A COMPARATIVE ANALYSIS OF SINGLE SLOPE SOLAR STILL COUPLED WITH FLAT PLATE COLLECTOR AND PASSIVE SOLAR STILL

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ABSTRACT

Solar still is a very simple solar device used for converting the available brackish or waste water into the potable water. This device can be fabricated easily with available materials. The maintenance is also cheap and no skilled labor is required to make it. This device can be suitable solution to solve drinking water problem. Here comparison is made between the solar still coupled with Flat Plate Collector as well as Passive Solar still. One year study shows that solar still coupled with Flat Plate collector increases the productivity of solar still of 35%. Lower the water depth increases the productivity of solar still and solar radiation can also produce considerable effect on productivity.

Keywords: *Passive Solar Still, Pyranometer, Thermocouples, FPC- Flat Plate Collector*

1. INTRODUCTION

There is an urgent need of clean, pure drinkable water in many countries. Often water sources are brackish and or contain harmful bacteria and therefore cannot be used for drinking. In addition, there are many coastal locations where seawater is abundant but potable water is not available. Pure water is also needful in some industries, hospitals and schools. Distillation is one of many processes that can be used for water purification. Solar radiation can be the source of heat energy. In this process, water is evaporated and thus separating water vapour from dissolved substances, and is then condensed as pure water. [1]

Hazim Mohammed Qibdawey.et.al [2] 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[3] 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 [4] 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/m^2/Day for simple basin and 8.02 to 8.07 L/m^2/Day for coupled so Tiwari.et.al[5] 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[6] 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 [7] 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. [8] 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. [9] 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 [10] 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 20^0 and the still glass cover inclination is 10^0.Rajesh Tripathi.et.al [11] has used semi cylindrical condensing cover and he has used temperatures of 40 to 80C 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.K. Malik & Sodha.[12] 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.

2. SYSTEM

Working Principle of Solar Still

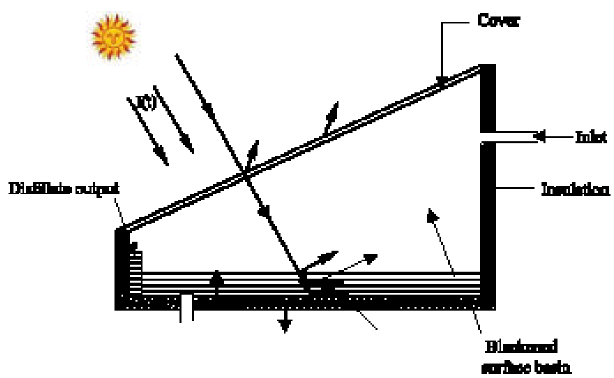

Fig.1. Schematic Diagram of Solar Still

Fig.1. Shows Schematic Diagram of solar still. It is an airtight basin, usually constructed out of concrete/cement, galvanised iron sheet or Fibre reinforced plastic (FRP) with top cover of transparent material like glass, plastic etc. the inner surface of the rectangular base is blackened to efficiently absorb the solar radiation incident at the surface. There is a provision to collect the distillate at lower end of the glass cover. The brackish or saline water is fed into the basin for purification. Solar radiation that passes through the transparent roof heats water in the blackened basin, thus evaporating water which gets condensed on the cooler underside of the glass and gets collected in tray as distillate attached to glass. [1]

System Description

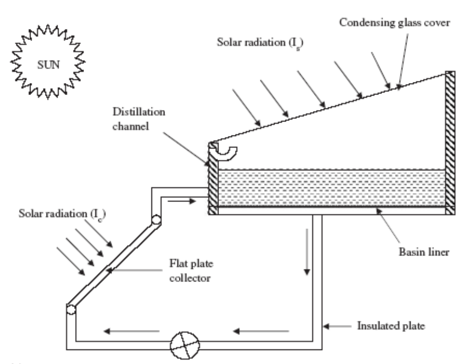

Fig.2. Schematic Arrangement of Solar still coupled with flat plate collector

The following experimental components were used in this work; single slope solar still, constant head tank and feeding tank. A frame was built to carry above mentioned instruments

A single slope solar still as shown fig.2. It has been constructed from a large variety of local materials. The materials selected have generally been based on knowledge of the conditions prevailing in various parts of solar still and an assessment of the material cost and ease of incorporating it in construction. The technical specifications are shown in table 1. Table 2 shows the specification of Flat Plate Collector (FPC)

Table 1

Technical Specifications of Solar still

Specifications	Dimensions
Basin Area,m^2	1
Glass Area, m^2	1.46
Glass Thickness, mm	4
Number of Glass	1
Slope of Glass	15^0

Table 2
Technical Specifications of Flat Plate Collector

Specification	Dimensions
Type of Absorber	Cu-cu Black/ selective coated
Size of Collector	1000w 2030 length 100 depth (mm)
Cover Plate	4 mm thick toughened glass
Net Absorber area	1.88 sq. meter
Net Collector area	Above 2 sq. meters
Absorber Coating	Black
Number of Risers	9 nos. Each extra riser increases the efficiency of collector by 9% to 12%.
Fin width (Pitch)	111mm
Riser Tube	9 nos.12.5mm diameter * 0.55mm (24 SWG) Cu tube 9 nos.
Material	Copper
Header	25mm diameter * 0.71mm (22 SWG) Cu tube 2 nos.
Method of bonding of riser and header	Brazing
Water/ Liquid holding Capacity of collector	2.5 liter / collector

2.2.1. Basin Liner:
This is a major part of the solar still. It absorbs the incident solar radiation that is transmitted through the glass cover. The basin liner should be resistant to hot saline water or brackish water, has high absorbance to solar radiation and resistance to accidental puncturing and in case of damage, it should be easily repaired. Here black paint is used to increase the absorptivity of solar still.

2.2.2 Glass cover:
In this work, glass of 4 mm thickness was used and its average transmissivity of 0.89, it was fixed at angle of 15 degree with horizontal as shown in fig.2. Glass cover has been sealed with silicon rubber, which is most successful because, It will make strongly contact between the glass and many other materials. The sealant is important for efficient operation. It is used to secure the cover to the frame, take nay difference in expansion and contraction between dissimilar materials.

2.2.3 Insulating Material
Insulating material is used to reduce the heat losses from the bottom and the side walls of the solar still in this work. The insulating material is a rock wool of 5 cm thickness and 0.048 W/ m^2 ^{0}C thermal conductivity.

2.2.4 Mirrors:
The mirrors fixed inside the solar still on the inner side walls are very useful, because the mirror can concentrate and reflects the scattered rays of the incident solar radiation in the solar still. Mirror material is a toughened glass, because single glass can not sustain incident of solar radiation.

2.2.5 Distillate channel and side components
The distillate channel used to collect the condensate from the lower edge of glass cover and carry it for the storage, it was made of aluminum sheet and side wall made of wood of 20 mm thickness.

3. RESULT AND DISCUSSION

In this paper, daily experiment on Single Slope Solar Still (passive Solar still) and same coupled with flat plate collector. The system is operated with six months (June 2010 – Nov, 2010) with moderate and low sunshine of Ahmedabad, Gujarat. The main target of this research paper is to improve the output of single basin solar still by using a flat plate collector and same from the alone solar still. The temperatures of brackish water, glass covers, water vapors and ambient temperatures are continuously recorded from 10: 00 am to 5:00 pm daily with help of inbuilt thermocouples.

Single slope solar still, is mounted on angle plate made of cast steel (to prevent from the corrosion) and it is movable to make adjustment the angle of the axis of the solar still. The standard orientation of solar still is assumed to be south to receive maximum amount of solar insolation

The effect of climate conditions and main the solar radiation, on production is investigated without coupling of flat plate collector which means that solar still alone. The variation of distillate output from the solar still and average solar radiation are shown in fig.3. It shows that the solar still productivity is proportional to the solar intensity, which depends on climate conditions of the place where it get installed. Fig.3 also shows that, distillate output from the solar still coupled with flat plate collector is more compared with passive solar still and it is 30% more.

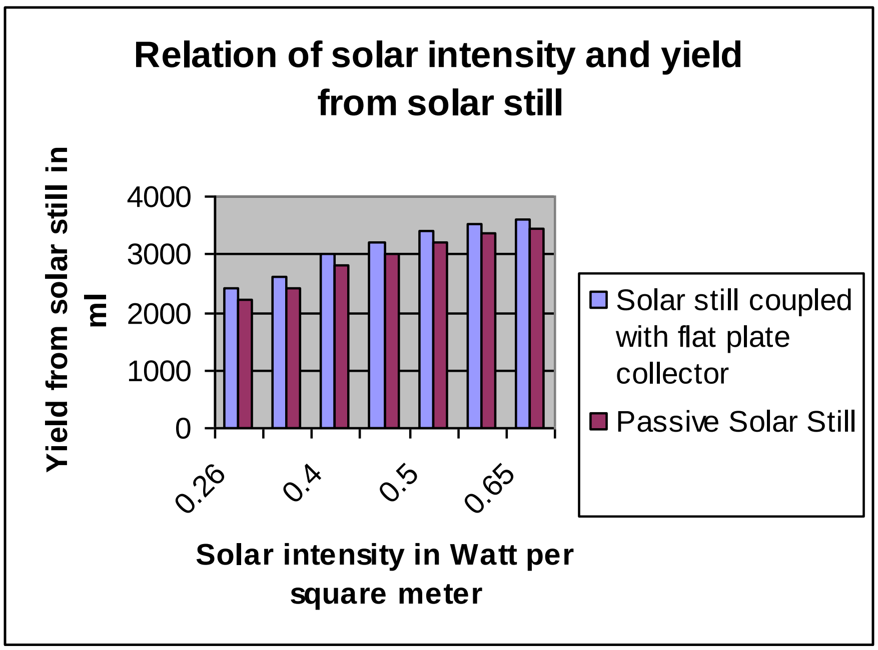

Fig.3. Relation of solar intensity and solar still distillate output during August, 2010

The effect of coupling a solar still with flat plate collector is as shown in fig.4. There is proportionality in water production with respect to the basin water temperature means the higher basin water temperature, higher rate of evaporation and more yield from solar still. The higher the temperature of water inside the basin, higher the distillate output from the solar still. This high productivity is gained by the solar still coupled with flat plate collector. This is explained by fact that when temperature of water inside the tube will heated by the incoming solar radiation, hence the water temperature will be increased and such kind of preheated water will be used in solar still, so less heat is required to evaporate the water into steam and higher distillate output is enhanced by solar still.

The percentage enhancement in daily productivity of solar still with couple of flat plate collector, (3450 mL) is calculated and found to be 30% more when solar still operated alone (4485mL)

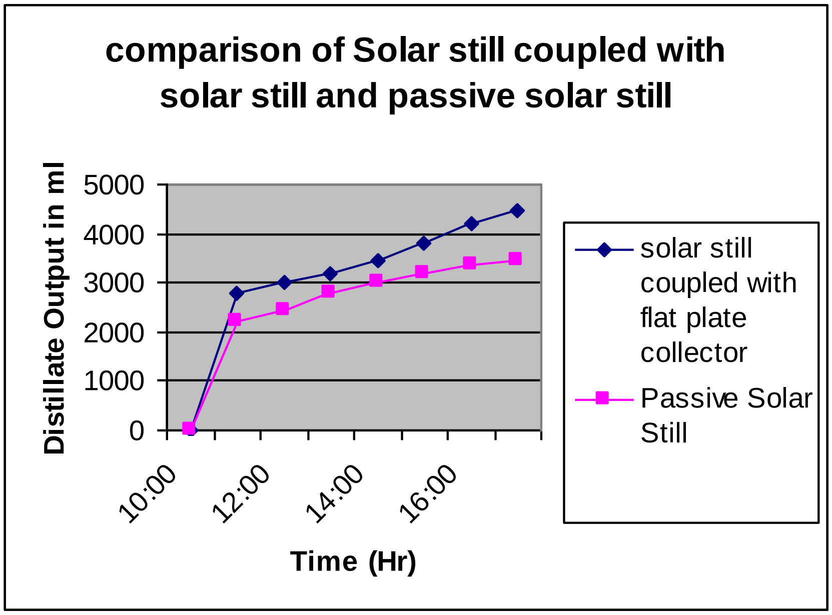

Fig.4. comparison of alone solar still versus solar still coupled with flat plate collector

Fig.5 shows the productivity of solar still as function of basin water depth, as we know that the productivity of solar still decreases with increase of water depth. Hence, to increase the productivity of solar still, water depth inside the basin should be lower and water quantity should be remain constant. Hence, 1.5 cm water depth can give better performance compared with 2.5 cm water depth as well as 4 cm water depth. We can also say that, when water depth decreases inside the basin, heat capacity of basin decreases and results in higher temperature inside the solar still and better evaporation and condensation produces improved distillate output.

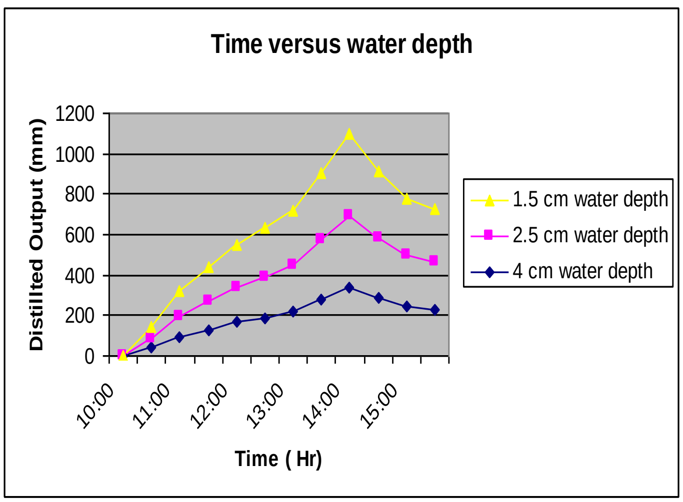

Fig.5. Effect of water depth on solar still productivity

Average daily output of solar still for six months starting from June 2010 to November 2010 were taken in this experiment. And from experiment, it concludes that, during October, it has higher isolation compared with any other month and due to higher isolation, distillate output from the solar still also increases. Fig.7 shows that, distillate output in October is higher compared with remaining five month.

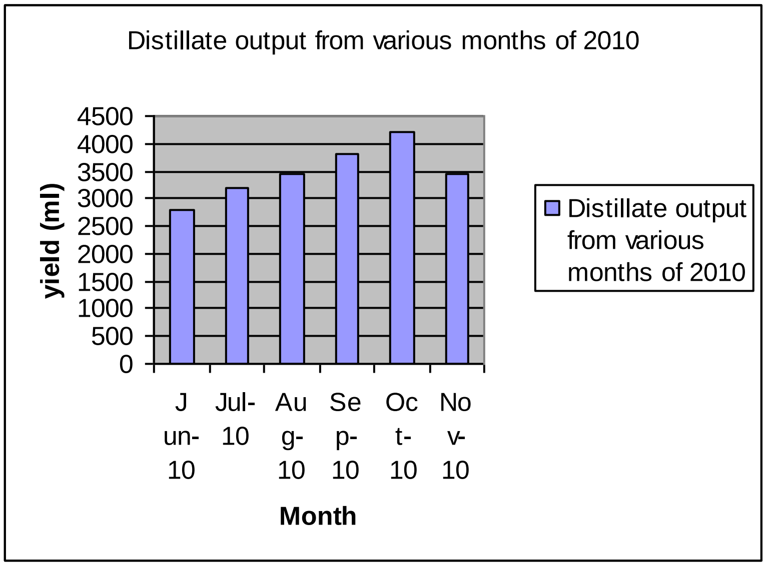

Fig.7. Average daily Production for different months of the year

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