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Regenerative Solar Still with Concentrator

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***Abstract* — Solar still desalination uses a sustainable and pollution-free source to produce high-quality water. The main limitation is low productivity and this has been the focus of intensive research. A major concern while increasing productivity is to maintain economic feasibility and simplicity. In this paper, a review has been presented on the various factors influencing the productivity of the solar stills by using concentrator. The various studies on the factors enhancing the productivity such as the area of absorption, the material of absorber, cooling of cover, water–glass cover temperature difference, inlet water temperature, are discussed here.**

Keywords- Solar energy , Solar still, Solar water desalination, Productivity.

1. INTRODUCTION

A solar still distills water, using the heat of the Sun to evaporate, cool then collect the water. There are many types of a solar still, including large-scale concentrated solar stills, and condensation traps (better known as moisture traps amongst survivalists).In a solar still, impure water is contained outside the collector, where it is evaporated by sunlight shining through clear plastic or glass. The pure water vapor condenses on the cool inside surface and drips down, where it is collected and removed.

Distillation replicates the way nature makes rain. The sun's energy heats water to the point of evaporation. As the water evaporates, water vaporizes, condensing into the water again as it cools and can then be collected. This process leaves behind impurities, such as salts and heavy metals, and eliminates microbiological organisms. The end result is pure distilled water.

2. TYPES OF SOLAR STILLS

2.1 Single Slope Single-Basin Solar Still

It consists of rectangular or square basin made of a thin metal sheet like galvanized iron whose inner surface is prepared in a selective fashion. The basin is perfectly insulated with glass, wool and mineral wool to minimize the heat losses from the basin. The top of the basin is covered with a transparent cover and is slanting making an angle 8-10^0 with the horizontal. At the slant edge of the cover, the distillate collecting trough is located as shown in Fig 2.1 as the outlet is provided at bottom of basin to drain out the deposits from the basin.

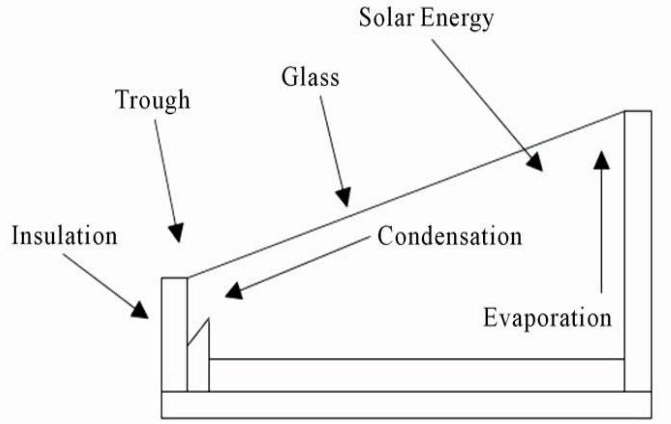

Fig:- 2.1. Single Slope Single-Basin Solar Still

2.2. Single Slope Double-Basin Solar Still

A double-basin experimental solar still is fabricated as shown in Fig:-. The solar still has a 3 mm thick top cover, inclined at 17° on all the sides, and supported by steel frames. The upper basin is partitioned into three segments to avoid the formation of dry spots on the higher portion of the inner glass cover. Silicone rubber sealant has been used to seal off and prevent the water leakage between the boxes of the still. A hole in the basin’s sidewall allows saline or wastewater filling, as well as collecting the condensed water. Moreover, this is also used for inserting the thermocouple wires required for temperature measurements. When the still is in operation, the hole is closed with an insulating material to avoid heat and vapor losses.

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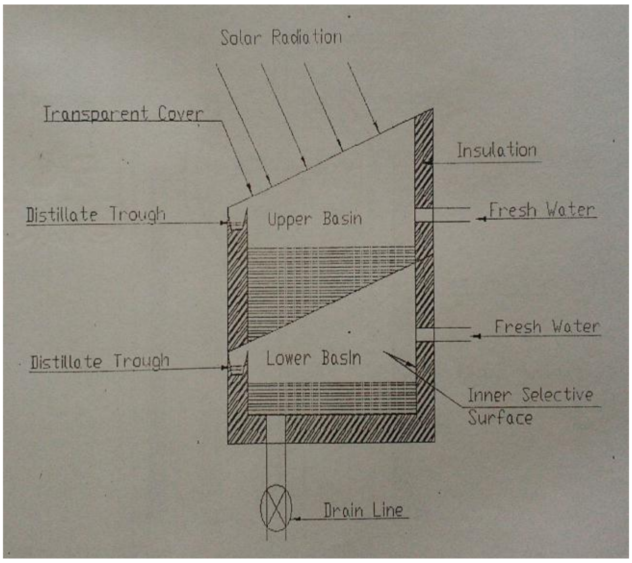

Fig:- 2.2. Single Slope Double Basin Solar Still

2.3 Spherical Solar Still

A spherical solar still design with a collector area of 0.28 m^2 is presented. The still consists of a shallow circular basin of diameter 0.60 m that is made of steel. The circular absorber basin is coated with black paint for maximum absorption of incident solar radiation. The circular basin is fixed at the middle of the spherical aluminum mesh at the radial height of 0.28 m. The saline water is stored in a basin with a capacity of 16 liters. The basin in the spherical solar still is fitted without having any physical contact with the top cover made of low-density polyethylene (LDPE) sheet. The LDPE sheet of thickness 0.107 mm is spread over the spherical mesh. A gap of 0.03 m is maintained between the circular basin and top cover. The evaporated water, which is condensed on the top cover, passes between this gap and drips down towards the distilled water collection segment as illustrated in Fig:- shows the pictorial diagram of the spherical solar still with a total height of about 0.63 m.

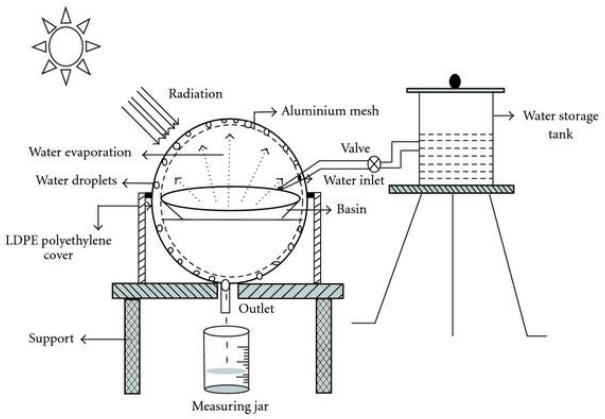

Fig:- 2.3. Spherical Solar Still

2.4 Double Slope Single-Basin Solar Still

It consists of basin prepared in a selective fashion in Fig 2.4 instead of a single transparent cover; two transparent covers are located on the top of the basin from the center, slanting on slight making an angle of 8-10^0 with the horizontal. The basin is insulated to avoid heat losses. Two distillate collecting trough are provided at the bottom of two slanting edges of the covers. The operation is same as that of single slope single basin solar still, but the cost of distilled water per unit of this type solar still is less than single basin solar still.

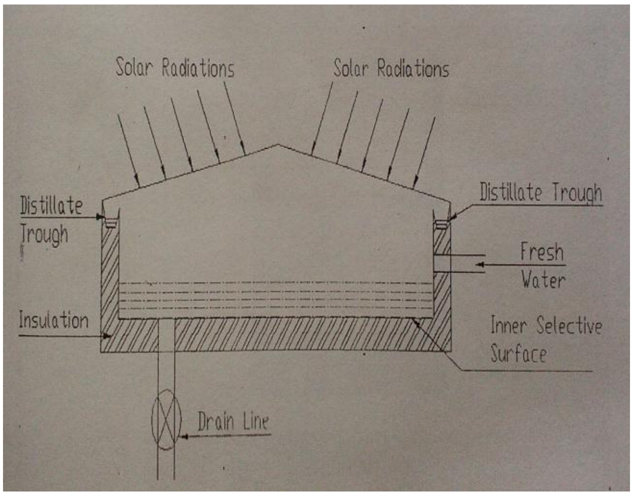

Fig:- 2.4. Double Slope Single-Basin Solar Still

3. REGENERATIVE SOLAR STILL

Solar still operates on the same principal as rainwater evaporation and condensation. A single slope single basin solar still has a top cover made up of glass, with an interior surface blackened to improved absorption of sun rays. Solar radiations are incident on the glass surface and allow the solar radiation to pass into the basin. The water starts evaporating due to increased in temperature. The vapors of water get collected on the inner surface of the glass. This water then gets collected in the trough. The water in the trough is then passed through the copper tubes fitted in the basin which act as a heat exchanger.

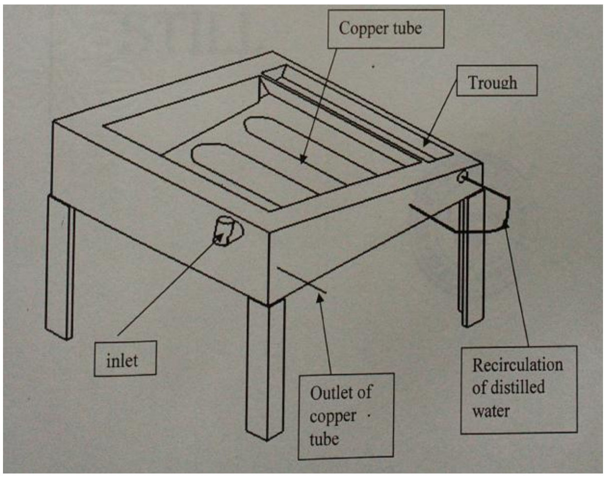

Fig:- 3.1. Solar still with Regeneration

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4. REGENERATIVE SOLAR STILL WITH CONCENTRATOR

In this solar still, the mirror is used as a concentrator so as to concentrate the sun rays on the glass surface of the basin which will ultimately increase the temperature and rate of evaporation of water in the basin.

Fig:-.4.1 Regenerative Solar Still With Concentrator

5. OBSERVATION OF SOLAR STILL

Test 1] Without Regenerative and Concentrator:

i] Day first

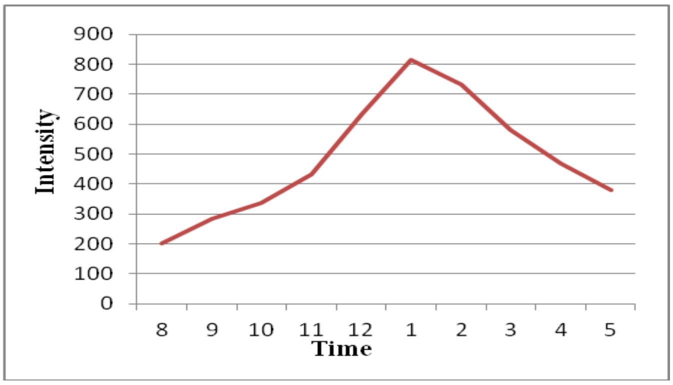
Time	Multimeter Reading (mv)	Intensity (W/m^2)
8 am	27	201.42
9 am	38	283.48
10 am	45	335.7
11 am	58	432.68
12 noon	85	634.1
1 pm	109	813.14
2 pm	98	731.08
3 pm	78	581.88
4 pm	63	469.98
5 pm	51	380.46

Feed water as a input = 3000 ml
Distilled water obtained as output = 1250 ml
Average solar intensity = 486.392 W/m^2
Efficiency of solar still =

$$\frac{\text{Mass of water obtain} \times [c_p(t_s - t_i) + L] \times 100 \times 1000}{\text{Total heat available}}$$

$$\frac{1.250 \times [4.18 \times (100-18) + 2257] \times 100 \times 1000}{486.392 \times 10 \times 3600}$$

η =18.55%

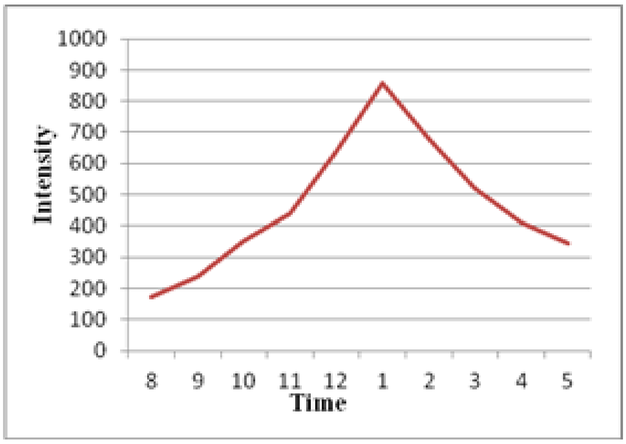


Graph of Solar Intensity vs. Time of the day .

ii]Day second

Time	Multimeter Reading (mv)	Intensity (W/m^2)
8 am	23	171.58
9 am	38	283.48
10 am	47	352.62
11 am	59	440.14
12 noon	86	641.56
1 pm	115	857.9
2 pm	91	678.86
3 pm	70	522.2
4 pm	55	410.3
5 pm	46	343.16

Feed water as a input = 4000 ml
Distilled water obtained as output =1000 ml
Average solar intensity = 441.632 W/m^2
Efficiency of solar still = 17.98%



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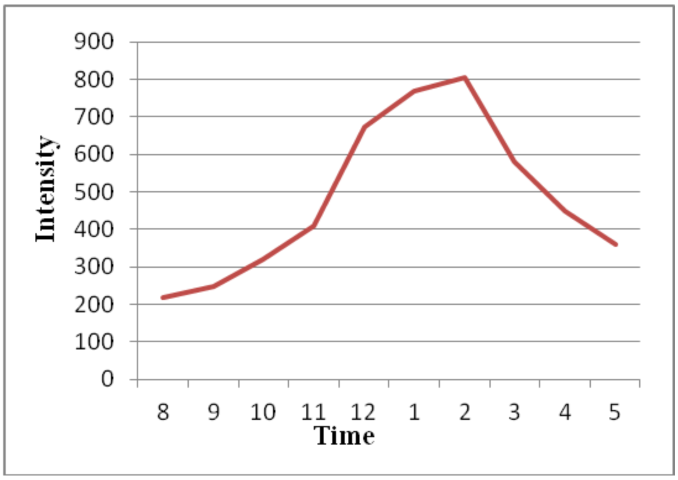
TEST 2] WITH REGENERATION:

i]Day first

Time	Multimeter Reading (mv)	Intensity (W/m^2)
8 am	29	216.34
9 am	33	246.18
10 am	43	320.78
11 am	55	410.3
12 noon	90	671.4
1 pm	103	768.38
2 pm	108	805.68
3 pm	78	581.88
4 pm	60	447.6

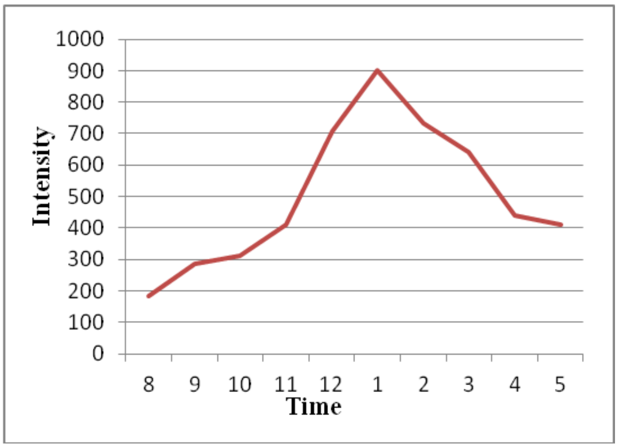
Feed water as a input = 3000 ml
Distilled water obtained as output=1300 ml
Average solar intensity=482.66W/m^2
Efficiency of solar still= 19.45 %



ii] Day second

Time	Multimeter Reading (mv)	Intensity (W/m^2)
8 am	20	149.2
9 am	39	291.68
10 am	47	352.112
11 am	53	395.38
12 noon	80	591.57
1 pm	117	872.82
2 pm	97	723.62
3 pm	80	596.8
4 pm	58	432.68
5 pm	47	350.62

Feed water as a input = 4000 ml
Distilled water obtained as output =1025 ml
Average solar intensity = 475.64 W/m^2
Efficiency of solar still = 15.56%

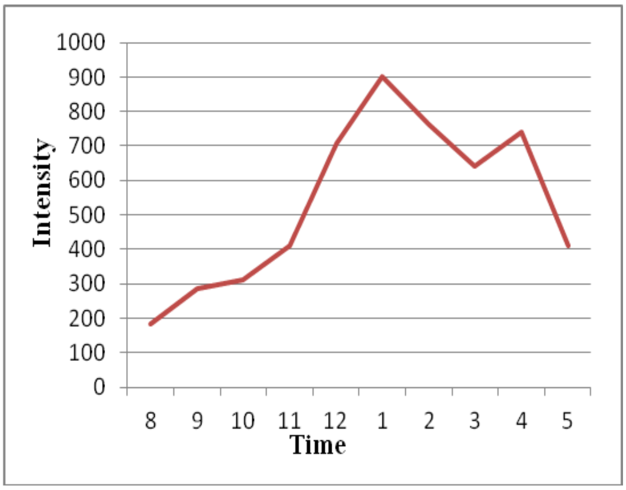


TEST 3] WITH REGENERATIVE AND CONCENTRATOR

i] Day first

Time	Multimeter Reading (mv)	Intensity (W/m^2)
8 am	24	184.26
9 am	38	285.718
10 am	42	313.32
11 am	55	410.3
12 noon	95	708.7
1 pm	121	902.66
2 pm	98	731.08
3 pm	86	641.56
4 pm	59	440.14
5 pm	55	410.3

Feed water as a input = 4000 ml
Distilled water obtained as output=2800 ml
Average solar intensity=502.80W/m^2
Efficiency of solar still= 37.11 %



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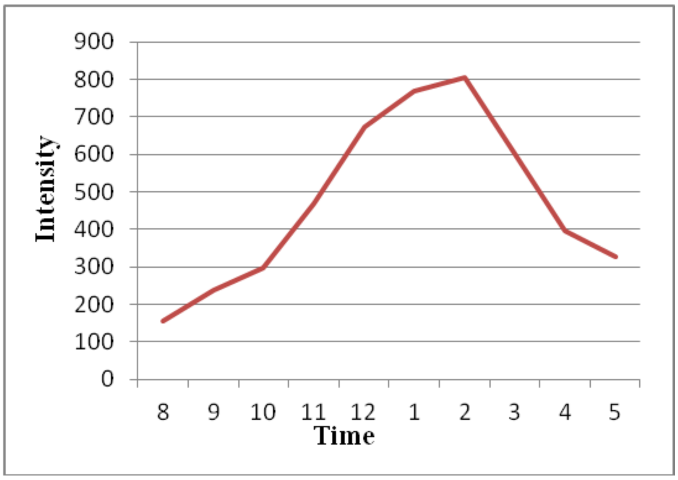
ii]Day second

Time	Multimeter Reading (mv)	Intensity (W/m^2)
8 am	21	156.662
9 am	32	238.72
10 am	40	298.4
11 am	63	469.98
12 noon	90	671.4
1 pm	103	768.38
2 pm	108	805.68
3 pm	81	604.26
4 pm	53	395.38
5 pm	44	328.24

Feed water as a input = 4000 ml
Distilled water obtained as output =2400 ml
Average solar intensity = 473.71 W/m^2
Efficiency of solar still=32.66%



CONCLUSION

Solar still can provide water more economically than any other method. The output obtains under regeneration test is more than without regeneration due to heat transfer of distilled water, that flow from copper tube. It can be further improved by using concentrator in which it gives more output than regeneration test due to high reflection of the sun radiation on a basin by the concentrator. Maintaining minimum water depth in the basin increases the productivity of the solar stills. The increase in the depth of water decreases the still productivity.

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