Impact Factor (SJIF): 3.632

International Journal of Advance Research in Engineering, Science & Technology

e-ISSN: 2393-9877, p-ISSN: 2394-2444

Volume 3, Issue 4, April-2016

DESIGN AND FABRICATION OF MICRO SCALE SOLAR DESALINATION UNIT WITH ENHANCED PRODUCTIVITY USING HEAT STORAGE MATERIALS

Winstor Jebakumar.V.S[1], Titus.R[2], Surjith.N[3], Sathishkumar.U[4]

[1]*PG Scholar, ME-Thermal Engineering,*
RVS College of Engineering and Technology, Coimbatore-641402.
Mail id:winstorjebakumar@gmail.com

[2]*Faculty of Mechanical Engineering,*
RVS College of Engineering and Technology, Coimbatore-641402.
Mail id: titus_me06@yahoo.com

[3]*PG Scholar, ME-Thermal Engineering,*
RVS College of Engineering and Technology, Coimbatore-641402.
Mail id:surjithmech21@gmail.com

[4]*Faculty of Mechanical Engineering,*
RVS College of Engineering and Technology, Coimbatore-641402.
Mail id:sathishgtc@gmail.com

ABSTRACT

Water is an important need for life and industrial applications. Due to the increase in rate of population and industries the demand for water is high. Both the energy and water plays an important role in the development of National economy. Availability of fresh water is decreased by the disposal of industrial effluents and agricultural sewages. Solar still is the best way of producing distillate water for agricultural and household purposes. In which the power is used from the sun, solar energy is free and abundant in nature. It can be used as an alternative source for fossil fuels and it is eco-friendly to nature. In this the conventional solar still was compared with the still with heat storage materials. The experimental analysis was conducted in RVS College of engineering and technology in the location (11.0300° N, 77.1300° E) of Coimbatore. The sample water have been taken from our college campus. The various parameters which are affecting the productivity and the various temperatures like water temperature, Inner glass cover temperature, and Outer glass cover temperature are measured in an hourly manner using thermocouples. The various parameters like solar intensity, wind velocity, are also measured for every hour. The productivity of the distillate water is collected in a measuring jar and efficiency of the still is calculated for the stills. In conventional still the distillate output is high for the lower depth of water 1cm, which gives the output of 0.722 kg/day and gives the efficiency of 23% and for the still with heat storage materials the output of 0.927 kg/day and the efficiency of 35% have been achieved.

Keywords: *Solar energy, Desalination, Basin, Solar Still, Water*

INTRODUCTION

The basic need for human beings are water. Due to the population and industrial growth the scarcity of water is increasing day by day. Desalination is one of the best techniques to reduce the water scarcity among the arid and semi-arid areas. There are various types of desalinations used for the production of water, but they uses fossil fuels and other mechanical parts, so it will not suitable for the environment and high cost. Small size basin type solar still works on the principle of raining and it receives power from the sun. It is very simple in construction and low maintenance is needed for these type of stills, but the low productivity and efficiency are demoting this type of desalination.

Many research works are undergoing in this topic for the productivity increment. M. Koilraj Gnanadason et al. conducted two single-basin solar stills made up of copper sheet were designed and tested for still alone and still with modifications. The productivity and the efficiency of the copper still is higher for the stills because copper has high thermal conductivity and the rate of heat transfer to water in that still is higher. The copper solar still is modified with black paint coating, pebbles, fins, and finally with vacuum. Black paint coating, pebbles, and fins were used and the output of the still is increased significantly. The vacuum still efficiency is higher as the productivity is more due to vacuum in the morning and evening i.e. during low ambient temperature. The average daily output was found to be around 2.56 kg/d for the basin area of 0.27 m^2. It also shows an increase in the productivity for the minimum depths of water level.Therefore, modified copper solar still coupled with vacuum pump is highly suitable and recommended for higher distilled water yield [1].

Z.M.Omara et al. done the experimental analysis in the conventional solar still and compared the results with the addition of latent heat storage materials of sandy layers of various colour and the thickness of the sand bed is also maintained. In which the various depth of sand was also measured for the optimum production of water. The black sand layer of 0.01 thickness gives high productivity when compared with yellow sand [2]. K. Kalidasa Murugavel et al**.** studied a single basin double slope solar still has been theoretically modeled. The production rate variations were different for different months. The still production varied from 2.7 L/m^2 day during June to 6.5 L/m^2 day during March. The average production of the still is 4.75 L/ m^2 day. The payback period of the still is one and half years [3].

M.M. Morad et al**.** studied a thermal analysis, passive and active solar stills were installed (solar still and solar still integrated with flat-plate solar collector) to use solar desalination technology for producing fresh water. The experimental results revealed that active solar still maximizes both fresh water productivity (10.06 l/m^2day) as well as internal thermal efficiency (80.6%) compared with passive solar still (7.8 l/m^2day productivity and 57.1% internal efficiency) under conditions of 1 cm basin brine depth and 3 mm glass cover thickness[4].

P. Vishwanth Kumar et al. [5] Studied the various types of solar stills and highlighted the merits and demerits of the design of the still and gives the future scope for design of the still to produce a sustainable amount of water. It has been concluded that in single basin solar stills the productivity can be increased from 34 to 42% by making cooling covers in the still or cooling the cover of the still and also that flat plate collectors with inclined angle gives more productivity than the semi-sphere, bi-layer or arch type covers[6].In this work conventional solar still is fabricated and compared with the modified still with heat storage materials and the productivity increment is analysed by varying the depth of the water inside the basin of the still for various days.

EXPERIMENTAL SETUP

The conventional solar still consists of an air-tight chamber in which evaporation and condensation of water take place simultaneously. The main components of the still are basin, outer box, insulation and absorber (glass).Fig 1 shows the experimental setup, The still basin is made up of GI sheet of size 1000 x 500 x 150 mm with the thickness of 1.5mm.The basin of the still is coloured with black to absorb more heat from the sun. GI sheet was chosen for the low cost, easily available material and corrosion resistant. It is easy for folding and machining according to our design so the construction is easier. The outer cover of the still is made up of plywood size 1100 x 600 mm with the thickness of 2 cm.

This material was chosen for the low cost and stability. The plywood has the thermal conductivity of 0.13 w/mk. So it conducts heat in a slow manner and also acts as insulator. The sides of the basin are covered with thermocol for insulation to prevent the heat loss from the basin. It has the thickness of 2.5 mm with the thermal conductivity of 0.033 w/m-k. It has been chosen for low cost and Glass cover have been chosen for the absorption of solar energy, for this purpose 4mm thickness of glass is chosen and places in the still at the tilt angle of 15^0 which is normal to the latitude of Coimbatore location (11.0300° N, 77.1300° E). The condensed droplets are trickles through inner surface of the glass due to inclination and the distilled water is collected in the measuring jar through the PVC pipe fixed at the end of the glass.

Table 1:Selection of Materials

Parts of the still	**Materials**	**Dimensions**	**Purpose of selection**
Still outer box	Plywood	1100 x 600 x 320 mm	Low cost and stability.
Still outer box	Plywood	1100 x 600 x 320 mm	Low cost and stability.

Top Glass Cover	Glass	1100 x 600 x 4 mm	High transitivity.
Insulation	Thermocol	25mm thick	Insulation, availability. Low cost.

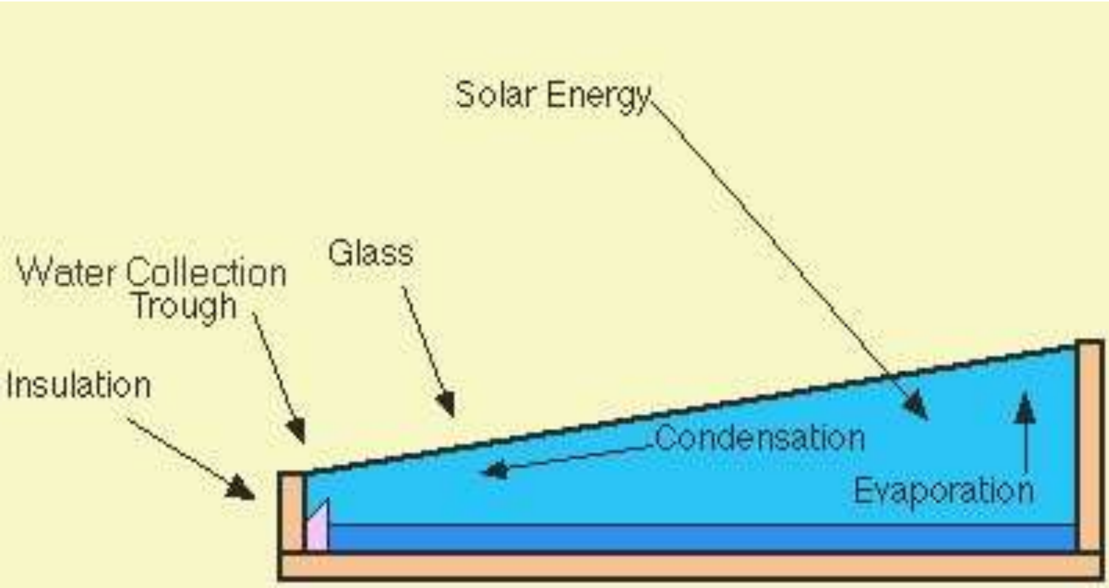

Fig 1: Single slope basin type solar still

The other accessories like PVC pipe, reducers and taps for the inlet and outlet of feed water and collection of fresh water. Saline water is stored in the tank and feed inside the basin manually according to the depth and the depth of the water was measured by the measuring scale which was fixed at one corner of the basin. The still should be air tight to reduce the evaporation loss so the edges of the glass were pasted with insulation tape. So it will be air-tight and the productivity will be increased.

In Fig (2) the heat storage materials have been shown. The gravel stones are denoted as HSM1 and the mixture of pebbles and gravel stone mixture have been denoted as HSM2.These materials have been chosen for their better storage properties and due to their availability and economical purpose.

Fig 2: Heat storage Materials

Fig 3: Still with Heat Storage Materials

. Fig (3) shows the energy storage materials are used for the productivity increment and to reduce the losses of heat sensible heat storage materials are utilized. In this work the gravel stones of uniform size 6.35 mm are used inside the basin. Then the mixture of pebbles and gravel stones are used as the energy absorbing materials. These materials are evenly placed inside the basin area of 0.5m^2.The various properties of the gravel stones and pebbles are given on the table (2)

Table (2): Properties of heat storage materials

Materials	**Density (Kg/m^2)**	**Thermal conductivity (W/mK)**	**Specific heat capacity (J/kg K)**
Concrete stone	1900- 2500	2.0 – 3.5	900 - 1000
Pebbles stone	3300	2.4 – 2.6	880

RESULTS AND DISCUSSION

The experimental study on single basin single slope passive solar still with black coated GI sheet is conducted at RVSCET, Coimbatore, Tamil Nadu, India (11.0300° N, 77.1300° E) .Experiments are carried out from 09:00 h to 17:00 h during clear sunny days. During the experiments, hourly variation of solar intensity, wind velocity, ambient, glass inside, glass outside, vapor, water, basin temperature and distillate yield are recorded. In which the readings are taken in three days for various depths of the saline water like (1, 2 and 3 cm) to find the optimum depth for the conventional still. The comparison of the still with heat storage materials are also analyzed experimentally.

The hourly variation of the yield or distillate output is taken out and plotted in the fig (4) for three concentrations of brine water and with the heat storage materials of the still. In which the productivity depends on the depth of the water with variation in time for the conventional still. The productivity is high of 0.13 kg in the time of 12 to 13 hrs for the low depth of 1cm of water and it decreases gradually in the late afternoon. By comparing the operation of solar still the still with the low depth of basin water of 1cm gives high yield per day. By using the heat storage materials (HSM1&HSM2) inside the basin with optimum depth of water which gives the higher yield because of the release of heat during the late afternoon. The higher yield of 0.17kg has been occurred for the HSM2 at the time of 14:00 hrs. The hourly variation of solar intensity is measured for the three concentrations in which the graph 2 shows the solar intensity varies parabolically, it occurs high at the mid hours of 11 to 14 hrs.

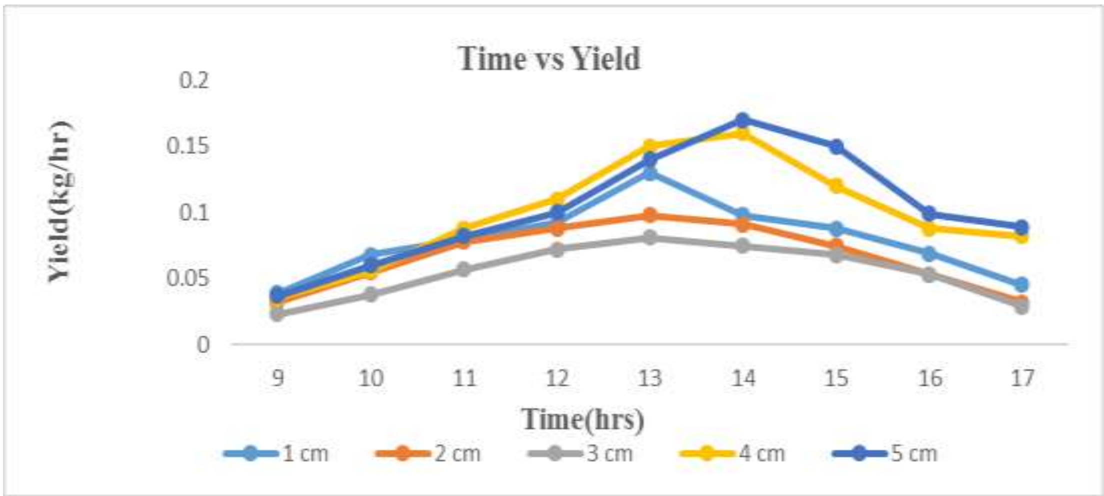

Fig (4): Time with the productivity of the still

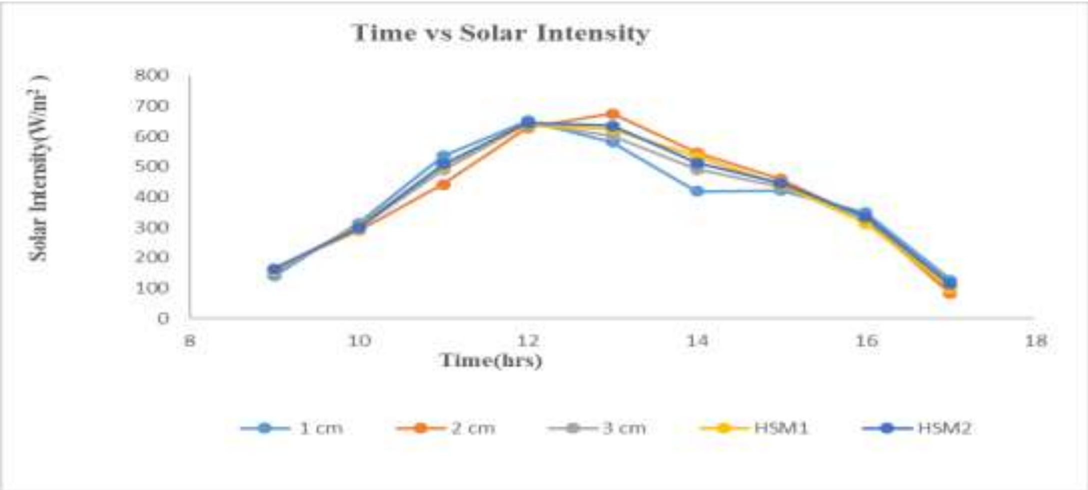

Fig (5): Variations of Solar Intensity with time

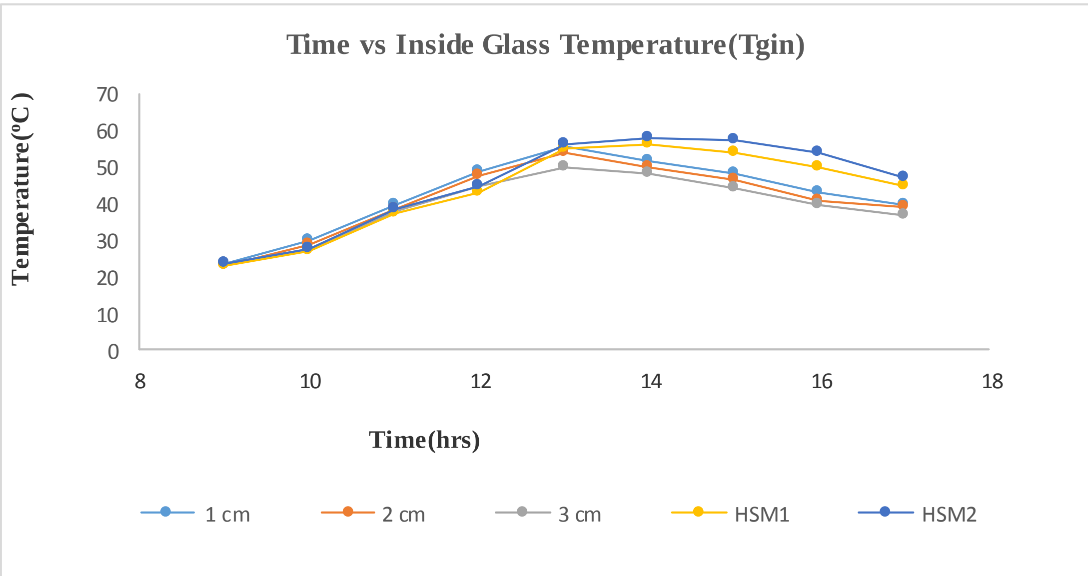

Fig (6): Variations of inside Glass Temperature

The hourly variation of solar intensity is measured for the three concentrations in which the fig 5 shows the solar intensity varies parabolically, it occurs high at the mid hours of 11 to 14 hrs

. The high solar intensity of 674.5 w/m^2 is obtained during the experimental days and the low intensity of 98.4 w/m^2 is obtained. In the morning, the temperature of water is low; therefore it needs high energy to change its phase from saturated liquid to saturated vapor phase.

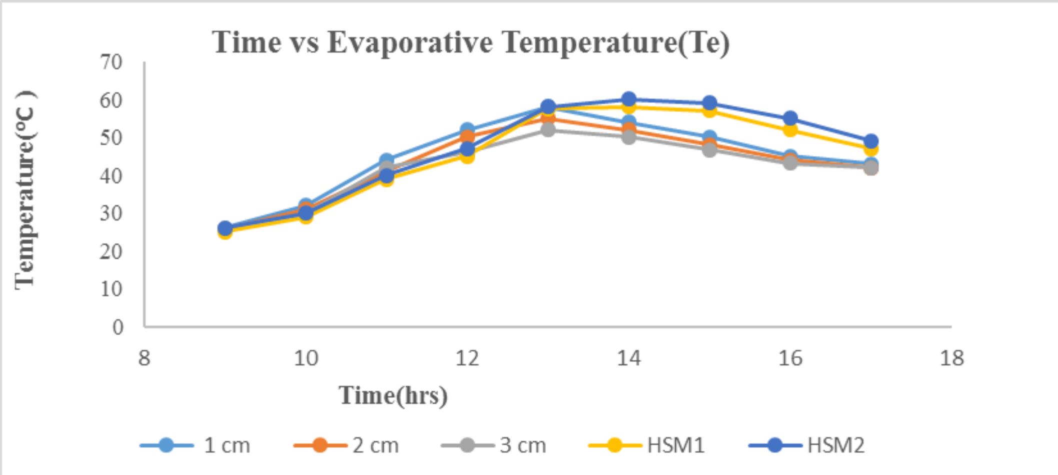

Fig (7): Variations of Evaporative temperature (Te)

All the temperatures (Tw, Te, Tgin, Tgout) are increased gradually and decreases in the late afternoon have been shown in Fig(6,7,8,9) it shows that the maximum water temperature is 63^{0}c and minimum water temperature of 29^{0}C.The temperature difference between the water temperature (Tw) and inner glass temperature (Tgin) is high due to the black coating of the GI sheet. The temperature of the various components are increased gradually up to the time of 14 hrs and then decreased gradually.

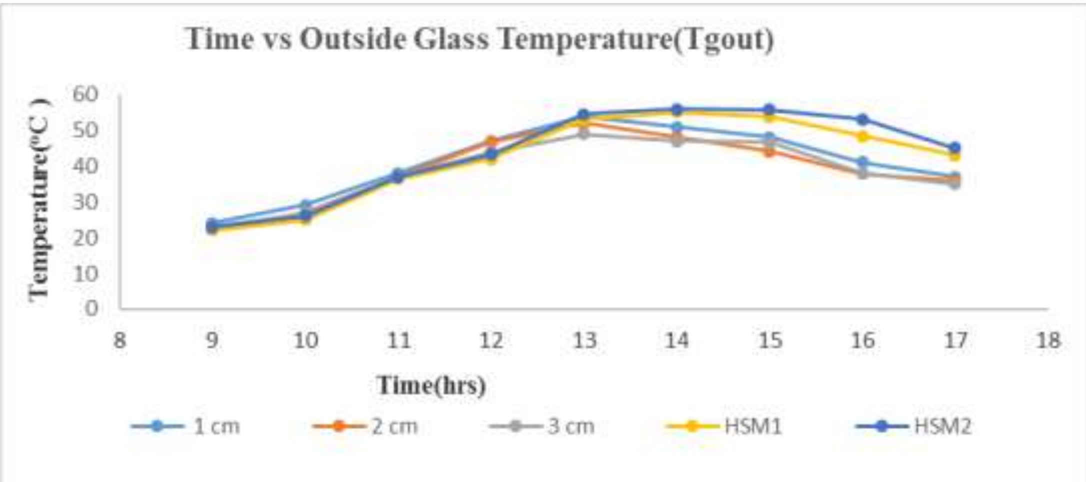

Fig (8): Variations of outside Glass Temperature

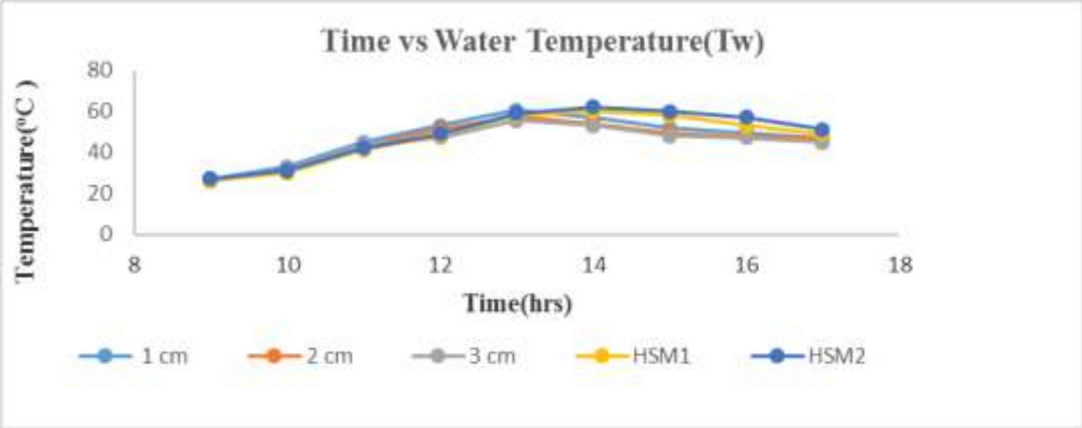

Fig (9): Variations of Water temperature (Tw)

The various temperatures are high at the range of 11 to 14 hrs for the still without the heat storage materials. The still with heat storage materials gives the high value of temperatures up to the late evening and the efficiencies also increased.

CONCLUSION

The passive solar still is constructed with the still basin made of GI sheet of 0.5 m^2. To observe more heat the basin is painted with black colour. The passive still have been experimentally compared in the month of December 2015 for various depths (1, 2, 3cm) of saline water inside the basin of the still and using the heat storage materials. The productivity is increased with increase in solar intensity and ambient temperature. The various parameters like wind velocity, ambient temperature, Water temperature (Tw), Evaporative temperature (Te), Inner and outer glass cover temperature (Tgin and Tgout) are measured in an hourly manner for various depths. The various temperatures of the still increases up to the time of 11 to 14 hrs then it decreases gradually. To find out the optimum depth of the still and it shows that the lower optimum depth of 1cm gives the high yield of 0.722 kg/day and by adding the heat storage materials the productivity have been increased. In which the higher productivity of 0.927 kg/day have been observed for the addition of HSM2 inside the still for the optimum depth of water. The efficiency of the still is higher for minimal depth of water without heat storage materials as 23% due to the addition of heat storage materials up to 35%.It concludes that the lower depth of saline water in the basin with heat storage materials (Gravel & Pebble stone mixture) gives high yield. This cost-effective design is expected to provide the rural communities an efficient way to convert the brackish water into potable water.

Nomenclature	
Te	Evaporative Temperature
Tw	Water Temperature
Tgin	Inside Glass Temperature
Tgout	Outside Glass Temperature
HSM1	HeatstorageMaterial1(Gravel Stones)
HSM2	Heat Storage Material 2 (Mixture of gravel& Pebble Stones)

REFERENCES

[1] M. Koilraj Gnanadason, P. Senthil Kumar, Vincent H. Wilson & A. Kumaravel on Productivity enhancement of a-single basin solar still , Desalination and Water Treatment, (2014) 1–11.

[2] Z. M. Omara and A. E. Kabeel, The Performance Of Different Sand Beds Solar Stills, *International Journal of Green Energy*, 11: 240–254, 2014

[3] Hitesh Panchal, Prathik Patel, Nikunj Patel & Hemin Thakkar on Performance analysis of solar still with different energy absorbing materials, International Journal of Ambient Energy, 10.1080/01430750.2015.1086683

[4] S. Shanmugan, Experimental investigation of various energy absorbing materials on performance of single slope single basin solar still With Hot water Provision, International Journal of Innovative Research in Science Engineering and Technology December 2013

[5] A.Balavignesh, D.B.Sivakumar, on Investigation On The Single Slope Solar Still With Reflecting Materials, Journal of Chemical and Pharmaceutical Sciences, ISSN: 0974-2115

[6]M.M.Morad, Hend .A.M. El-Maghawry, Kamal I.Wasfy on Improving the double slope solar still performance by using flat plate solar collector and cooling glass cover, Desalination 373(2015) 1-9

[7] K. Kalidasa Murugavel and K. Srithar, Effect of Cover Plate Transmittance on Solar Still Performance, *International Journal of Green Energy* (2015) 12, 431–439

[8] P.Vishwanth kumar, Anil kumar, Om Prakash, Ajay kumar kaviti on Solar stills system design: A review, Renewable and sustainable energy reviews 51(2015) 153-181

[9] Syed Firozuddin, Dr. P. V. Walke on Thermal Performance on Single Basin Solar Still with Evacuated Tubes Solar Collector-A review

[10] Selvendiran.R, Manikandan.D, Suresh Babu.K on Experimentation and performance analysis of single slope single corrugated basin solar still JCHPS 79 234-235.