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PERFORMANCE ANALYSIS OF SOLAR STILL WITH MODIFIED ABSORBER PLATE

Aravind U.P[1], Kalaivanan .R[2], Saravanan .S[3]

[1]*P.G. Scholar, Energy Engineering Management, Annamalai University, Tamilnadu, India*
[2]*Professor, Dept. of Mechanical Engineering, Annamalai University, Tamilnadu, India*
[3]*Associate Professor, Dept. of Mechanical Engineering, Annamalai University, Tamilnadu, India*

Abstract – *Water is essential to human life. In the last two decades the solar energy is used for many applications in which the solar still are used for producing distilled water. The solar still is also used in purifying the saline and waste water. There are number of ways like reverse osmosis, membrane filtration and electro dialysis for purification of water compared to the above said purification process; the solar energy is the most economical one for the water purification. An attempt has been made to construct two type of solar still of 0.186 m² basin area. Type I made of toughened glass black coated at the bottom and Type II copper plate coated black is placed below the glass still and form modified absorber. The experimental results shown that the performance is improved in Type II solar still compared with Type I solar still.*

Key Words: Solar distillation, copper sheet, black paint coated, distillate output

1. INTRODUCTION

More than two-third of the earth's surface is covered with water. Most of the available water is either present as seawater or icebergs in the Polar Regions. More than 97% of the earth's water is salty; rest around 2.6 % is fresh water. Less than 1% fresh water is within human reach. Even this small fraction is believed to be adequate to support life and vegetation on earth.

As the available fresh water is fixed on earth and its demand is increasing day by day due to increase in population and rapid increase of industry, there is an essential and earnest need to get fresh water from the saline or brackish water present on the earth or inside the earth. This process getting fresh water from the saline / brackish water can be done easily and economically by desalination.

According to World Health Organization (WHO), the permissible limit of salinity in water is 500 ppm and for special cases up to 1000 ppm while most of the water available on the earth has the salinity up to 10,000 ppm whereas seawater normally has salinity in the range of 35,000-45,000 ppm in the form of total dissolved salts.

Nature itself provides most of the required fresh water, through hydrological cycle. A very large-scale process of solar distillation naturally produces fresh water. The essential features of this process are thus summarized as the production of vapors above the surface of the liquids, the transport of vapors by winds, the cooling of air vapors mixture, condensation and precipitation. This natural process is copied on a small scale in type solar stills.

In their thirst for water, people have looked longingly throughout history at this endless supply. Some brackish, or slightly salty water, is found inland. Today, more than ever, many people believe that desalting ocean water and brackish water holds the answer to the ever-increasing demand for fresh water in many areas.

The salt in seawater is mostly the same substance as common table salt. A person can safely drink water that contains less than ½ pound of salt to 100 pounds of water, or 0.5 kilogram of salt to every 100 kilograms of water. But seawater has about seven times this amount of salt. A person who drinks only seawater will eventually die. The body cells will dehydrate as they try to get rid of the excess salt from the seawater. Nor can people use seawater in agriculture or industry. It kills most crops, and quickly rusts most machinery.

People have found many ways to desalinate, the process for removing salt from seawater and brackish water. Desalination offers hope of relieving water shortages near the seacoasts. However, desalination does not hold the answer to all of the earth's water problems. Even if the oceans contained fresh water, people would still have to face such problems as pollution, flood control and water distribution. People are following many methods for water purification, the most common type of water purification process is solar distillation.

The use of solar energy is more economical than the use of fossil fuels in remote areas having low population densities, low rainfall and abundant available solar energy. The productivity of fresh water by solar distillation depends drastically on the intensity of solar radiation, the sunshine hours and the type of the still. The high intensity of solar radiation makes the direct use of solar energy a promising option for their arid communities to reduce the major operating cost for the distillation plant and energy utilizing water purification method is essential to ensure safe drinking water to all.

In the present work in order to test the performance of single slope solar still, two identical solar stills are made of toughened glass, in which one is coated with black matt paint at the outer surface and another one is modified absorber by

adding cooper plate coated black placed below the clear glass absorber.

2. LITERATURE REVIEW

Arunkumar et al, studied experimentally on various solar stills, converts the brackish water into portable water.

Prof. Alpesh Mehta experimentally studied single slope solar still, converts the brackish water into portable water.

El. Sebaii studied the effect of wind speed on the daily productivity of some active and passive solar stills using computer simulation for different sol.ar stills designs. He found that for the active and multi-effect passive stills the daily productivity increases with the increase of wind velocity up to a typical velocity, beyond after this the productivity becomes insignificant. For the single effect passive stills, he found that that there is a critical basin water depth beyond which the productivity increases as the wind velocity increases until the typical velocity. He concluded that the typical velocity is independent on the solar still shape and the mode of operation (active and passive) with some seasonal dependence.

Rajesh Tirupathi et al, studied basin water depth is having significant effect on productivity of basin. Investigation shows that the water depth is inversely proportional to the productivity of the still.

Anil Kr. Tiwari et al, studied experiment with deep basin reveals that, the productivity of still decreases with an increase in depth of water during daylight and the reverse is the case of overnight.

Tiwari et al., carried out a study and concluded that the single slope basin still gives better performance than a double slope in cold climate, whereas the opposite result was achieved in warm climates.

With heat storage (or) absorbing medium. Materials like black rubber, gravels, aluminum sheet etc. are used in basin solar stills which not only increase the basin solar radiation absorption but also increase the heat capacity of the basin due to their property of high heat storage capacity.

Phadatare and Verma conducted an experimental study on the effect of water depth on the internal heat and mass transfer in a single basin single slope plastic solar still. The plastic still was fabricated from Plexiglas. Based on experimental results, the authors concluded that the maximum efficiency of 34% was obtained for a still with a water depth of 2 cm with a distillate output of 2.1 L/m^2/day.

With heat storage (or) absorbing medium. Materials like black rubber, gravels, aluminum sheet etc. are used in basin solar stills which not only increase the basin solar radiation absorption but also increase the heat capacity of the basin due to their property of high heat storage capacity. Sakthivel and Shanmuga sundaram studied the effect of black granite gravel as a storage medium and found that, the still yield is increased17–20% compared with conventional still.

Jayakumar et al., An investigation was carried out on solar air heaters (SAHs) of different absorber materials. The experiments were conducted to establish the performance of both modified type with composite absorber (black painted GI absorber placed below the toughened glass) and conventional type (black painted GI absorber plate) for flows of air on either sides of schemes. In the modified type, mass flow rate of 0.0169 kg/s, has resulted in increased efficiency for top side, bottom side and both side flow. Compared to top side and bottom side flow, the efficiency was more in both side flow due to increase in the rate of heat transfer. The composite absorber in the modified type, higher solar radiation absorption has provided a larger amount of heat transfer to air.

3. COMPONENTS OF TWO SOLAR STILLS: --

Absorber plate: -

One Solar still specially having glass of 0.004 m thickness coated with black paint at bottom surface. Another one copper plate coated black same dimension of absorber plate is placed below the glass absorber plate. Due to the self-weight of the glass still the copper plate joined together without air gap and form modified absorber.

Side wall of solar still: -

Both the outer wall side of glass stills is also black painted to make as black body and ensured fitting and joints.

Glass wool: -

Insulation is provided at the bottom side of the solar stills using glass wool in order to restrict the heat transfer from basin to the atmosphere. The thickness of the glass wool is 0.02 m.

Thermocol insulation is provided on all four outer side walls of the solar stills with insulation material like thermocol in order to restrict the heat transfer from side walls to the atmosphere. The thickness of insulation is 0.01 m.

Fabrication: -

Each of the single slope solar still basin area is 0.186 m^2.

Fig -1: of solar stills

Table -1: specification of solar still: -

Time	WATER COLLECTION (ml)	
	Type-I	Type-II
9:30 AM	0	0
10:00 AM	0	50
10:30 AM	10	60
11:00 AM	60	75
11:30 AM	60	70
12:00 PM	60	65
12:30 PM	65	65
01:00 PM	120	130
01:30 PM	110	120
02:00 PM	65	85
02:30 PM	95	105
03:00 PM	70	85
03:30 PM	50	75
04:00 PM	45	60
04:30 PM	40	60

Length: 0.6m

Breath:0.6m

Slop of glass cover: 3°

Glass thickness : 0.004m

4. DATA REDUCTION: --

Experimental Efficiency :

$\eta = [(m*LH)/(Iss*As)]*100$

Where

M – mass of distillate water collected in kg/hr. m^2

LH – Latent heat of evaporation of water temperature in kJ/kg

I_{ss} - Solar intensity in kJ/hr .m^2

Solar intensity = [(Pyranometer reading/ pyranometer constant)]*100

A_s - Area of the basin in m^2

Pyranometer constant = $9.64 *10^{-6}$ v/Wm^{-2}

5. EXPERIMENTAL ANALYSIS OF SOLAR STILL: -

The two identical single slope solar still are fabricated. One is ordinary single slope solar still (black paint coated absorber) and other is Type II solar still (copper sheet as absorber) both with area 0.186 m^2 are fabricated and are placed in the north to south direction to obtain maximum solar intensity throughout the day for the experimental analysis.

In this setup the analysis tested with three different quantities of water of two different types of water in six different days.

In this study various operating conditions have been examined such as glass cover outer and inner temperature. Basin inner and outer temperatures, atmosphere temperature, basin water temperature, still air temperature, solar intensity, wind velocity and distillate productivity are measured. The total distillate productivity and solar intensity for each day are also measured. Also different experimental tests are carried out at different ambient conditions.

Experiment 1: Bore water 2 lit quantity

In this experiment the two basin are to be filled with bore water up to 2 lit quantities. Measurements are made on 25-3-2019 from morning 9.30 am to 4.30 pm

Experiment 2: Bore water 2.5 lit quantity

In this experiment the two basins are to be filled with bore water up to 2.5 lit quantity. Measurements are made on 26.03.2019 from morning 9.30 am to 4.30 pm

Experiment 2: Bore water 3 lit quantity

In this experiment the two basins are to be filled with bore water up to 3 lit quantities. Measurements are made on 29.03.2019 from morning 9.30 am to 4.30 pm.

Experiment 4: Sea water 2ltr quantity

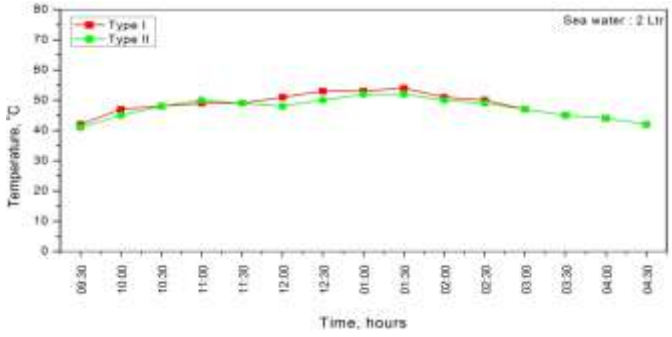
In this experiment the two basins are to be filled with sea water up to 2 lit quantities. Measurements are made on 02.04.2019 from morning 9.30 am to 4.30pm

Experiment 5: Sea water 2.5 lit quantity

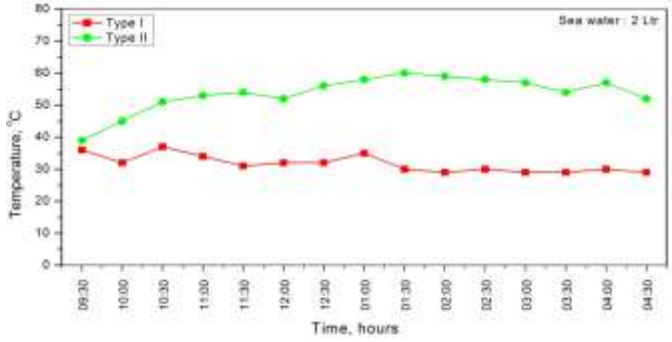
In this experiment the two basins are to be filled with sea water up to 2.5 lit quantity. Measurements are made on 04.04.2019 from morning 9.30 am to 4.30 pm.

Experiment 6: Sea water 3 lit quantity

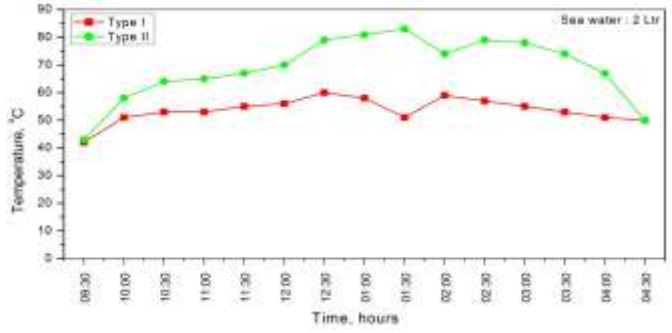
In this experiment the two basins are to be filled with sea water up to 3 lit quantities. Measurements are made on 05.04.2019 from morning 9.30 am to 4.30 pm.



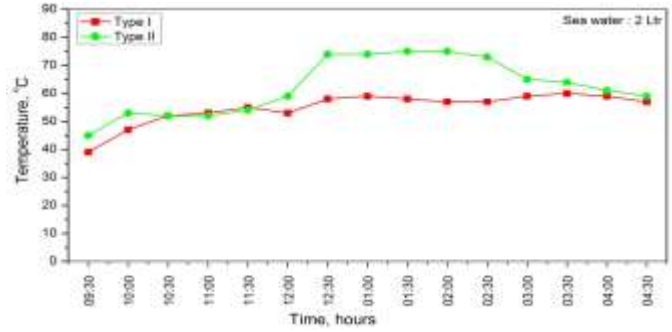
Graph-1: Time Vs Top cover glass plate temperature



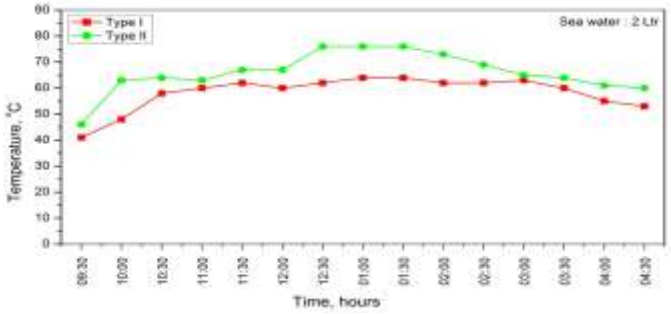
Graph-2: Time Vs Absorber plate temperature



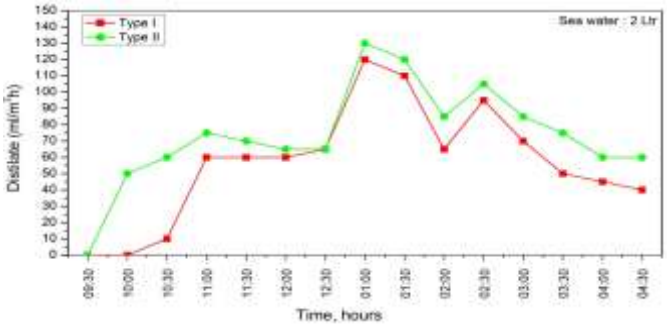
Graph-3: Time Vs Absorber plate temperature bottom side



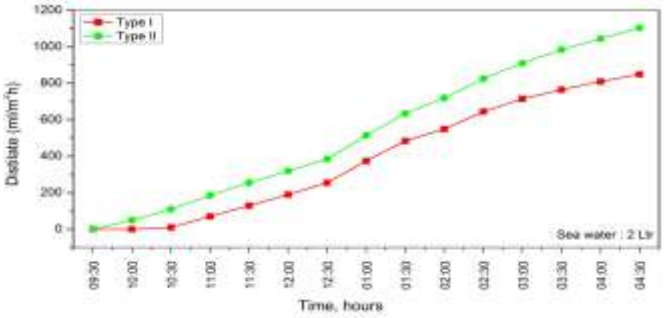
Graph-4: Time Vs Basin water temperature



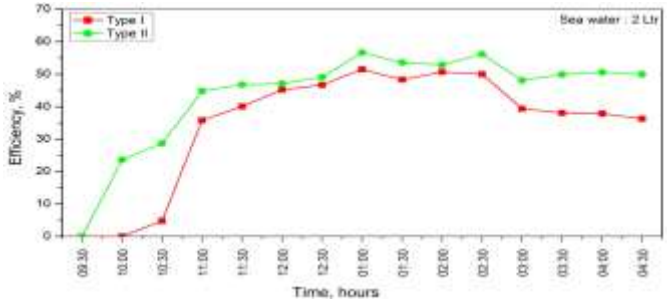
Graph-5: Time Vs Still vapours temperature



Graph-6: Time Vs Distillate water productivity



Graph-7: Cumulative distilled water productivity



Graph-8: Time Vs Experimental efficiency of the still

Time Vs Experimental efficiency of the still shows the variations of still experimental efficiencies are present in the two different types of solar still. The Efficiency of Type II solar still is higher than the Type I solar still from afternoon onwards.

6. CONCLUSIONS: -

- In this work two identical single slope solar still with Type 1 black coated at the outer surface and Type II copper plate coated black placed below the clear glass still and form modified absorber arrangement for constant absorber area 0.186 m^2 are fabricated and tested with two different types of water with various quantities(2000ml,2500ml,3000ml) in the basin.
- The variation of production rate, cumulative production and water, vapour, cover glass, absorber plate temperatures are analyzed.
- The results show that the Type II solar still is found to be more productive and overcome the problem of peeling of black coated in the glass of Type I solar still.
- Water collection of type-II solar still produce 0.25Lit more than that of type-I

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