DEVELOPMENT OF SOLAR STILL SYSTEM: A REVIEW

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ABSTRACT

The earth covered with 71% of water but 97.5% of water are saline water which is not directly used to drinking purpose. A process is used to convert saline water into fresh water is called as solar desalination, for desalination process system is used is known as solar still. Distillation is one of a process to purify water by using solar energy which is the form of heat energy. Solar energy has an advantage of zero fuel cost. Without the using high grade of energy (electrical energy), freshwater is derived from solar still. The yield from the solar still depends upon design construction material and operational parameters. Various methods and equipment have been used in the previous research to improve the efficiency of the solar still. Many researchers have also observed many parameters which are influencing the performance and output of solar stills. In the present work, a study has been conducted on parameters which improves the output of solar still and their result.

Keywords: *Desalination, Solar Radiation, Performance, Solar Still*

I. INTRODUCTION

Distillation is the processes available for getting fresh water from salty, brackish or contaminated water, river water or rain water. Sunlight (Solar radiation) is one of several forms of heat energy that can be used to power that process. Sunlight has the advantage of zero fuel cost, but it requires large space (for its collection) and generally more costly equipment to get higher temperatures. To dispel the belief, boiling of water is not necessary to distill it. Simply increasing its temperature, at values lower than its boiling point, will result in increasing the evaporation rate. Solar stills can provide a method for those arid areas where sunlight is available in large amount, but water quality is worse. This device is be used for producing potable water. Solar stills are cheap and having less maintenance cost, but the problem is that the low productivity of solar still is low. Solar stills can be used for low capacity and small water supplying systems it can produce drinking water by solar energy only, and do not need other energy sources such as fuel or electricity. There are many methods for converting brackish water in to drinking water.

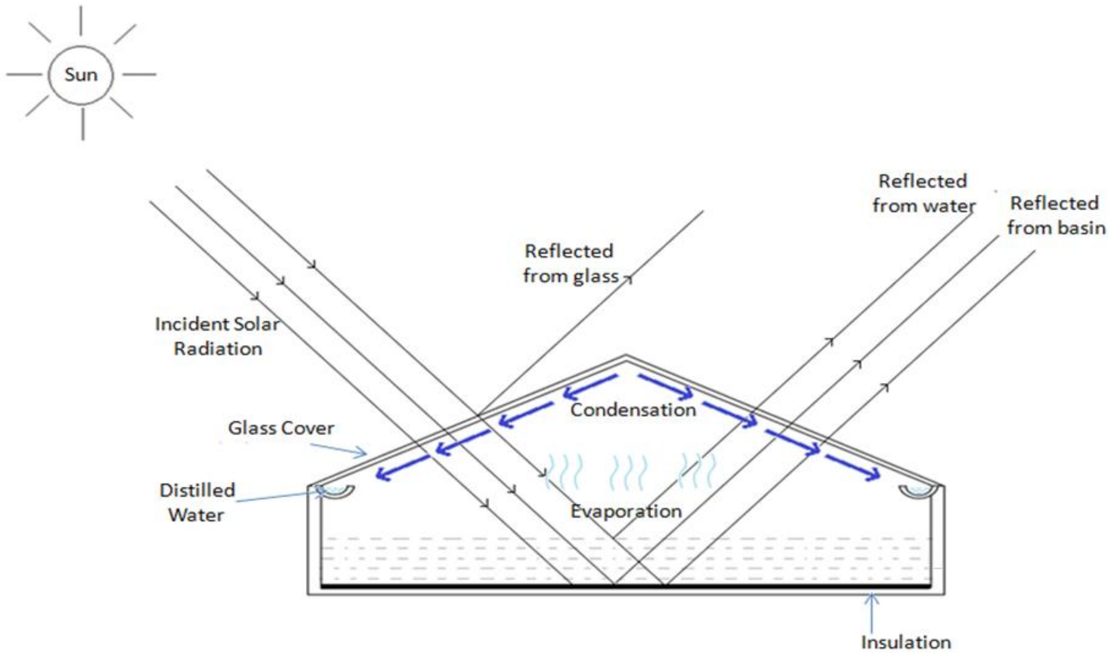

Fig .1A Schematic Diagram of Solar Still

Desalination based on energy, on the other hand, it is sustainable system and a zero-pollution. Non-conventional resources such as solar energy is cheap and available any periods of time and help avoid dependence on external energy supplies. Solar-distilled water is much less cost than bottled water purchased in the store.

Solar still is a distillation system it size can be small or large. It is designed either to complete the requirement of a single family by generating from ½ to 3 gallons of drinking water a day on the average, or to produce much more amounts for village. In some location of the world the lack of fresh water is partially overcome by covering sea salt water basins with glass in greenhouse-like structures.

Solar still is possibly the oldest method of desalination of water. Its principle of operation is similar to rain; the radiation from the sun evaporates water occur at a temperature higher than the ambient. In the soar still, system the saline water is fed on a black plate in the lower portion of system. The heat of the sunlight causes the water to evaporate and water vapor condenses to form purely droplets of water when it reaches the cool transparent surface made of glass or plastic. The droplets slide down along the leaning surface and are collected.

The aim of this system is to represent the basic principles of distillation by solar still, classification of solar still systems, and the developments in solar still systems.

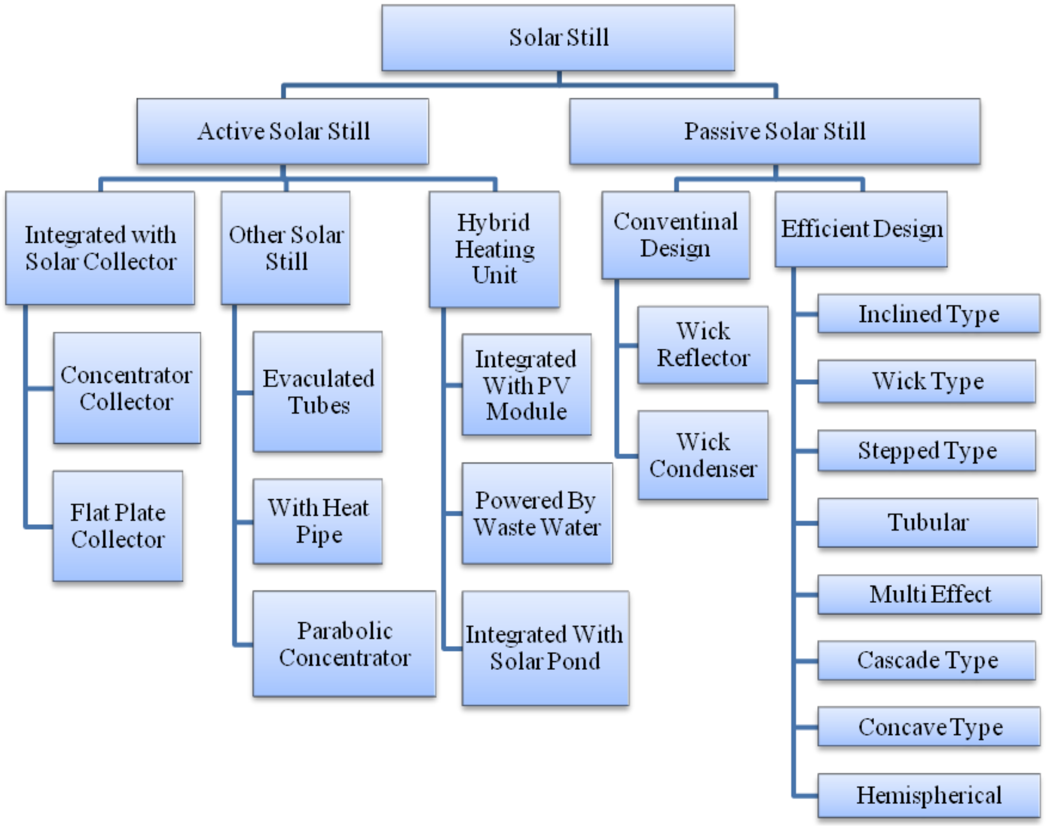

Fig. 2. Classifications ofsolarstilldistillation

II.THEORETICAL ANALYSIS

To design solar distiller, a thermal circuit is analyzed shown in the figure. This circuit considered the convection, conduction and radiation energy in the system with evaporation and condensation processes.

Equation 1: at nodeT_w

$$q_{solar} = q_{evap} + k_{ins}A\frac{(T_w - T_\infty)}{l_{ins}} + h_w A(T_w - T_{air}) + A\varepsilon\sigma\left(T_w{}^4 - T_g{}^4\right)$$

Equation 2: at nodeT_{air}

$$h_w A(T_w - T_{air}) = h_g A\left(T_{air} - T_g\right)$$

Equation 3: at nodeT_g

$$A_g\varepsilon\sigma\left(T_w{}^4 - T_g{}^4\right) + A_g\left(T_\infty - T_g\right) = q_{cond} + h_g A\left(T_{air} - T_g\right) + A_g\varepsilon\sigma\left(T_g{}^4 - T_\infty{}^4\right)$$

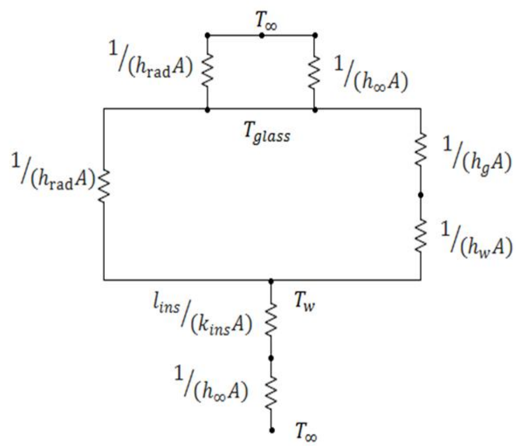

Fig .3. Thermal circuit

Internal Heat Transfer for the Still: In solar still heat is transferred by evaporation, convection and radiation. The evaporative and convective transfers take place simultaneously.

III. LITERATURE REVIEW

Review of various parameters which improves the performance of solar still

the factors affecting the performance of a solar still is listed below from literature. In most of the observations is conducted and the factor which are influence the output that are solar intensity, wind velocity, ambient temperature, water-glass temperature difference, glass angle, free surface area of water, absorber plate area, temperature of inlet water and depth of water affect the productivity of the solar still. The variables which are not controlled by us those are solar intensity, wind velocity, ambient temperature. Other parameters can be controlled to improve productivity the productivity of solar stills.

Comparative study of parameters which improves the output of solar still and their result are shown in Table.1

Table.1. Comparative study of parameters which improves the performance of solar still

Sl No.	Author	Implementation	Observation (Improved Performance)	Result
1	El-Sebaiiet al.[9]	Baffle suspended absorber plate	productivity increased by18.5–20%	By using suspended absorber plate Preheating time is minimized for evaporating water.
2	Naimet al.[10]	Charcoal particle	productivity enhanced by 15%	Accordingly, a good absorber medium is a Charcoal particle act
3	Zeinab et al.[11]	Packed layer	productivity improve from 5–7.5%	In daytime the heating operation of still water is done by a packed layer of glass ball and after sunset, for increasing productivity of the fresh water.
4	Voropouloset al.[12]	Integration of storage tank	By increasing temperature of saline water result in Improve Productivity	The implementation of storage tank is not only to increase saline water temperature; but also, to increase the temperature difference between saline water and glass temperature.
5	Naimet al.[13]	Phase Change Materials (PCM)	By using PCM, the efficiency achieved by still is 36.2%	Using Emulsion of paraffin wax, paraffin oil and water mixture as Phase Change Material (an energy storage material)
6	Nafeyet al.[14]	Gravel and Black rubber	Distillate Output is achieved by using black rubber whose thickness is 10 mm results 20% improvement and 20–30 mm	black rubber is absorbing and releasing solar energy faster than gravel.

			thick gravel results 19% imprudent	
7	Akash et al.[15]	black ink, Black rubber mat and black dye	By using black rubber mat, black ink and black dye productivity increased by 38%, 45% and 60% respectively .	The ability of absorbing high in Black dye then black ink and black rubber mat.
8	Sakthivel et al.[16]	Jute cloth	20% yield capacity increases, and 8% more efficiency compared to conventional solar still	by using jute cloth Available latent heat of condensation between the saline water and glass cover is effectively used.
9	El-Sebaiiet al.[17]	Sand (Medium of Sensible heat storage)	The daily productivity and efficiency are increased by 4.005 kg/m2 day and 37.8% respectively by additional 10 kg of sand	By increasing mass of sand and thermal conductivity of still, the daily productivity and efficiency of the still decreases
10	Abdallah et al.[18]	Absorbing materials	By using absorbingmaterial, productivity more than conventional system. Coated metallic wiry sponges-28%, Uncoated metallic wiry sponges -43%, Volcanic rocks-60%.	An absorbing material in solar still is used to some additional characteristics such as absorptivity, permeability and extinction of metallic wiry sponges.
11	Tiwari et al.[19]	To optimizing the inclination of glass cover, thermal analysis was conducted to get maximum yield.	In summer and winter, by increasing inclination a significant reduction in evaporative heat transfer co-efficient was observed. location and glazing material decide the optimum inclination.	By increasing the inclination of glass yield increases in winter and in summer vice-versa.

12	Abdul Jabbar[20]	Productivity of tilted cover angle and their effect	Increase of the tilted angle cover results in increased thermal losses and cause of increased reflected radiation results decrease in the yield	In various seasons, for simple solar still establishment of relation between optimum tilt angle and the latitude angle Also relation between the cover tilt angle and productivity
13	Al-Kharabshehand Yogi Goswami[21]	To create a vacuum distillation (by using atmospheric pressure and gravity)	kg/m2/ day. Modified system (vacuum distillation)– 6.5 kg/m2/day.	At 40cm water depth maximum collector outlet temperature 61.2ºC and Maximum pressure is about 4.7 kPa absolute. .

IV. ADVANTAGES AND LIMITATIONS

The Advantage of Solar Distillation are listed below-

1. Simple in construction.
2. Minimum water wastage
3. Low-cost Equipment
4. It produces High-quality water.
5. water can be purified like sea water, river water, and rainwater.
6. No requirement of external source like electricity.
7. Easy to operate.
8. Maintenance cost is low.
9. Design easy, portable and compact.
10. Useful in a remote area
11. Intuitive operation and setup.
12. No operation cost, only setup cost exists.
13. Efficiently produces a minimum of 2 gallons of potable water per day

LIMITATIONS

There is some limitation for use of sunlight like in a rainy and cloudy season when an appearance of the sun is not so effective therefore purification water will be disturbed. Also, in a cloudy season, the efficiency will decrease, and the system can't operate in absence of sun (after sunset) so water needs to store in the day time. Solar still will never be an effective solution for large communities because it can’t produce a large volume of potable water. Some minerals are missing in this water.

V. CONCLUSION

Solar still is the simple device to get potable water at no cost. for this process, use of solar energy as fuel. The single basin types single-solar still known as a conventional solar still system. There are many designs of solar still system. modified conventional solar still system results a better performance, such as multi-basin, multi-slop solar still systems, and other coupled with active solar heating system (solar collector) to increase the water temperature. Especially, solar stills are best choice to get fresh drinkable water in arid areas. This system study gives the factors that influence the output and efficiency of solar stills. The factors which is most important including climate,design, and operational parameters. The productivity of the solar still was directly correlated with total solar radiation, ambient air temperature and wind speed. In addition, the productivity of the still is also dependent indirectly water depths, thickness of cover, gap distance between water.

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NOMENCLATURE

Symbol	Meaning	Unit
T_w	Temperature of the water in the basin	Kelvin (K)
T_{glass}	Temperature of the glass surface above the basin	Kelvin (K)
T_{air}	Temperature of the air between the water and glass	Kelvin (K)
T_∞	Ambient temperature around the solar still	Kelvin (K)
q_{solar}	Solar energy entering the	Watt (W)
q_{evap}	Energy required to evaporate a given amount of water	Watt (W)
q_{cond}	Energy required to condense a given amount of water	Watt (W)
A	Area of the basin	m^2
A_g	Area of the glass	m^2
k_{ins}	Thermal conductivity of insulation	$\mathrm{W/m\ K}$
l_{ins}	Length of insulation	m
h_∞	heat transfer coefficient for convection fromT_{glass} to T_∞	$\mathrm{W/m^2K}$
h_g	heat transfer coefficient for convection from T_{air} to T_{glass}	$\mathrm{W/m^2K}$
h_w	heat transfer coefficient for convection from T_w to T_{air}	$\mathrm{W/m^2K}$
σ	Stefan-Boltzmann Constant	$\mathrm{W/m^2K^4}$