Performance Enhancement of Single Slope Solar Still using different types of Absorbers

Chandan Kumar, Prakash Chand Kolesaria, Dinesh Kumar sharma, Amit Jhalani
Department of Mechanical Engineering, Swami Keshvanand Institute of Technology, Management and Gramothan, Jaipur, India
Email: - chandan.kumar@skit.ac.in, ***pckolesaria@gmail.com, dinesh.sharma@skit.ac.in, amit.jhalani@skit.ac.in***
Received 22.07.2022, received in revised form 19.08.2022, accepted 02.09.2022
DOI: ***10.47904/IJSKIT.12.2.2033.57-61***

Abstract- Water plays an imperative role in all our daily activities and its utilization is increasing gradually because of increased living standards of human being. There is now a freshwater crisis in several nations. Desalination is a crucial technique for producing fresh water that may be utilised for agriculture, industry, and human consumption. The purpose of this study is to investigate the impact of employing black granite stone and graphite particles as energy absorption materials in solar stills in order to increase the efficiency of solar stills. Graphite coated solar still produces 14 % and 12 % more potable (distillated) water as compared to black granite solar still in summer and winter season respectively.

Keywords– Solar still, Distillation Device, Sustainable Drinking water.

1. INTRODUCTION

The availability of fresh water has become a need in modern life as a result of the population, industrial, and agricultural sectors' fast rise. Through many water treatment methods, solar distillation is one of the various water treatment processes that uses renewable energy. The issue of fresh water shortage, particularly in rural regions, may be resolved easily and inexpensively by distilling water using solar energy. The solar distillation process offers the advantages of being environmentally benign, cheap maintenance, and free of fuel costs. Its drawbacks include taking up a lot of space and moving slowly, which reduces the amount of distillate produced per unit of time. [1]. When it's sunny, a basic still may produce 2.5 to 5 litres per square metre every day. Researchers have examined a variety of design factors (water depth, condensing cover material, water depth, thickness and inclination of cover plate, type of solar still), climatic factors (solar radiation, wind velocity, ambient temperature), and operational factors (salinity of water) that affect the efficiency of solar stills in order to increase the production of solar stills [2]. There are several ways to increase the solar still's effectiveness, including varying the brackish water depth [3, 4], the angle of tilt [5] the energy absorber material [6] and nanofluids [7].

The objective of this study is to increase the efficiency of solar still by used graphite particles and black granite stone.

Concentrated sun radiation was used to warmth up the working fluid. This works fluid imparted its warmth to the saline water stored in solar still basin and increase the rate of evaporation, thereby increased output of potable water.

The basic solar still has undergone some modifications:

- To study the temperature of water and glass with and without Granite stone and Graphite particles.
- To study the effect of parameter like water depth, tilt angle on efficiency and distillate output.

2. COMPARATIVE STUDY OF DIFFERENT TYPE OF SOLAR STILL

Table 1 shows a comparative study of different types of solar stills that operate in different parameters and under different conditions.

Table 1 Comparative study of solar stills

S.N	Authors	Year of publication	Augmented by	Distillation process	Efficiency increase
1	O.O. Badran [8]	2007	Asphalt Sprinkler combination with the asphalt	Single basin type solar still	• 29% • 41%
2	O. Osta et al. [9]	1998	Black dye Black rubber mat Black ink	Single basin type solar still	• 60% • 38% • 45%
3	Gopalakrishnan et al. [10]	2008	Sponge type Wick type Fin type	Single basin type solar still	• 15.3% • 29.6% • 45.55%
4	A.E. Kabeel [11]	2009	Concave wick surface was used for evaporation	Single basin type solar still	• 30%

5	R. Gugulothu et al. [12]	2015	• PCM • $K_2Cr_2O_7$, • $MgSO_4$ $7H_2O$, • CH_3COONa	Single basin type solar still	MgSO4 7H2O is give better efficiency
6	S Abdallah et al. [13]	2009	Coated metal Wiry Sponges Uncoated metal wiry Sponges Black Rocks	Single basin type solar still	• 28% • 43% • 60%
7	M.M. Abu-khader et al. [14]	2008	Inclusion of internal mirrors step-wise basin step-wise basin with sun tracking system	Single basin type solar still	• 30% • 180% • 380%
8	S.K. Agarwal et al. [15]	2013	Blackened jute cloth	Single basin type solar still	• 68%
9	A. Ileietal. [16]	1997	Different glass cover thickness • (3mm,5mm,6mm, plastic)	Single basin type solar still	Thinnest give highest efficiency up by 15.5%
10	P. Dumka et al. [17]	2019	Sand filled cotton bags • 40 kg • 30 kg	Single slope (modified solar still) MSS	• 31.31 % • 28.96%
11	A. Sohani et al. [18]	2020	• Side mirror and sun tracking	Passive SS Active SS	• 36% • 22.3%
12	F.A.Essa [19]	2020	Flat disc, SS without Wick at 0.1 rpm Flat disc, SS with Wick at 0.5 rpm Corrugated disc, SS without Wick at 0.1 rpm Corrugated disc, SS with Wick at 0.5 rpm	MSS with rotating disc	• 56% • 96% • 74% • 124%
13	S. W. Sharshir et al.[20]	2019	• ZnO NANO- ROD SHAPE	Tubular solar still	• 38%
14	H.Hassan et al. [21]	2020	Preheating salty water • 40% • 50% • 60% Using black steel wool fibers with • 60% preheating	Solar still	• 8.2% • 13% • 20% • 38.07%

3. System Description

The setup was installed at Jaipur ($27^0$5’59’’N, $75^0$35’8’’E). To obtain the sun's strongest light, the solar still was maintained facing south [22]. A digital thermometer was used to gauge the temperatures of the water in the basin and the glass top plate. The reading obtained from the digital thermometer in ^{0}C. To measure distillate water a measuring jar was used and the reading obtained was in ml. The total dissolved solids meter was used in the experiment to measure amount of solvated solids presence in water. Parts per million (PPM) of dissolved solids were used to calculate the quantity of dissolved solids. Table 1 shows the fabrication Technical Specification of the experimental solar stills.

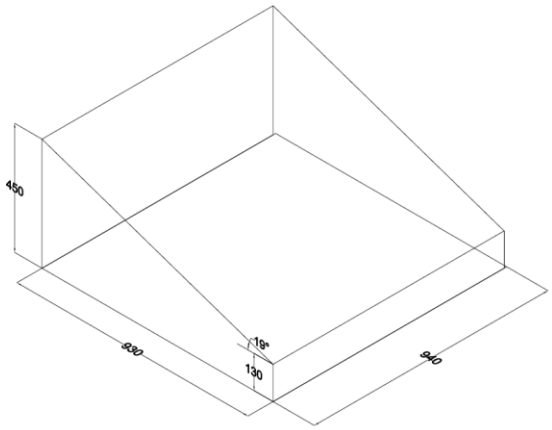

Figure 1: Dimension of solar still

Table 2: Technical Specification of the experimental solar stills

Parameter	Value
Solar stills basin area	0.874 m^2
Solar stills outer area	0.970 m^2
Glass cover plate inclination angle	19^0
Height of lower end of solar stills	0.13 m
Height of higher end of solar stills	0.45m
Length	0.93m
Width	0.94m

The solar still is constructed from 24 gauge galvanised iron sheet, 15mm granite stone, and a top cover plate made of transparent glass that is 3.5mm thick. All sides of the Granite stone solar still are insulated from the environment using thermocole of 15mm thickness and the solar still basin of G.I. sheet placed in wooden casing to encapsulate the insulation material. Inside of the solar still is coated

by the graphite particles to improve the rate of solar absorption.

Figure 2: Exprimental Solar Stills

3.1 Materials and Instruments used in Setup

S.No.	Materials and Instruments	Purpose
1	G.I.sheet	Side walls and basin of solar still
2	Transparent glass	Glass cover
3	Thermocol sheet	Insulation of side wall of granite still
4	Granite stone	Side wall and basin of solar still
5	Plastic pipe	Input and output of water
6	Digital thermometer	Measurement of temperature
7	TDS meter	Quality of water
8	Magnetic compass	Facing of solar still
9	Measuring jar	Measurement of output water
10	Digital anemometer	Measurement of wind velocity
11	Wooden block	Placing solar still

4. RESULT AND DISCUSSION

The role of solar radiation intensity becomes very dominant. The amount of water collected with a solar still is directly correlated with the strength of the sun's rays and is measured as the device's output. When the ambient temperature and sun radiation intensity are both relatively high, the distillate yield is at its highest.

4.1 Variation in the Temperature of Glass Cover

As ambient temperature and solar radiation intensity increases, the temperature of the glass cover (Tg) also rises. In comparison to traditional solar stills and solar stills made of black granite, the temperature of the glass in graphite covered solar stills is the greatest.

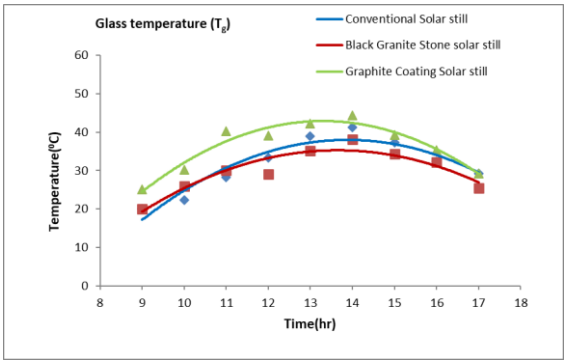

Figure 3: Variation in the temperature of glass cover with time of the day (Dec 23, 2022)

The glass temperature is maximum around 02:00 PM which is similar to that of winter days. During summer, temperature of surrounding is also high as compared to winter days which eventually help in lowering the heat losses to the environment.

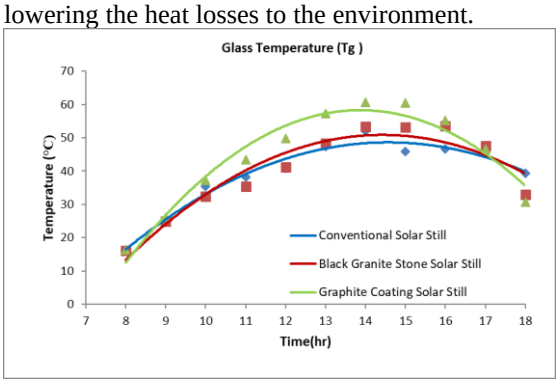

Figure 4: Variation in the temperature of glass cover with time of the day (March 07, 2022)

4.3 Variation in the basin water temperature

The basin water is kept at 10 mm depth for all specified experimental setups. This is per standard for solar still and for comparison with reference work reported earlier. The basin water temperature increases due to the heating effect of solar radiation with the help of absorber surface.

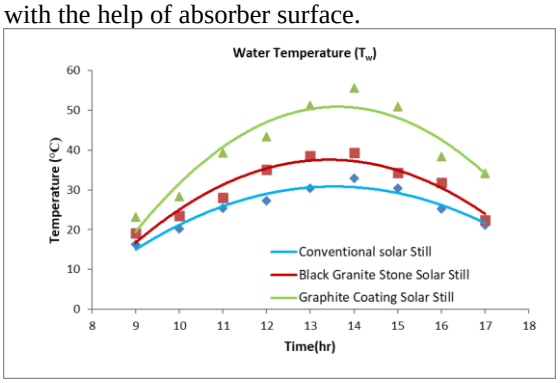

Figure 5: Variation in the basin water temperature of solar still with time of the day (Dec 23, 2021)

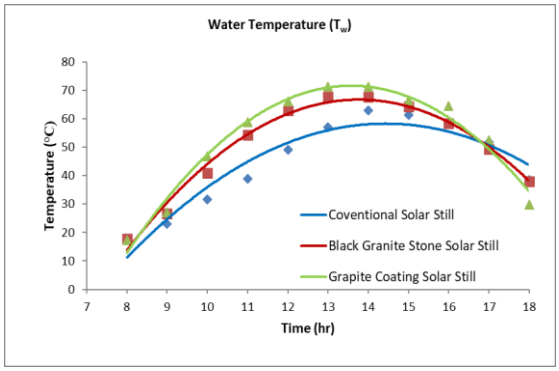

Figure 6: Variation in the basin water temperature of solar still with time of the day (March 07, 2022)

Thus temperature rise of basin water is directly related with the solar radiation intensity. However, the peak of basin water temperature is around 02: 00 PM which is similar to that of glass temperature. It can be noted from these figures that basin water temperature is significantly higher for summer days as compared to winter days.

4.4 Production of Potable Water with Solar Stills

The goal of the entire process is to use the solar still to turn saltwater water into drinkable water. It is clear that the amount of drinkable water produced changes depending on how intense the solar radiation is when it strikes a still surface. Therefore, in this section, potable water production have been discussed with respect to time of the day and compared among all configurations [23, 24].

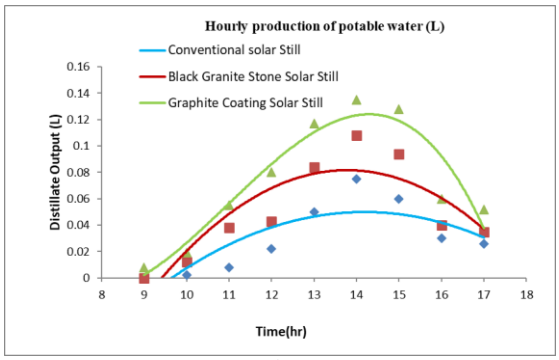

Figure 7: Hourly production of potable water with various solar stills (Dec 23, 2021)

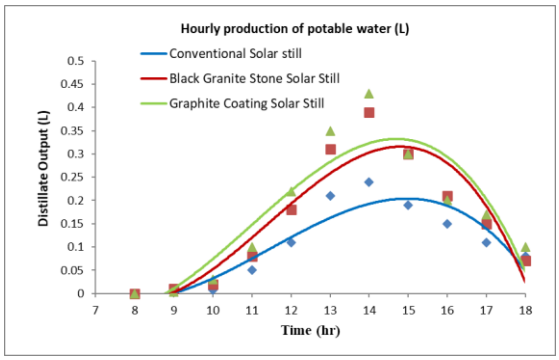

Figure 8: Hourly production of potable water with various solar stills (Mar 07, 2022)

4.5 Instantaneous Efficiency

The amount of water evaporating is directly proportional to the solar still's instantaneous efficiency, whereas the intensity of the sun's radiation is indirectly related. In comparison to traditional solar stills and solar stills made of black granite, graphite coated solar stills have much better immediate efficiency.

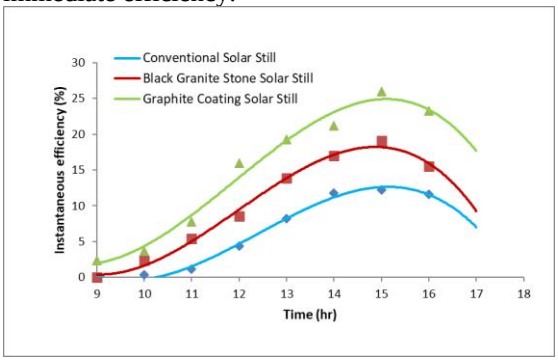

Figure 9: Variation of Instantaneous Efficiency during winter days (Dec 23, 2021)

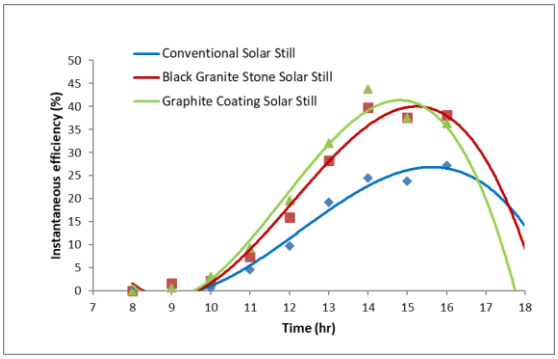

Figure 10: Variation of Instantaneous Efficiency during summer days (Mar 07, 2022)

5. CONCULSION & FUTURE SCOPE

The finding obtained from the above experimental study are listed below:

- Graphite is better absorbing material than black granite stone due to its high thermal conductivity and better absorptivity.
- Graphite coated solar still is a better choice to have better productivity of potable water as compared to black granite solar still and conventional solar still.
- Graphite coated solar still produces 14 % and 12 % more potable (distillated) water as compared to black granite solar still in summer and winter season respectively.

This work can further be extended for considering othe new materials and their economic analysis.

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