Experimental study of double slope solar still with rotating cylinder

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Abstract*: *Solar still is cheap, environmentally friendly and one of best efficient solution of water scarcity and unavailability of drinking water. But major obstacle to their use is limited productivity of conventional solar still. Therefore, objective of this work is to increase productivity of solar still by modifications. Here we create Modified Double Solar Still (MSS) by adding rotating hollow cylinder in Traditional Double Solar Still (TSS). To increase the surface area of evaporation we put rotating cylinder inside the basin. We have filled water as cylinder was partially inside it. At very low speed hollow cylinder has been rotating inside basin. We have performed two experiments, first one for TSS which is without cylinder and second is for MSS which is with cylinder. Cylinder is rotating continuously, during rotation upper part of it in with direct contact with sun light and downward part inside water. Cylinder's upper portion can absorb heat from direct sun light and when it come downward, it can release heat inside water so that temperature of water rises rapidly and also rate of evaporation of water increase therefore it will become helpful to improve productivity of solar still. From the analysis of both the experiments, it is evident that productivity has increased 57% in MSS compared to TSS.

***Keywords*: Solar Still, Solar Water Distillation, Solar Energy, Renewable Energy.**

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I. INTRODUCTION

In the world around 2/3 of the total population which is four billion people are experiencing a problem of water scarcity for at least one month in each year. More than two billion people living in countries with insufficient water supply. [1] Solar energy has been most valuable and useful energy sources. With compare to other sources of energy, solar energy is an affordable, clean, cheap and most importantly environmentally friendly energy [2]. It is a very favorable resource to deal with the globalization challenges such as rising energy demand and water shortages. Lack of clean water is considered a major problem in a world that is deteriorating over time, due to climate change and population growth [3]. In civilized areas pure water is accessible, while in rural area there is a real shortage of drinking water. In addition to industrial enlargement, there are increasing the level of the contaminations in drinking water. Solar water distillation is used to produces clean water from undrinkable contaminated water and saline water. Technology of distillation of water energy consumes from the sun without the use of fuel which will reduce global emissions [4]. Radiation of solar heats and then evaporates the dirty water of the basin and separates it from impurities and salt. When water vapour and hit glass cover and latter returns as liquid droplets [5]. Researchers have been proven that solar distillate productivity have been increased through design, operational and environmental parameters. As environmental parameters like as solar radiation intensity, humidity, ambient air temperature is very difficult to control, we can increase productivity by design and operational parameters. [6, 7, 8]. Our next study on [9] researches, developments and its reviews on distillation of solar stills, which shows developments and researches on traditional solar still. The effect or impact of different configurations or designs of solar still is occurs in its productivity. With comparison of single slope solar still, pyramid type solar still has higher productivity and double slope solar still is more productive than single slope due to more surface area of glass cover [10, 11, 12]. Productivity of the double basin still is 40% more than productivity of the single basin solar still [13]. Efficiency of double slope solar still with North-South

orientation is comparatively higher than East-West orientation. Also double slope solar still with North-South orientation is higher than single slope solar still at same depth of water. As depth of water decrease productivity or amount of output water increase [14, 15, 16]. Various black absorbing materials or black colour paint absorb heat from direct sun rays and increase rate of water evaporation [17]. Optimum angle of glass cover is near to the angle of latitude of the experimental site. According to experimental place Anand, Gujarat we took angle of glass cover as 25 degree [18]. Thickness of glass cover also affects on solar still performance. Normally as glass cover thickness is lower, output of solar still will be increased. By this studies out of 3,4,5 and 6 mm thick glass 4 mm glass cover thickness is optimum [19, 20, 21]. By [22] this study we calculated heat loss and area calculation for double slope solar still for our modified solar still. To increase productivity of solar still we can put hollow cylinder inside solar still basin. Hollow cylinder rotate at very less speed so that heated surface of rotating cylinder can pass through water and water evaporate. Productivity of single slope solar still with rotating cylinder is more than single slope solar still without rotating cylinder. Reason behind it is force convection due to rotating cylinder [23]. Force convection can increase evaporation rate of water and ultimately increase productivity [24]. As we know productivity of double slope solar still is higher than single slope, we have introduced double slope solar still with rotating cylinder.

II. EXPERIMENTAL METHODOLOGY

A. *Experimental Setup*

Solar still consist frame of 0.40 mm thick galvanized iron sheet. Basin of solar still which can be filled by dirty water made by G. I. sheet. One hollow cylinder also made by galvanized iron sheet. Hollow cylinder 0.25 mm thick galvanized iron sheet installed on steel shaft with bearing

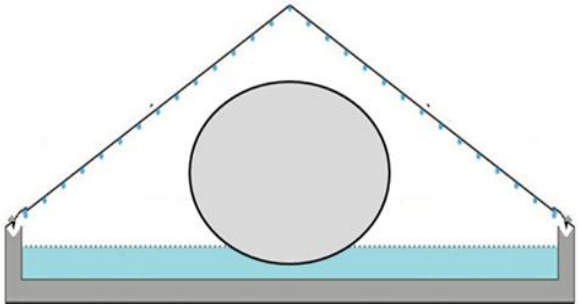

Fig. 1 Double Slope Solar Still with Rotating Cylinder

for providing rotation. Inner surface of basin and outer surface of cylinder coated by black paint. Reason behind black color coating is to absorb maximum amount of heat from sun light. As we know black color has ability to absorb heat easily and in greater amount. All the parts of basin are fixed with silicon glue to prevent water leakage. For providing insulation we used thermocol sheets with 30 mm thickness. We applied thermocol sheet to every side other than top to G.I Sheet basin by silicon glue. Top most cover of the solar still which is has thickness of 4 mm.

Fig. 2 Preparation of Working Model in workshop

Transmissivity of glass is 90% which is good for transmission of sun rays. To get desired output we provided 25 angles on both top side and we put glass on it. Glass cover is fixed on wooden frame. To collect water droplets PVC channels are used. PVC channel used to collect water from inner incline glass surfaces. This distilled water then pass-through PVC channels which were also at some inclination so that water flow gets collected in plastic tank.

B. *Experimental Procedure*

After doing all necessary arrangements of our projects we have assembled our project on terrace in front of sun light. As mentioned in research survey we used North-South orientation to get maximum output water. As latitude of Anand, Gujarat is 23 we took 25 angle to glass cover so direct sun rays applied on glass cover and maximum amount of evaporation was observed.

Fig. 3 Manual Rotating

Two different types of experiments were performed with double slope solar still. First one was without rotating cylinder and second one was with rotating cylinder. We filled 25 L dirty or high TDS water in basin. Then we put glass covers on both slopes. Also attached thermocol sheets on all sides of basin so that there was very less amount of heat loss during practical work

Second experiment was with rotating cylinder. In which we put hollow cylinder in basin area and gave very less continuous RPM to cylinder by manually. We prepared setup for manual rotating. As objective of our project, we have to

check either productivity of solar still increase or not by adding rotating cylinder in basin area.

III. Experimental Observation

We took readings of output water collected at every 1 hour 30 minutes for 12 hours per day from 8 A.M. to 8 P.M. At every 1 hour 30 minutes also we calculated temperature of input water in basin and quantity of output water in ml. In Table 1 and Table 2, time, temperature of input water and productivity of output water is shown.

Table 1 Experimental Observation of Traditional Solar Still (TSS)

Time	Temperature (^{o}C)	Productivity (ml)
8:00 am	29	-
9:30 am	32.5	-
11:00 am	37	15
12:30 pm	43	50
2 :00 pm	46	105
3:30 pm	48	180
5:00 pm	41.5	275
6:30 pm	36	320
8:00 pm	32	350

Table 1 shows experimental readings of solar still without rotating cylinder. At starting temperature of water is 29 C. At starting 1.5 hour we couldn't get water. Then slowly evaporation of water start & at 11 a.m. we got 15 ml pure water. At afternoon as temperature of atmosphere increased, temperature of water also increased and amount of pure water also increased. Between 2:00 p.m. to 3:30 p.m. we got maximum amount of pure water.

Table 2 shows experimental readings of solar still with rotating cylinder. At starting temperature of water is same as previous case. Also in starting 1.5 hour we couldn't get water. Then at 11 a.m. we got 25 ml pure water which was more than previous experiment At afternoon as temperature of water was highest at 3:30 p.m. which was 51 C. Also, between 2:00 p.m. to 3:30 p.m. we got maximum amount of pure water.

In first practical at the end of day we got 350 ml pure water and in second practical we got 550 ml pure water

Table 2 Experimental Observation of Modified Solar Still (MSS)

Time	Temperature (^{o}C)	Productivity (ml)
8:00 am	29	-
9:30 am	33	-
11:00 am	38	25
12:30 pm	44.5	80
2 :00 pm	48	180
3:30 pm	51	320
5:00 pm	43	440
6:30 pm	38	510
8:00 pm	34	550

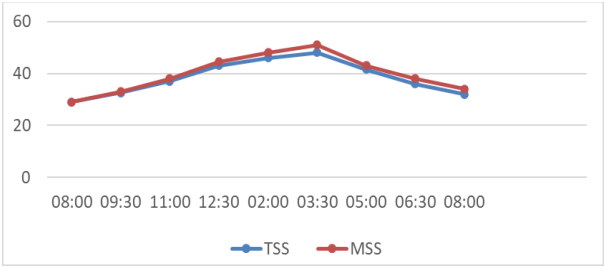

Fig. 4 Temperature vs Time

Fig. 4 shows relation of temperature vs time between traditional solar still and modified solar still. In both the cases temperature of water was same at starting. Then temperature slowly rise up to 3:30 p.m. Temperature of water was highest at 3:30 p.m. After that temperature was decreasing. If we compare both practical then we find that temperature of water was high in case of modified solar still by compared to traditional solar still.

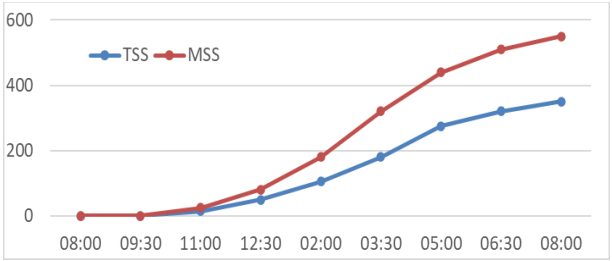

Fig. 5 Productivity vs Time

Fig. 5 shows relation of productivity and time between traditional solar still and modified solar still. Here by mean of productivity we are showing output pure water. Productivity was increasing with time. If we compare both

practical then we find that amount of output water was higher in modified solar still with comparison to traditional solar still.

IV. Result & Analysis

A. Water Quantity Analysis

In experimental observation we found that at the end of the day in Traditional Solar Still (TSS) we got 350 ml pure water and in Modified Solar Still (MSS) we got 550 ml pure water. In modified solar still quantity of water was 200 ml higher as compared to traditional solar still, which is around 57% more than traditional solar still.

B. Water Quality Analysis

Table 3 Water Quality Analysis

By our results, distill water we got from solar still is safe, drinkable and healthy which could be proved by result analysis.

	Input water	Output water
pH	7.6	7.0
TDS	750 ppm	50 ppm
Hardness	2.4 NTU	0.4 NTU

C. Cost Analysis

Table 4 Cost Analysis

Components	**Cost**
Galvanized iron sheet basin	500
Galvanized iron sheet drum + Steel Rod	300
Glass cover	350
Thermocol	150
PVC pipe	50
Black paint spray	150
Silicone glue	50
Total	**2150**

D. Payback Value

Cost of 1L water = 20 □
Daily water cost = 0.55 L * 20 □ = 11 □
No of Days = Total Cost / Daily Cost
= 2150/11
= 195.45 days
So, 196 days require to recover total cost of the modified solar still.

V. Conclusion

Efficiency of Modified Solar Still (MSS) is significantly increased by 57% as compared to Traditional Solar Still (TSS). So rotating cylinder with very low RPM can increase evaporation of water and ultimately increase output water. As compared to single slope solar still, double slope solar still and single slope solar still with rotating cylinder, double slope solar still with rotating cylinder has higher efficiency. Hence, it is advisable to use double slope solar still with rotating cylinder.

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