Experimental Investigation of Double Sloped Solar Still Coupled with Flat Plate Solar Water Heater

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Abstract - Since depletion of non-renewable sources of energy increase, renewable energy plays important role for human energy requirement. The effective utilization of solar energy is going to be the prime importance in future to replace the convectional source of energy.With the depletion of non-renewable sources of energy namely, fossil fuels, renewable sources of energy such as tidal, geothermal, solar, wind etc. are going to play a vital role for our energy requirement. The paper gives details of the utilization of solar energy for double sloped solar still coupled with flat plate solar water heater. It involves the construction, testing, and analysis of double sloped solar still coupled with plat plate solar water heater for small scale domestic purpose.The available report is reviewed the basic systems, different solar radiation measuring techniques and proposed system which can be done solar desalination in quite simple manner. Working of the system is as same as the rain following principle. During the experiment saline/brackish water is heated from solar radiation directly into the flat plate collector as well as in the solar still up to 50^0 to 70^0. Hot water from the collector can be store in storage tank while water in still is get evaporated due to solar radiation and then it will be condense. This condense water can be used as for the drinking purpose. Hot water store in the tank can be used for the various domestic purposes as well as it can be used in night for desalination. This system gives high thermal efficiency. It is not harmful for the environment but overall cost is quite high as compare to convectional solar still.

Keywords*: Desalination, Double sloped solar still, Solar Heater, Flat Plate Collector*.

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I. INTRODUCTION

Solar energy is the primary source of energy for our planet. Solar energy is very large, inexhaustible and clean source of energy. The power from the sun intercepted by the earth is approximately 1.8×10^{11}MW which is many thousands of times larger than the present consumption rate on the earth of all commercial energy sources. Solar energy is the unconventional sources of energy, so supply of energy from the sun is continuous basis. The main advantages of solar energy are that, it is an environmentally clean source and second it is free a source of energy available in almost all parts of the world.

Fresh water is the basic needs of the human for the survive purpose. But only 2.5% water available on the earth which can be capable of the drinking purpose. Around which the available water very small quality of the drinking is within human reach. So after some year this may be caused the large shortage of fresh water for the consumption.

The demand of the fresh water is rapidly increase, while supply has been decreasing. So it is a right time for technology to take an important role and match the supply with the demands for the fresh water. There are many solar desalination technology were invented to match the demand and supply conditions. In this report we talked about the doubled sloped solar still coupled with flat plate solar water heater. It is a simple technology and more economical than the other available methods.

This system basically work on the two sub-system such as flat plate solar water heater which can be use for heating of water with the help of solar energy and solar still can be use for purification purpose. We give an overview of the how double sloped solar water heater is works. Then we are introducing our approach with experimental results. We then conclude the paper.

II. LITERATURE REVIEW

Solar still is the device which can be used for the purification of the saline water. Efficiency of the solar still is very low. So to increase the efficiency of the system certain techniques are used which improves the performance of the solar still. In some cases still coupled with the flat plate or evacuated tube solar water heater. In some cases parabolic collector connected to the solar still. There are also different material can be used to improve the performance of the system. Utilization of the single sloped solar still coupled with evacuated tube solar collector which enhances the productivity of the solar still [2]. It has tested and demonstrated the best method to utilize the ETC solar water heater for solar still productivity and extracting hot water for use. Work is carried out on single basin solar still integrated with a flat plate collector [FPC][4]. A single stage basin type solar still and a convectional flat plate collector were connected together in order to study the effect of augmentation on the still under local condition. The multistage evacuated solar still system that consists of three stages stacked on the top of each other. The result in [5] shows that, the maximum production of the solar still was found in the first stages and is 6 kg/m^2/day, 4.3kg/m^2/day, in second stage and 2 kg/m^2/day in first stage at a vacuum pressure of 0.5 bar. Indeed, the total productivity of the solar still is affected very much by changing the internal pressure. The productivity decreased as the pressure increased due to the lower evaporation rates at the higher pressure values. The effectiveness of the single basin passive solar still can be

improved [6]. The different methods are used to improve the productivity of single basin passive type solar still. Various techniques are experimented in [7] which can be play important role to improve the performance of the system. It gives the information about different material which can be used to store the heat to improve the efficiency of the system. The performance of solar desalination system is improved with two modifications in the present convectional solar system [8]. In first modification it use packed layer which can be installed in the bottom of the basin to increase the efficiency of the still. The experimental investigation of the behaviour of a solar still coupled with hot water storage tank is conducted in [9]. [10] It described the system in which the solar still coupled with the solar collectors. This design can gives more output than other convectional system.

III. EXPERIMENTAL SET UP AND PROCEDURE

The major elements of the experimental setup are double slope solar still and flat plate solar water heater. The experiment set up used for the study is shown in figure.1. The still is made up of G.I. sheet of $1m^2$ areas and the same is also acting as a basin. The inner side of the G.I. plate acts as absorber plate and it is painted with black colour. Another box of the outer structure was designed and fabricated to hold the still.

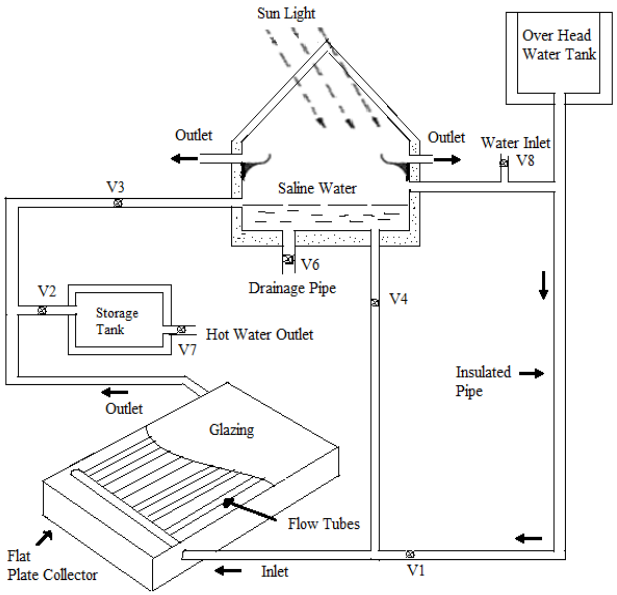

Figure 1: Schematic experimental set up

Insulation is provided at bottom and side to reduce the heat losses. Puf with thermal conductivity of 0.021W/m K is used for this purpose. The water in the basin is condensed by using an acrylic of thickness of 0.3 cm and it is fixed at an angle of 32^0 of the both side with respect to horizontal axis. The purified water condensed from the still cover is collected by folding G.I. sheet in the upper side of the sheet in the box shape. Further the box shaped collection tray is connected with P V C pipe to collect the purified water in a measuring jar. Four holes are made in the solar still. Two holes for the bottoms of the still one for the drain and other for the recirculation of the water present in the still. Third hole can be used for the inlet for the cold water from the cold water storage tank. And fourth one can be used for the outlet of the purified water. Digital thermometer can be used can be used for measurement of the cold water temperature as well as hot water temperature. Thermo couple wire with temperature indicator can be used for the measurement of the various temperature of the system such as, water temperature at the bottom of the still, vapour temperature; bottom of the cover, upper side of the cover, storage tank temperature, collector outlet temperature and last one is the atmospheric temperature.

Solar light coming from sun is transmitted through a glass cover to the water in the basin. Thus the basin water gets heated up and evaporates. The evaporated water gets collected inside layer of the glass cover where it gets condensed. This condensed water flows down the cover due to the slope provided and reaches the channels, where it is collected by the collection jar. At the beginning of the experiment, cold water is filled in the basin through the inlet pipe. Experiment is carried away for 24 hour time span. For each experiment, the glass cover is cleaned in the morning to avoid the dust deposition over the outer layer of the glass. The experiments were conducted in October 2014. The readings were taken from 9 am to 6 pm at hourly intervals. The variables measured in this experiment are cold water, basin temperature, vapour temperature, inner glass temperature, outer glass temperature, ambient temperature and productivity.

IV. RESULT AND DISCUSSION

The results taken on various days after one hour between 9.00 AM to 6.00 PM. On the basis of observation taken on solar Still with flat plate collector, graphs are drawn as shown in the following figures:

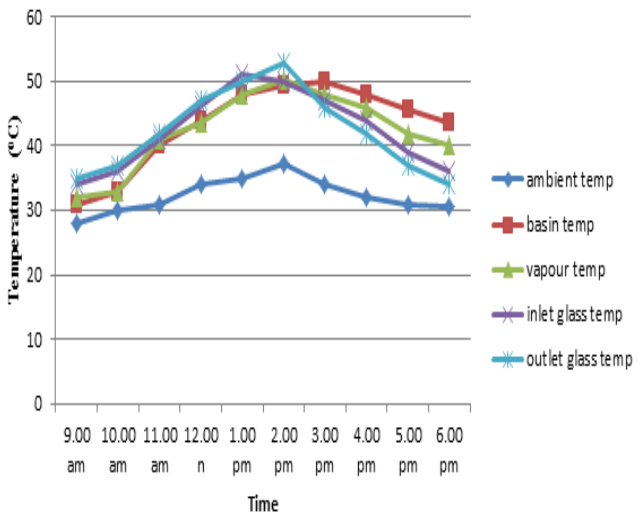

Figure 2: Graph of observations on 02/10/2014.

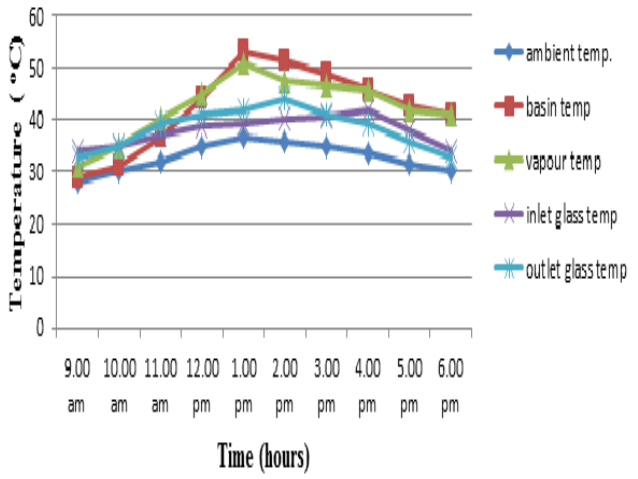

Figure 3: Graph of observations on 03/10/2014.

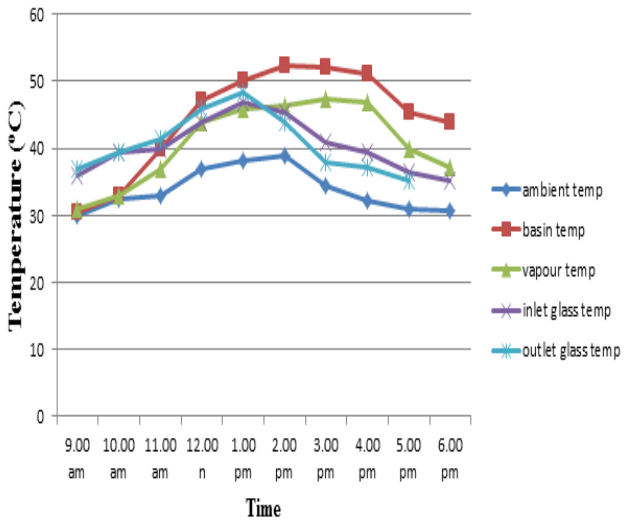

Figure 4: Graph of observations on 04/10/2014.

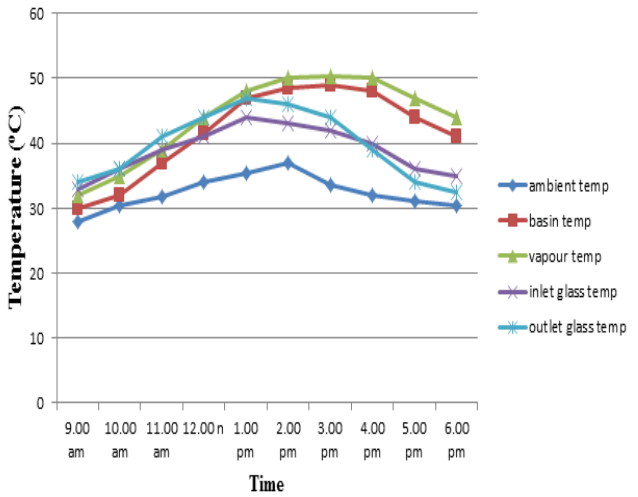

Figure 5: Graph of observations on 05/10/2014.

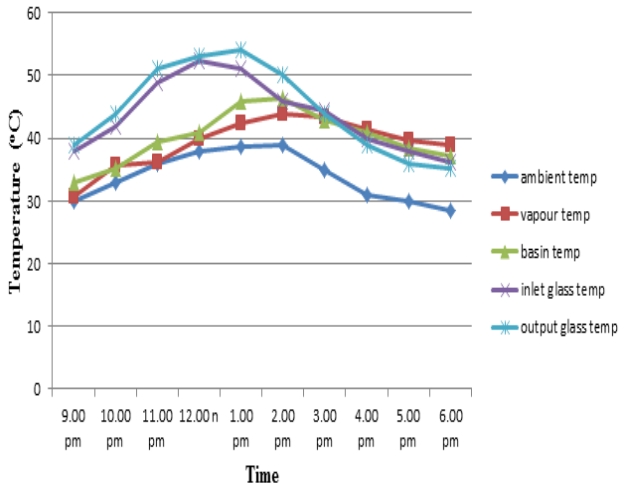

Figure 6: Graph of observations on 18/10/2014.

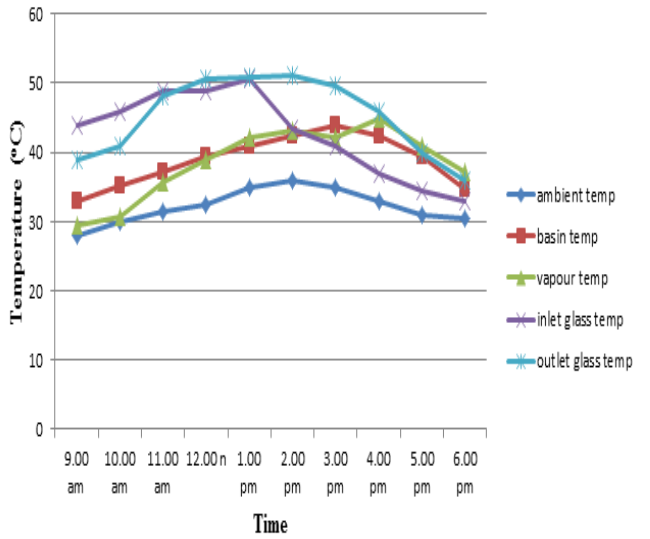

Figure 7: Graph of observations on 19/10/2014.

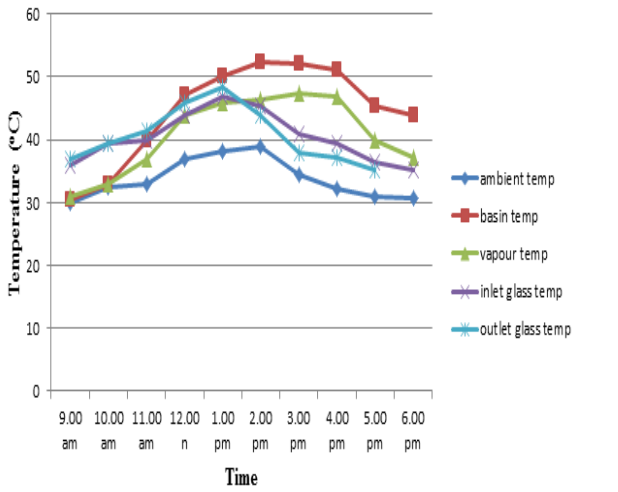

Figure 8: Graph of observations on 20/10/2014.

Time in hr	Productivity (ml/hr)
9.00 am	0
10.00 am	0
11.00 am	0
1.00 pm	140
2.00 pm	270
3.00 pm	310
4.00 pm	280
5.00 pm	140
6.00 pm	70

Table 1 : Productivity chart average.

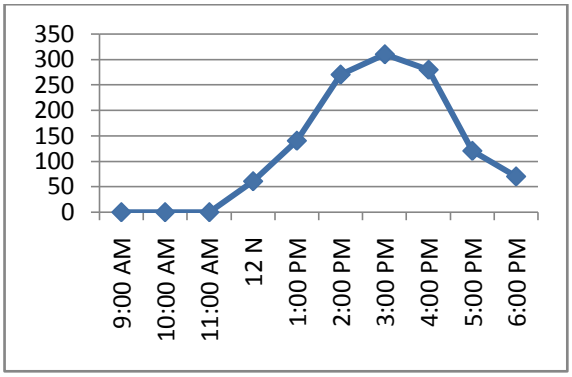

Figure 9: Graph of Productivity chart average.

Average productivity of solar still coupled with flat plate collector of seven day as shown in figure 9 and table 1.

The main objective of the experiment was to improve the performance of ordinary still. In order to increase the productivity of doubled sloped solar still coupled with the still.Average productivity of the experimental set up during 24 hours of the 7 days was 2.1liters. The main advantage of double sloped solar still is its construction is easy and cab be performed by the local people from locally available material. Hard maintenance is not required and with almost less operation cost. The initial capital cost of skills is roughly proportional to capacity, where as other methods have significant economics. But the only thing is they require large areas of land for installation and have low output.Their productivity rate depends on the available solar radiation. If there is no sunshine, the productivity is almost zero.

V. CONCLUSION

An experimental investigation of flat plate solar water heater coupled with the passive double sloped solar still was done in this report. It was found that productivity of the flat plate solar water heater coupled with passive sloped solar still is more than as compared with the convectional solar still. This system can be work on the hybrid nature which gives hot water for the domestic purpose as well as purified water for drinking purpose of the human being. We also concluded that, thermal efficiency of the active solar still is lower than the passive solar still. This system is more useful for rural application, where the quality water is not suitable for drinking.

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