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Experimental performance analysis of a modified single basin double slope solar still with pin and square fins absorber

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Abstract —Enhancement in distillate output from the solar still is a main goal of many researchers all over the world. In this present work paper discusses the experimental performance analysis of modified double slope single basin solar still with fins. Here, two types of fins are used in solar still basin such as pin and square fins. Performance of modified still is compared with conventional still. It is observed that productivity of modified still (pin fin) attain maximum, when compared to modified (square fin) and conventional still. Hence, enhancement in distillate output was achieved by use of pin fin absorber plate in solar still.

Keywords- solar still, pin fin, square fin, distillate output and enhancement

I. INTRODUCTION

Pure water is one of the important natural resources for life forms such as plants, animals, human beings. Nowadays, the demand for fresh water is increasing day-to-day life rapidly due to sudden expansion of population and accelerated industrial growth. Solar distillation is simple and most effective process to convert impure water into pure water in semi-arid, arid and remote areas where water dearth is more. M.M.Morad.et.al has performed experiment on double slope solar still with flat plate collector and cooling glass cover. They have maintain basin brine depth (1cm) and glass cover thickness (3mm) and by applying flash tactic cover cooling with 5 minutes on and 5 minutes off. Finally, they have found that productivity attain maximum in active solar still compare to passive still [1]. Shailendra Kumar Shukla.et.al has developed a thermal model to determine the internal heat transfer coefficient by using inner glass cover temperature [2]. H.P. Garg.et.al has studied the effect of operational (water depth, glass temperature, water temperature, exposure area), climatic (solar radiation, wind velocity, atmospheric temperature, humidity), design parameters (glazing material, spacing between glazing and water, inclination of glazing, bottom insulation) in single slope and double slope solar still annual performance [3].

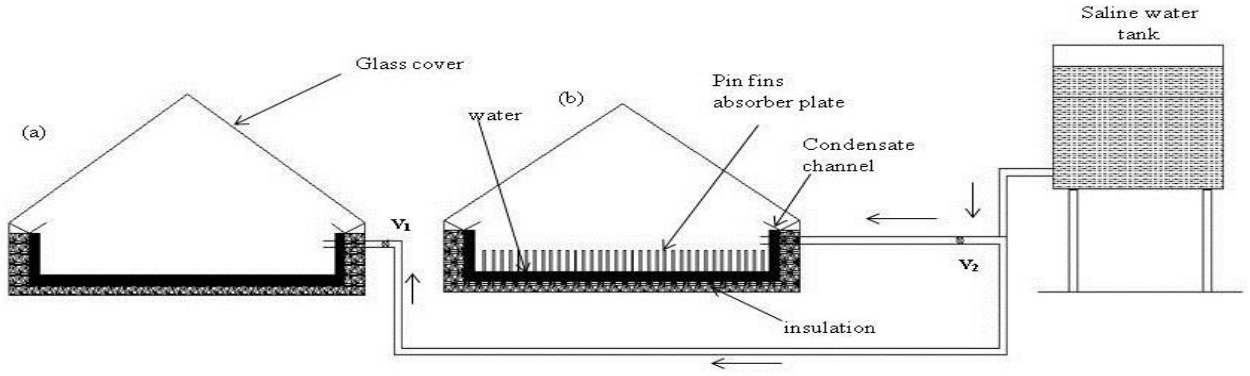

Figure 1. Schematic view of solar still. (a) Conventional still, (b) modified still with pin fins absorber

In this investigation, he has studied the performance of single slope solar still using different operational parameters like water depth in basin, glass and water temperature, material used for insulation and finally found that, distillate output of still is increased up to 51% when combined with enhancers like asphalt basin liner, sprinkler used in solar still. It also showed that the productivity of distillate output can be increased by reducing the depth of water in basin by O.O. Badran [4]. O.O. Badran and H.A. Al-Tahaineh have studied the effect of coupling a flat plate collector on solar still and its productivity. They took parameters such as water depth, direction of still, solar radiation to enhance the distillate output productivity. Finally, found that productivity increased up to 36% when coupled with flat plate collector [5]. Augmentation of solar still productivity has been investigated by using flat plate collector. They took two types of water such as tap and feed water. Hence, productivity increased by 231% in tap water and by 52% in salt water as feed by Ali A. Badran.et.al [6]. T. Arunkumar.et.al has done experiment on hemispherical solar still. They found that daily productivity increased upto 42% with effect of top cover cooling [7]. M.S. Sodha.et.al has made experiment on double basin still. Hence, productivity attains average value of 36% higher than single basin still [8]. Bassam A/K Abu-Hijleh.et.al has studied the effect of parameters like sponge cube size, percent volume of sponge, water depth and water salinity and by use of black coal, black steel cubes were also investigated. Hence, productivity can be enhanced by using sponge cube in basin [9]. Bilal A. Akash.et.al carried out work on increase in the distillate output. They used different absorbing materials such as black rubber mat, black dye and black ink. Hence, resulted in enhancement attained 60% in black dye used as absorbing material [10]. M.R. Rajamanickam.et.al has conducted experiment on double slope solar still with different environmental parameters like ambient temperature, wind speed, solar intensity and operational parameters like feed water quantity, water depth and orientation and proved that, attain maximum distillate output of 3.07 L/m^2 /day when depth of water in basin 0.01m in the double slope solar still [11]. Hitesh N Panchal.et.al has conducted experiment on single basin single slope solar still. They took different parameters like sun direction, solar radiation to enhance the productivity of distillate output. They found that coupling of evacuated heat pipe collector with solar still can increases productivity up to 32% and also productivity is decreased while using higher water depth in basin. Sanjeev kumar.et.al Performance of active solar still is optimum while using parameters like inclination of collector is 20° and inclination of glass cover is 15° [12]. Hitesh Panchal.et.al used different thermal energy storage materials such as marble pieces and sandstones in solar still to enhance the productivity. They proved that solar still attain maximum productivity 30% and 14% by using sandstones and marble pieces as thermal energy storage medium [13]. Vivek Sachan.et.al has integrated fins in basin to increase the heat transfer rate from basin liner to water. Increasing the fins in basin also increases the productivity in solar still [14]. Z.M. Omara.et.al has performed experiment on solar still and enhances the productivity. Increasing the surface area of absorber and heat transfer rate in solar still by using finned and corrugated basin still and proved that daily productivity reached 47.5%, 41%, 35% in finned, corrugated and conventional still [15].

In present work, we aim to evaluate the effect of using pin and square fins absorber on double slope solar still to enhance the productivity of distillate output. The experimental setup of still is discussed in section II. The experimental results are discussed in section III. Conclusions are detailed in section IV.

II. EXPERIMENTAL SETUP

The experiment work consists of two double slope-single basin solar stills such as conventional still and modified still as shown in Figure 1 and Figure 2. A mild steel plate of thickness about 1.4 mm is used to fabricate both double slope solar still. The size of the basin is 1 m x 0.75 m x 0.08 m. glass of 4mm thickness is used as a transparent cover in both stills. Thermo col 50 mm used as insulator in still because of prevents heat losses in all sides. A distillate collection channel (V-shape) is provided below the lower edge of glass on both sides.

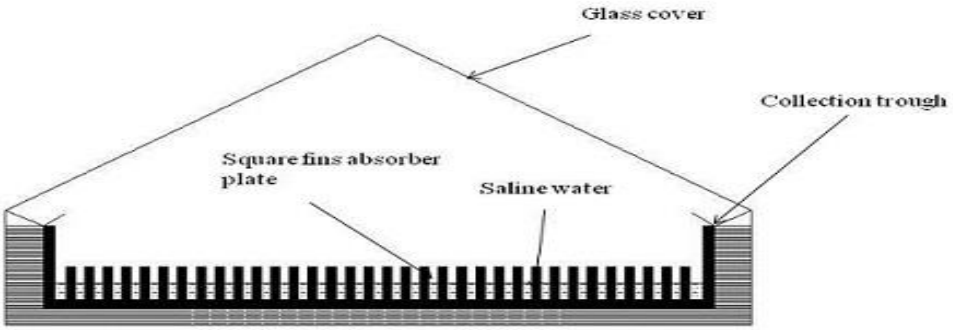

Figure2. Modified still with square fins absorber

The experimental setup was fabricated and tested at M RK Institute of Technology, Kattumannarkoil, Tamil Nadu, India during the months of Feb-April.Two types of absorber plates are used namely pin fins absorber plate and square fin absorber plate as shown in Figure.3 and Figure.4. These plates are used as basin plate in modified solar still. A mild steel pin fin size about (0.08 m height x 0.01 m diameter) and mild steel hollow pipe square fin size (0.02 m length x 0.05 m height). The total of 138fins in absorber plate of both solar still. A storage tank capacity of 40 l is used to supply saline water to two solar still such as conventional and modified still as shown in figure 1.water level in basin is maintained in required level 2cm. Inside the still water evaporated after that condensed inside the glass cover due to glass temperature, absorber plate temperature and finally fresh water is collected in bottle via v-shaped channel is placed below lower edge of glass cover. Different temperatures like water temperature, glass temperature, and absorber plate temperature, are measured every hour by using k-type thermocouples with temperature indicator. Solar radiation and wind velocity is measured by using pyranometer and digital anemometer. The yield of distillate output is measured by using measuring jar.

Figure.3. Pin finned basin

Figure.4. Square finned basin

III. RESULTS AND DISCUSSION

The experiments were conducted for varying water depths (2 and 4 cm) in solar still with two types of absorber plates are integrated in basin. To compare obtained modified still results with conventional still. Figure.5. shows hourly variation of solar radiation during day hours. Maximum average solar radiation is received at noon. Figure.6. shows the variation of modified still distillate output with conventional still output.

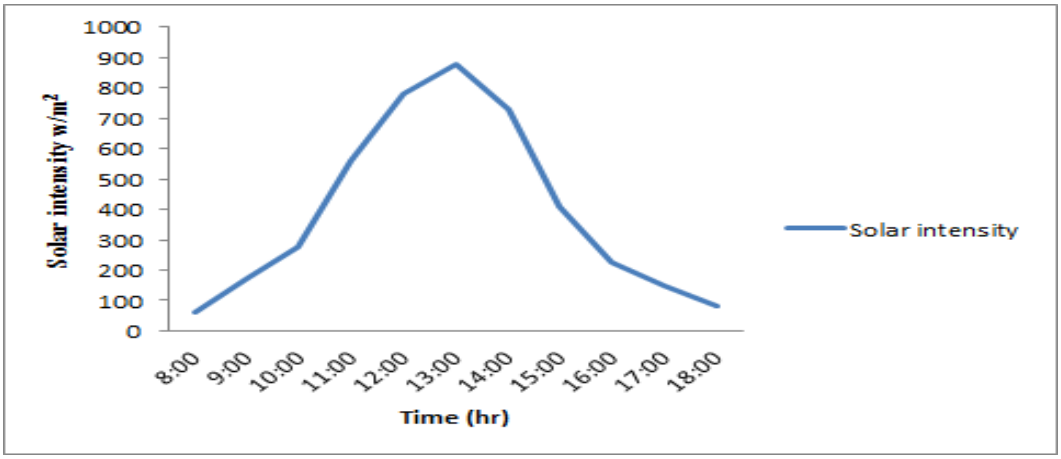

Figure.5. Variation of solar intensity with respect to time

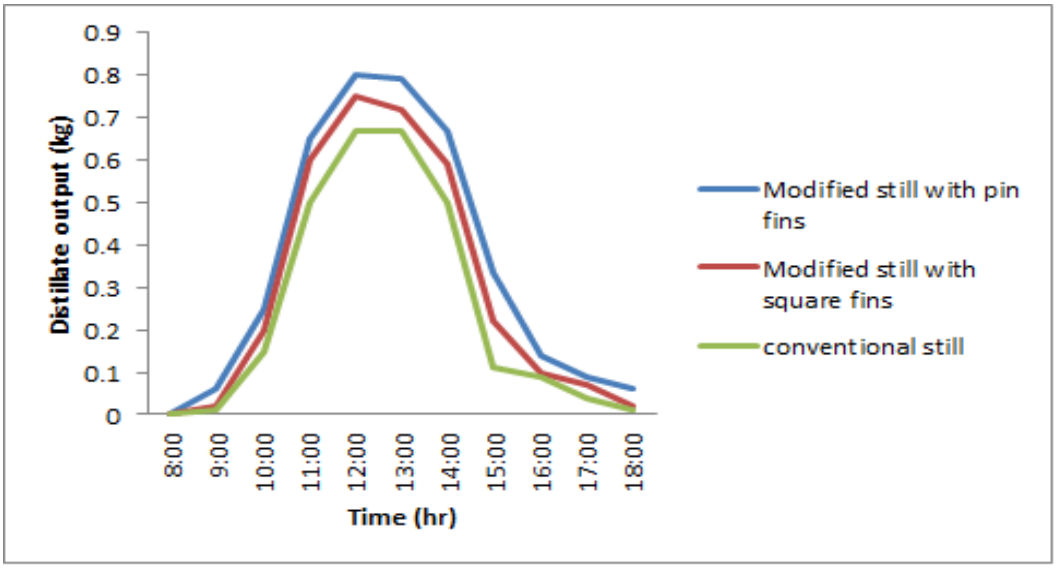

Figure.6. Variation of distillate output with time

Hence, daily productivity of solar still is improved by integrated pin finned basin in solar still. Figure.7 shows the variation of different temperatures in square finned basin solar still.

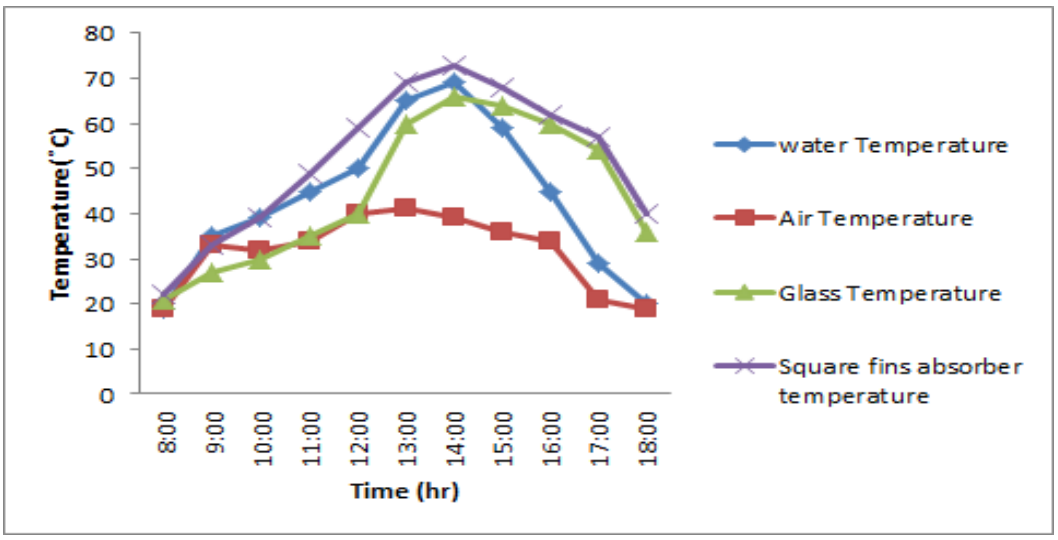

Figure.7. Variation of square finned basin solar still temperature with time

In Figure.8. shows the variation of different temperatures like water, glass, air and conventional still basin with respect to time. Figure.9. shows the variation of pin finned basin temperatures with time. Finally, water temperature is higher in pin finned basin than square finned basin solar still. In figures.7, 8, 9 shows the temperature of pin finned basin is higher compared with square finned basin as well as conventional still basin.

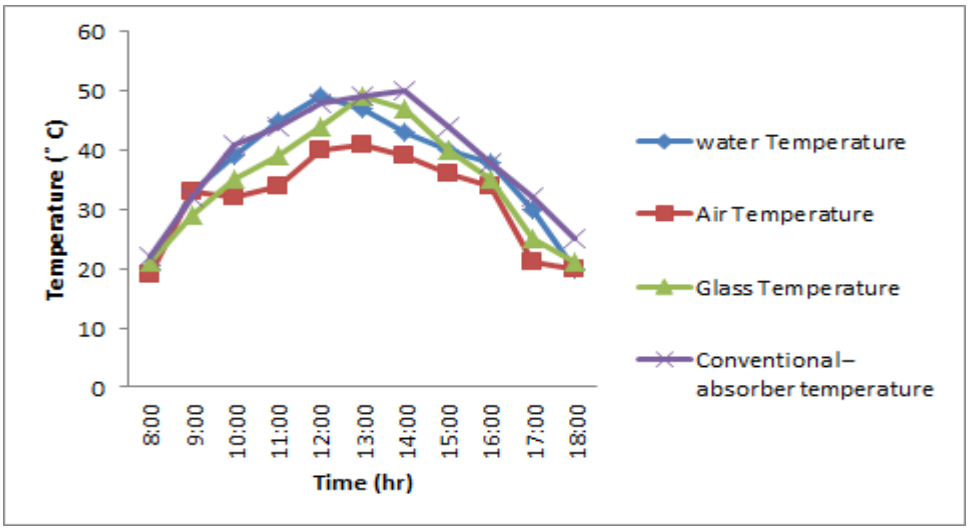

Figure.8. Variation of temperature with time

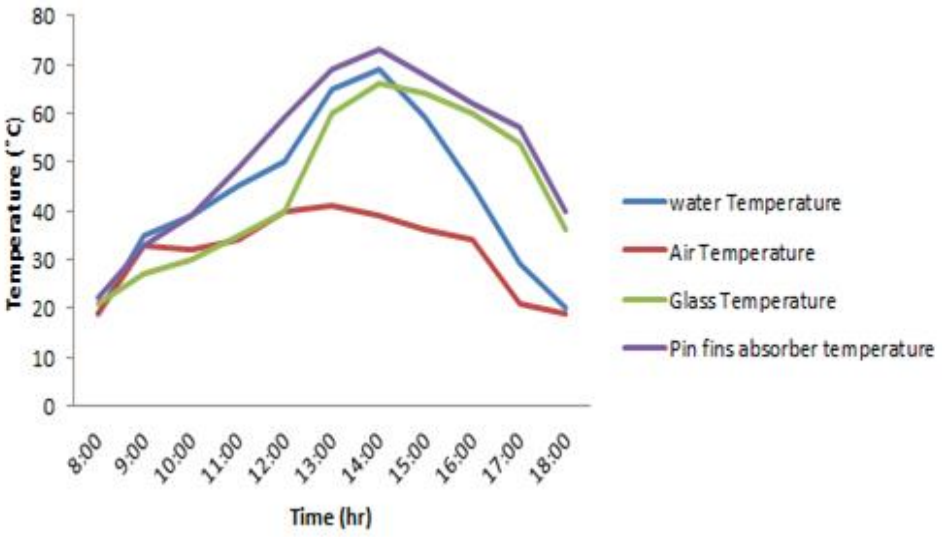

Figure.9. variation of pin finned basin temperature with time

IV. CONCLUSION

The main aim of this present work is to enhance the productivity of double slope solar still by using two type of absorber plates are integrated in basin. The performance of Pin and square fins are almost same but minimum difference in productivity of distillate output and temperature of basin. Maximum productivity of about 4.3 kg/m^2.day and 3.8 kg/m^{2}day is obtained in pin finned and square finned solar still. Enhancement in distillate output is achieved by using pin finned basin in double slope solar still under least water depth (0.02m) in basin.

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