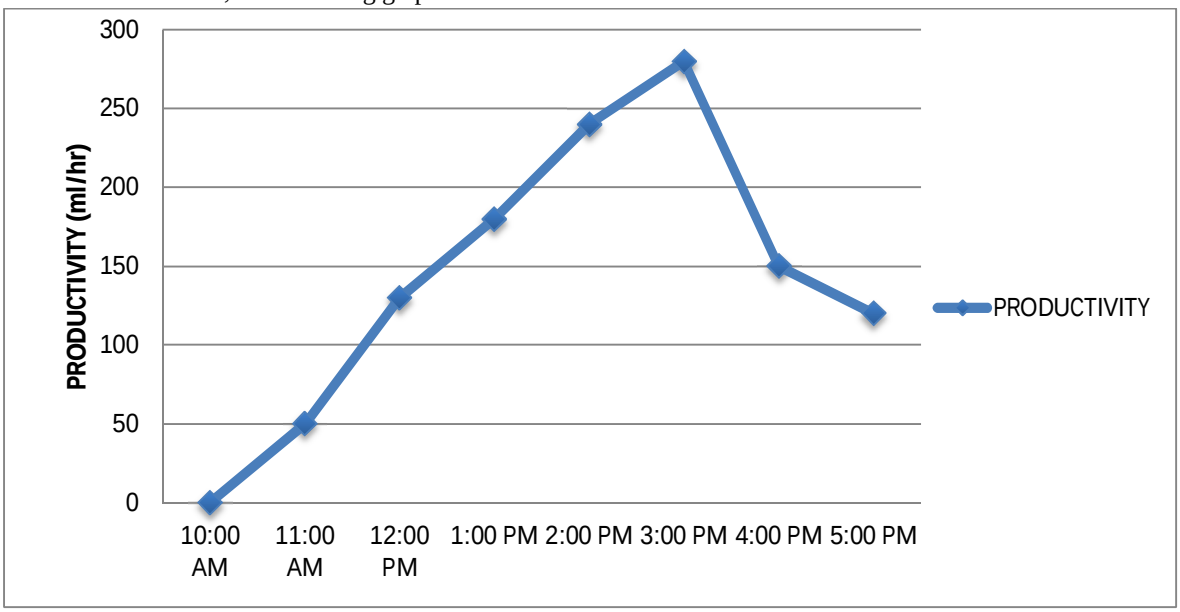


Fig. 2 Graph for productivity vs. time on day 1

Date: 13/04/2019 Time: 10.00 AM to 5.00 PM
On the basis of observation taken, the following graphs is drawn:

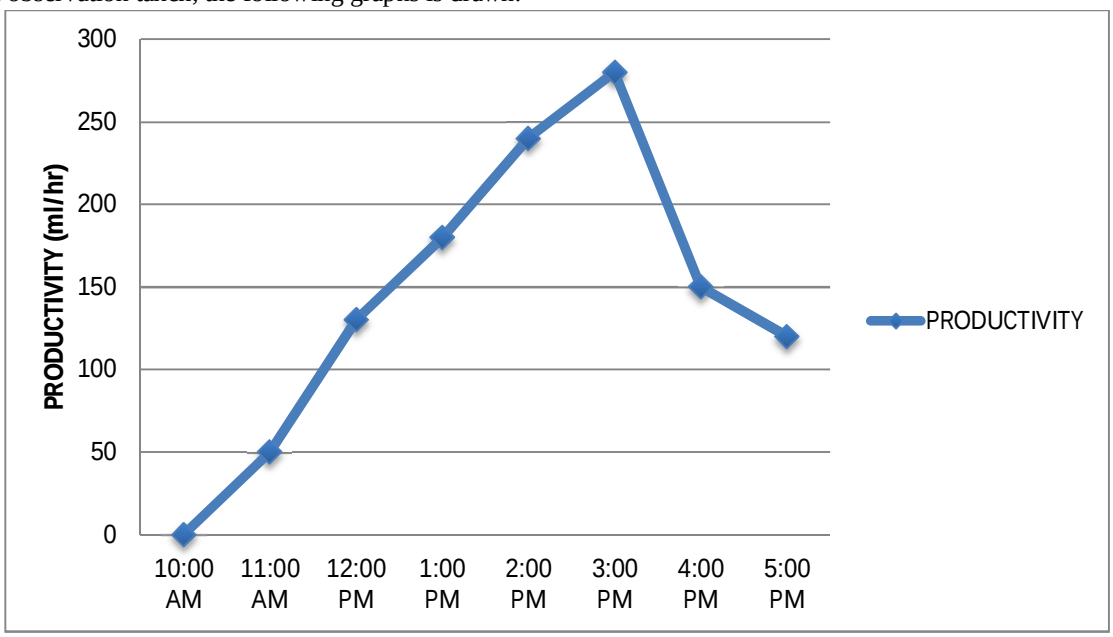


Fig. 3 Graph for productivity vs. time on day 2

Date: 15/04/2019 Time: 10.00 AM to 5.00 PM

On the basis of observation taken, the following graphs is drawn:

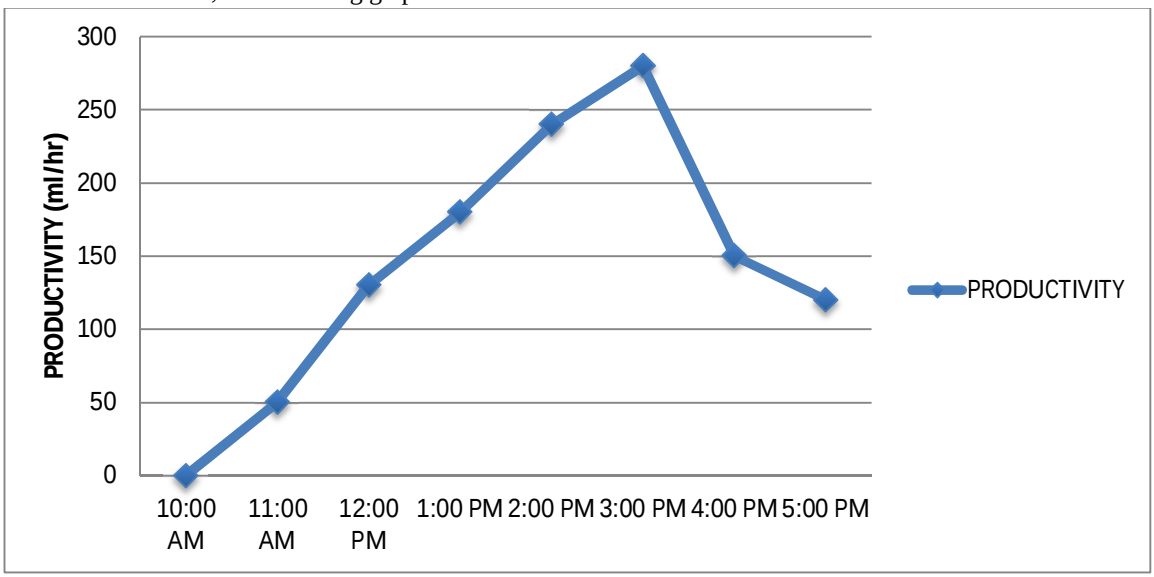


Fig. 4 Graph for productivity vs. time on day 3

From the above results, it is concluded that maximum water distillate is obtained between 3:00 PM to 4:00 PM and we know that solar radiation is maximum at 12:00 PM. This time lag is due to evaporation and condensation.

The main objective of this work was to improve the performance of ordinary still. The ordinary still was coupled with evacuated tube and tested with outdoor condition.

By comparing these results of solar still with ETC tube with solar still alone, the following results were obtained:

For day 1 the volumetric flow rate of solar still with evacuated tubes was 46.7 % more than solar still alone.

For day 2 the volumetric flow rate of solar still with evacuated tubes was 48.5 % more than solar still alone.

For day 3 the volumetric flow rate of solar still with evacuated tubes was 50.1 % more than solar still alone.

## IV. CONCLUSIONS

The various conclusions coming out of this study are presented below.

*A.* Solar distillation is a better alternative for saline water desalination because it is simple and clean technology with free energy.

*B.* The orientation of the glass cover depends on the latitude of the place that's why for northern latitude south facing and southern latitude north facing stills are used.

*C.* the glass has the properties such as higher transmittance, wetting property with water have less transmittance loss for solar radiation during condensation and higher thermal conductivity that's why glass is highly suitable for the cover.

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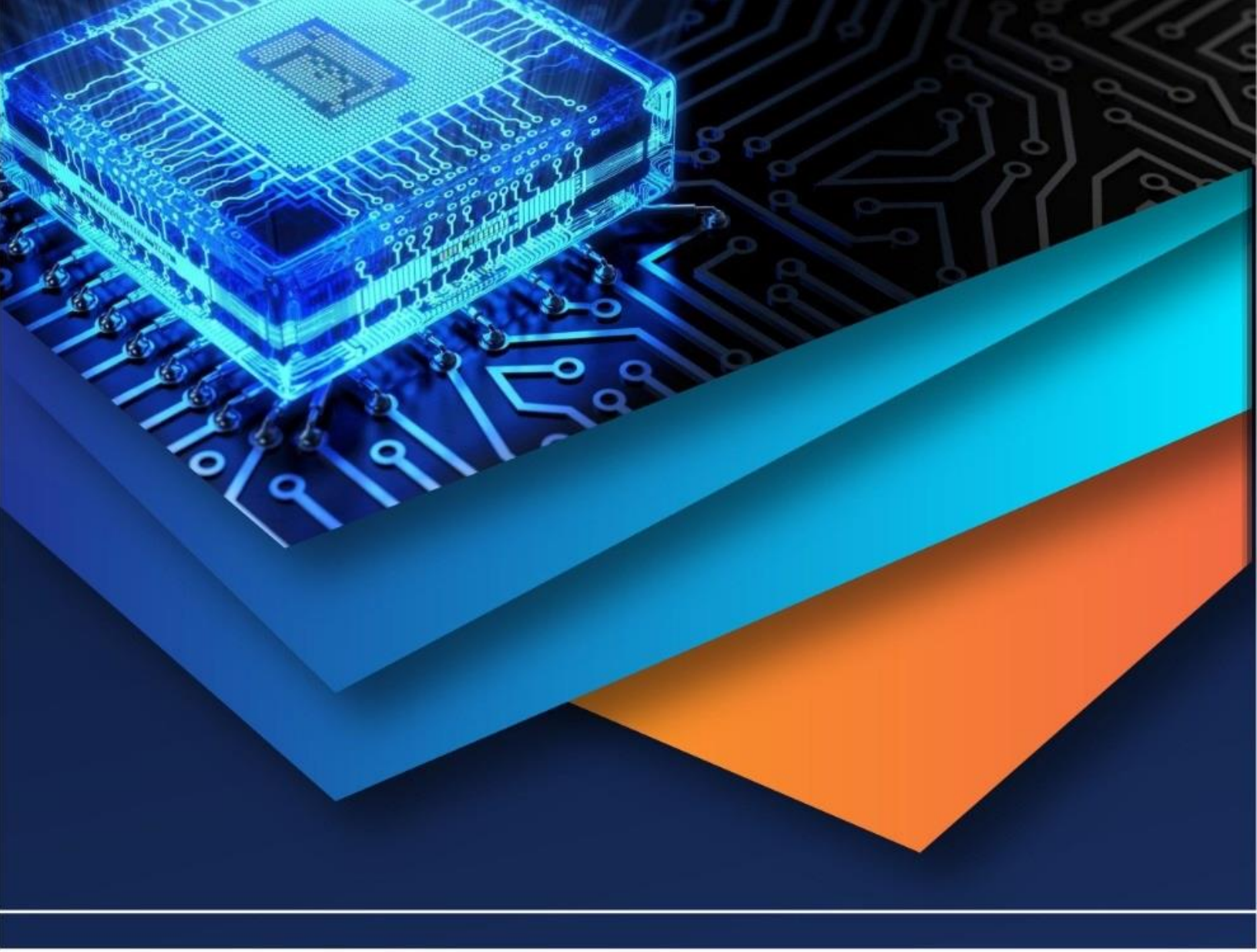

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