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## Enhance the Productivity of Spherical Solar Still using Fins Absorber

K. Syed Jafar<sup>1</sup>, R. Venkatesaperumal<sup>2</sup>

Assistant Professor, Department of Mechanical Engineering, Annamalai University, Annamalai nagar,  
Tamil Nadu, India<sup>1,2</sup>

**Abstract:** In the present work an attempt has been made to investigate the performance of a finned basin spherical solar still. Two similar spherical solar stills are fabricated for experimental investigation. The absorbing plate of one of the solar still is integrated with fins to enhance the rate of heat transfer for basin liner to water and another still is without fins. It is observed that daily distillate output from the finned basin solar still is 18% more than the conventional spherical solar still.

**KEYWORDS:** Spherical solar still, Absorber plate, Fins, Distilled water.

### 1. INTRODUCTION

Today fresh water demand is increasing continuously, because of the industrial development, intensified agriculture, improvement of standard of life and increase of the world population. Only about 3 % of the world water is potable and this amount is not evenly distributed on the earth. On deserts and islands where underground water is not readily obtainable and the cost of shipping the places is high it is worthwhile to take into consideration of producing potable water from saline water, using solar energy that is in abundance in deserts. Out of 6 billion people on earth, more than one billion i.e. one in six, lack access to safe drinking water. India is located in the equatorial sun belt of the earth, thereby receiving abundant radiant energy from the sun. In most parts of India, clear sunny weather is experienced 250 to 300 days a year. Solar still is a simple, easy to construct, low cost device that can be used to produce potable water from brackish water. It has many features, but the daily productivity from the still is not sufficient to meet the end users need. Over the years, different solar stills has been designed and developed by many researchers. Numerous experiments and theoretical investigation has been carried out to increase the daily productivity of the still. Hassan E.S. Fath. Et al [1] under a passive mode of operation, a transient analysis of a new, simple design, two effects, and solar distillation unit is presented. The unit consists mainly of a single sloped basin solar still of a shutter fashion type reflector, purging its vapor to a second effect still connected at the shaded side of the first effect still. Based on energy balance for the different components of the two effects distillation unit, hourly variations in the unit energies, temperatures, productivity and efficiency were obtained. Aghareed M. Tayeb et al [2] the efficiency of solar energy utilization and the performance of four different designs of basin-type stills are considered. The stills have the same area of evaporation but different shapes and different areas of condensation. The effect of these design factors, as well as the effects of materials of construction and some operating factors, such as basin temperature, cover temperature, ambient temperature and solar intensity is examined and analyzed. The efficiency of the stills is also calculated. The results show that a higher ratio of condensation area ( $A_c$ ) to evaporation area ( $A_e$ ) leads to a higher productivity, if not contradicted by another effect such as shading. Basin temperature has a positive effect on productivity, but the effect of cover temperature is not so pronounced. The productivity is affected directly and positively by solar intensity. The efficiency of these different stills is calculated, and it was found to range from 14.9 to 21.8%. A. J. N. Khalifa et al [3] an experimental study was conducted on new designs of basin type solar stills. Several single and double slope stills

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were constructed. Tests were conducted to show the effect of some modifications on the performance, such as productivity and efficiency. The modifications examined included preheating of feed water by means of a solar heater and utilizing external and internal condensers for vapor condensation as well as for feed water preheating. The results showed improvements in the output and efficiency of the solar stills due to the employment of the above modifications. Aybar et al [4] studied the inclined solar distillation system in which water flows down on the inclined absorber plate (bare plate or covered with black wick) and evaporated water condenses on the inclined glass cover. Tripathi and Tiwari et al [5] considered the solar radiation that comes not only to the glass cover but also to each of side walls of still, and they calculate the total energy gain by the water, and they use this total energy in the energy balance equation. Fath et al [6] presented the mathematical modelling of the multi-basin solar still with a passive condenser section, and thermal analysis of pyramid-shaped multi-slope and single-slope solar configurations. This research work focused the distribution of solar radiation and make solar still more effective with increasing the productive output of it. In the present work a spherical solar still has been fabricated to enhance the productivity of solar still by adding fins on the basin liner.

### II. EXPERIMENTAL SETUP AND PROCEDURE



Figure.2.1. Absorber with Fins

A spherical solar still is a very simple device used for converting available brackish or saline or waste water into potable water. This is fabricated easily with locally available materials. The maintenance is also very cheap and no skilled labour is required. Moreover, it is an excellent solution for solving the drinking water or potable water problem. Two similar spherical solar still designs with collector area of  $0.28 \text{ m}^2$  are presented. The first one is a finned still and the second is a conventional still. The still consists of a square basin and it is coated with black paint for maximum absorption of incident solar radiation. The saline water is stored in a basin with a capacity of 10 liters. The basin in the spherical solar still is fitted without having any physical contact with the top cover made of low-density polyethylene (LDPE) sheet. The LDPE sheet of thickness 0.107 mm is spread over the spherical mesh. A gap of 0.03 m is

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maintained between the circular basin and top cover. The evaporated water, which is condensed on the top cover and drips down towards the distilled water collection segment as illustrated in Figures 2.1.

Table 2.1. Experimental instruments with accuracy, range and percentage errors

Instrument	Accuracy	Range	%Error
Solar power meter	$\pm 1 \text{ W/m}^2$	0 to 4,000 $\text{W/m}^2$	0.5
Temperature indicator	$\pm 0.1 \text{ }^\circ\text{C}$	0 to 200 $^\circ\text{C}$	0.5
Measuring flask	$\pm 1 \text{ ml}$	0 to 5,000 ml	1
Anemometer	$\pm 0.1 \text{ m/s}$	0.2 to 40 m/s	1

The performance of the system depends greatly on accuracy of instruments used and also methods of measurement. Operating temperatures and flow rates of system parameters are the main key performance indicators. The solar intensity was measured using a solar power meter. It has sensitivity of  $\pm 1 \text{ W/m}^2$ . The temperature of the glass, basin are measured by the use of a thermocouple which is completely sealed in the still. The measured temperature is shown on the digital temperature indicator. The air flow was measured using a hot wire anemometer. The device has a velocity range of 0.2 to 40 m/s with 0.1 m/s resolution. It has accuracy of  $\pm 5\%$ . In the study of heat transfer, fins are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. The amount of fresh water produced is measured using the calibrated measuring can. And the fresh water recovery is measured by dividing water input to the system by water output.

### III. RESULTS AND DISCUSSION

Test runs were conducted on a set of experiment. Utmost precaution was taken to obtain the results as accurate as possible, the hourly variation of the basin water, glass cover and inside air temperatures for spherical still are shown in Fig.3.1 and 3.2. It shows that at the start in the early morning and at the end in the evening the basin water temperatures and glass cover temperatures of both the stills match very closely, but the difference increases and attains maximum value in the afternoon. This difference in the time for the maximum values of solar radiation and that of basin water temperature is due to the higher thermal inertia of the basin water mass. The wind velocity is also important parameter which affects the glass outside temperature of the solar still. The high wind velocity cools the glass cover faster due to which condensation at higher rate is attained and ultimately it is expected to give higher yield. The initial days of the experiments were conducted for 24 h period to understand the climatic parameters. The minimum and maximum temperature of ambient air during the day was  $29^\circ\text{C}$  and  $35^\circ\text{C}$  respectively. The maximum solar radiation on the solar still is  $790 \text{ W/m}^2$ . In the morning, the temperature of water is low, therefore it needs high energy to change its phase from saturated liquid to saturated vapour phase. The result shows that temperature and required heat are inversely

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proportional. In the early afternoon the temperature of water reaches the maximum so it needs less heat to vaporize and vice versa in the late afternoon. The various temperatures and yield were recorded on hourly basis.

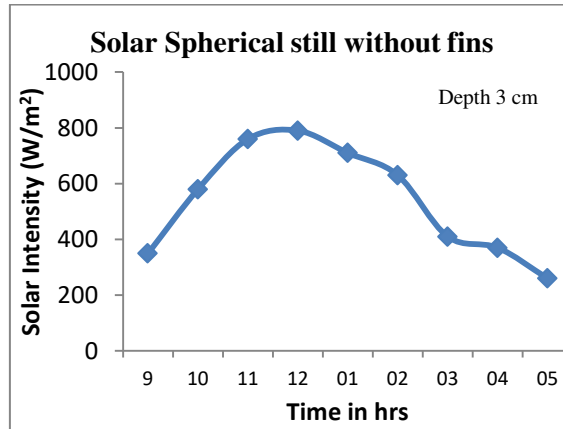


Figure.3.1. Solar Intensity Vs Time

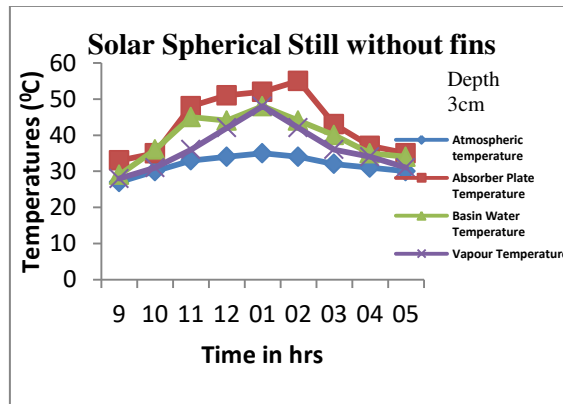


Figure.3.2. Temperature Vs Time

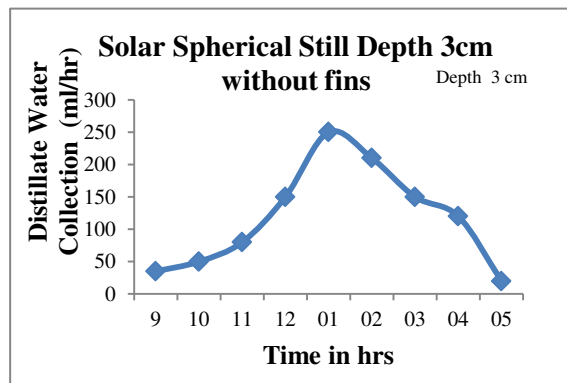


Figure.3.3. Solar productivity Vs Time

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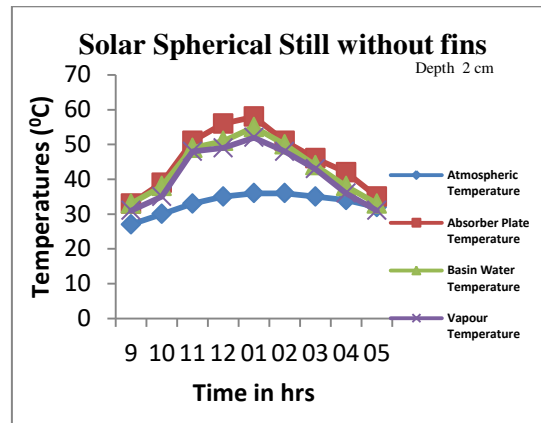


Figure.3.4. Temperature VS Time

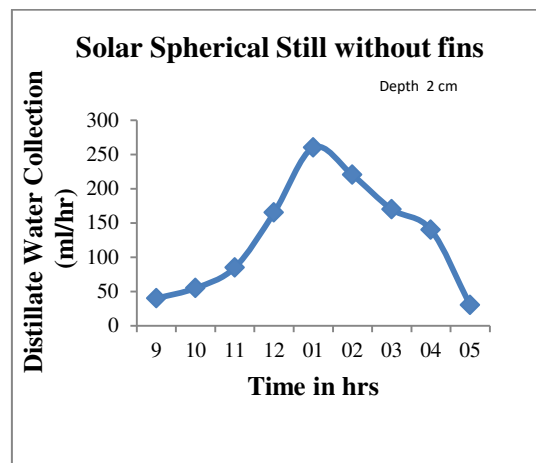


Figure.3.5. Solar productivity Vs Time

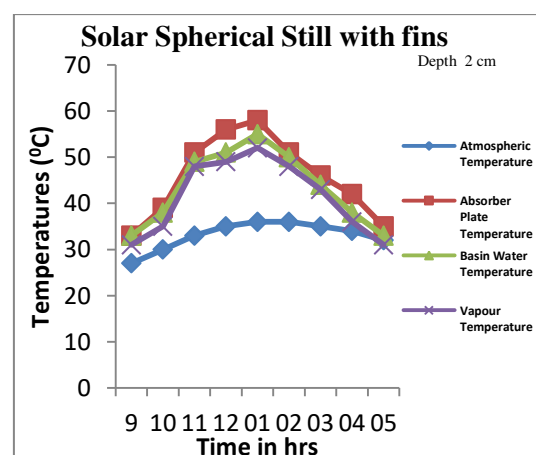


Figure.3.6. Temperature Vs Time

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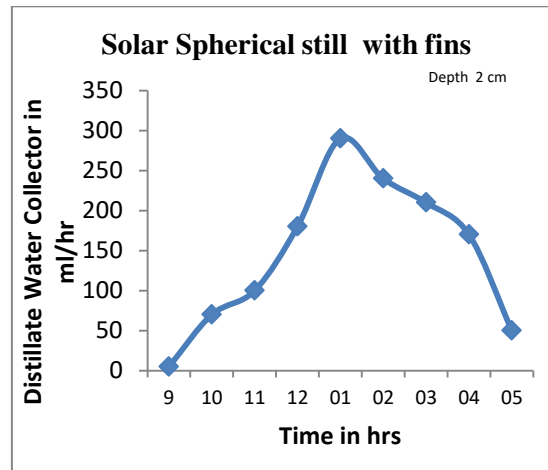


Figure.3.7. Solar productivity Vs Time

Figure 3.1 shows the variation of hourly temperature on spherical solar still without fins (depth 3 cm). The temperature readings showed similar trend in increasing with the increases of solar radiation during the day as shown in fig.3.2. The absorber plate and basin water temperatures are almost equal during the morning hours and varied in afternoon hours due to the low heat capacity of the basin material. It was found that the basin temperature was higher than water temperature. During experimentation the variation of temperature was in the order of  $T_v < T_w < T_{ab}$ . The maximum water temperature is a function of solar intensity and ambient temperature. The basin water temperature is the main factor which affects the yield of the solar still. The low water depth leads to increase in the evaporation rate and in turn it produces higher yield. The spherical absorber with fins solar still produces high yield. Figure 3.3 shows that maximum still productivity occurs during noon time because of maximum condensation rate. Figure 3.4 and 3.5 shows the different temperatures and still productivity for 2cm water depth for without fins in the absorber plate. Figure 3.6 and 3.7 shows the different temperatures and still productivity for 2cm water depth while using fins in the absorber plate.

### IV. CONCLUSION

Fresh water productivity from a conventional slope solar still is very low due to low rate of heat transfer from basin line to water. In the present work, the fins are attached on the basin liner of a spherical still to increase the rate of heat transfer from basin line into the water. It is observed that the addition of fins to the basin liner not only increases the day time productivity but it also increases the productivity during off shiny hours. The efficiency of the spherical solar still integrated with fins was found to be 20% more than the conventional spherical solar still.

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