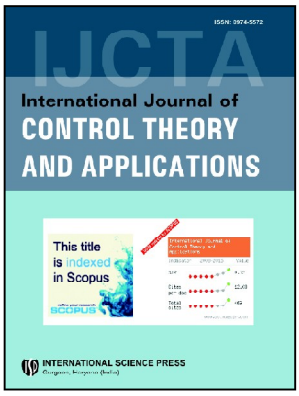

International Journal of Control Theory and Applications

ISSN : 0974-5572

Volume 9 • Number 50 • 2016

Design and Performance Analysis of "v" type Solar Desalination Still

[1]A. R. Vijay Babu, [2*]D. Manikanta Swamy, [3]K. Pavan Kumar and [4]Abu Talha Siddiqi

Department of Electrical and Electronics Engineering, VFSTR University, Vadlamudi, Guntur, India,
E-mail: manikantainter@gmail.com

Abstract: The paper reports implementation, design and performance evaluation of "v" type solar still under the climatic conditions of Vadlamudi, India. It is a very efficient and effective method of converting brackish water into fresh water in rural regions of a nation. The yield obtained from solar still was 2430 ml/m^2/day. The experimental parameters such as glass temperature, inner air temperature; ambient air temperature, solar radiation and distillate output are recorded in sunny days of March 2016. The water purity in terms of Ph, conductivity, hardness and alkalinity is improved after desalination.

Keywords: solar still; desalination; brackish water; Ph; conductivity.

1. INTRODUCTION

As we know that fresh water is the key to the survival of living organisms and human beings. About 97% of water present on the earth is saline and consists of harmful bacteria and about 2% of water is in solid state in the form of glaciers and polar ice cups. So, ultimately only 1% of the water resource is compatible for drinking and domestic needs [1-2]. Desalination is the process of removing alkalinity from brackish water to make it suitable for domestic purpose. Now-a-days, people are shifting towards solar desalination from the conventional fuel based desalination as solar energy is sustainable and emission free. But the main concern of solar desalination is its low efficiency compared to other conventional processes. The factors that affect the productivity of solar based desalination is the difficulty of raising the evaporation temperature and decreasing the condensation temperature as evaporation and condensation take place in the same container.

It is show that the for a single slope basin type solar still, the output ranges from 2.9 m^2-day to 5.6 m^2-day [3]. The major concern is the difference in temperature between glass cover and the water in the basin as it controls the rate of condensation on the glass cover. A number of methods are proposed for increasing the rate of condensation. For example use of an external reflector and mixing a dye with the water in the basin [4].

In the ordinary solar distillation process the water is condensed on the inner surface of top covers and simultaneously releases its latent heat. This results into the increase in the temperature of glass cover and a drop in the temperature difference of water in the glass cover and basin. And this is the thing which affects the efficiency and rate of vaporization [7]. To maintain the maximum yield rate, the water depth inside the still

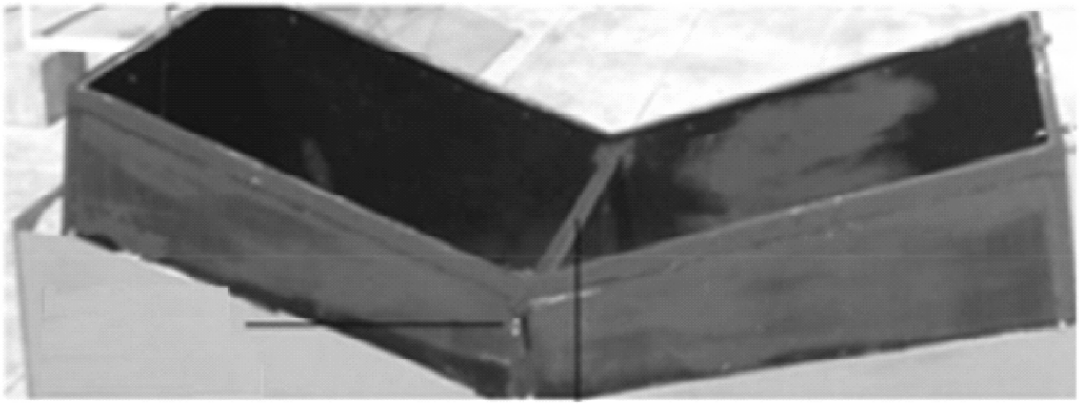

Figure 1: Solar desalination still

should not exceed 2cm [8]. A double slope "v" type solar still [9] with charcoal absorber and boosting mirror has an advantage of collecting the water output without any hindrance. In the current study, the performance of a "v" type solar still is investigated which has the better potential that means higher distillation yield per unit area, as compared to all other desalination processes as shown in Fig.1. In this solar still, the water is present inside the still and water droplets formed after condensation gets collected at the centre of the still by means of a pipe.

2. DESIGN OF SOLAR STILL

Shown in Fig. 2 and the parameters and specifications of the solar still are tabulated in table 1.

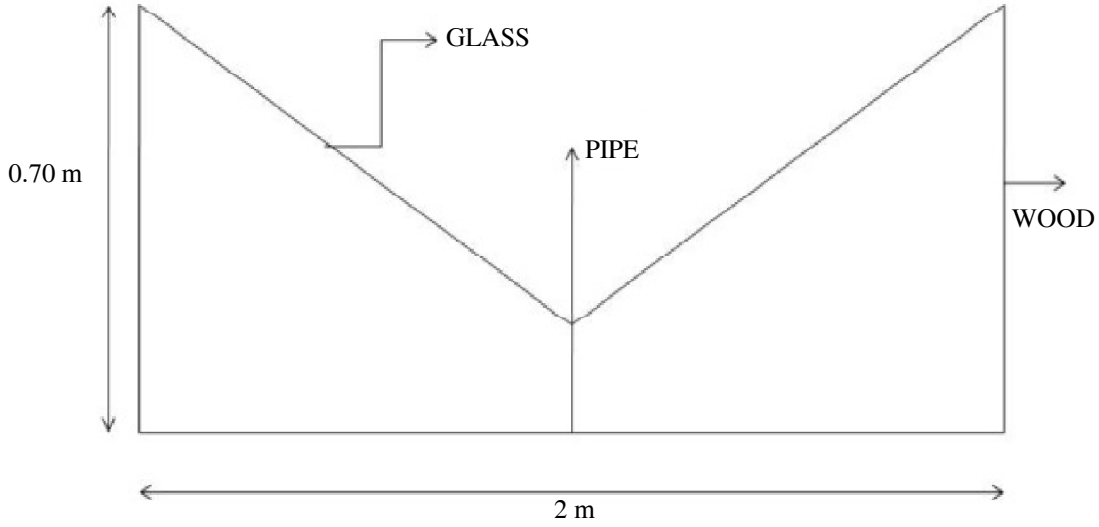

Figure 2: Design of the proposed still

The dimension of a rectangular basin is 2m× 0.70m× 0.05m and it is painted with black color for better solar absorption. A drain pipe of 6.5 mm radius was used for collecting water at the center of the still. A wooden case is used as a thermal insulator to reduce the heat. The top cover of the still is made of glass of 3mm thickness and glass covers tilted at an angle of 2^{o} towards the center of the still to minimize air leakage and for smooth outward flow of distilled water. Two input valves are provided at both the ends of wooden casing to fill the solar still by brackish water.

The experiments were carried out for the duration of 9-18h to record the ambient temperature (t_a), glass temperature (t_g) and temperature of the water inside the still (t_w) using calibrated k-type thermo couples.

3. DISCUSSION AND RESULTS OF SOLAR DESALINATION

Experiments are performed on the proposed "v" type solar still in Guntur, India. The weather report of Guntur is presented in Table 1.

Table 1
Still operation and technical details

Sl. no.	*Climatic conditions*	*Parameter*	*Value*
1	Clear sky	Solar radiation (W/m^2)	0-351
		Ambient (°C)	23-45
		Relative humidity (%)	24-31
		Average wind velocity (km/h)	10
2	Design	Basin absorptivity (α_b)	0.95
		Basin emissivity (b)	0.95
		Absorptivity of cover (α_g)	0.05
		Reflectance of cover	0.05
		Transmittance of glass (τ_g)	0.95
		Specific heat of water (C_w)	4200 J/Kg/K
		Length (l)	2m
		Breadth (b)	0.70m
		Thickness of cotton gauze (t)	0.2mm

During experimentation, the solar radiation received is in the range of 0-351W/m^2 and ambient temperature various from 23-45°C. The wind speed is 8-10 kmph. The effect of solar radiation and ambient temperature is shown in Fig. 3. The experimentation is performed by placing the still in open area under the sun. It is observed that the yield of fresh water produced is directly proportional to the solar radiation. The yield of the fresh water

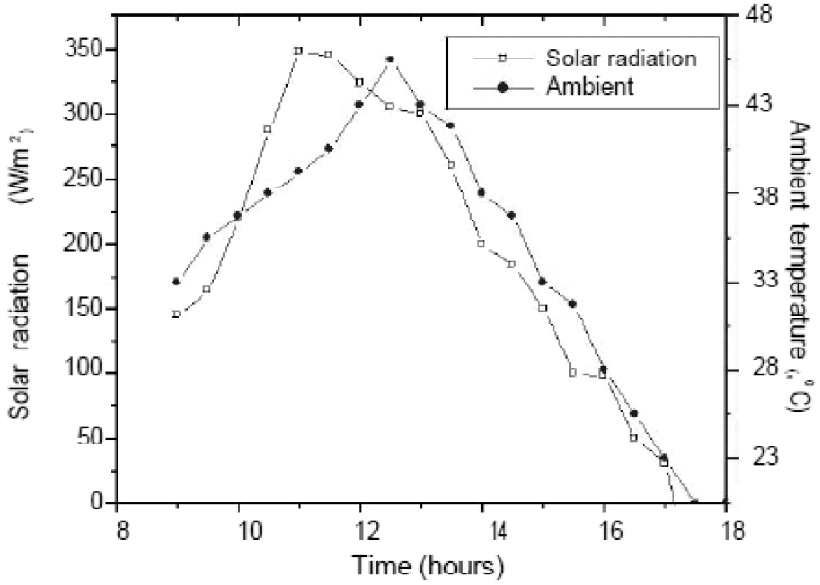

Figure 3: Effect of ambient temperature and solar radiation

produced from the still is increased with increase in solar radiation over the duration of the day. The yield obtained from solar still was 3400 ml/ day. The effect of solar radiation and ambient temperature on the yield is shown in Fig. 4 and Fig. 5. The quality check of the fresh water produced from the still was performed at the environmental lab at VFSTR University, Guntur and the results are tabulated in Table 2. The results indicated that the water produced from the still are portable and can be used for drinking and domestic purposes. The Ph, hardness, alkalinity and electrical conductivity of two different water samples (1 and 2) were tested before and after the desalination and the results were averaged. The level of conductivity is deceased from 0.10 Sm^{-1} to 0.01 Sm^{-1} After the desalination which makes it suitable for portable for drinking and domestic purposes.

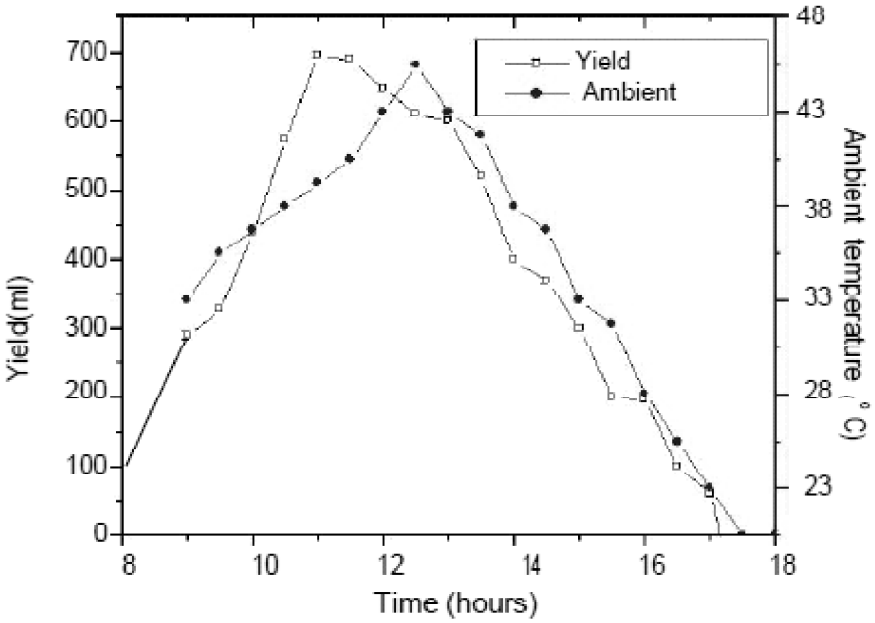

Figure 4: Effect of yield and solar radiation

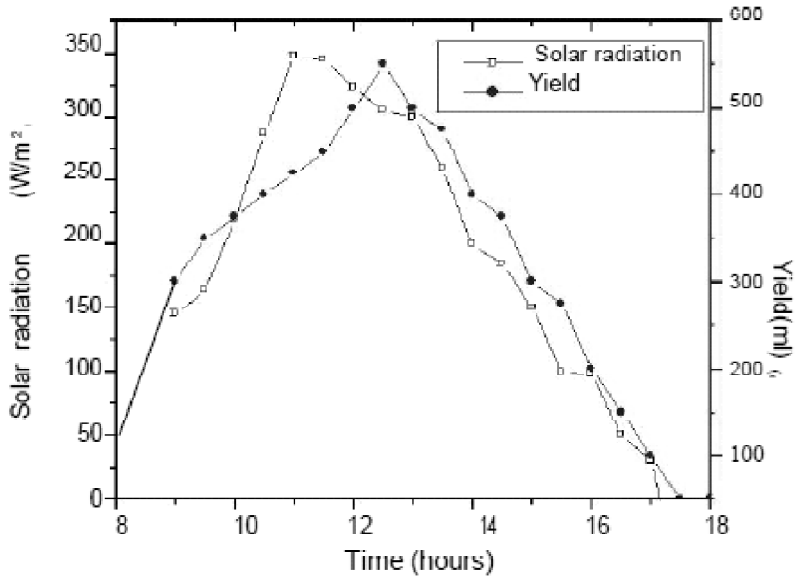

Figure 5: Effect of yield and ambient temperatur

The estimation cost of different components of a solar still is given in Table 3. The total cost of the fabricated "V" type solar still was approximately INR 3230, i.e. INR 2307/m^2 (as the still area was 1.4 m^2). The life cycle cost (LCC) of the fabricated solar still discounted at 5% over its life time of 10 years is INR 3742 assuming an annual maintenance cost of INR 500. With an output of 3.4 liters per day the LCC of the portable water produced from the still is approximately INR 3.01 per Liter over its life span of 10 years.

Table 2
Tested and quality results

Sample	*Ph*		*Conductivity (sm^{-1})*		*Hardness (ppm)*		*Alkalinity (gpl)*	
Sample 1&2(Avg)	Before desalination	After desalination	Before desalination	After desalination	Before desalination	After desalination	Before desalination	After desalination
	6.83	6.35	0.1	0.01	508.6	160.14	500	150

Table 3
Cost estimation for the components of solar still

Components	*Cost (INR)*
Rectangular basin (2 m × 0.70 m)	1200
Glass cover (2 m × 0.70 m)	150
Black paint and primer	120
Valve and pipe	140
Total cost of basic system	1600
Cotton gauze	20
Total cost of the solar till	3230
Life cycle cost of the still over 10 years of life span	3742
Life cycle cost of water per liter	3.01

4. CONCLUSION

In this paper the design and performance evaluation of "v" type solar still is presented under the climatic conditions of Vadlamudi, India. The Ph, hardness, alkalinity and electrical conductivity of two different water samples (1 and 2) were tested before and after the desalination and the results were averaged. The level of conductivity is deceased from 0.10 dSm–1 to 0.01 dSm–1 after the desalination which makes it suitable for portable for drinking and domestic purposes. The level of conductivity is deceased from 0.10 dSm^{-1} to 0.01 dSm^{-1} making the brackish water suitable for drinking and domestic purposes. It is observed that the LCC of the portable water obtained from the still is approximately INR 3.01 per Liter over its life span of 10 years. The "v" type solar still is expected to provide an efficient and effective way to convert the brackish water into distilled water in rural regions.

REFERENCES

[1] V. Velmurugan, M. Raghu Gopalakrishnan, R.K. Srithar, Single basin solar still with fin for enhancing productivity, Energy Convers.Manage. 49 (10) (2000) 2602–2608.

[2] T. He, L. Yan, Application of alternative energy integration technology in seawater distillation, Desalination 249 (2009) 104–108.

[3] G.N. Tiwari, H.N. Singh, R. Tripathi, Present status of solar distillation, Sol. Energy 75 (5) (2003) 367–373.

[4] N. Nijegorodov, P.K. Jain, S. Carlsson, Thermo-electric, high efficiency solar stills, Renew. Energy 4 (1) (1994) 123–127.

[5] Bilal A. Akash, Mousa S. Mohsen, Omar Osta, Yaser Elayan, Experimental evaluation of a single-basin solar still with different absorbing materials, Renew. Energy 14 (1–4) (1998) 307–310.

[6] J.M. Pearce, D.C. Denkenberger, Numerical simulation of the direct application of compound parabolic concentrators to a single effect basin solar still, Proceedings of the Solar Cookers International Conference in Granada, Spain, July 12–16 (2006), July 12–16 2006.

[7] T. Arunkumar, R. Jayaprakash, Aminul Ahsan, D. Denkenberger, M.S. Okundamiya, Effect of water and air flow on concentric tubular solar water desalting system, Appl. Energy 103 (2013) 109–115.

[8] K. Kalidasa Murugavel, S. Sivakumar, J. Raiz Ahamed, Kn.K.S.K. Chockalingam, K. Sridhar, Single basin double slop solar still with minimum basin depth and energy storing materials, Appl. Energy 87 (2010) 514–523.

[9] B. Selvakumar, Sanjay Kumar, R. Jayaprakash, Performance analysis of "V" type solar still using charcoal absorber and boosting mirror, Desalination 229 (2008) 217–230.