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Design and Experimental Analysis of Flat-Plate Collector to Improve the Efficiency of Double Slope Solar Still

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ABSTRACT: The effect of coupling a flat plate solar collector to the productivity of double slope solar stills was investigated in an experimental environment. Other factors that could improve efficiency (such as water depth, wick materials, and heat storage materials) were also investigated. Packing components were included in the flat plate collector (i.e. iron chips, stones and red bricks). The still with a 10 mm water depth, square fin, black cotton, and iron chips as the flat plate collector's packing portion has the highest water productivity of 3130 ml. Also the increase of water depth has decreased the productivity, while the still productivity is found to be proportional to the wick material used and packing element used.

KEYWORDS: Flat plate solar collector, Double slope solar still, Wick materials, Heat storage materials.

I. INTRODUCTION

Fresh waters are the fundamental need for human health, and pollution from human activity is adversely affected. In addition to water, man along with food and air is a basic requirement. The normal available fresh water supplies are rivers, streams and underground water tanks, since water is two-thirds of the land filled with water, but less than 1% is fresh water. Some 71% of the planet's water is protected but 96.5% of the world's water is found in the sea, 1.7% in groundwater, 1.7% in glaciers and ice caps and 0.001% in air as vapor and clouds. Freshwater is just 2.5% of the earth's water, and 98.8% of the water is in ice and groundwater. Renewable energy sources are being given ever greater importance because of environmental challenges and dwindling fossil fuel supplies. Solar energy has been a reliable source of energy in recent years. The convergence of solar radiation into heat is one of the simplest and most direct applications of this energy.

II. RELATED WORK

Experimental study and evaluation of single slope solar still combined with flat plate collector, parabolic trough and packed bed was conducted by Jamel Madiouli, Ashraf Lashin, Ihab Shigidi, Irfan Anjum Badruddin, Amir Kessentini [1]. Effects of water and basin depths in single basin solar stills study was introduced by Mehrzad Feilizadeh, M.R. Karimi Estahbanati, Animul Ahsan, Khosrow Jafarpur, Amin Mersaghian [2]. The effects of various types and layouts of wick materials on the thermal performance of conventional solar stills was studied by H. M. Ahmed [3]. Use of thermal energy storage materials for enhancement in distillate output of solar still was studied by Hitesh N. Panchal [4]. An experimental study on the efficacy of modifications in enhancing the performance of single basin double slope solar still was conducted by S. Joe Patrick Gnanaraj and V. Velmurugan [5].



III. METHODOLOGY

The main methodology of the study is to do the experiment to be handle the double slope solar still was modified to accommodate external flat-plate collector. Detail experimental investigation was carried out to access the performance of the solar still for the cases, the effect of water depth, wick material heat storage material usage, flat-plate collector usage. For optimization Taguchi method is used for finding optimal internal modifications parameters. An extensive experimentation has been carried out to analyze the convective and evaporative heat transfer coefficients to obtain the thermal model using the experimental values of water and glass temperature and distilled output.

IV. EXPERIMENTAL SETUP

The Double slope type solar still consists of inlet and outlet for water, basin, transparent glass, external flat plate collector with copper pipe and transparent glass. The following are the dimensions of double solar still

1. Length of the basin is 600 mm.
2. Breadth of the basin is 600 mm.
3. Depth of the basin is 200 mm.
4. Thickness of the basin wall is 0.1 cm.
5. Angle of Inclination is 30°.
6. Length of the glass is 600 mm.
7. Breadth of the glass is 300 mm.

The following are the dimensions of flat-plate collector,

1. Length of the flat-plate collector is 600 mm.
2. Breadth of the flat-plate collector is 600 mm.
3. Depth of the flat-plate collector is 200 mm.
4. Angle of inclination of flat-plate collector is 30°.
5. Diameter of copper pipe is 6 mm and no. of passes are 7.
6. Length of glass cover is 60 cm.
7. Breadth of the glass cover is 60 cm.

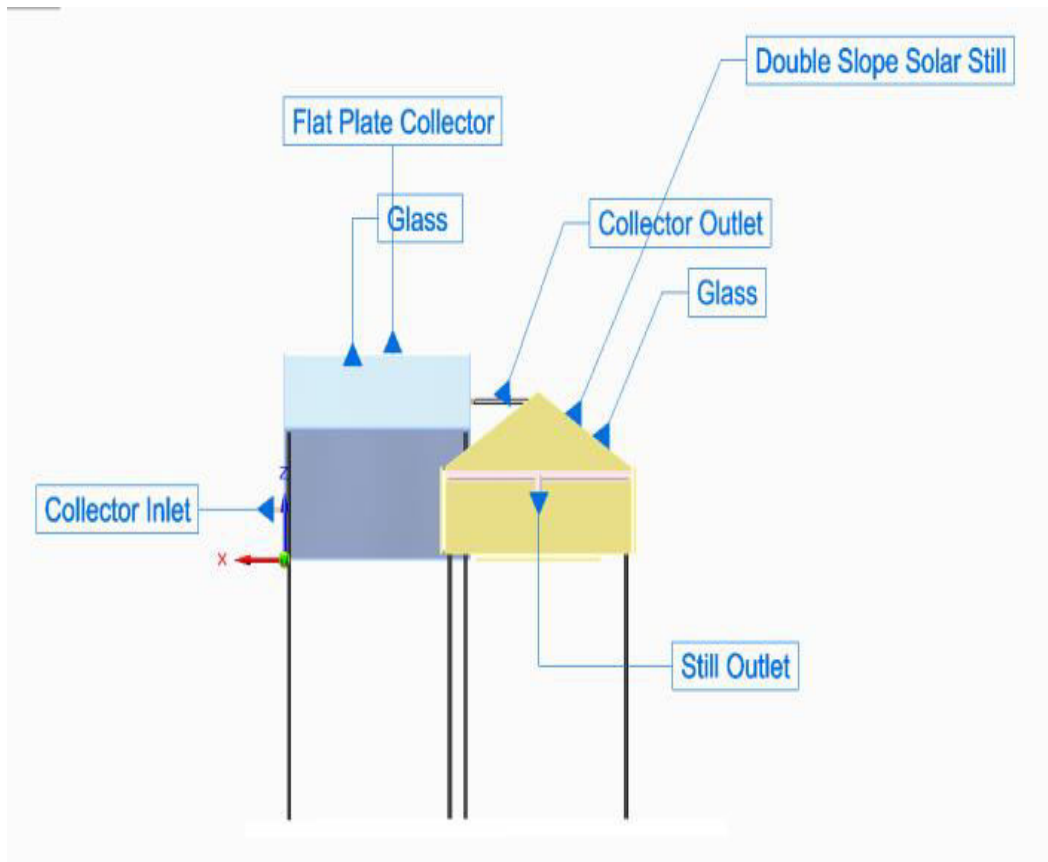


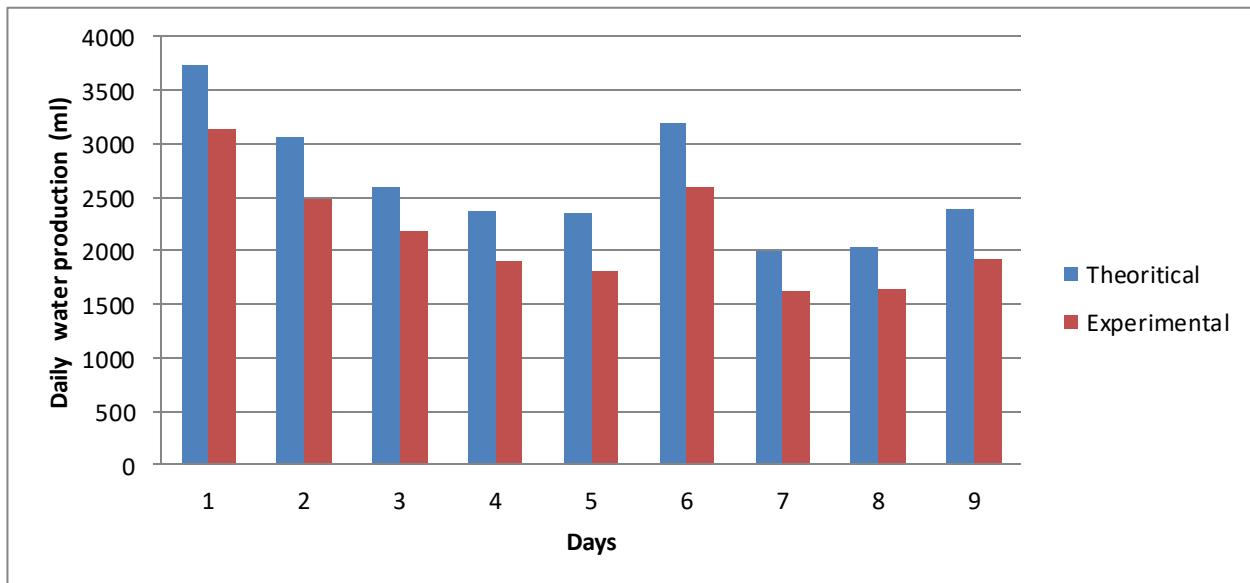
Fig. 1 Experimental Setup

V. RESULT DISCUSSION

When the basin was filled with 10 mm of water, square fin covered with black cotton as wick material is placed inside the basin and iron chips was used as packing element, the production of water at 1 PM had the peak production of 790 ml. In other modifications i.e 20 mm, 30 mm water depth, circular fin, pin fin and other packing elements had the peak 620 ml.

TABULATION 1

Day	Theoretical Water Production (ml)	Experimental Water Production (ml)
1	3737.9	3130
2	3058.15	2490
3	2590.6	2185
4	2380.15	1910
5	2355.8	1805
6	3185.5	2595
7	1995.7	1620
8	2035.3	1647
9	2383.5	1925



Graph 1 Days vs Daily water production (ml)

A comparison between estimated theoretical values and the test values obtained after performance of the experiment is often needed. There's a difference between the two in general. When the gap is very small, it shows that the experiment delivers optimal efficiency. The big gap shows that there is a gap in the experiment and there are plenty of opportunities to improve the still's efficiency by correction of defects.

VI. CONCLUSION

These solar energy distilling plants are relatively inexpensive, low-technology systems, especially useful where the need for small plants exists. However, there is still much room for innovation and improvement. It is well known, that solar distillation exhibits a considerable economic advantage over other salt water distillation processes, because of cost-free energy and reduced operating costs.

The operation of a solar distillation system coupled with a solar collector has been investigated experimentally. Comparison of the output between coupled and stand alone still was studied. It was found that the productivity of still with 10 mm water depth, square fin, black cotton and iron chips as packing element for the flat-plate collector as the highest water productivity of 3130 ml. It can be concluded that, the present still design leads to higher distilled water output due to higher basin water temperature.

Producing fresh water by a solar still with its simplicity would be one of the best solutions to supply fresh water to small isolated communities with no technical facilities.

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