# Experimental Study of Circular Solar Still Basins With Perforated Fins For Desalination Process

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**ABSTRACT** *In recent years, freshwater shortage problem posing great threat to the humans are attracting great importance around the world owing to rapid development of global economy, fresh water pollution, increase in population, and improvement of living standards. One of the best ways to get pure water is by desalinating seawater or brackish water. Desalination is a process, which is used to remove dissolved minerals in feed water sources, such as seawater or non potable water for getting pure water. The safest and most effective water purifier in the market today works on reverse osmosis principle. But it is not affordable to common man. To overcome this problem we can utilize the most abundantly available solar energy to get pure water through solar still basin. In the present work is to experimental study of circular solar stills by using a sea water as a working fluid. Three similar circular still basin were designed among them one is conventional still and other two still are modified by adding a with solid fins and with perforation fins at the base of the stills. Before feeding the sea water into the modified still basin it will be preheated by using copper coil water heater. The experiment were conducted on all the stills, hourly yields productivity were noted finally the productivity of all the solar stills were compared. The water properties before and after desalination are estimated.*

**Key words**: *Solar still. Solar desalination. Copper coil water heater, solid fins and perforation fins.*

## 1. INTRODUCTION

Water is the basic human requirement for various purpose like domestic, agriculture and industrial applications etc,. While supplying fresh and pure water still we are failed especially in arid remote areas[1]. In the earth around 97% of water not suitable for consumption due to salinity and for consumption as potable water available only 3% [2]. In many countries are facing drinking water problem due to limiting the natural resources like Middle East and North Africa including Saudi Arabia, desalination method is practical solution for these area which is being used as industrial, agriculture applications and fresh water for domestic purpose[3]. Solar still is a device used to convert brackish water into potable water by using solar energy only and do not require any other sources such as electricity or fuel[4]. It is easy to construct, low maintenance and do not require skilled worker but it has problem with low productivity[5] . In the present work three circular solar still has been fabricated to increasing the productivity of solar still with and without perforation fins are used at the base of the modified solar still basins. By using a fins at the base of the still they enhance the heat transfer rate from the basin liner to water and helps to yield the daily productivity.

## 2. EXPERIMENTAL SETUP


Figure 1: Experimental setup

The experiment were conducted on VTU PG Studies Mysore. from the morning 9am to evening 5pm. Figure shows the experimental setup and it consists of circular solar still basins, copper coil water heater, fins, glass Connecting pipes, and there are three control valves are provided one for water inlet, and another one is to over flow and one more is to brain . The solar still have 0 .39m$^2$ area and it placed in north south direction to absorb maximum radiation from the sun. The saline water from the tank is flows into condenser cold water inlet and the outlet of cold water is connected to copper coil water heater where the water is pre heated in the coil heater and then flows into the still basin low discharge is maintained by control valve and 1cm water depth inside the still basin is maintained for conventional still. The water inside the still absorb the solar radiation and evaporation take place. $12^0$ slope is provide to basins and the condensed water on the glass flows along with provided slope then it will be collected at one side the port is provided for collect the water and comparison were made between conventional as well as with and without perforation fins based solar still basins.

## 3. THEORETICAL SIMULATION

### 3.1 Convective heat transfer coefficient

The convective heat transfer coefficient between water and glass is given by[6]

$$h_{c,w-g} = 0.884\{ (T_W-T_g)+\frac{[P_W-P_g][T_W]}{[268.9\times10^3-P_W]}\}^{0.33}$$

Where $T_W$ = Water temperature
$T_g$ = Glass temperature
$P_w$ & $p_g$ Partial pressure of water at water and glass temperature

### 3.2 Evaporative heat transfer coefficient

The evaporative heat transfer coefficient between water and glass given by[6]

$$h_{e,w-g} = \frac{(16.273\times10^3)h_{c,w-g}(P_w-P_g)}{T_w-T_g}$$

### 3.3 Rate of heat transfer from the water surface to glass cover ($q_{cw}$)

The heat transfer rate from water to glass cover is take place by convection in the upward direction through the humid air and it can be determined by[6]

$q_{cw} = h_{cw} (T_w - T_g)$

Where $h_{cw}$ is Convective heat transfer coefficient
$T_w$ is water temperature
$T_g$ is glass temperature

### 3.4 The hourly productivity

The hourly productivity is given by [6]

$$P=\frac{h_e(T_w-T_g)*3600}{h_{fg}}$$

Where $h_{fg}$ = Latent heat of vaporization of water at basin water temperature.

## 4. RESULTS AND DESCUSSION

### 4.1 VARIATION OF AMBIENT TEMPERATURE WITH TIME

Figure 2 shows the variation of the ambient temperature with time. The solar still basins working under the solar energy, the clouds clear atmosphere plays a very important role in productivity of solar stills. The ambient temperature in the experiment conducting day as shown in the figure 2

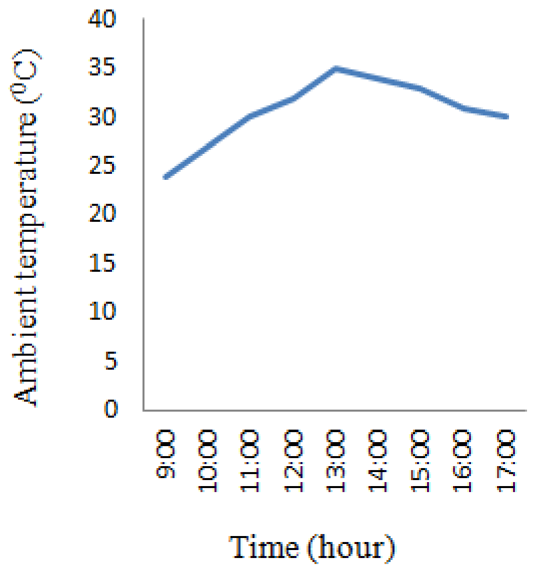


Figure 2: Ambient Temperature v/s Time

### 4.2 VARIATION OF WATER TEMPERATURE WITH TIME

Figure 3 shows the variation of the still basin water temperature with time. The water temperature in the without perforation fin based solar still is high as compared to solid fin based still and conventional still basin as shown in the figure 3. The use of the perforation fins helps to create turbulence inside the still basin and transfer the heat from the basin liner to water.

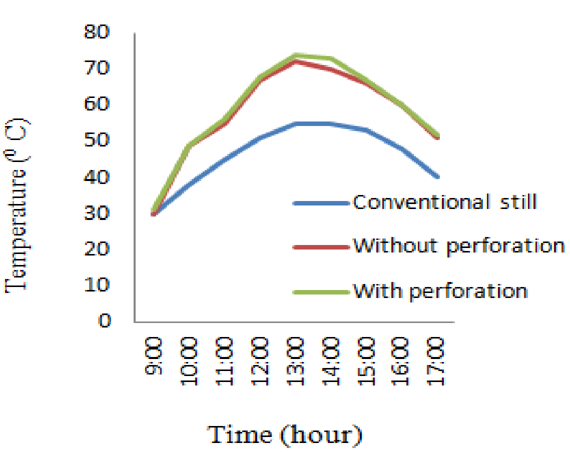


Figure 3: Water temperature v/s Time

### 4.3 VARIATION OF GLASS TEMPERATURE WITH TIME

Figure 4 shows the variation of solar still basin glass temperature with time. If increasing water temperature as well as ambient temperature glass temperature also increases. In this case also the perforation fin based solar still basin have higher glass temperature compared to solid fin based and conventional solar still basins as shown in figure 4. In the beginning the glass temperature of all the three still basins are same afterwards the glass temperature varies. For better yielding the productivity the difference between the water and glass temperature should maintains the minimum.

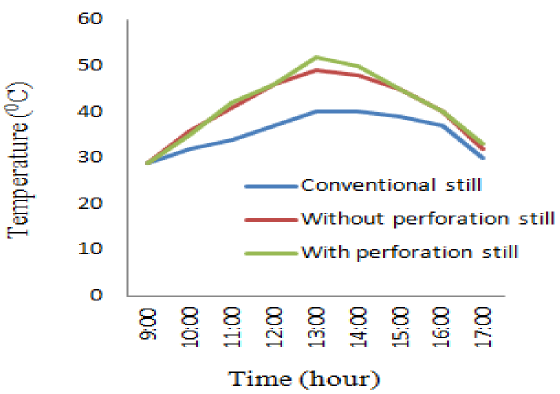


Figure 4: Glass Temperature v/s Time

### 4.4 VARIATION OF CONVECTIVE HEAT TRANSFER COEFFICIENT WITH TIME

Figure 5 shows the variation of convective heat transfer coefficient between water surface and glass with time. The water temperature in the still basins increases linearly with increasing solar intensity and convective heat transfer rate also increases between water and glass. The modified perforation fins based solar still having higher convective heat transfer rate as compared to solid fin based and conventional solar still basins.

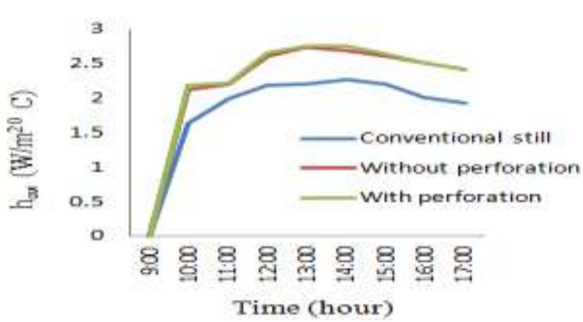


Figure 5: Convective Heat Transfer Coefficient v/s Time

### 4.5 VARIATION OF EVAPORATIVE HEAT TRANSFER COEFFICIENT WITH TIME

Figure 6 shows the variation of evaporative heat transfer coefficient from the water surface to glass cover with time for the three basins. The higher evaporative heat transfer coefficient leads to higher evaporation and higher productivity. The evaporative heat transfer coefficient for the modified perforation fins based solar still basin having higher evaporative heat transfer rate as compared to solid fin based and conventional solar still basins.

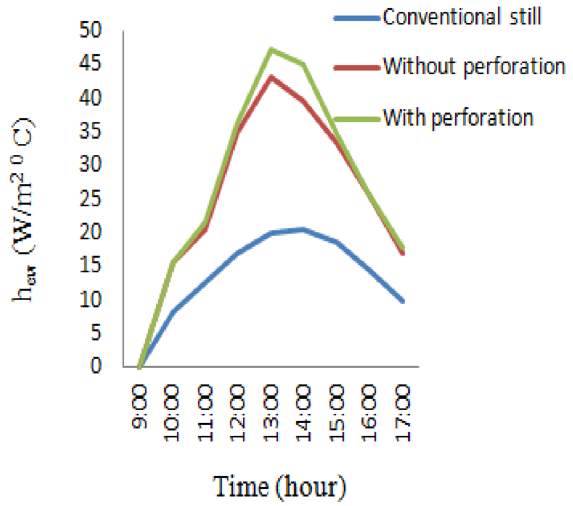


Figure 6: Evaporative Heat Transfer Coefficient v/s Time

### 4.6 VARIATION OF PRODUCTIVITY WITH TIME

Figure 7 shows the variation of productivity with time for three solar stills. Usually the daily productivity of conventional solar still basin is low. By integrated with some thermal energy to achieve more yield. The modified solar still had fins at the base along with pre heating of water by copper coil water heater enhance the productivity as compare to conventional still basin. The perforation fin based solar still having higher productivity as compared to solid fin based and conventional solar still basins as shown in figure 7. The hourly productivity of collected water in each still basins is measured from morning 9am to 5pm and obtained productivity of those stills is calculated in the table 1. Due to some heat loss from the basin little variation in the experimental obtained productivity as compared to theoretical value.

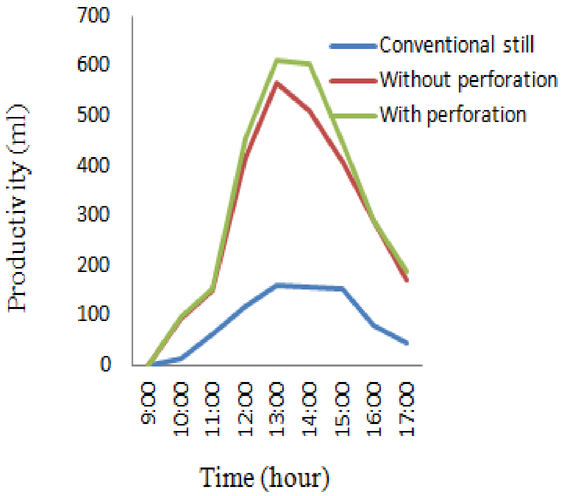


Figure 7: Productivity v/s Time

| Solar still | Theoretical | Experimental |
|---|---|---|
| Conventional solar still | 930.5ml | 794 ml |
| Without perforation fin based solar still | 2770.2ml | 2605 ml |
| With perforation fin based solar still | 3022.2ml | 2847 ml |

Table 1: Productivity of Stills

### 4.7 Water sample testing report

The sea water sample before conducting the experiment and after desalination obtained water sample were tested at BANGALURU WATER SUPPLY AND SEWERAGE BOARD, Central water testing laboratory, Quality Assurance Division, High Grounds, Bengaluru.

| Parameters | Sea water | Distilled water | As per IS-10500:2012 | |
|---|---|---|---|---|
| | | | Desirable Limit | Permissible Limit |
| pH | 8.06 | 7.30 | 6.5 | 8.5 |
| Conductivity | 21.1 | 27.9 | - | |
| Total hardness mg/L | 4240 | 40 | 300 | 600 |
| Chloride mg/L | 28,72 | 36 | 250 | 1000 |
| Calcium mg/L | 720 | 24 | 75 | 200 |
| Magnesium mg/L | 862.4 | 43.88 | 30 | 100 |

### 5. CONCLUSION

In this experiment the modified solar still operating with external copper coil water heater and perforation fins. The experimental investigation shows the improvement in the daily productivity of the modified solar still. The productivity of the perforation fin based solar still with copper coil water heater yields more productivity than the solid fin based still and conventional still. The productivity of the with perforation fin based solar still is higher than the productivity of without perforation fin based solar still.

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