AMBIENT APPRAISAL

Analysis of Stepped Basin V Type Solar Still with Different Water Depth and External Boosting Mirrors

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Study Area: Jabalpur, Madhya Pradesh, India

Coordinates: 23° 14' N, 79° 90' E

Key words: Stepped solar still for different water depths (5mm, 10mm, and 15mm)

Abstract

It's the right of all to get healthy and safe drinking water. Just 0.5 percent of the earth has fresh water available. Solar desalination from solar still is the most desirable process for safe drinkable water at a very affordable cost. We work experimental and theoretical analysis on conventional and stepped basin V type solar still with different water depth and external boosting mirrors. This still is designed for experimental research in Jabalpur. This experimental work presents the result of four different setups of solar stills in January on the date of 21/01/2021 and 22/01/2021 with respect to time from 9:00 am to 4.00 pm. We have done three experiments. According to date 21/01/2021, we have conducted two experiments in equal Ambient Temperature (°C) and Solar radiation (w/m²). In the same way on 22/01/2021 we have conducted one experiment.

Introduction:

Water is the blessings of God. It is really crucial for the life of individuals. Around 97 percent of water is saline and just 3 percent of the earth's water is safe for human consumption. For desalination, solar energy may use. worldwide solar stills are often used for desalination, but their productivity is limited. So it's a need to design improved techniques that should strengthen solar stills performance. Numerous researches have investigated strategies to increase efficiency (Gnanaraj *et al.*, 2016).

Solar Distillation :Solar distillation is often a feasible choice to produce freshwater in arid areas where seawater is abundant. Solar is still used to generate freshwater for drinking, farming, and household use. Salt and certain other impurities like waterborne bacteria, microbiological and heavy metals are separated from the water during the distillation process. The outlet water becomes pure like rainwater (Yadav & Kumar, 2016). The process acts like a greenhouse, where seawater evaporating and condensing on the cover's inner surface (Rubio *et al.*, 2020). Solar distillation is a process of purifying water (saline & brackish) through the use of solar energy. It is basically an analogy of the natural hydrological cycle adopted in solar distillation by man. It uses a device called 'Solar still'. This device consists of a glass cover, an insulated basin with brackish water, and a distillate collecting channel (Nougriaya *et al.*, 2020).

Experimental Protocol and Results:

The experimentation has been performed at Jabalpur, India (23° 14' N, 79° 90' E). The solar still used in this work is fabricated by 1 mm thick galvanized iron sheet. The still is further insulated with thermocol 10 mm thick in bottom and sides. It is further supported by a wooden frame from outside. The solar still is covered the top by transparent glass of thickness 4 mm. The heights of high side and low side (middle) is 280mm and 100 mm. overall dimensions of the basin (outside) is 860mm × 500mm. Glass cover dimensions is 495mm 460mm (2 no.). The performance of the conventional basin V type and proposed stepped basin V type solar still is verified under different parameters. These parameters are basin design, water depth, and boosting mirrors.

Experimental study: Experimental Overall thermal efficiency for conventional basin V type solar still can be calculated as (Gupta *et al.*, 2016).

$$E = \frac{(Q \times h)}{(A \times I)}$$

Where,

E = Overall thermal efficiency

Q = Daily output (litre)

h = Latent heat of vaporization

A = Area of the glass surface of the solar still (m²)

I = Average daily solar radiation (MJ/m²)

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Table-1: Experimental Overall thermal efficiency for conventional basin V type solar still

Time (h)	Ambient Temp. (°C)	Solar rad. (w/m ²)	Q Output (litre)	E=Qh/AI	Efficiency %
9	21	605	0	0	0
10	25	688.6	0.06	0.118913822	11.89138
11	26	744	0.095	0.174260428	17.42604
12	30	840	0.12	0.194962043	19.4962
13	29	1016	0.19	0.25521606	25.52161
14	30	862	0.125	0.197902306	19.79023
15	27	632	0.1	0.215938971	21.5939
16	25	563	0.06	0.145442377	14.54424
			Average	0.172	17.2008

Theoretical study: theoretical Overall thermal efficiency for conventional basin V type solar still can be calculated as (Gupta *et al.*, 2017).

$$\eta_{\text{still}} = \frac{\Sigma m_w \times L}{\Sigma I \times A \times 3,600}$$

m_w = hourly distillate output (kg)
 L = latent heat of vaporization (Kj/kg)
 I = daily average solar radiation (W/m²)
 A = Area of glass cover (m²)

Table 2 Theoretical distillate output and overall thermal efficiency for conventional basin V type solar still

Time (h)	Ambient Temp (°C)	Solar Radiation (w/m ²)	Mw Output (L)	Efficiency %
9	21	605	0.00	0.00
10	25	688.6	0.0534	11.311
11	26	744	0.1126	21.936
12	30	840	0.1461	25.097
13	29	1016	0.1905	26.782
14	30	862	0.1672	27.975
15	27	632	0.0924	21.233
16	25	563	0.0601	15.542
		Average		18.73 %

In the same way as shown in table 1 and 2 we have done Experimental and Theoretical analysis on V type conventional basin solar still, V type stepped basin solar still, V type stepped solar still with different water depths (5mm, 10mm, and 15mm) and V type stepped basin solar still with External boosting mirrors (single and double).

Discussion:

This experimental work presents the result of four different setups of solar stills in January on the date of 21/01/2021 and 22/01/2021 with respect to time from 9:00 am to 4.00 pm. We have done three experiments. According to date 21/01/2021, we have conducted two experiments in equal Ambient Temperature (°C) and Solar radiation (w/m²). In the same way on 22/01/2021 we have conducted one experiment. The result of the efficiency and output of water for all three experiments are given below.

- For Conventional Basin V Type Solar Still Experimental and Theoretical output of water is 0.750 l/day and 0.8224 l/day, as well as Experimental and theoretical results of efficiencies, are 17.201% and 18.73%.
- For Stepped Basin V Type Solar Still With 5 mm Water Depth Experimental and Theoretical output of water is 1.040 l/day and 1.0662 l/day, as well as Experimental and theoretical results of efficiencies, are 23.852 % and 24.473.
- For Stepped Basin V Type Solar Still With 10 mm Water Depth Experimental and Theoretical output of water is 0.930 l/day and 0.9799 l/day, as well as Experimental and theoretical results of efficiencies, are 21.329 % and 22.718 %.
- For Stepped Basin V Type Solar Still With 15 mm Water Depth Experimental and Theoretical output of water is 0.830 l/day and 0.8745 l/day, as well as Experimental and theoretical results of efficiencies, are 19.036 % and 20.02 %.
- For Stepped Basin V Type Solar Still Without External Boosting Mirrors Experimental and Theoretical output of water is 1.235 l/day and 1.234 l/day, as well as Experimental and theoretical results of efficiencies, are 25.100 % and 25.459%.
- For Stepped Basin V Type Solar Still With Single External Boosting Mirrors Experimental and Theoretical output of water is 1.405 l/day and 1.433 l/day, as well as Experimental and theoretical results of efficiencies, are 28.555 % and 29.45%.
- For Stepped Basin V Type Solar Still With Double External Boosting Mirrors Experimental and Theoretical output of water is 0.745 l/day and 0.789 l/day, as well as Experimental and theoretical results of efficiencies, are 15.141 % and 15.995%.

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