Experimental Investigation with Software Validation for Exergy Analysis of Solar Still by Reticular Porous Media with Glass Cover of (IAO) Coating – A Review

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Abstract: *About 70 percent of the world is covered by water, only 2.5 percent of it is fresh water, the rest is saline and ocean-based, so there arise a need for producing fresh water from the saline water so as to maximize the fresh water supply to the world hence desalination process is come into existence to draw fresh water from saline water. There are many ways to distillate the water, by using some available energy resources like fossil fuels or from renewable energy sources. The attention is more concentrated on renewable energy resources such as solar energy, wind energy, tidal energy etc. Main focus is on solar energy because it is available in large amount and it has no adverse effect on environment. To improve the performance of solar still productivity various active and passive techniques are used. To improve the solar still productivity many methods are available. By increasing the temperature difference between the evaporative and condensing surface the productivity of solar still can be increased. For this one of the efficient techniques to improve the productivity is by using porous material and IAO coating glass.*

Keywords: *Porous materials, IAO coating glass, Solar still.*

I. INTRODUCTION

Fresh water is a basic human requirement. Access to this vital matter is not possible for many people, specifically in developing countries. Most of water resources are available dirty or salty. This discloses the importance of desalination process. Solar stills are famous desalination devices with many applications. Generally, these devices can be utilized in regions where no pure water is available or during power outages. They are free of charge and reduce the consumption of fossil fuels and air pollution, and accordingly causes cost savings. Many researchers used various active and passive techniques to improve the efficiency and productivity of the stills.

Desalination Technologies

The classification of solar desalination system is as shown in figure 1.1. Desalination is by definition a process removing minerals and salts from saline water to produce freshwater, that can be used for human use or irrigation. It's applied to seawater and brackish water with different performances criteria. It's normally considered that salinity below 500 ppm is suitable as drinking water. Basically, a complete desalination process includes 3-4 steps with, first pumping water (from sea, estuaries or saline aquifers), pre-treatment of pumped water (filtration, chemical addition) desalination process and last, post treatment if necessary (in some case, adding few minerals).

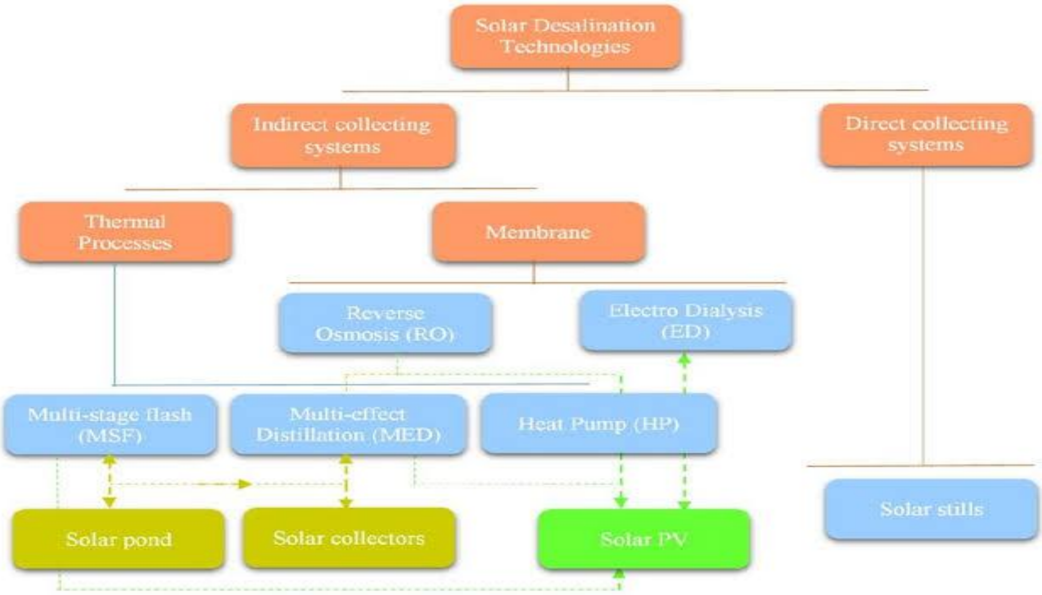

Figure 1.1: Classification of Solar Desalination System

There are different ways to produce fresh water with desalination technologies. More common technologies are:

- ➢ Reverse Osmosis
- ➢ Multi-Stage Flash Process
- ➢ Multi Effect Distillation.

Working of Solar Desalination System

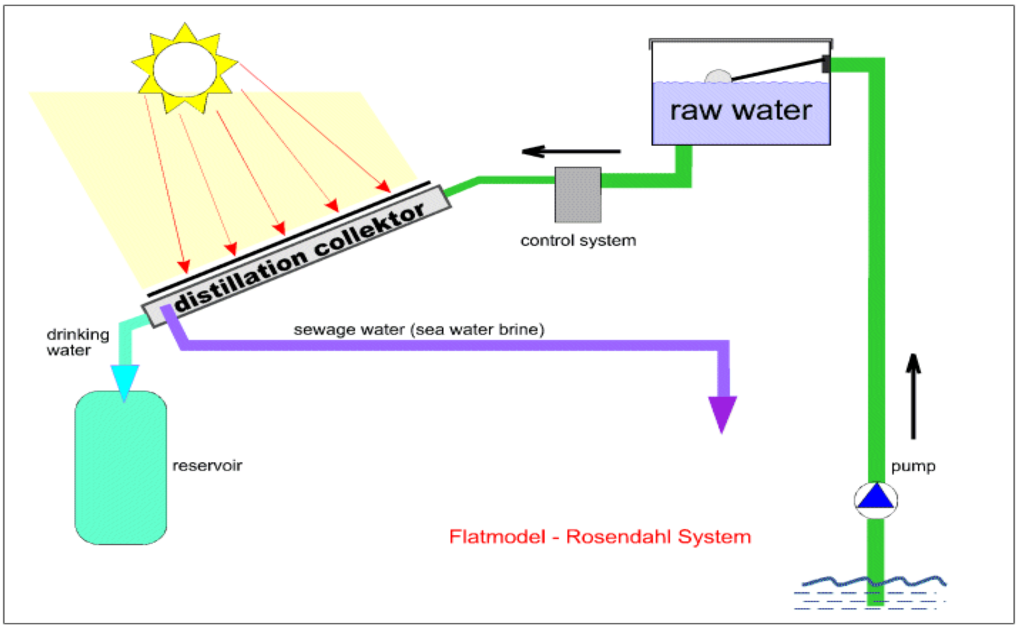

Figure 1.2: Solar Still Process [2]

A basin of solar still has a thin layer of water, a transparent glass cover that covers the basin and channel for collecting the distillate water from solar still as shown in figure 1.2. The glass transmits the sun rays through it and saline water in the basin or solar still is heated by solar radiation which passes through the glass cover and absorbed by the bottom of the solar still. In a solar still, the temperature difference between the water and glass cover is the driving force of the pure water yield. It influences the rate of evaporation from the surface of the water within the basin flowing towards condensing cover. Vapour flows upwards from the hot water and condense. This condensate water is collected through a channel. The efficiency of the solar still depends upon the following important parameters:

- ➢ Tilt angle of cover plate
- ➢ Depth of water
- ➢ Feed water flow rate

- Cover plate temperature
- Convective heat transfer from cover plate and side walls
- Solar tracking
- Coating
- External enhancement like heat pipe, coolers.

II. SEVERAL RESEARCHES RELATED TO SOLAR STILL SYSTEM

N. Rahbar and J.A.Esfahani (2012) utilized the heat pipe and thermoelectric module simultaneously in a solar still. They concluded that the productivity of this type of still improves by combination of heat pipe and thermoelectric cooler. The maximum daily efficiency of the still in the period of experiments is 7%. The daily productivity is directly proportional to solar radiation and ambient temperature, but wind velocity has an inverse effect on productivity. The temperature of the cold side of thermoelectric module was apparently lower than wall temperature. So by using thermoelectric module, higher temperature difference is achieved. By combination of heat pipe and thermoelectric cooler, it is possible to increase the productivity of PTSS [1].

M.M. Morad, H.A.M. El-Maghawry, K.I. Wasfy (2015) enhanced the performance of a double slope solar still by using flat-plate solar collector and cooling glass cover. They found that flowing thin film of cooled water on the glass cover causes a decrease in the cover surface temperature and subsequently an increase in the condensation rate. For passive solar still, the highest productivity of 6.38 l/m^2·day was obtained when the brine depth was 1 cm with glass cover thickness of3 mm (without applying glass cover cooling); while, the highest productivity was 7.80 l/m^2·day (with applying cover cooling flash tactic 5 min on and 5 min off).For active solar still (solar still integrated with flat-plate solar collector), the highest productivity of 8.52 l/m^2·day was obtained when the brine depth was 1 cm with glass cover thickness of 3 mm(without applying glass cover cooling); while, the highest productivity was 10.06 l/m^2·day (with applying cover cooling flash tactic 5 min on and 5 min off) [2].

A. E. Kabeel and M. Abdelgaied (2016) used phase change material as a thermal storage medium to enhance the performance of solar still. In this work, the effect of PCM on the behavior of the solar still with PCM was investigated experimentally under the weather conditions of Tanta city (Egypt). The rise in the temperature of PCM for the solar still with PCM is due to the intensity of solar radiation absorbed by the absorber surface, the absorber plate made from copper sheet. Afternoon, during the period of low intensity of solar radiation and during the night the PCM will represent a source of heat for the basin water to keep the temperature difference with the outer glass. For this purpose, it is recommended to merge the PCM in the solar still to produce the distillate water after sunset. The experimental results showed that the daily freshwater productivity for the solar still with PCM is higher than that of the conventional solar still. The freshwater productivity reached approximately 7.54 l/m^2 day for the solar still with PCM while its value was 4.51 l/m^2 day for the conventional solar still. The daily freshwater productivity for the solar still with PCM is 67.18% higher than that of the conventional solar still. The solar still with PCM is superior in daily freshwater productivity (67%–68.8% improvement)compared to the conventional solar still, during the period from June to July 2015 (Egypt) [3].

L. Sahota and Tiwari (2016) used Aluminum Oxide nanoparticles to improve the performance of a double slope solar still. The peak or optimal value of the maximum temperature difference$(\Delta T)_{max}$ between base fluid and nanofluid arises for 35 kg fluid (BF/NF) mass and 0.25% concentration of all three different Al_2O_3, TiO2, and CuO nanoparticles. The value of $(\Delta T)_{max}$ increases with an increase in the concentration of Al_2O_3, TiO_2, and CuO. $(\Delta T)_{max}$ increases only up to 0.25% concentration (nanoparticles) and then it starts decreasing beyond it. Incorporation of Al_2O_3 nanoparticles in the basefluid(water)gives higher value of $(\Delta T)_{max}$ as compared to TiO_2, and CuO–water based nanofluids. Thermal energy (E_{th}) and instantaneous thermal energy efficiency(ηt_h) is higher for Al_2O_3–water based nanofluid followed byTiO_2, and CuO–water based nanofluid. The same trend has been observed for thermal exergy (E_{ex}) and thermal exergy efficiency($\eta_{hourly,ex}$). The productivity (yield) of passive DSSS is obtained more for Al_2O_3–water based nanofluid from the east and west sides such that all three different nanofluids follow the order of production of yield as Al_2O_3> TiO_2>CuO–water based nanofluid [4].

Y.A.F. El-Samadony et al. (2016) investigated the effect of glass cover tilt on radiation heat transfer rate for a stepped solar still. His results showed that the productivity increases with an increase in the glass cover tilt. The performance evaluation of a stepped solar still was theoretically investigated. The effect of taking radiation shape factor between hot saline water and glass cover into consideration on the productivity of solar still was studied numerically. From the analysis, he conclude that, As the glass cover inclination angle increases, the radiation shape factor decreases and consequently the productivity increases. Taking radiation shape factor into account gives more accurate still productivity than ignoring it. There are about 6 to 18% deviations in distillate productivity between the two cases. Taking radiation shape factor into account is very important for low solar insolation and/or high glass cover inclination angle and vice versa. An acceptable correlation with a maximum deviation of 3.16% for the percentage of productivity increase is obtained as a function of the studied parameters (I and θ) [5].

Elango and Murugavel (2015) studied the influence of the water depth on the productivity for single and double basin solar stills. They concluded that water depth, insulation thickness, and glass material of the still have a substantial influence on the productivity improvement. Single and double basin double slope glass stills have been fabricated. The stills were studied under insulated and un-insulated conditions for their production at various water depths of 1, 2, 3, 4 and5 cm. Although fabrication of the double basin increased the manufacturing cost a little, high yield of the distillate made it a better one. The output was high at the lower water depth of 1 cm for both single and double basin double slope solar stills. A maximum of 4.315 l/0.81 m^2 day (5327/m^2 day) was obtained at1 cm water depth by the insulated double basin double slope glass still. But, the insulated single basin double slope still gave only3.565 l/0.81 m^2 day (4.401 l/m^2 day).Day and night productivity of single and double basin solar stills. The production difference of the single basin is more than the double basin during the heating period and the double basin is more during the cooling period. The performance of the double basin double slope solar still was higher than the single basin solar still under both insulated and un-insulated conditions. 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 [6].

S.W. Sharshir et al. (2016) reviewed the main techniques and factors to improve solar stills efficiencies. They reported that the productivity of a single slope solar still is greater than that of a double slope one. Moreover, they concluded that usage of air and water solar collectors leads to enhance the daily productivity about 175%. Also, a minor increase in the solar still productivity has achieved by increasing the environmental temperature. By reducing the water depth in the basin, the evaporative heat transfer coefficient increases therefore, the production increases. The inclination and the direction of the cover are dependent mainly on the location latitude. If the inclination of the cover is equal to a latitude angle, the cover will receive the solar radiation close to normal in all seasons of the year. By increasing the insulation thickness of the still, the productivity increases [7].

Srivastava and Agrawal (2013) looted nine thermocol pieces covered by blackened jute in basin of a solar still. They reported about 68% more distillate output on clear days for the modified still in comparison to the conventional one. The modified still performs better than the conventional basin type still due to higher operating temperatures and quicker start up time. The productivity increase slightly with the initial increase in wind transfer coefficient but after a certain value it starts reducing appreciably [8].

Srivastava and Agrawal (2013) used thin bamboo sticks covered by blackened cotton cloth in basin of a solar still. They observed 56% higher distillate output for modified still in the February in comparison to the conventional one. Quicker and early morning start-up and enhanced evaporation rates were obtained in the case of the modified still. Base and side heat losses are less in case of the modified still. The modified still gives better performance at smaller basin water depth [9].

Al-Nimr and Dahdolan (2015) proposed a new mathematical model for concentrated solar still used a porous evaporator and an internal condenser. They found that the efficiency and productivity of still increase with a decrease in the wind speed and condenser temperature [10].

A.E. Kabeel (2009) studied the performance of solar still with a concave wick evaporation surface. He conclude that, the average distillate productivity of the proposed still during the 24 h time is about 4.0 l/m^2. The proposed concave solar still efficiency reached about 45% [11].

III. REFERENCES

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