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# DESIGN AND FABRICATION OF MODIFIED SINGLE SLOPE SOLAR STILL WITH SOLAR POND

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## ABSTRACT

A single basin solar still with the area of 90 cm x 70 cm and slope $11^0$ was fabricated and tested at (11.9310° N, 79.7852° E) Villianur, Pondicherry, India. The inner surface was coated with black paint, fins were added to the basin and reflecting mirror was placed at the bottom surface in order to increase the heat transfer rate. A solar pond was also fabricated with top surface area 90 cm x 90 cm and bottom surface area 30 cm x 30 cm and fitted with fins at the bottom and reflecting mirror at the top to store more heat inside the solar pond. The Pond was divided into three zones upper converting zone (UCZ), middle converting zone (MCZ) and lower converting zone (LCZ) based on heat transfer rate. Experimental investigation was done on January, February and March of 2016. The readings were taken for 8 hours on each day. During daytime the high radiation strike on lower converting zone of solar still to produce the maximum output. An experiment was conducted on single basin solar still coupled with pond and the results are reported in this paper.

**Key words**: Efficiency, Reflectors, Solar pond, Solar still.

## INTRODUCTION

For existence of human race on earth water is the most wanted substance. There is a rapid increase in the demand for fresh water due to huge increase in population, more upcoming of industries and enhancement of agricultural production. The need for fresh water (potable water) has increased drastically from 15-20 liters/person/day up to 75-100 liters/person/day. Fresh water can be obtained by distillation process in a solar still. Various methods have been adopted to increase the solar still temperature thereby leading to an increase in the efficiency of solar still. The solar desalination method is a simple technology and required low maintenance cost. The basic principles of solar desalination are simple, yet effective, the solar radiation heats water to the point of evaporation. The water evaporates, water vapor rises, condensing on the top surface of glass surface for collection. This process removes unwanted impurities, such as heavy metals and salts. Al-Hamadani et al.[1] studied

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the productivity of solar still alone and an efficiency of 30% was observed. Velmurugan. V et al. (2007)[2] studied the performance of a solar still integrated with solar pond and productivity increased by 53%. Velmurugan. V et al. (2009)[3] studied stepped solar still with addition of fins to improve performance and obtained a productivity of 1.27 l/$m^2$. Velmurugan. V et al. (2009)[4] modified a solar still with addition of pebbles, sponge and obtained an increase in efficiency up to 65% and 68% respectively. Selva Kumar. B et al. (2008)[5] studied V type solar still with addition of charcoal and obtained an efficiency of 30.05%. Swetha K et al. (2013)[6] studied the performance of solar still modified by phase changing material with Laurie acid an efficiency of 36% was noted at the end of the study. T. Raja seenivasan et al. (2013)[7] studied single basin and double basin solar still with wick, porous and energy storing materials .The most productivity was noted when iron pieces were used as energy storing material. Sakthivel et al. conducted a study of regenerative solar still with addition of jute cloth as heat storing material. The modification increased the efficiency of still by 20%. M. Appadurai et al (2015)[9] did analysis of fin type solar still integrated with fin type mini solar pond. The productivity was found increased by 27.6% than conventional still. Ali. F. Muftah et al. (2014)[10] studied the factors affecting basin type solar still. The results indicate addition of a passive condenser to the still increases the total yield about 70%. Furthermore, integrating solar collector increases productivity by 36%.

## EXPERIMENTAL

A single slope solar still was fabricated. The still was made of wood with size 90 cm x 70 cm and depth 40 cm. A basin of the size 82 cm x 62 cm and depth 25 cm was kept inside the solar still. The basin was made with Galvanized iron [GI] steel and coated with black paint to increase the heat absorption. A fully reflective mirror was fitted at the bottom surface of the solar still and the solar radiation was reflected inside the mirror by a curved glass fitted at the bottom, which increase the heat transfer rate. At the Top surface of the solar still an angle of slope $11^0$ was maintained since at Pondicherry latitude and longitude angle is 11.9139° N, 79.8145° E.

**Fig. 1: Fabrication of solar still**

## Modification of solar still

The heat absorption was further increased by adding five rectangular fins of size 2.5 cm x 2 cm x 50 cm inside the basin. Glass wool, an insulation material was placed between two walls of the solar still to prevent heat loss to the surrounding atmosphere.

## Fabrication of rectangular solar pond

A solar pond in the shape of a rectangular pyramid frustum of size 90 cm x 90 cm at the top, 30 cm x 30 cm at the bottom and 120 cm height was fabricated by Galvanized iron [GI] steel. The solar pond was classified into three regions an upper converting zone (UCZ) 30 cm, middle converting zone (MCZ) 90 cm and lower converting zone (LCZ) 30 cm for calculation purpose.

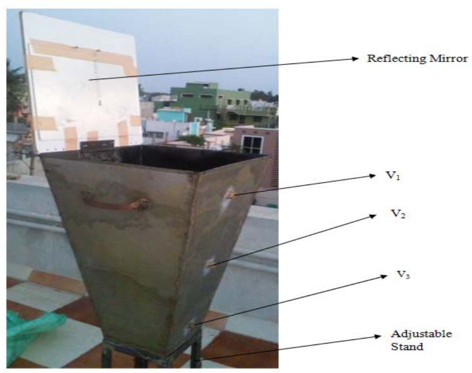


**Fig. 2: Fabrication of solar still**

To increase the heat transfer rate the solar pond was modified by adding cylindrical fins at the bottom surface. A reflecting mirror was fitted at the top surface, which can be rotated at various angles, to reflect more heat inside the solar pond. The outer surface of the solar pond was covered by glass wool, an insulation material. For increasing the thermal conductivity 1 kg salt was spreaded on bottom surface. Heat is transferred using copper tubes from all the three levels UCZ, MCZ, LCZ of the pond to the still and readings taken in each of the above cases shown in Figs. 3, 4 and 5.

## Selection of measurement parameters

### Solarimeter

To measure the solar intensity a solarimeter was used. The least count of the solarimeter was ± 1 W/m$^2$. The minimal experimental value = 40 W/m$^2$. Percentage error for solarimeter used in the experiment was found to be 0.5%.

**Fig. 3: Integration of solar still and solar pond on UCZ**

**Fig. 4: Integration of solar still and solar pond on MCZ**

**Fig. 5: Integration of solar still and solar pond on LCZ**

## Anemometer

The velocity of ambient air was measured using anemometer. The accuracy of the anemometer was ± 0.1 m/s. Minimal experimental value was 1 m/s. Percentage error for anemometer used in the experiment was 10%.

## Collection tank

Output was measured with a collection tank. The accuracy of the collection tank was ± 10 mL. Least experimental value = 100 mL. Percentage errors for collection tank used in the experiment were 10%.

## Efficiency

% Daily efficiency

= [Output/Input] x 100

Daily efficiency is obtained by the output of the single basin solar still and divided by the input of the solar basin solar still. Daily efficiency for all modification was shown in Tables 1, 2, 3 and 4.

**Table 1: Efficiency comparison on high and low radiation days with various modifications of single basin solar still**

| S. No. | Description | During high radiation (600–720 W/$m^2$) | | | |
|---|---|---|---|---|---|
| | | Date | Input water in liters | Output 8H/D in liters | Daily efficiency % |
| 1 | Still alone | 02.02.16 | 5 | 1.4 | 28 |
| 2 | Still and fins | 03.02.16 | 5 | 1.5 | 30 |
| 3 | Still, fins and glass wool | 05.02.16 | 5 | 1.8 | 36 |
| 4 | Still, fins, glass wool and Reflecting mirror | 07.02.16 | 5 | 2.1 | 42 |

| S. No. | Description | During low radiation (400–550W/$m^2$) | | | |
|---|---|---|---|---|---|
| | | Date | Input water in liters | Output 8H/D in liters | Daily efficiency % |
| 1 | Still alone | 05.01.16 | 5 | 0.9 | 18 |
| 2 | Still and fins | 06.01.16 | 5 | 1.2 | 24 |
| 3 | Still, fins and glass wool | 15.01.16 | 5 | 1.4 | 28 |
| 4 | Still, fins, glass wool and Reflecting mirror | 20.01.16 | 5 | 1.9 | 38 |

**Table 2: Modified solar still connected to upper converting zone (UCZ) during high radiation days**

| S. No. | Description | During high radiation (600–720 W/m$^2$) | | | | |
|---|---|---|---|---|---|---|
| | | Date | Input water in liters | Output 8 H/D in liters | Daily efficiency % | Increase in efficiency % |
| 1 | Modified solar still + Solar pond | 01.03.216 | 5 | 1.5 | 30 | 7 |
| 2 | Modified solar still + (Solar pond with glass wool) | 02.03.216 | 5 | 1.7 | 34 | 21 |
| 3 | Modified solar still + (Solar pond with cylindrical fins) | 03.03.216 | 5 | 1.8 | 36 | 29 |
| 4 | Modified solar still + (Solar pond with reflecting mirror) | 04.03.216 | 5 | 2 | 40 | 43 |
| 5 | Modified solar still + (Solar pond with reflecting mirror, cylindrical fins and glass wool) | 04.03.216 | 5 | 2.1 | 42 | 50 |

**Table 3: Modified solar still connected to middle converting zone (MCZ) on high radiation days**

| S. No. | Description | During high radiation (600–720 W/m$^2$) | | | | |
|---|---|---|---|---|---|---|
| | | Date | Input water 5 Liters | Output pure water 8 H/D | Daily efficiency % | Increasing efficiency % |
| 1 | Modified solar still + Solar pond | 01.03.216 | 5 | 1.6 | 32 | 14 |
| 2 | Modified solar still + (Solar pond with glass wool) | 02.03.216 | 5 | 1.8 | 36 | 29 |
| 3 | Modified solar still + (Solar pond with cylindrical fins) | 03.03.216 | 5 | 2 | 40 | 43 |
| 4 | Modified solar still + (Solar pond with reflecting mirror) | 04.03.216 | 5 | 2.2 | 42 | 57 |
| 5 | Modified solar still + (Solar pond with reflecting mirror, cylindrical fins and glass wool) | 04.03.216 | 5 | 2.4 | 48 | 71 |

**Table 4: Modified solar still connected to lower converting zone (LCZ) during high radiation days**

| S. No. | Description | During high radiation (600-720 W/m$^2$) | | | | |
|---|---|---|---|---|---|---|
| | | Date | Input water 5 Litres | Output pure water 8 H/D | Daily efficiency % | Increasing efficiency % |
| 1 | Modified solar still + Solar pond | 01.03.216 | 5 | 1.8 | 36 | 29 |
| 2 | Modified solar still + (Solar pond with glass wool) | 02.03.216 | 5 | 1.9 | 38 | 36 |
| 3 | Modified solar still + (Solar pond with cylindrical fins) | 03.03.216 | 5 | 2.1 | 42 | 50 |
| 4 | Modified solar still + (Solar pond with reflecting mirror) | 04.03.216 | 5 | 2.2 | 44 | 57 |
| 5 | Modified solar still + (Solar pond with reflecting mirror, cylindrical fins and glass wool) | 04.03.216 | 5 | 2.6 | 52 | 86 |

% Increase in productivity

$$= [[\text{Output}_{\text{With Modification}} - \text{Output}_{\text{Without Modification}}]/ [\text{Output}_{\text{Without Modification}}]] \times 100$$

It is defined as the difference between the output of single basin solar still with and without modifications divided by output of single basin solar still without modification was shown in Tables 2, 3 and 4.

## RESULTS AND DISCUSSION

### Conventional single basin solar still

The experimental setup consists of a solar still modified internally by adding fins, Glass Wool and reflecting mirror at bottom. The experiment was conducted in the months of January, February and March 2016 at high radiation and low radiation conditions and output measured was shown in Table 1 and Fig. 6.

### Integration of internally modified solar still with solar pond

The solar still was connected to solar pond at three different levels (UCZ, MCZ, LCZ). The productivity of solar still when connected to each zone of the pond was found out with and without various additional modifications of pond was shown in Tables 2, 3 and 4.

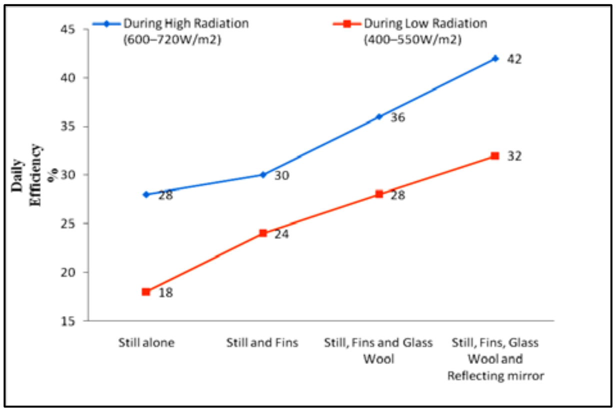


**Fig. 6: Graphical comparison of daily efficiency at high and low radiation with various single basin solar still modifications**

Fig. 6 comparison of daily efficiency on UCZ, MCZ & LCZ with different modifications of Solar Pond From this graphical representation Fig. 6 it can be easily understood that solar still had maximum productivity(82%) when connected to the LCZ zone of solar pond with all additional modifications.

Fig. 6 shows the daily efficiency of modified solar still when connected to solar pond with various modifications.The maximum efficiency was obtained when all the modifications were combined together.The maximum efficiency of still with all modifications in: UCZ-4 2%, MCZ-48%, LCZ-52%.

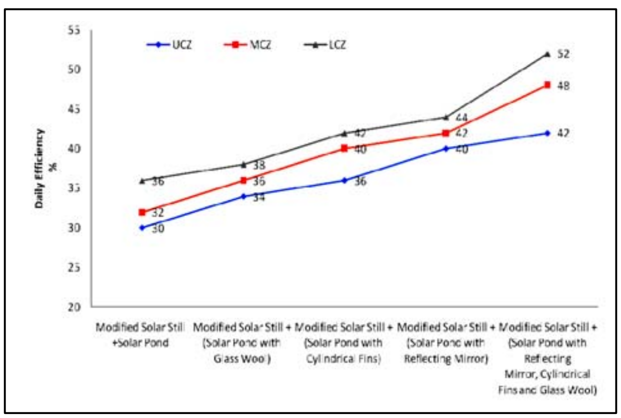


**Fig. 6: Effiiency of modified solar still linked with different zones of solar pond**

Fig. 7 shows the increase in efficiency of modified solar still when connected to solar pond with various modifications.The maximum increase in efficiency was obtained when all the modifications were combined together.The maximum increase in efficiency of still with all modifications in: UCZ- 50%, MCZ-71%, LCZ-86%.

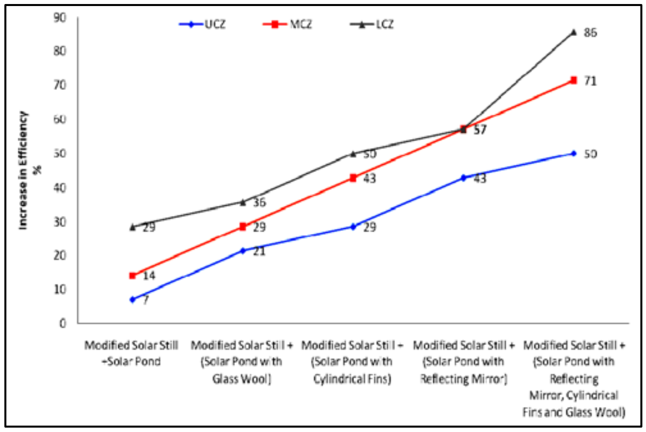


**Fig. 7: Increase in efficiency of modified solar still linked with different zones of solar pond**

## CONCLUSION

The addition of solar pond to the conventional solar still increase productivity. Further increase of efficiency of the still was obtained when modifications were done to both the pond and still with fins, glasswool and reflecting mirror.

(i) The maximum efficiency of solar still was obtained when connected to the LCZ zone of solar pond.

(ii) The maximum efficiency of 86% from the conventional solar still was obtained when it was connected with LCZ zone with combination of all modifications on both still and pond.

The modifications in the solar pond increased the overall daily efficiency of still from 42% to 52%.

### Author's biography

Mr. oe Patrick Gnanaraj. S. has completed his under graduation in Mechanical Engineering from Sardar Raja College of Engineering, Tirunelveli and Post graduation from National Engineering College, Tuticorin. He has more than seven years of teaching experience. He has published two research papers in International Journals.

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