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Enhancing the Performance of Multi Slope Multi Basin Solar Still

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ABSTRACT: Solar still is one of the best solutions to solve water problem in remote arid areas. High amount of brackish water is available in nature. The salty water cannot be use directly for any purpose. Solar desalination is the natural process for converting saline water into pure water. Solar stills are used for the purpose of conversion of saline to drinking water. One of the methods to increase the productivity is by decrease the volumetric heat capacity of the basin. A layer of water with wick material in the basin will increase the evaporation area and enhance the production. A basin type Multi slope solar still with mild steel plate was fabricated and tested with minimum mass of water and different wick materials like pebbles, black granite, washed stone etc.

KEYWORDS: Solar Energy, Multi Basin Solar Still, Thermal conductivity through solar still

I. INTRODUCTION

Water is very important for the survival of human race. The plants and animals also need water for their existence. During recent times, the large scale industrial and agricultural development exerts much pressure on the existing water resources. About 97% of the water available in our planet is salty sea water. About 2% of water exists in frozen state in glaciers and polar regions. Only 1% of the water is available for human consumption. Solar stills of the basin type have been used for over 100 years due to their simple technology, easy operation and low cost. They are also pollution free and environment friendly. The most important drawback of single basin solar still is its low efficiency because of the loss of latent heat of condensation through the glass cover of the still. The productive capacity of a simple type solar still is in the range of 2–5 L/m²/day. This makes the system highly uneconomical. The distillation productivity of a solar still is significantly influenced by ambient temperature, insulation, wind velocity, dust and cloud ambient condition, saline water depth, salt concentration, inlet temperature of water, water and glass temperature difference, water free surface area, absorber plate area and glass angle.

According to Tiwari AK [1] Economic analysis of two small solar distillation plants coupled to fountain reservoir designed to meet drinking water requirement of 300 l/day for hot and dry climate of Jodhpur (India). Yousef MS [2] discussed a comprehensive exergetic performance investigation of a single slope a passive solar still system is theoretically presented. Energy and exergy methodologies have been applied for all components of the solar still comprising glass cover, brackish water, and basin-liner. Also, exergy irreversibility analysis was conducted to identify and localize the sources responsible for the exergy destruction and losses in the system for further analysis and improvement. The results showed that the maximum energy and exergy efficiencies of the proposed system are 32.5 % and 2.23 %, respectively. The maximum irreversibility or exergy destruction in each component, i.e. glass cover, saline water, and basin-liner, has been estimated as 61.1, 50.2 and 717 W/m², respectively, related to the maximum solar exergy input of 1005 W/m². Mashaly AF [3] study explains the model based on artificial neural network (ANN) was

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developed in order to predict the thermal performance of an inclined passive solar still in an arid climate, in which the thermal performance of the still was expressed as instantaneous thermal efficiency (ITE). Agricultural drainage water (AWD) was used as a feed for the desalination process, and this is considered a non-conventional water source. EL-Samadony [4] theoretically analyzed the radiation heat transfer rate inside a stepped solar still. The productivity of the solar still is found to be sensitive to the radiation shape factor particularly at low solar radiation of 200W/m² and glass cover inclination angle i.e. latitude angle of the site and vice versa. According to Rajaseenivasan [5] the maximum distillate of 1.27 kg/m² and 0.46 kg/m² was collected for glass basin solar still with charcoal and conventional solar still respectively. Alaiian [6] experimentally proved that the system productivity increased by more than 23% when pin finned wick is applied. Kabeel [7] demonstrated that the fresh water productivity reached approximately 7.54 L/m²/day for the solar still with PCM (phase change material). According to Omara [8] the water productivity of corrugated solar still with wick and internal reflecting mirrors was 145.5% higher than the conventional still. An experimental study was conducted by Deshmukh [9] on double basin solar still using evacuated tubes and reflector.

Shafii [10] studied a solar still equipped with thermoelectric models and evacuated tube collectors. The total daily efficiency of the system for cases of full evacuated tubes with/without propeller fan as well as half full case is calculated as 52%, 46% and 37% respectively. Park [11] showed that the productivity of the hybrid still increased linearly with increasing heat input, recording 18.02 kg/m² at 22.37 mJ/day. Kumar [12] used agitation effect and exhaust fan in the modified basin still and the output was 39.49% more than the conventional system. According to Morad [13] the active solar still (solar still integrated with flat plate solar collector) recorded the highest productivity of 8.52 L/m² day.

II. METHODOLOGY

The main source of the solar still is producing fresh water from salty water. Solar stills can be made into various modifications based on adding more basins, adding thermal conducting materials, adding various dyes, basin made of different materials, also by change the arrangement of basin etc. The production of the freshwater in the still depends upon various factors. First, the evaporation rate of the salty water inside the still basin and then based on condensation rate of the evaporated saline water by adding thermal conducting materials. The condensation rate depends on several parameters which are different among the still temperature and vapor temperature, the difference of the temperature between the still and the ambient temperature and the surface area of the still. In multi slope multi basin solar still consists of more basins are situated in different direction. In this case to improve thermal radiation, thermal conducting materials are added to increase heat convection. Then the setup made of thermal conducting materials is measured and the readings are noted. With the help of readings calculation and graph were made to show difference in efficiency range.

III. EXPERIMENTAL SETUP

In multi slope multi basin solar still the observation would be considered over the performance and based on the experimental setup made. This solar still has four slope and consists of four basin made up of galvanized mild steel sheet (3mm thickness) and covered with glass particles. The dimension of the slope is 55 x 100 cm² and the thickness of the slope is 15 cm each and the slopes are situated at suitable angle of 20°. The sheet metal is folded at three end of required dimension and one is free for heat circulation. At inside of basin some sheet metal is cut in to pieces and welded as layer by layer. It seems like a tray over array of several layers in one. The slope consists of this basin which would be situated over four sides opposite to each other and it is welded together. Then the glass particles were cut in to pieces and covered over the slope and sealed without any air gap occurs. The saline water is filled in the tray and a tube is outlet connected over the collector to collect fresh water. Due to the solar energy over the glass cover the radiation get enter in to the basin where evaporation and then condensation takes place. The saline water got evaporated and condensed as droplets of fresh water which is settled on the glass cover and collected over the tubes in a collector.

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To enhance the performance of multi slope multi basin solar still the additional slopes are added which is to be constructed between the slopes which increases the efficiency of water. This modification made to cover the area gap between the slopes which increases more number of basins to improve the water efficiency and the output is increased at high rate comparatively to the previous model. The slope is constructed with the measurement of $55 \times 120 \text{ cm}^2$ on each gaps which seems to be a triangular shape and finally the shape of the solar still is considered to be an octagonal shape respectively.

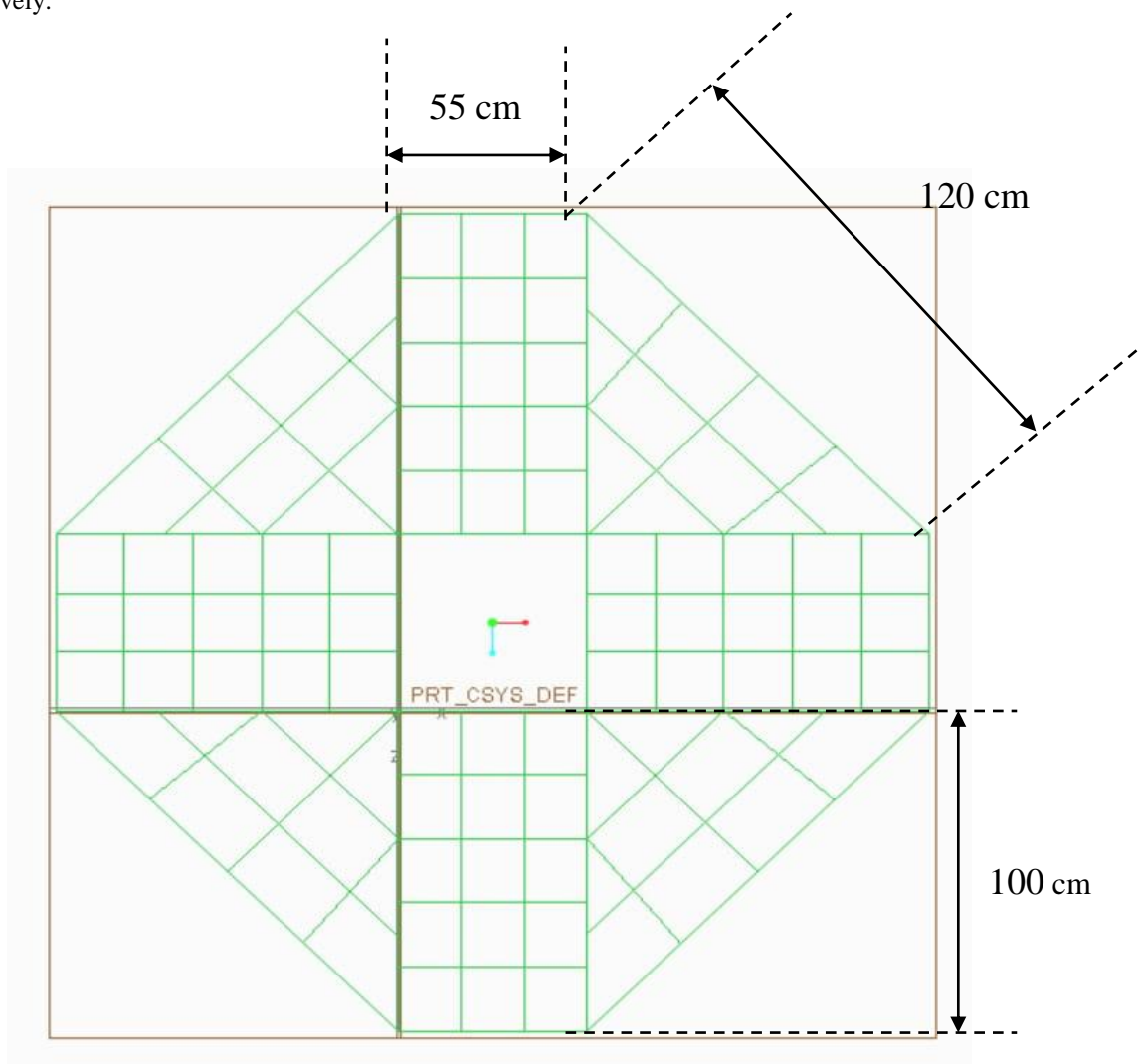


Fig 4.1 2D Layout of multi basin multi slope solar still.

Here we use some thermal conducting material such as pebbles, black granite, washed stone etc to increase the heat radiation faster and more. These materials are tested one by one and the readings are noted which is helpful to find the heat variation, efficiency and energy loss of radiation. The observation was made and the readings are collected one by one and the total efficiency can be calculated and the variation can be evaluated through the result analysis. Due to this modification the process Rate is increased in to double and we got more water with high efficiency and quick response.

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IV. RESULT DISCUSSION

TABULATION 1

COLLECTOR WITHOUT MODIFICATION (FOUR BASINS ALONE)					
S.NO	DATE	DESCRIPTION	INPUT WATER IN LITERS	OUTPUT WATER IN LITERS	EFFICIENCY%
1	12-03-2020	STILL ALONE	12	8	66.6
2	13-03-2020	STILL WITH PEBBBLES	12	8	66.6
3	14-03-2020	STILL WITH BLACK GRANITE	12	9	75
4	15-03-2020	STILL WITH WASHED STONES	12	10	83

TABULATION 2

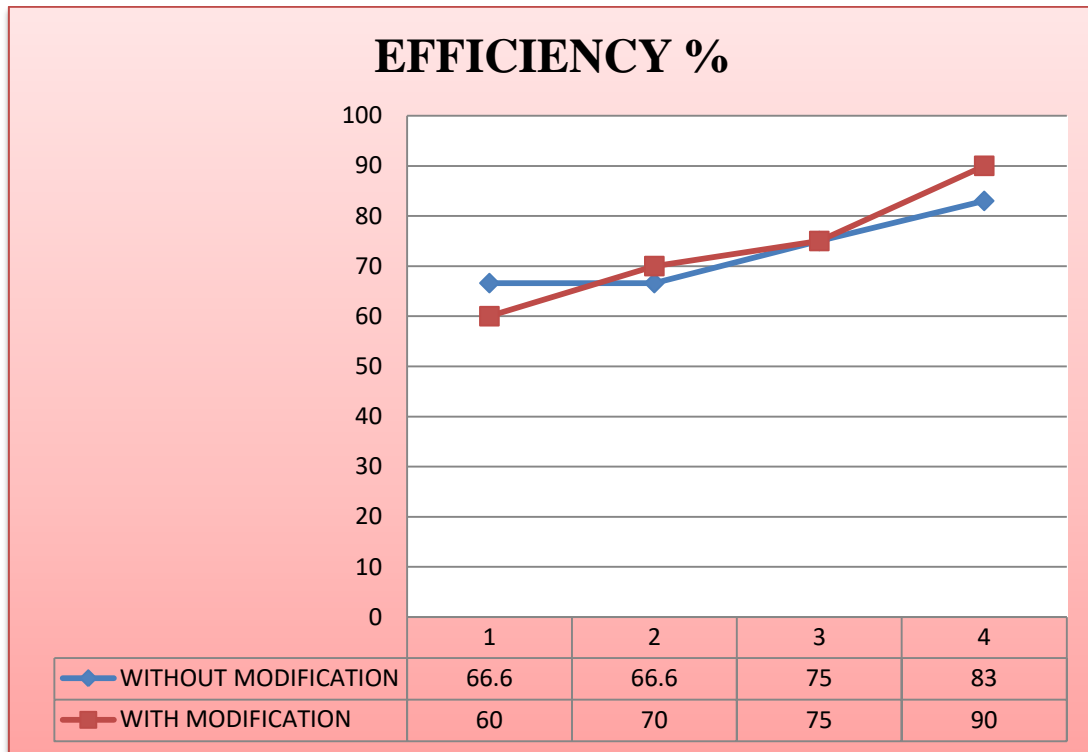
COLLECTOR WITH MODIFICATION (EIGHT BASINS)					
S.NO	DATE	DESCRIPTION	INPUT WATER IN LITERS	OUTPUT WATER IN LITERS	EFFICIENCY%
1	16-03-2020	STILL ALONE	20	12	60
2	17-03-2020	STILL WITH PEBBBLES	20	14	70
3	18-03-2020	STILL WITH BLACK GRANITE	20	15	75
4	19-03-2020	STILL WITH WASHED STONES	20	18	90

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V. CONCLUSION

Finally the multi slope multi basin solar still was fabricated with various modifications and its performance was measured and the efficiency is calculated. Multi slope multi basin solar still produce more water than other conventional solar stills. The performance was high due to addition of more basins and thermal conductivity materials respectively. The efficiency of multi slope multi basin solar still was measured and discussed through the readings and graph plotted. The efficiency among modified solar still is about 90% which is comparatively higher than solar still without modification is about 83% respectively. To yield the productivity rate high by adding thermal conducting material and proper maintenance required.

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