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Performance of an Active Still Coupled With CPC

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Abstract:

In all over world for past few years the demand of fresh water level has increased enormously, in order to overcome that problem the best replacement source is renewable energy (Solar Desalination), solar still desalination system offers sustainable tools for fresh water production. In last few years' desalination technologies are widely used in land based plants and ships In order to provide fresh water. However, this wide application is often hindered by their relatively low production rates compared to other desalination methods. The cost of desalination methods were started to decrease with the invention of new efficient technologies. Sunlight is one of the main sources that can be used to supply heat energy required by solar still. Its main advantage is that it has no fuel cost but desalination system required more space and generally more cost equipment. The solar desalination technologies allow only pure water to evaporate leaving behind the impurities in the basin. In this project, a solar still coupled with CPC which will lead to increase basin temperature as well as its efficiency and productivity of still. Eventually, when Compared to Single slope solar still distillation process the productivity of water can be achieved at higher rate.

Keywords: solar desalination, solar still, CPC.

I. INTRODUCTION

Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy, especially when other sources in the country have depleted. This solution is solar water distillation. However there are many challenges that must be overcome when considering solar energy usage. The main issue faced today with the implementing solar power is the extremely high capital cost involved with installing new solar power plants. Because solar power plants are more efficient in sunny climates and due to large space requirements, solar power plants are often designed in desert climates, sometimes miles from near the town. These present difficulties in transporting the produced electricity.

Desalination is one of the oldest technologies used by people for water purification in the world. To overcome the demand of fresh water could be solved only through efficient and effective utilization of renewable energy resource such as solar, wind, biomass, tidal, and geothermal energy, etc. In our India still the rural peoples are often to lack for access of clean drinking water. As increasing of our population rate the rate of fresh water level also increased enormously, so in order to overcome that problem the best replacement is solar desalination process. In this process sunlight is the main sources for providing heat energy required for still.

Solar Distillation process is considered to be one of the widely used techniques for converting saline water into fresh water. Two methods are commonly used for solar distillation direct and indirect method. Indirect method where as the sun heat the water which is fed into the evaporation chamber from an outside source, it begins to evaporate. However, only pure water evaporates, leaving behind impurities, including salts and waste. For an indirect method which runs one of the systems includes MEH, MSFD, MED and Reverse osmosis. The project mainly focuses on a solar still coupled with compound parabolic collector, which will lead to increase basin temperature as well as its efficiency and productivity of solar still.

II. LITERATURE SURVEY

A vast literature survey were carried out for this project, many of the researchers has been found maximum overall thermal efficiency and by using different collectors they has been found increases of productivity of still as well as efficiency. In past few years' desalination technologies are enormously used in land based plants and ships in order to provide the fresh water production from salinewater.

Although it can be rather expensive to build a solar still it required more space and generally more cost equipment, to overcome that cost new efficient technologies to be invented. Solar desalination process is one of the best replacement methods for fresh water production.

A.M. Rajesh, et al [1] has to perform a "single basin solar still integrated with a flat plate collector [FPC]". A single stage basin type solar still and a conventional flat plate collector were connected together in order to study the effect of augmentation on the still under local climatic conditions. The input of still was connected to a locally made fin tube collector. Experiments were conducted with and without coupling flat plate collector. Measurements of various parameters, temperatures, solar intensities and distilled water production were noted between 8 to 5 PM sunlight days. Enhancement in the yield is observed from this system 25 to40%

Ahmed et al.[2] has to been designed, fabricated and tested the "multistage evacuated solar still system that consists of three stages stacked on the top" of each other. And the results show that, the maximum production of the solar still was found in the first stage that is 6 kg/m^{2}and they suggested that the first stage is better when compared with second and third stages.

Badran and Al-Tahainesh [3] presented the effect of

"coupling a flat plate collector on the solar still productivity". He has been found that coupling of a solar collector with a still has increased by 36%. And also the results showed that, the output of the still is higher for the least water depth in the basin (2cm).

Hazim Mohammed Qibdawey.et.al [4] has presented the paper entitled "solar thermal desalination technologies". He has given the detailed explanation about the direct and indirect desalination technologies of solar still like vapor compression, multistage flash evaporation, membrane distillation etc. They said Evacuated glass tube collector is more useful compared with flat plate collector. And also they also suggested that, coupling a CPC can increase the temperature more than Evacuated glass tube collector and Flat Plate collector.

K. Sampathkumar, et al [5] were carried out the "solar still coupled with evacuated tubes" to enhance the productivity of the solar still. The experiments were conducted using tap water as feed. And he has been found that, after augmentation of the evacuated tubes, the daily production rate has increased by 49.7 % and it increased by 59.48% with black stone.

Prasad and Tiwari, [6] coupled a compound parabolic concentrator (CPC) to the basin of active solar still in which additional thermal energy at higher temperature was fed for production of maximum distilled water. This type of system is referred to as an active solar system. From experimental results it was concluded that the rate of thermal energy release increases with increase in glass cover inclination and also increasing the yield rate of still as well as increasing the efficiency.

Rai and Tiwari [7] describe about "The transient performance of a single basin solar still coupled with flat plate solar collector" the journal inferred that the average daily production of the distilled water has 24% higher than single basin solar still. From their study shows that, the rate of daily distillate deceases with the salt concentration.

Shatat and Mahkamov [8] studied the "Performance of a multistage water desalination still connected to a heat pipe evacuated tube solar collector". The author has been found and show the system has been produced about 9 kg of fresh water per day and has a solar collector efficiency of 68%.

T.Arunkumar, K.Vinothkumar et.al [9] conducted "experimental study on a CPC tubular solar still tied with pyramid solar still". The author has been showed that the maximum output extracted from the proposed system the overall efficiency of the system is calculated as 17.01% for without cooling and 21.14% for with cooling.

Yadav [10] has been studied the performance of a "solar still coupled with a flat plate collector using thermosyphon mode and forced circulation mode" for New Delhi climatic condition. He has been found that, the system using the forced circulation mode gives 5– 10% higher yield more than that of the thermosyphon mode and 30–35% enhancement in the yield has been observed with simple solar still. And he suggested that the forced circulation mode is better when compared with thermosyphon mode.

The summary of literature survey after studied of various papers, many researches are being carried out still has to been coupled with collectors and they have been found and proved to increases the productivity of the still as well as efficiency, so from my project the paper entitled the solar desalination technologies the author suggested that the coupled of CPC give higher basin temperature when compared with flat plate and evacuated tube collectors. And the various active methods and passive methods are being carried out by many researchers, so in my project work is based on still coupled with CPC by using an active method because,

Passive method: There is no extra thermal energy is fed into the basin so the temperature on basin is low and the productivity is comparatively low.

Active method: Extra thermal energy is fed into the system, so it will increases the basin temperature as well as increases the evaporation rate and to increase the productivity of solar still.

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III. EXPERIMENTAL SETUP

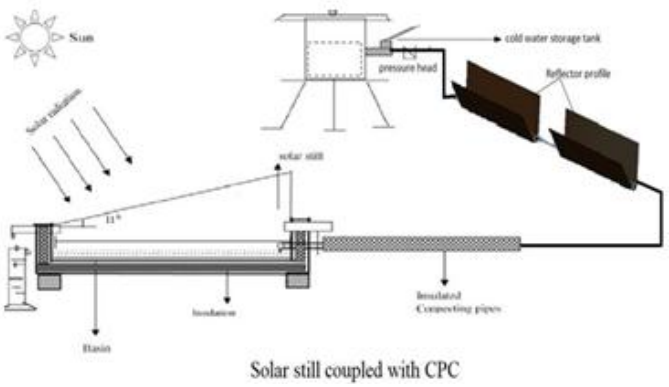

Fig. 1: Schematic of experimental setup

The experimental setup of the system is shown in Fig 1. The distilled yield extracted from both CPC tubular solar still and Single slope solar still. The single slope solar still is directly coupled with compound parabolic concentrator (CPC) through an insulated pipe. The cold water from the water tank is passed to cool the tubular cover of the still through inlet. The heat energy gained from the top cover cooling process is extracted through outlet and stored in the basin of four sloped solar still. The basin water temperature is raised to a maximum level within a short period, the operating temperature of the still becomes higher and distillation has been started. Due to increasing of basin temperature inside solar still evaporation rate also increased and the rate of water outlet is increased by coupling with CPC. As well as the radiation falls on the surface of the single solar still which keeps the temperature at a constant level than it reduces through convection. The condensate yield is started to increase due to the temperature difference between water in the basin and top cover of the pyramid still top cover temperature is decreased by cold water flow over it. Thus the temperature difference is wider and produces a distillate yield to a larger quantity.

Fig. 2: Solar still coupled with CPC Arrangement

Technical Specifications of Solar still

S No	Components	Dimensions
1	Basin Area	0.5 m^2
2	Glass Area	0.7 m^2
3	Glass Thickness	4 mm
4	Number of Glass	1
5	Slope of Glass	11°

Experimental procedure

From the sun solar radiation is transmitted through a glass cover to the water in the basin. And the basin water gets heated up, it get evaporated and condense in the inside layer of glass cover, then the condensed water flow down the cover due to slope of glass and finally it reaches the channel and near the channel jar to be placed, and finally water is collected by the jar. where initially before starting experiment water to be filled inside the basin up to 5cm height through inlet pipe, readings to be taken from 9a.m to 5p.m.by using thermocouple we have to measured water temperature (Tw), basin temperature (Tb), vapor temperature (T_V), inner glass temperature (T_{gi}), outer glass temperature (T_{go}), ambient temperature (T_a).the 1st set of experiment were conducted single slope solar still alone the productivity to be measured.

The 22nd set of experiment were conducted for single slope solar still coupled with CPC, initially from the CPC water to be heated with help of solar radiation and the heated water get input to solar still, from active method extra thermal energy fed into the basin and also from the sun solar radiation is also transmitted through a glass to water in the basin. Due to increasing of basin temperature evaporation rate get increased and it get condensed the condensed water flow down the cover due to slope of glass and finally water is collected by the jar. Readings to be taken from 9a.m to 5p.m. by using thermocouple we have to measured water temperature (Tw), basin temperature (Tb), vapor temperature (T_V), inner glass temperature (T_{gi}), outer glass temperature (T_{go}), ambient temperature (T_a). Productivity can be calculated. The productivity enhancements were compared with the first experimental setup.

Technical Specifications of Solar still coupled with CPC

S No	Geometric Parameters	Dimensions
1	Half acceptance angle	60°C
2	Geometric concentration ratio	0.66
3	Aperture area of the module	0.75 m^2
4	Reflector Height Length 1.73 m	0.05 m
5	Reflector Width	0.18 m
6	Reflector Reflectivity	0.85
7	Glass tube diameter	56 mm
8	Glass Thickness	2 mm
9	Collector Length	1795 mm
10	Absorber Material	Copper

IV. RESULT ANDDISCUSSION

Based on the observation graph to be drawn for single slope solar still alone:

From the graph (Fig 4) shown as the varying time with hourly water output with use of CPC, where the maximum water gets at 2.00 P.M output of water is 220 ml and the whole day it comes around 1.644 lit. Compared with CPC and Without CPC the o/p water rate is higher for use of CPC. So it gives higher productivity. When compared with normal single slope solar still.

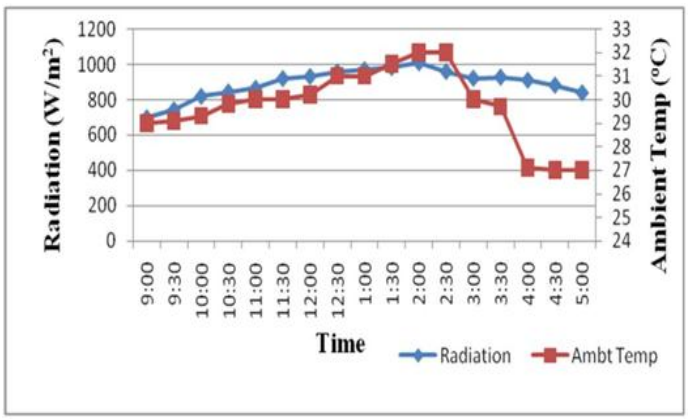

Fig. 3: Time Vs. Ambient Temperature Vs. Radiation

Based on the observation graph to be drawn for single slope solar still coupled with CPC:

Methodology: Measured Values of Single Slope Solar still

Time (min)	Solar Radiation (W/m^2)	Ambient Temp. (°C)	Tw (°C)	Tintenal air (°C)	Tg (°C)		Hourly output water ml/m^2	Effficiency (%)η
					Tgi	Tgo		
9.00	700	29	38	39	37	38	10	1.05
9.30	745	29.1	40	41	39	40	20	1.92
10.00	820	29.3	41	43	41	41	20	2.04
10.30	845	29.8	43	43	42	42	30	2.23
11.00	865	30	44	45	43	43	30	2.48
11.30	920	30	46	47	45	46	60	3.14
12.00	932	30.2	48	46	46	47	65	3.47
12.30	958	31	50	48	47	47	80	3.72
1.00	970	31	53	50	50	50	100	4.47
1.30	982	31.5	56	52	51	52	160	9.59
2.00	1010	32	58	56	55	56	180	12.45
2.30	960	32	57	55	55	56	110	10.21
3.00	922	30	55	54	52	54	90	10.05
3.30	928	29.7	53	52	50	50	70	9.92
4.00	911	27.1	53	51	48	49	65	9.75
4.30	883	27	52	50	45	45	50	9.08
5.00	840	27	49	47	44	45	60	9.21

Based on above 2 Readings single slope solar still and still coupled with CPC Calculations can be carried out and result to be discussed in the form of graphs for varying radiation, ambient temperature, Hourly water output, and Efficiency can be calculated.

Methodology: Measured Values of Single Slope Solar Still Coupled with CPC

Time (min)	Solar Radiation (W/m^2)	Ambient Temp. (°C)	Tw (°C)	Tintenal air (°C)	Tg (°C)		Tcpc		Hourly output water ml/m^2	Efficiency (%)η
					Tgi	Tgo	Inlet	Outlet		
9.30	890	29	38	39	37	37	31	33	10	1.6
10.00	878	29.4	40	41	39	38	34.2	35	10	1.91
10.30	925	30	44	46	42	40	37	38.5	30	2.63
11.00	940	30.2	49	50	46	44	39	40.8	60	3.86
11.30	955	31	52	53	50	48	41.8	43.5	80	4.24
12.00	972	31	57	56	53	51	44.7	46.1	110	5.95
12.30	980	32	61	59	58	55	47.5	49	135	6.42
1.00	994	33	65	62	62	60	50	52.1	150	7.08
1.30	1011	33	68	65	63	61	53	55	175	9.16
2.00	1025	34	70	69	66	64	56	58.7	220	15.77
2.30	1005	34	69	69	66	63	58.3	58.7	200	13.22
3.00	988	32	66	67	62	60	57.2	57.4	160	12.43
3.30	972	32	62	64	60	58	55.5	55	110	10.57
4.00	965	30	59	60	57	56	49.3	49.9	70	9.98
4.30	960	30	55	57	54	53	48	48.6	60	9.64
5.00	930	29	50	51	48	50	45	46	40	9.34

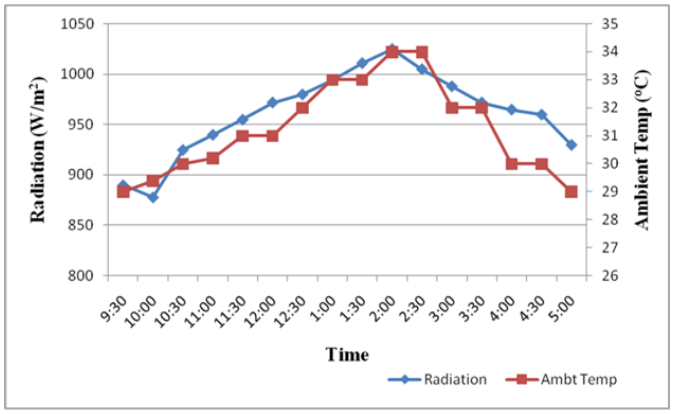

Fig. 4: Time Vs Ambient Temperature Vs Radiation

The maximum ambient temperature is 34^{o} C and Maximum Intensity is 1030 w/m^2at 2.30 P.M

Based on the observation graph is drawn for Comparison of Efficiency with SSSS and Still coupled with CPC

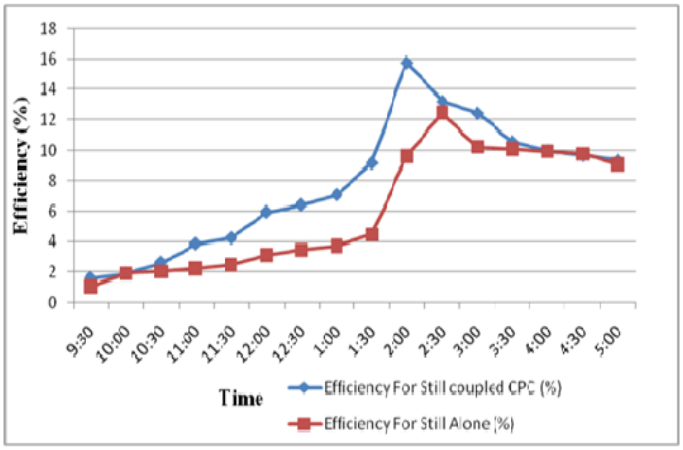

Fig. 5: Time Vs Efficiency

Based on the observation graph is drawn for Comparison of Hourly water O/p for without CPC and with CPC (ml)

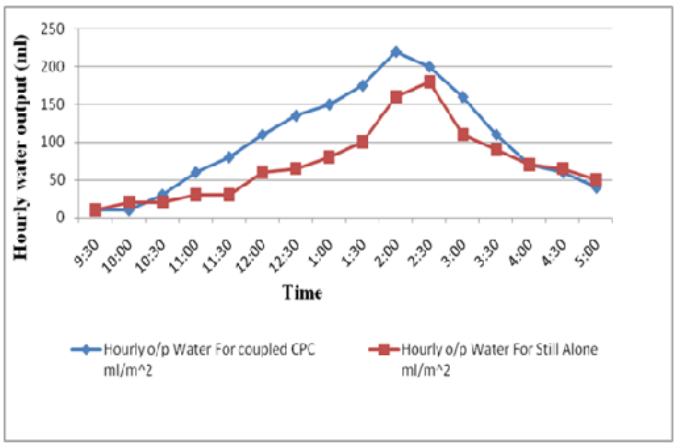

Fig. 6: Time Vs Hourly water output (ml)

V. CONCLUSION

Experimental Analysis was done for single slope solar still coupled with Compound Parabolic Collector is studied and its efficiency is calculated. The temperature of the saline water in the basin can also be increased through the addition of external heating. It is completely different than that of other substitution effect to increase the temperature of basin water. Total heat loss from lower basin still is transfer to the upper basin which increases the evaporation rate and to increases productivity of water. These results showed that the maximum output extracted from coupled CPC is 1.644lit/day and the Productivity was being found to be 0.2230 kg/m^2hr. The water output rate is higher as compare to Single slope solar still. It is easy and very convenient process of distillation

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