OPTIMIZATION OF DOUBLE SLOPE SINGLE BASIN SOLAR STILL WITH ENERGY STORAGE MEDIUM

[1]A. Abdul Munaf, [2]S.Joe Patrick Gnanaraj, [3]G.Suresh, [4]S.K.Rajesh Kanna, [5]M.Bakkiyaraj
[1, 3, 4,5]Associate Professor, Department of Mechanical Engineering, Rajalakshmi Institute of Technology, Chennai, India.
[2]Associate Professor, Department of Mechanical Engineering, Francis Xavier Engineering College, Thriunelvelli, India.

Abstract : Double slope solar stills are used for over 100 years to get fresh water from saline water. But their productivity with all modifications is in the range of 2-5 l/m^2/day. It is highly uneconomical and not suitable in places where space is a limiting factor. To overcome this problem double slope solar stills are recommended. In this work, an attempt was made to improve the efficiency of still by external reflectors, glass wool insulation the combination. Finally the efficiency of the simple still was compared with that of external reflectors, glass wool the mixture. Use of external reflectors and glass wool increases the overall temperature of the still water and improve the evaporation respectively thereby this will improve the condensate making of the solar still. It was observed that productivity increased by 72% for still with reflectors, 124% for still with glass wool and 156% for still with collector glass wool combination when compared with conventional solar still.

***IndexTerms* - Solar still, reflecting mirrors, glass wool, condensate production.**

I. INTRODUCTION

Water is one of the most essential element for life on earth, today each basic elements viz. air, water, soil etc., are impure which causes an unbalance in the survival of the living things on the earth. In case of water effluents from industrial, agricultural sectors are dumping into the water bodies thus making it non-usable. Also the annul rainfalls are getting low so that our underground water levels are lowering at an alarming rate [1]. This also makes water too hard which cannot be used for domestic purposes. In short, both water quantity and qualities are becoming low. Thus, efficient water treatment is necessary for this century to relief the thirst of our globe [2].

Distillation using solar energy is a great possibility to harvest the potable water from waste water orbrine. Solar energy is made trapped in a solar still where the water gets heated and the condensed water can be utilized as potable water. Efficiency of a still depends on various factors viz. absorber area, water temperature, glass temperature etc., [3]. If we can improve the overall water temperature, it will increase the evaporation rate and gives higher productivity. External reflector used to reflect the energy from sun to solar still, overall water temperature of still becomes higher which increases the still efficiency. Glass wool is another option to improve the evaporation rate. Glass wool is highly insulation [5] and when it is placed inside the gap between wood and basin, glass wool gets filled entirely with water due to the capillary effect. Due to the increased effective surface area of water, evaporation becomes higher. By combining external reflector and glass wool, the productivity can be further increased due to its combined effect. Evaporation is proportional to the overall temperature of still water and when the collector water is added, the temperature raise causes higher evaporation. Due to increased temperature, glass wool evaporation also becomes higher so that the combination can produce better result. Various factors can influence the rate of production of the solar still. Experiment was done with water level of 1cm depth, still with collector, still with sponge and then the combination. Different arrangement can cause changes in the productivity in the still. Temperature variation for still water, glass, absorber, vapour are noted and studied. Cumulative condensate production is measured hourly and compared with that of productivity of simple still with water depth of 1 cm.

II. EXPERIMENTAL SETUP AND PROCEDURE

DOUBLE SLOPE SOLAR STILL. - Solar still consists of absorber, insulator and transparent glass for trapping thermal energy from the solar radiation. Absorber is a sheet metal of mild steel with dimension 0.80mx0.60m and thickness of 0.8mm and it is painted black. Coating with black paint can increase the heat absorbing capacity of a material. Height of the absorber region is 10cm. Still is insulated with plywood of thickness1.5cm.The still is covered with transparent glass in top which has a thickness of 4mm as shown in fig.1. Glass is maintained at a slope of 30º (in double side). This slope is sufficient for the smooth flow of condensate towards the collecting pipe. APVC pipe with a suitable slope is made at both end of still in order to collect the condensate. The temperature of the water and absorber changes with time according to water depth and solar strength. Water has higher specific heat capacity and it needs higher heat energy to raise its temperature to one unit whereas, absorber has lower specific heat than water and can attain higher temperatures for a given quantity of heat. Evaporation becomes higher as the water temperature increases.

Fig.1 Experimental setup for Solar still with External Reflector

The top glass is double sloped transparent through which the sunlight can go through and maintains heat energy like green house. This results in the rise of water temperature as the day progress. The bottom sides of glass (inside the still) have higher temperature whereas outer surface of the glass has lower temperature and condensation occurs due to this temperature difference.

EXTERNAL REFLECTOR - Fig 2 shows the productivity of solar with and without reflectors. From this it is clear that the use of reflectors in the still increases the productivity.

Fig.2 Experimental setup for Solarstill with External Reflector

GLASS WOOL - Glass wool is an insulating material made from fibers of glass, gases possess poor thermal conduction properties compared to liquid and solid and thus makes a good insulation material if they can be trapped, if the material is able to restrict heat transfer in a material. It is shown in figure 3.

Fig.3 Experimental setup for solar still with coated with glass wool

III. EXPERIMENTAL PROCEDURE

1. Still I - Double slope solar still alone of water depth 1 cm (on 10/06/2016),
2. Still II -Still with external reflector (on11/06/2016),
3. Still III - Still with glass wool (on 12/03/2016) and
4. Still IV-Combination of still reflector and glass wool (on13/06/2016).

It is done for 9 hour in a fair sunny day from 9 Hrs to 19 Hrs. Solar still was placed in a glass facing north south direction.

The various measured parameters such as solar intensity,

1. Ambient temperature,
2. Glass temperature,
3. Water temperature,
4. Vapour temperature done with Solar Power Meter
   (Model number: TM207, Accuracy: Within +10W/m^2, Resolution: 1 W/m^2)
   Digital thermometer (Measuring range: 50^{0}C to +200^{0}C, Accuracy: +1^{0}C, Resolution: 0.1, Probe size: 3.9 mm (ϕ) x 140mm (L). All the parameters and amount of condensate production was noted for every one hour.

IV. RESULT AND DISCUSSION

SOLAR INTENSITY - The variation of solar intensity with time for the period from10thJune 2016 to13th June 2016 is shown in the Fig4.

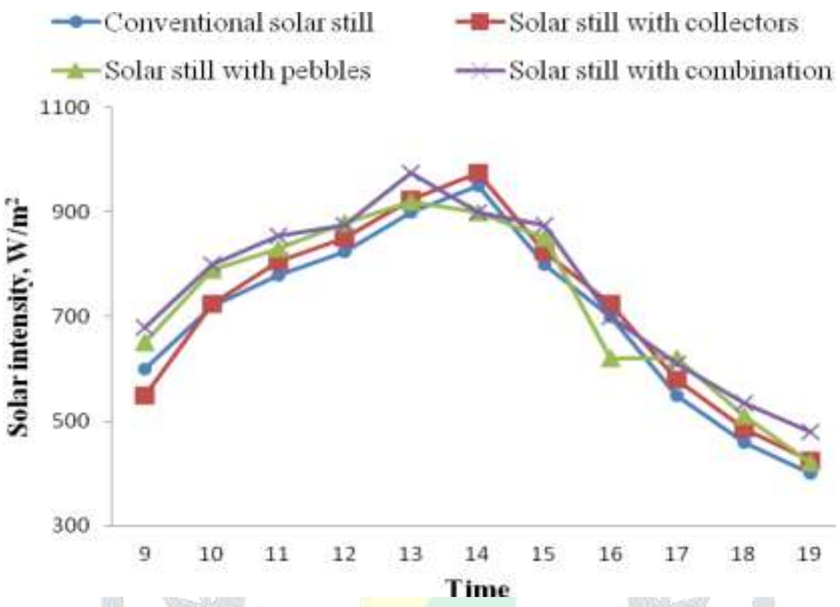

Fig.4 Solar Intensity with Time

Productivity of the solar still depends on the amount of solar radiation available and thus the still productivity should be compared with the solar intensity of experimented days which is random. Due to this, experiment was done on four successive fair sunny days which made result comparable.

TEMPERATURE VARIATION - The changes of measured temperature of glass, vapour, still water, ambient and absorber mirror with local time on the four consecutive days are plotted in the Fig.5. Water temperature is higher than the other temperature as seen from the graph. Also, glass temperature is always smaller than the other measured values.

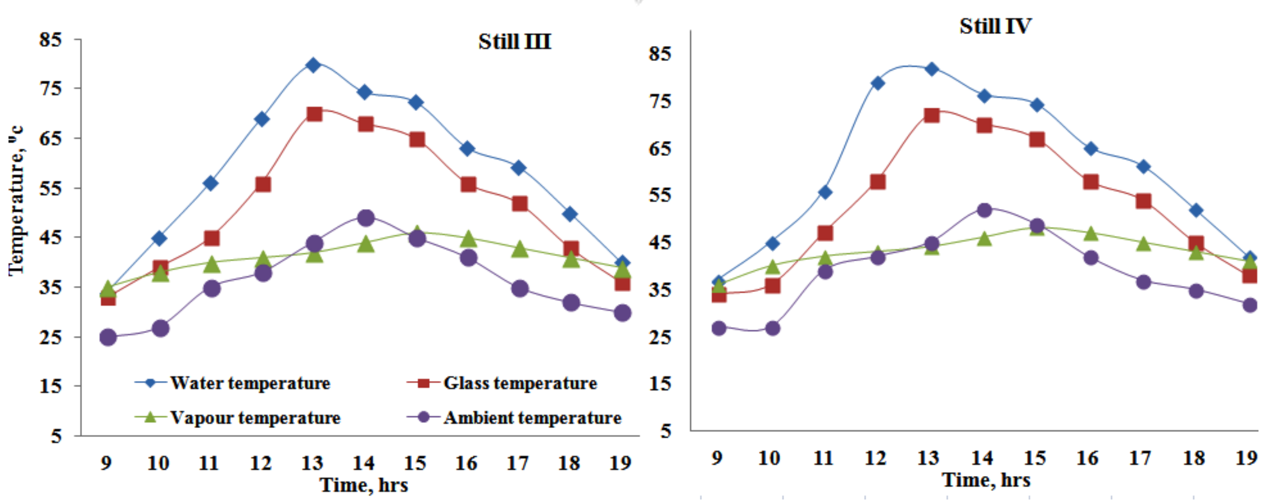

Fig.5 Temperatures vs. time and Date

All the initial temperatures are at minimum value and it increases as the day progress. Each parameter attains its maximum value at the peak time (around 2.00pm). Different variation in each parameter as observed from the plot is due to the different specific heat capacity of each element.

HOURLY PRODUCTIVITY - Yield from the still measured for every one hour. The production of condensate with time is shown in Fig.6. It is clear from the graph that hourly production was higher for almost all the time. Hourly production should be compared with the hourly solar intensity and it can be deduced that the condensate production is proportional to the solar intensity available. Also, the hourly production was higher for the reflector and glass wool combination in most cases except in the evening hours.

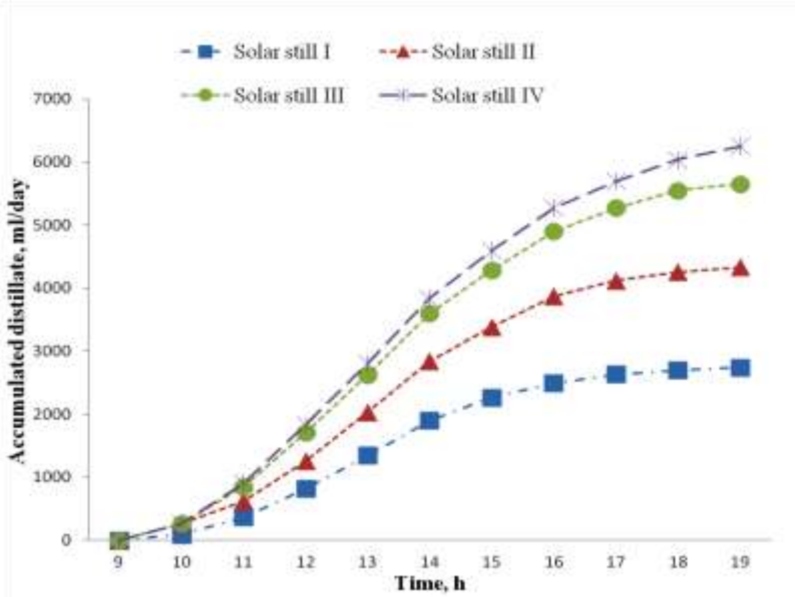

Fig.6 Hourly Condensate Productions

COMPARISON OF CUMULATIVE YIELD FOR VARIOUS DEPTHS - Cumulative production is the total amount of added hourly production for a period of 9 to 19 hours (calculated from the figure 9) as shown in figure 7.It is clear from the graph that total productivity is higher for still with reflector and glass wool combination and lesser for simple still of the same water depth (from 9Hrs to 19Hrs).

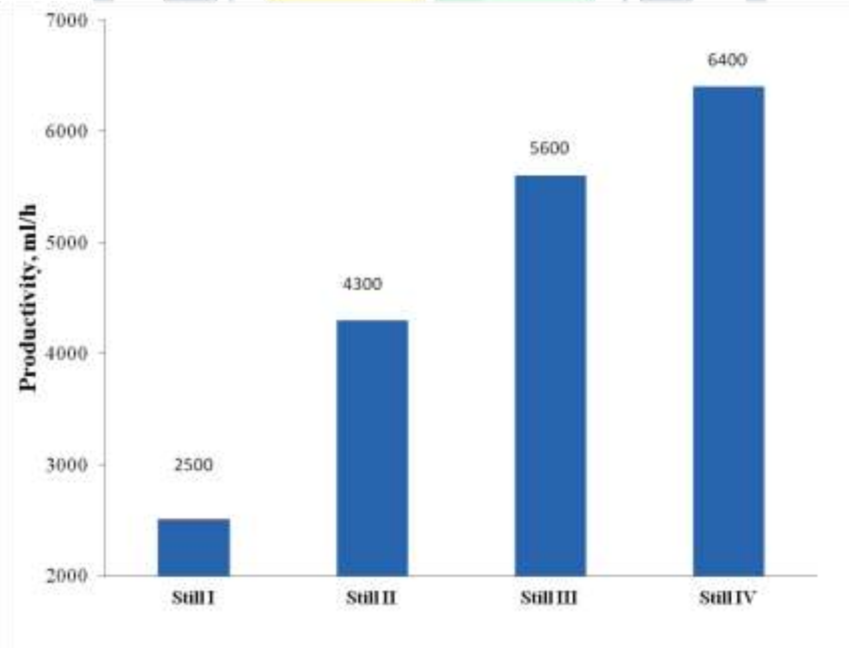

Fig.7 Cumulative Condensate Productions

Variations in the cumulative production are due to usage of collector and sponge that can be seen from the plot. Rate of evaporation varies due to various modes of still and due to this, cumulative production becomes different in each case.

V CONCLUSION

1. Based on the experimentation, increasing productivity per ml/h for a period of 8 hours for simple still, still with reflector, still with glass wool and still with the reflector glass wool combination are 2500 ml/h, 4300ml/h, 5600ml/h and 6400ml/h respectively,
2. It was increased by 72% for Still II, 124% for solar still III and 156% for the Still IV, when compared to that of still with1cm water depth.
3. It is obvious that the productivity of still with reflector or got increased due to the mixing of higher temperature water in the still.

VI REFERENCES

[1] V.Velmurugana, K.Srithar, Performance Analysis of Solar Stills Based on Various Factors AffectingtheProductivity-AReview,Renewable and Sustainable Energy Reviews15, pp.1294–1304, 2011.

[2] T.Rajaseenivasan, K.KalidasaMurugavel, T.Elango, R.SamuelHansen, A Review of Different Methods to Enhance the Productivity of the Multi-Effect Solar Still, Renewable and Sustainable Energy Reviews 17, pp. 248–259,2013.

[3] Hitesh N.Panchal, MiteshI. Patel, BakulPatel , Ranvirgiri Goswamiand Manish Doshi, A Comparative Analysis of Single Slope Solar Still Coupled with Flat Plate Collector and Passive Solar Still, International Journal for Scientific Research &Development, Vol. 2,pp. 111-116,2011.

[4] Raj ThundilKaruppa R, Pavan P and Reddy RajeevD,Experimental Investigation of a New Solar Flat Plate Collector, Research Journal of Engineering Sciences, Vol. 1, pp.1-8, 2012.

[5] Shanmugan Sengottain, Janarathanan Balasundaram and Chandrasekaran Joseph, Thermal Asymmetry Model of Single Slope Single Basin Solar Still with Sponge Liner, Thermal Science, Vol. 18, pp. S439-S450,2014.

[6] Ekramian,S.Gh.EtemadandM. Haghshenasfard, Numerical Analysis of Heat Transfer Performance of Flat Plate Solar Collectors, Journal of Fluid flow, Heat and Mass Transfer, Vol. 1, pp. 38-42, 2014.

[7] M.K.GaurandG.N.Tiwari,Optimization of Number of Collectors for Integrated Pv/THybrid Active Solar Still, Applied Energy87, pp. 1763–1772, 2010.

[8] Sunil.K.Amrutkar,Satyshree Ghodkeand Dr.K.N.Patil, Solar Flat Plate Collector Analysis, IOSRJournal ofEngineering(IOSRJEN), Vol. 2, pp.207-213,2012.

[9] MounaHamed,Ali Fellahand AmmarBenBrahim, Parametric Sensitivity Studies on the Performance of a Flat Plate Solar Collector in Transient Behavior, Energy Conversion and Management, Vol. 78, pp. 938–947, 2014.

[10] M.Koussa,A.Cheknane,S.Hadji,M. Haddadiand S. Noureddine, Measured and Modeled Improvement in Solar Energy Yield from Flat Plate Photovoltaic Systems Utilizing Different TrackingSystemsandUnderaRangeofEnvironmentalConditions,AppliedEnergy88,pp.1756–1771, 2011.

[11] BehroozM.Ziapour,VahidPalidehand Ali Mohammadnia, Study of an Improved Integrated Collector-StorageSolarWaterHeaterCombinedwiththePhotovoltaicCells,EnergyConversion and Management 86, pp. 587–594, 2014.

[12] MohamedA.EltawilandZ.M.Omara,EnhancingtheSolarStillPerformanceUsingSolar Photovoltaic, Flat Plate Collector and Hot Air, Desalination 349, pp.1–9, 2014.