



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 4, April 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512



9940 572 462



6381 907 438



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Experimental and Theoretical Analysis of an Inclined Solar Desalination System

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ABSTRACT: The inclined solar still having low productivity. The evaporation rate also low. The waste heat from the inclined used for basin still. It will increases the total distillate water productivity. The productivity increases by integrate the inclined solar still with basin still and hot water storage tank.

KEY WORDS: solar still, basin still, productivity, heat transfer and mass transfer

I. INTRODUCTION

Water is the most important substance in a life of all survivals. As the population of world increasing rapidly the demand of potable water is also increased. According to the survey of World Health Organization (WHO) in all over world one billion people do not get clean and fresh water. 41% of world population lives in water stressed areas. There are various alternative renewable sources for the desalination. Among all those solar energy has the potential which gives future energy demand. Due to increase in population of developing countries need for the potable water is also increased. These countries cannot afford to use conventional desalination systems. So these countries can use solar powered desalination systems. These countries are having higher solar radiation also.

II. MATERIAL USED

In the integrated system the following materials are used,

- Mild steel sheet
- Glass
- Plastic hose
- Thermocol
- Copper tube
- Digital thermometer

Mild steel sheet

Mild steel is the most widely used steel which is not brittle and cheap in price. Mild steel is not readily tempered or hardened but possesses enough strength. It having good thermal conductivity property.

Glass

Lower glass surface temperature increases the circulation of air inside the still which improves the evaporative and convective heat transfer between saline water and glass cover, also cooler glass inner surface enhances condensation. Glass is a good conductor of heat when it is found in fiberglass. Glass allows radiant heat to pass through freely. When there is a difference in temperature from one side of the glass to the other, heat will transfer through the glass and frame

Plastic hose

- Corrosion Resistant.
- Non-Conductive.
- Wide Range of Chemical Resistance.
- Lightweight, Easy to Handle and Install.

Thermocol

Thermocol comes with many advantages. Most importantly, it features a closed-cell structure and thus supports low thermal conductivity. It is highly preferred for thermal insulation. Other materials possess an open cell structure and are thus incompetent when subject to moisture.

Copper tube

Copper has a thermal conductivity of 231 Btu/(hr-ft-F). This is higher than all other metals except silver, a precious metal. Copper has a 60% better thermal conductivity rating than aluminium and a 3,000% better rating than stainless steel. It used for increases the productivity by preheating.

Digital thermometer

Sensor cable length: 1 meter 1pcs digital thermometers Temperature measurement accuracy: 1°C Temperature range: -50~ 110°C Temperature display resolution 0.1.

III. OBJECTIVES

- To design a inclined solar still with basin still.
- To fabricate the designed system for performance analyzing.
- Understand and study the various performance improvement of the solar desalination system.

IV. EXPERIMENTAL WORK

Inclined solar still

The body of the inclined solar still was fabricated by mild steel plate. The dimension of the inclined still was 1 x 1 x 0.15 m. The saline water from the solar water pre heater, flows from the higher end of the inclined still to lower end of the still. The grooved shape absorber plate used in the still. The feed water supplies to the absorber plate by distribution pipe fixed on the higher portion of the still. A glass cover of 1 m² surface area is fitted above the still with air tight insulation. The glass having thickness of 4mm. The inclined still was inclined at an angle of 30°. The solar radiation was absorbed by water through transparent glass and evaporation takes inside the still. The evaporated water condensate inside the glass cover, so the condensate channel provided lower end of the slope for receiving the condensate distillate water. The waste hot water stored in hot water tank and small amount of hot water flow into the basin still with the help of manually operated ball valves. The mass flow rate of the system maintained 50 ml/min. The system operates between 7 am to 7 pm. The inclined still was fully insulated by thermocol.



Fig 1 Inclined Solar Still

Basin still

The body of the basin still made by mild steel plate. The dimension of the system was $0.7 * 0.7 * 0.15$ m. The flat plate absorber plate used which is made by mild steel plate. The basin still having an angle of 30° for maximum absorb of solar radiation. The glass of thickness 3mm closed the upper portion of the basin still with air tight casing for reduce the escape of the evaporate water and reduce the heat loss. The depth of the water in absorber plate constantly maintain 2 cm. The waste hot water from the inclined still flow into the basin still manually and maintain the level 2 cm. The basin still was fully insulated by thermocol. The condensate channel fixed lower end of the inside glass. The waste heat from the inclined still recovery by basin still and increase the output of the distillate productivity.



Fig 2 Basin Still

Hot water tank

The hot water tank was used for store the waste hot water from the inclined still. The tank was insulated by thermocol. The tank dimension was $0.6 * 0.6$ m². The waste hot water used for home application like vessel washing, cooking, floor cleaning etc...

Working Principle

The water flows into the inclined solar still. The inclined still having distribution pipe for uniformly spread the hot water into the inclined still. The solar radiation was easily go through the transparent glass. The solar radiation was absorbed by the absorber plate which coated by black paint. The water was evaporated and condensate in the glass cover because of inside and outside glass temperature difference. The condensate water collected in the condensate channel and stored in the distilled water output 1. The waste hot water stored in the hot water storage tank. The small amount of water from the inclined still was flows into the basin still for waste heat recovery and it will be increase the distilled water output. The basin still water depth maintained 2 cm. The basin still productivity collected in distilled water output 2.

The system having mass flow rate of 50 ml/min. The digital temperature sensor was fitted in the feed water tank, solar water preheater outlet, inclined still inner and outer glass, absorber plate, between the glass and absorber plate which is used to measure the vapor temperature, inclined still water temperature, basin still glass, basin still water temperature and hot water tank.



Fig 3 Inclined Still with basin still

MEASURED PARAMETERS:

T_w = Temperature of water

T_g = Temperature of glass

$Q_{(e,w-g)}$ = Evaporative heat transfer (water to glass)

$h_{(e,w-g)}$ = Evaporative heat transfer coefficient (water to glass)

P_w = Saturated pressure of water

P_g = Saturated pressure of glass

$h_{(c,w-g)}$ = Convective heat transfer coefficient (water to glass)

T_v = Temperature of vapor inside the still

T_{FD} = Temperature of feed water

T_{CET} = Copper tube exit temperature

V. RESULT& DISCUSSION

The experiment was conducted between 20\03\2021 and 21\03\2021.

Day 1: Reading take in Inclined still.

Day 2: Reading take in Inclined still and basin still.

Day 1

Table 1 Inclined still

S. No	TIME (hr)	Theoretical Productivity of Water (ml)	Experimental Productivity of Water (ml)
1.	7	0	0
2.	8	27	20
3.	9	87	70
4.	10	100	80
5.	11	317.16	270
6.	12	380.12	340
7.	1	440.87	400
8.	2	593.06	530
9.	3	483.42	420
10.	4	330.83	250
11.	5	210.72	160
12.	6	180.2	110
13.	7	40.52	30

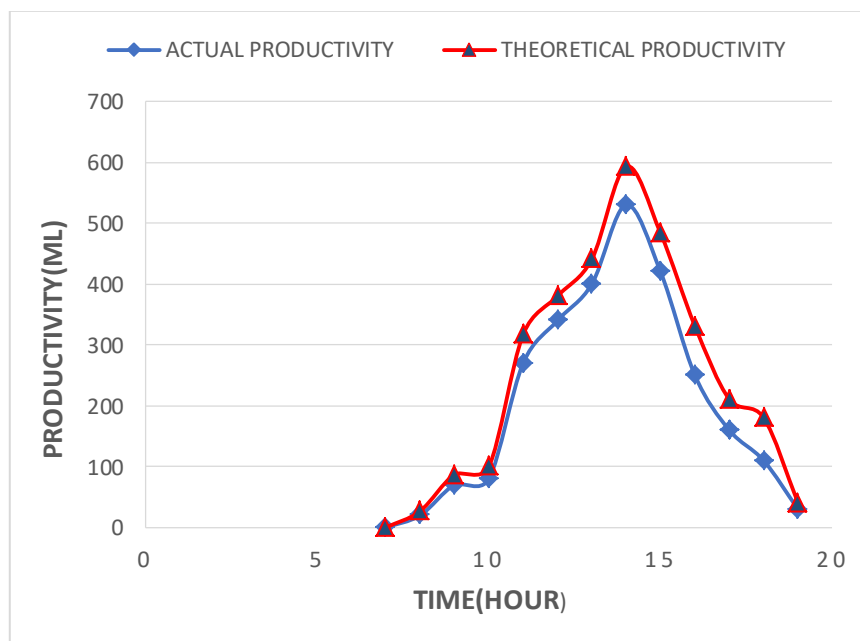


Fig 4 Inclined still productivity

Day 2

Table 2 Inclined and Basin still productivity

S. No	TIME (hr)	Theoretical Productivity of Water (ml)		Experimental Productivity of Water(ml)	
		Inclined Still	Basin Still	Inclined Still	Basin Still
1.	7	0	0	0	0
2.	8	31.54	15.2	25	10
3.	9	58.24	30.4	45	20
4.	10	74.47	57.35	60	50
5.	11	176.56	102.7	150	90
6.	12	367.89	139.3	310	130
7.	1	590.7	153.72	470	145
8.	2	637.00	170	510	160
9.	3	522.76	165.72	400	150
10.	4	265.45	130.32	220	110
11.	5	133.86	108.72	130	90
12.	6	114.8	62.35	70	50
13.	7	72.4	27.6	20	20

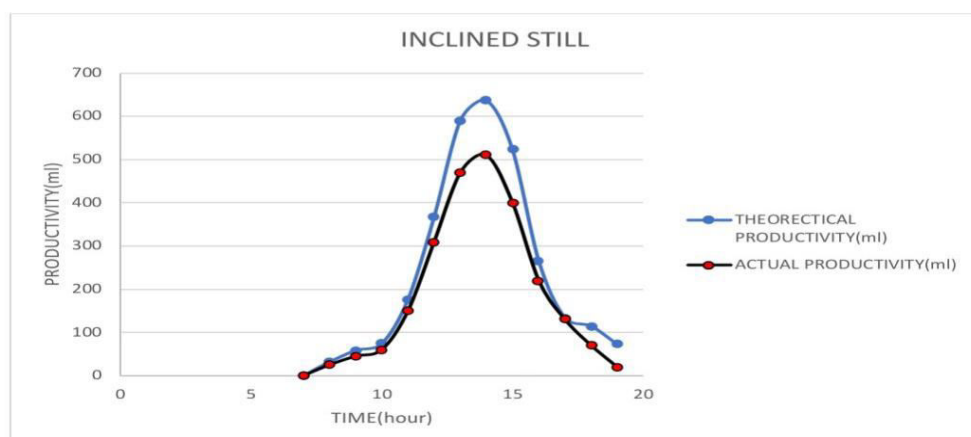


Fig 5 Inclined still productivity

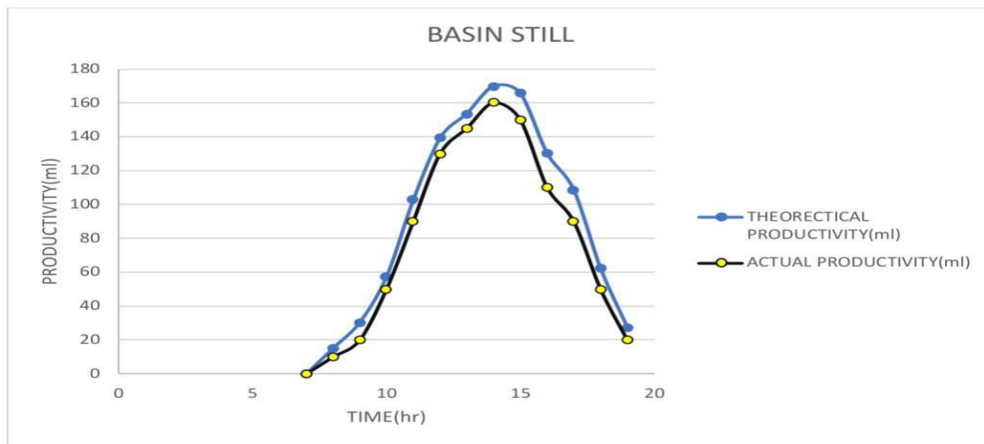


Fig 6 Basin still productivity

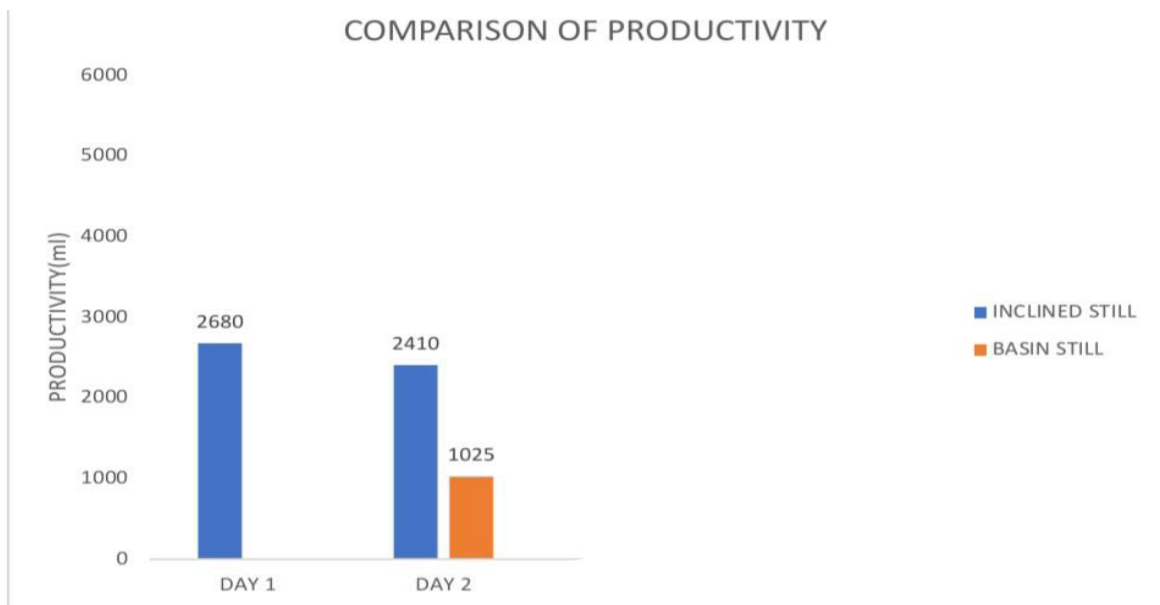


Fig 7 Comparison of productivity

VI. CONCLUSION

The model presented can be used to study the effect of solar radiation, ambient temperature, wind speed, glass cover temperature, transparent cover properties, etc. on the distillate output.

- The model presented can be used to study the effect of solar radiation, ambient temperature, wind speed, glass cover temperature, transparent cover properties, etc. on the distillate output.
- The increasing of temperature difference between the feed water and the glass leads to a better production.
- The output was high at the lower water depth of 2 cm for basin still.
- The increasing of ambient temperature decreases the heat loss from solar still, resulting in higher distillation rate.
- It is concluded that, the supplementary basin, lowered water depth, insulation and glass material of the still have a considerable effect in increasing the productivity of the still.
- The inclined still without integration the productivity was 2680 ml/day. The still integrated with the waste heat recovery system (Basin still) the productivity was 3435 ml/day. It was increases the productivity by



22%.

- The hot water productivity was 14 lit per day.

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