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Performance Evaluation of Solar Still Using Experimental Analysis

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Abstract— The purpose of this work is to design a water distillation system that can purify water, a system that is relatively cheap, portable, and works on renewable solar energy. Solar Distillation is an attractive alternative because of its simple technology, non-requirement of highly skilled labour for maintenance work and low energy consumption. In this paper solar still basics are discussed along with different designs considerations and layouts of stills. Development of model was done along with testing for different conditions. Experiential results were compared along different conditions. Compare to existing solar still modified still has 53% more efficiency.

Keyword—Solar still, Energy absorbing Materials, Solar distillation, Solar energy.

1. Introduction

Distillation is one of many processes available for water purification, and sunlight is one of several forms of heat energy that can be used to power that process. To dispel a common belief, it is not necessary to boil water to distill it. Simply elevating its temperature, short of boiling, will adequately increase the evaporation rate. In fact, although vigorous boiling hastens the distillation process it also can force unwanted residue into the distillate, defeating purification. Solar Distillation is by far the most reliable, least costly method of 99.9% true purification of most types of contaminated water especially in developing nations where fuel is scarce or too expensive. Solar distillation is used to produce drinking water or to produce pure water for lead acid batteries, laboratories, hospitals and in producing commercial products such as rose water. Conventional boiling distillation consumes three kilowatts of energy for every gallon of water, while solar distillation uses only the free pure power of the sun. Expensive filtration and deionizing systems are even more expensive to purchase and use and will not totally purify the water by removing all contaminants. No additional heat or electrical energy is required in our still and even after the sun sets, distillation continues at a slower pace into the night. Recently, we have been experimenting with a unique optional solar energy booster using our top quality "Sola Reflex reflector" to increase the water vaporization by increasing the temperature on the

internal fluid heat absorber. This will add efficiency and increases the amount of daily pure water production.

Principle of Working

Solar still works on the principle of solar distillation. A solar still duplicates the way as rain water i.e. evaporation and condensation. Saline water is filled in the black painted basin of the solar still. This is enclosed in a completely air tight surface. A sloping transparent cover is provided at the top. Then solar radiations are allowed to fall on it. Solar radiation is transmitted through the cover and is absorbed in the black lining. The distillator is designed so that an efficient amount of solar radiations gets trapped inside it. This increases the internal temperature of distillator causing the saline water to evaporate leaving behind all the salt contents, insecticides, herbicides, bacteria, viruses etc.

Sun's rays penetrate a glass surface causing the water to heat up through the greenhouse effect and consequently, evaporate. When the water evaporated inside the solar still, it leaves all contaminants and microbes behind the basin. The evaporated water condenses on the underside of the glass and runs into a collection trough and then into an enclosed container. Condensation in solar still is strong function of basin water temperature and temperature difference between basin and inner glass temperature among other

operating parameters of still viz. depth of water, wind velocity etc.

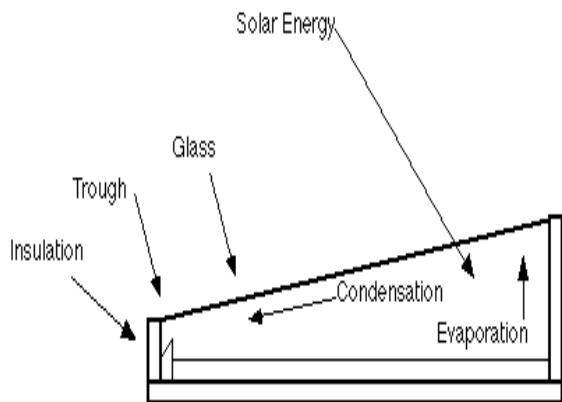


Fig 1: Solar Still Layout

Still Background:

Solar distillation is a tried and true technology. The first known use of stills dates back to 1551 when it was used by Arab alchemists. Other scientists and naturalists used stills over the coming centuries including Della Porta (1589), Lavoisier (1862), and Mauchot(1869).

The first "conventional" solar still plant was built in 1872 by the Swedish engineer Charles Wilson in the mining community of Las Salinas in what is now northern Chile (Region II). This still was a large basin-type still used for supplying fresh water using brackish feed water to a nitrate mining community. The plant used wooden bays which had blackened bottoms using logwood dye and alum. The total area of the distillation plant was 4,700 square meters. On a typical summer day this plant produced 4.9 kg of distilled water per square meter of still surface, or more than 23,000 liters per day. This first stills plant was in operation for 40 years! Over the past century, literally hundreds of solar still plants and thousands of individual stills have been built around the world.

Literature has been studied and some of the findings are highlighted below;

N.Sri Gokilavani et. al. [1] in their study an attempt is made to model a conventional solar distillation system and comparing the experimental results with simulated model.

Abdulrakib M Kachwala et. al. [2] the objective of this study was to determine a best combination of different parameter for good convective and evaporative heat transfer coefficients.

C. Uma Maheswari et. al. [3] this work deals with the thermal and CFD analysis of single basin double slope solar still. The modeling of still is done in solid works software and CFD analysis in ANSYS.

CFD analysis for different months of solar irradiance was carried out. Maximum production rate and temperature distribution in the still was analyzed.

Md. Irfan Ali et. al. [5] this paper presents the experimental studies done on a solar still integrated to the solar-pond. The solar still base was coated with granular activated carbon (GAC) for enhancing the evaporation rate. From the simulated results we found that 50g/Kg salinity is the optimal value that should be maintained at the bottom layer of the solar-pond.

Wael M. El-Maghlany [12] in his investigation represents the optimum inclination angles of the glass cover of the double slope solar still, and orientation for maximum collected solar energy that could be captured by the solar still glass cover. The inclination angle (β) is changed from 10° to 60° on both sides of the glass cover to get independently the optimum inclination angles for each side that not necessary to be the same.

Vinod Kumar Verma et. al.[14] this paper represents the performance of operating parameter of solar still. The Taguchi method is employed to determine the optimal combination of design parameter. This work presents new optimize parameter using Taguchi method in the case of passive solar still.

II. Problem Definition, Objective

Problem Definition:

The aim of this work is to accomplish the goal of water distillation by utilizing and converting the incoming radioactive power of the sun's rays to heat and distill undrinkable water, converting it into clean drinkable water. A solar collector will be utilized to effectively concentrate and increase the solid angle of incoming beam radiation, increasing the efficiency of the system and enabling higher water temperatures to be achieved.

Objective:

- To develop Solar Still set up.
- To investigate performance of Solar Still experimentally at different coating conditions.
- Study of Cooling strips addition effect on solar still performance

III. Experimental Set up

A. MODEL

Solar still consists of main frame for storing water and chamber that absorbs heat from solar rays and traps it into chamber for supplying to water for distillation purpose. Further distilled water gets

collected to glass cover and slides on sides from where it collected to chamber as pure water.

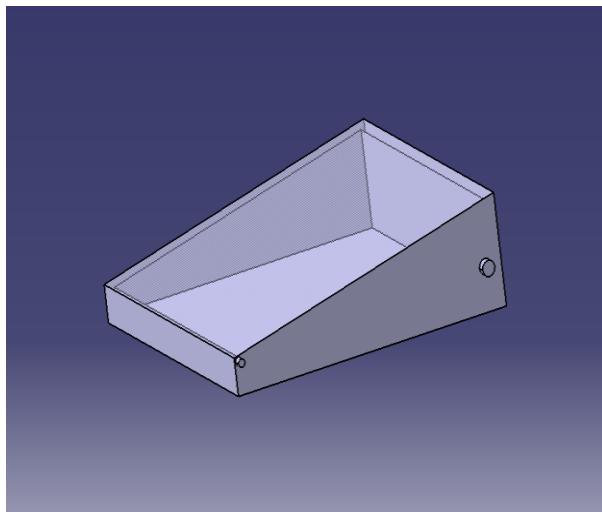


Fig 2: CAD model of Solar Still



Fig 3: Solar still model

From fig 2 we can see the CAD model of solar still. In fig 3 actual developed models is shown. Thermocouples are used to see the room temperatures for information only.

B. MATERIAL

Wood is used to made solar still along with glass for box covering and trapping the heat.

C. METHOD

Water of 5 lit is taken for all test conditions. This is initially put in basin for 24 hrs for each case. And yield is measured for respective cases. The readings are taken for 2 days i.e. two trials for each condition for getting better results. These tests are done for charcoal coating, rubber coating, and black coating; also readings by providing cooling strips on glass

cover and results are discussed in subsequent section in detail.

Experimental Results

Max Io = Maximum Solar Irradiation value in a day, w/m^2

Table 1. Existing system results: Without black coating

Reading 1: 05 March	
Start Time	8 am
End Time	7:59 am
Yield	575 ml
Max Io	0.68
Reading 2: 06 March	
Start Time	8:15 am
End Time	8:14 am
Yield	587 ml
Max Io	0.69

Similarly, the readings are taken for all other conditions and are given in table below.

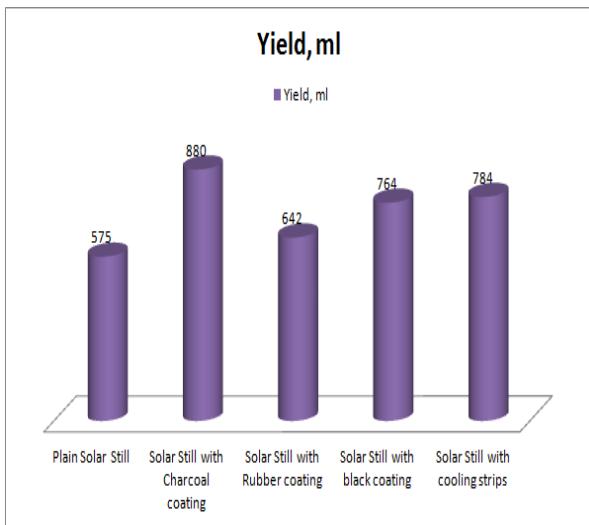
Table 2. Existing system results: With Different Absorbing Materials

Condition	Yield Reading 1	Yield Reading 2
Plain Solar Still	575 ml	587 ml
Solar Still with Charcoal coating	880 ml	878 ml
Solar Still with Rubber coating	642 ml	635 ml
Solar Still with black coating	764 ml	769 ml
Solar Still with cooling strips	784 ml	781 ml

V. RESULTS AND DISCUSSIONS

Results are plotted in graphs below and we can see from the results that at charcoal coating getting better results than all other operating conditions.

In best possible conditions we got yield of 880 ml and lowest yield is 575 ml; i.e. for charcoal we got 53 % more yield than plain solar still. Cooling strips adds the yield than existing but not as much as charcoal does.



Graph: Yield at different Operating conditions

VI. Conclusion

- Model is developed for solar still distillation system.
- Charcoal presence gives better result than other conditions.
- Model with charcoal coating gives 53% more efficiency than existing solar still.

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