A Review on Wick Type Solar Still

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Abstract Solar energy is available to mankind in excess and can be used for fulfilling the demand of drinkable water across the planet. To do so solar still are being used in different parts of the world. Solar radiation provides heat to evaporate the saline water inside the still and help in distillation. But, a conventional solar still does not generate enough distillate water so different modifications are being made in solar still. These modifications can be done to increase the evaporation rate, pre-heating saline water to kick start evaporation or to use thermal storage system. These are some of the modifications which are done to increase distillate output. So a review is done in this paper to identify different methods which are useful in increasing the distillate output of the still

Keywords- Solar still, Active solar still, passive solar still, Wick

Introduction

The fresh water demand is continuously increasing each year due to the increasing population. Fresh water is essential for every living organism. Earth surface contains over 70 percent of water and only 3 percent of it is fresh water which is present in ponds, lakes, rivers and glaciers [1]. Over 90% of water available to us is salty water and it cannot be used for drinking. So, to utilize the non-drinkable water purifiers are used. But these purifiers are quite expensive and everybody cannot afford it. So, to cope up with this problem the idea of using solar still came. It uses solar energy to purify impure water which can be used for drinking purposes. When the solar radiation strike on the solar still it heats up the basin water. As the temperature rises water starts evaporating. It gets condensed on the glass surface and slide down to the collector from where the collected distilled water is removed [2]. The merits of this type of system are the low installation and manufacturing cost which makes it available to everyone.

Solar Still

Solar still is an equipment used to purify impure water by evaporation and condensation process. It consists of a basin for impure water, collector for distilled water, glass on the top so that vapour does not go outside the solar still, a wick cloth which traps heat and also provides capillary action, phase change material (PCM) acting as thermal storage device for solar still and then there is an insulated frame on which everything is mounted. Due to radiations from the sun the temperature inside the still starts to increase and evaporates water. Water vapours move upwards to the glass which is covering the still where due to difference in temperature between covering glass and the atmosphere transfer of heat occurs. Due to the transfer of heat the glass temperature decreases. The vapours start condensing over the surface of glass. Due to the slope of the glass the vapours slide down the glass, gets collected in the collector and distilled water is obtained [7]. The distilled water is then transferred to the storage tank through pipes. In Fig.1 solar still id shown.

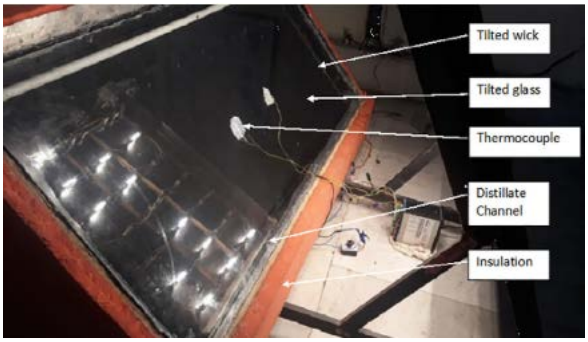

Fig. 1 – Solar still [8]

There are different types of still. But there are 2 basic types of still. These are:

1. Passive type solar still
2. Active type solar still

Passive solar still only use radiations from sun for heating water and producing distillate output. Passive still having 3mm thick glass is 16.5% more effective than that of passive solar still having 6mm thick glass [9].

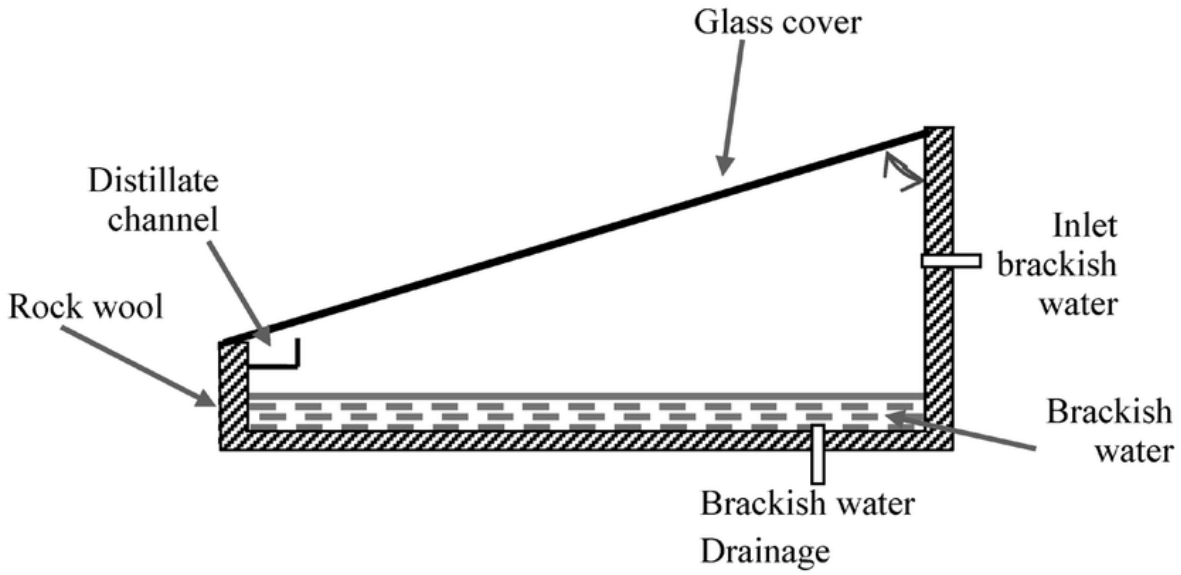

Fig. 2 – Passive solar still

Active solar still use thermal storage system or mechanical device which will supply hot water to the still. 51% more distillate output can be produced by these still compared to conventional ones.[9].

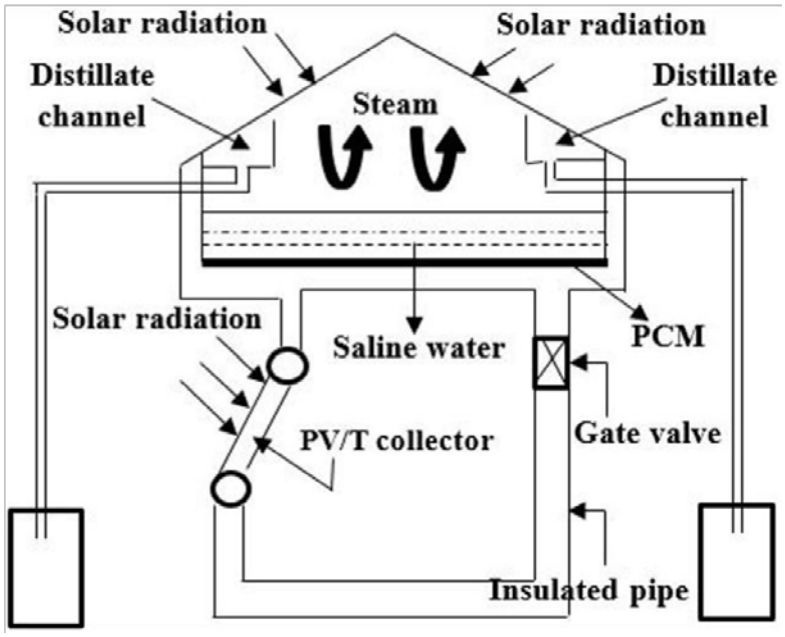

Fig. 3 – Active type solar still [10]

Gravels can also be used as thermal storage system in the solar still. Gravels absorb heat when the heating process occurs inside the solar still. As the solar irradiance decreases gravel starts to lose heat and thus help in evaporation after decrease in solar irradiance. The

productivity of the solar still can be increased up to 19% by using black gravels of size 20-30mm, with 20l/m^3 volume of water and glass cover having slope 15^o [8].

Under these solar still there is another solar still in which wick cloth is used to increase the surface area for evaporation [9]. This wick can be placed parallel to the basin surface or can be tilted.

Literature Review

In an experiment performed by Taamneh in 2012, it was found that use of fan with solar panel is effective for enhancing evaporation inside the solar still and productivity of this kind of solar still can be increased up to 25% than the conventional solar still [3].

In year 2016 another experiment was performed by Haddad et al. in which vertical rotating wick was incorporated with the solar still. A conveyor type mechanism is created with the help of wick cloth, rods and motor. As the motor is powered it rotates with the speed of 0.2 RPM and starts moving the wick slowly. Due to continuous movement each portion of the wick remains wet. Because the wick is in vertical position the evaporation happens at the surface of the water and on the wick also. With this method the increase in the distillate output in summer and winter was about 14.72% and 51.1% respectively as compared to the conventional one [4].

In an experiment performed by Nayi in 2018, it was found that using wick on tilted surface of pyramid still the average productivity was up to 50.25%. And by using small fans evaporation rate was increased which enhanced daily productivity by 25% [5].

In year 2020, Katekar performed an experiment using single basin solar still fitted with paraffin wax as thermal storage system and found the increment in distillate output, energy efficiency and exergy effectiveness of approximately 180%, 67.2% and 40% respectively. This result was found for single basin passive type solar still. For active solar still the productivity result was found to be 307.54% [3].

In an experiment performed by Negi et al. in 2021 a solar still having tilted wick was used. A flat plate collector was also used along with the still which provided preheated water to the still. The maximum temperature attained by the basin and glass was found to be 327.4K and 337.3K during afternoon and was 295.1K and 297K during morning. This was the result for case 1 in which conventional solar still was used. In case second, a wick was used wick is tilted at 30^0 angle. By using tilted wick the output of distillate water increases up-to 4PM but as the solar intensity decreases the output decreases. At the end it was found that the cumulative efficiency was around 22.1% higher and during day it was around 16.7% higher [6].

Fayaz et al. [17] - An experiment was performed on solar still having variable slope of the wick in the basin to enhance the daily yield. The slope of the glass was taken as 45^{o} in this setup. The slopes taken in this setup were 0^{0}, 15^{o}, 30^{o}, 45^{o}. The purpose of using the wick was to slow down the inertial of water and also increase the evaporation rate inside the still. The experiment was performed at Chandigarh University on March, 2021. Initially different flow rate were checked to check the optimal value. It was concluded that when the flow rate was taken as $0.01g/m^2$ gave more output during morning compared to others. When the flow rate was takes as $0.02g/m^2$ the output was more during noon and afternoon compared to others and the overall distillate output found during the experiment was $3.51kg/m^2$, $3.60kg/m^2$ and $3.41kg/m^2$ for $0.01g/m^2$, $0.02g/m^2$ and $0.03g/m^2$ respectively. Finally when the experiment was performed for varying tilted wick it was found that the maximum distillate output was attained when the angle of tilt for wick was 30^{o} and the output generated was $3.60kg/m^2$.

Matrawy et al. [18] – A study was performed on modeling and experimental study of a corrugated wick type solar still and compared with a conventional solar still. A reflector was also attached with the still so that maximum radiations can be concentrated into the still. The mathematical model was compared with the experimental setup and the maximum deviation for global radiations were found in between them were about 2-3%. The maximum deviation for diffused radiation were about 13% to 10.8%. It was found that at 2 PM the output attained by corrugated surface was 0.7kg/h and for conventional solar still it was found to be 0.23kg/h. The maximum output for corrugate and conventional were 0.93kg/h and 0.76 kg/h respectively. The daily output of corrugated and conventional still were found to be 5.9 kg/m^2 and 4.4 kg/m^2. When compare it was noted that the corrugated wick type solar still with incline reflector gave about 34% more distillate output than the conventional solar still.

Feilizedah et al. [15] – A study was performed on optimization of geometrical dimensions of single slope basin type solar still. In this experiment a numerical model was created which was then compared to the experimental data. The purpose of this work was to check the effect of change in the dimensions of still. Two single slope solar still were made having active areas of $1.12m^2$ and $0.56m^2$. Insulation was provided on the wall and the bottom so that heat transfer through them would me as low as possible. Top of both the stills were

covered by 4mm thick glass placed at an angle of 30°. Once that was done it was made sure that the stills are air tight. To increase the absorptivity black rubber were placed on the still liner. The experiments were done on both cold and warm day on different dimensions of the still to check the prediction by the numerical model. The experiments were conducted for 24hrs and started at 7Am in Shiraz, Iran. The depth of water taken for this purpose was 2cm. the stills were oriented in south direction. For measurement of temperature thermocouples were used and for measurement of solar radiation Kipp and Zonen pyranometer was used. Firstly the height of the still was changed. It was changed in such a way that the slope of top class cover remains 30°. For that the dimensions of both front and back wall changed equally. It was observed that by increasing the height of the walls the shape factor of the walls w.r.t. the base was reduced and it produced less distillate output. Thus, shorter the height of the still more it will be efficient. If the length of the still is increased then the production of distillate output increases. It was also noted that if the length of the still is more than 2 times the width the increase in production was not noticeable. When the width of the still was varied the height of the still was also changed so that the slope of glass cover remains same. In this case it was noted that the distillate output of the still firstly increased with increase in width but after a critical point it started decrease. According to the mathematical model the critical ratio of width to length in case of summer and winter were 0.15 and o.6 respectively. So finally it was concluded that the distillate output of the solar still increases with increase in length and the if the width of the still is being change then the it should not exceed the critical value otherwise the output of the still will decrease.

Conclusion

Based upon the literature it can be concluded that

- The tilted surface of the wick in the still plays an important role in the still.
- It can also be said that continuous movement of vertical rotating wick also plays an important role in increasing the evaporation rate of the still.
- It can also be said that the dimension of still plays also plays an important role in the distillate output of the still. If the length and width of the still is increased, the

output can be increased but. If the height of the walls of the still is increased it can decreased the output of the still.

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