EXPERIMENTAL INVESTIGATION ON COUPLING EVACUATED HEAT PIPE COLLECTOR ON SINGLE BASIN SINGLE SLOPE SOLAR STILL PRODUCTIVITY

Hitesh N Panchal
Assistant Professor
Mechanical Engineering Department
L C Institute of Technology, Mehsana Gujarat
Email: Engineerhitesh2000@gmail.com

Dr. Manish Doshi
Member of Institution of Engineer (MIE)

Anup Patel
Assistant Professor
L C Institute of Technology, Mehsana

Keyursinh Thakor
Assistant Professor
L C Institute of Technology, Mehsana

ABSTRACT

Solar still is very important device to convert the available brackish water into drinkable water. Here work is carried out to know the effect of coupling an Evacuated Heat Pipe Collector on the solar still. Other different parameters like Water depth, Sun direction and solar radiation to enhance the productivity. It has found that coupling an Evacuated Heat pipe collector with a solar still has increased the productivity by 32%. Also it has found that the productivity is reduced while using higher water depth and solar insolation is directly proportional to the Productivity.

Keywords: Pyranometer, Thermocouples, Evacuated Heat Pipe Collector

1. INTRODUCTION

O.O. Badran [1] performed experiment on single slope solar still using different operational parameters like basin water depth, glass cover thickness, insulating materials and proved that, productivity of distilled output is increased upto 51% when combined
enhancers such as asphalt basin liner and sprinkler have been applied on single slope solar still. Kalidasa Murugavel et.al.[2] gave brief report on solar desalination regarding with various methods of improving the productivity. They suggested that different materials are used in basin solar still to improve the heat capacity, radiation absorption capacity and condensation rate. Kalidasa Murugavel at.al [3] used different wick materials like light cotton cloth, light jute cloth, sponge sheet of 2 mm thickness and different porous materials like washed natural rocks of different average sizes. He proved that wick materials could improve the distilled output. M.E. El-Swifty and M.Z. Metias[4], said some sun rays are received by the back plate and side plates of the basin, hence this effect reduces the amount of radiation available to the basin for heating. So they used reflecting mirrors. After, Imad Al-Hayek and O O Badran [5] proved that single slope solar still with reflecting mirror increase the distilled output 20% more than double slope solar still. H.A. Tahaineh and O.O. Badran [6] used solar collector coupled with solar still and investigated that the productivity. They took different parameters like water depth, direction of solar still, solar radiation to enhance the solar still productivity. They found that coupling of flat plate collector with solar still can increase the productivity upto 20%. Hazim Mohammed Qibdawey.et.al [7] has presented paper entitled “solar thermal desalination technologies”. He has shown the direct and indirect desalination technologies of solar still like vapour compression, multistage flash evaporation, membrane distillation etc. They said Evacuated glass tube collector is more useful compared with flat plate collector. They also suggested that, coupling a CPC can increase the temperature more than Evacuated glass tube collector and Flat Plate collector. Rajesh Tripathi. et.al[8] as found the distribution of solar radiation using concept of solar fraction inside the single slope solar still by using Auto Cad 2006 for given azimuth angle and latitude angle. From numerical computations, climate conditions of New Delhi have been carried out. M Bouker.et.al [9] has done performance of simple solar still compared with coupled one. He tasted for all day productivity under clear sky conditions with different depth levels of brackish water for winter and summer period from Jan to March. 2000. He found that productivity in summer period varied from 4.01 to 4.34 L/m2/Day for simple basin and 8.02 to 8.07 L/m2/Day for coupled so Tiwari.et.al [10] have done thermal analysis of double effect distillation unit in active operation. He observed that
increase of 30% and 20% in efficiency of solar distillation working under active and passive mode. H.N. Singh et al. [11] have done experiment on active and passive solar still for different climate conditions like Chennai, Jodhpur, Kolkata and Mumbai on the basis of numerical computation. He has found that annual yield significantly depends on water depth, condensing cover inclination for both active and passive solar still and annual yield for a given water depth increasing linearly with collector area for active solar still. Rustam Mamlook et al. [12] have taken a case study of solar distillation system by fuzzy sets. The study reveals that wind speed, ambient temp, solar intensity, sprinkler, coupled collector, solar concentration, water depth etc. Based on increase of production results show that factors were found to affect on yield of solar still. Tiwari et al. [13] have been developed a computer model to predict the performance of single slope solar still basin on both inner and outer glass temperature. They concluded that there is a significant effect of operating temperature range on the internal hears transfer coefficients. Voropoluos et al. [14] Evaluated experimentally and theoretically a simple and efficient method for the behaviour of solar stills. Their method relates the main climate data and operating conditions of the still with distilled water output in daily and night base with linear equations using characteristics coefficient. Kumar et al. [15] presented the annual performance of an active solar still. Analytical expression for water and glass cover temperature and yield has been derived in terms of design and climate parameters. Numerical computations have been carried out for Delhi climate conditions. it has been observed that for given parameters, annual yield is optimum when the collector inclination is 200 and the still glass cover inclination is 100. Rajesh Tripathi et al. [16] has used semi cylindrical condensing cover and he has used temperatures of 40 to 80°C and found that there is an increase of about 15% in the evaporative heat transfer coefficient due to the size of the condensing cover and increase of about 7.5% of evaporative heat transfer coefficient due to change of material. Malik & Sodha. [17] attached a hot water storage tank to the solar still and they proved that coupling of hot water storage tank increase the 10% distilled output of single slope solar still.

Our goal for the present investigation on solar still is to design and develop an improved solar still which can use in house of India as well as output of a solar still through Evacuated Heat Pipe Collector under Indian Climate Conditions.
2. EXPERIMENTAL SET UP

Figure 1 Schematic Diagram of Solar still coupled with Evacuated Heat pipe Collector

Present investigation consists of solar still coupled with Evacuated Heat Pipe Collector. It has black painted basin of area of 1 square meter filled with brackish water supplied to it from a collector which preheats the water by use of solar energy, such kind of solar still also called Active Solar still. The evaporating basin is covered by a sheet of toughened glass having 4 mm thickness which allows the sunrays directed to basin. Angle of tilting the glass cover is 15 degree. A trough running along the bottom side of the glass cover ensures the collection of the potable water toward the collecting vessel.

The glass also holds the heat inside the still for continuing the evaporation of water inside the basin. An inlet pipe is fixed at the rear of the still for feeding the brackish water. Holes were drilled in the body of still to fix the thermocouples (to measure the various temperatures of solar still). An Evacuated Heat Pipe Collector (1.50 m long, 0.5 m width and 0.20 m thick) has been used to evaporate the water which is inside the basin. The Evacuated Heat Pipe Collector is made of many parallel tubes having ½ inch diameter and 1.6 m length.

In this Solar still following factors have highly considered for the investigation:

- To made simple in construction, maintenance and operation.
- To be rigid and firm enough to resist the worst environmental Conditions.
- Local materials have used for making low cost solar still. Figure 2 Shows Evacuated Heat Pipe Collector.
Schematic Diagram of the system is shown in figure 1A rectangular trough is fixed at the downstream end of the slope for collection of the potable water. The solar still is filled each morning and days production is collected at the time interval of 1 Hour. Silicon rubber is used as sealant to prevent the heat losses inside the solar still as well as leakage losses. The side walls and base of the solar still are insulated with locally available material called “Rock Wool” having thermal conductivity of 0.034 W/m² K of 5 cm thick. A constant Head tank was used to control the brackish water inside the solar still. Depth of water level was maintained 2 cm during the period of investigation work. The solar still has been designed installed and operated at Ahmedabad.

![Figure 2 Evacuated Heat pipe Collector](image)

3. RESULT & DISCUSSION

In this Research paper I report on daily experimentation of a single slope solar still and same still coupled with evacuated Heat pipe collector. The system was operated continuously for several months of year 2010 (April to October) under different climate conditions with good and low sunshine. The work aimed to enhance the solar still output through improving the still operations condition by using Evacuated Heat pipe Collector. The temperatures of brackish water, glass cover (Inner glass cover and outer glass cover), vapor temperature and ambient temperature were recorded continuously.

This solar still unit mounted on angled iron stand which is movable to make any adjustment to the angle of axis of still to enhance enhanced solar radiation for better output. The standard orientation of the solar still was assumed to be towards south to receive maximum solar insolation.
The influence of climate conditions and mainly the solar insolation on the solar still production is investigated without coupling an evacuated heat pipe collector i.e. solar still alone. The variations of daily solar still output and average solar radiations for different days in September are shown in figure 3.

Figure 3 Relation of the solar insolation and solar still output during September, 2010.

Figure 3 shows that solar still productivity is proportional to the solar insolation or radiation (Direct radiation + Diffused radiation), which depends on climate conditions of each day. The effect of coupling a solar still with evacuated heat pipe collector is shown in figure 4. From figure 4, it can be concluded that,

Figure 4 Comparison of yield between alone solar still and coupled solar still

There is proportionality in fresh water production (yield) with respect to the basin water temperature. The higher the temperature of water, higher output will be from the solar still as fresh water or distilled water. This productivity is expected as a result of coupling an evacuated heat pipe collector with solar still because of supply of artificial heat source with solar radiation. Coupling an evacuated heat pipe collector with solar still has higher efficiency compared with alone solar still, because increase in temperature of water inside the basin, increase the rate of evaporation and condensation so higher
distilled water. Comparison between efficiency of alone solar still and solar still coupled with evacuated heat pipe collector is shown in figure 5

![Figure 5 Comparison of efficiency between alone solar still and coupled solar still](image1)

Figure 5 Comparison of efficiency between alone solar still and coupled solar still

The percentage of improvement in daily productivity due to coupling an evacuated heat pipe collector (3029 mL) is calculated and found to be 30% more than that when the solar still was operated alone (2300 mL). Figure 6 shows the results of experiments performed during month of September to determine the optimum angle for the solar still by changing the solar still direction few degrees towards the east and west from the geographic south to detect the optimum angle that will give the best yield. Such deviation is required as the movement of the sun varies in direction between summer and winter. From the productivity of the solar still, it can be seen that the optimal angle is found to be 15 degree to the west of the geographic south during the winter season in Ahmedabad. These results show that, tracking the sun is one of the best methods to increase the yield from the solar still.

![Figure 6 Effect of solar still direction on yield](image2)

Figure 6 Effect of solar still direction on yield.
Figure 7 Effect of various depths on solar still

Figure 7 shows the productivity of the solar still as a function of basin water depth, it is known that the productivity decreases with the increase of the water depth. This increase in still productivity as a depth decrease could be attributed to the lower heat capacity. (Lower heat capacity, higher the yield from the solar still). It can be concluded that the output of the solar still is maximum for the least water depth in the basin. Figure 7 shows the comparison between various water depths.

4. CONCLUSION

The operation of a solar still coupled with evacuated Heat pipe collector has been investigated experimentally. Comparison of the productivity between coupled solar still and alone solar still was studied. It has found that productivity of coupled solar still was found to be 30% higher than alone solar still. It also shown that present solar still design leads to higher distillate water output (yield) due to higher temperature of basin.

REFERENCES


