Performance Evaluation of Double Solar Stills: A Review Paper

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Abstract— Solar distillation is a simple experiment of converting saline water into pure potable water. Since solar energy is a low price option, heat source from the sun is used for purification in the present work.In solar distillation, water is evaporated using the irradiation from the sun and then the evaporated water vapour is allowed to condensate as distilled water. This process eliminates salts and other impurities. In the work, double slope single basin solar stillhas been fabricated using the cheaply available material. In this solar still aluminium is used as a basin material. Aluminium is used because it has good thermal conductivity of 205 w/mk. An extensive study was made to evaluate the effect of water depth in the basin on the productivity of the stills. The results clearly states that the productivity of the system is inversely proportional to the water depth in the basin.

Keywords: Solar Still, Solar Energy, Portable Water, Double Slop, Solar Distillation

I. INTRODUCTION

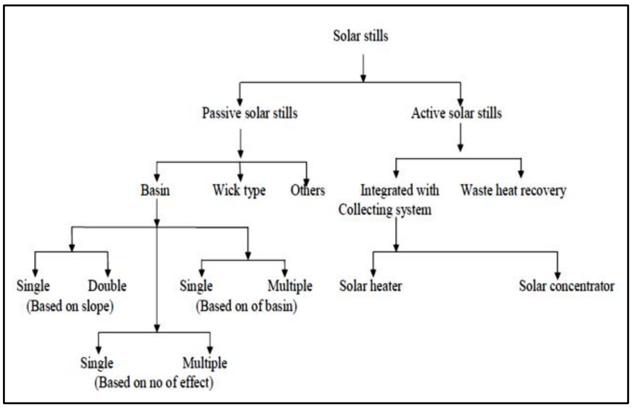
Due to rapid population growth and industrial developments, the need of quantum of drinking water increased. So far the only possible way of getting drinking water is from rivers, lakes, wells, etc., which must be purified as they may contain harmful microorganisms and mineral contents. And the purification process involves namely sand filtration, chlorination and boiling. India is almost having 18% of total world population and only 4% of water source is available for serving the Indian community. However, due to the growth in population, urbanization and industrial needs, the demand for water is rapidly increasing. The decrease in annual per capita of water available is from 6042 m³ during 1947–1545 m³ in 2011, whereas, during 2001 the total annual per capita of water available is only 1816 m³. From the latest survey, this water availability will be reduced to 1340 m³ by 2025and 1140 m³ by the end of 2050. Moreover, the utilization of

Ground water source is 431 billion cubic meter as a major source for drinking and domestic purpose and nearly 690 billion cubic meter of surface water as a major source for irrigation purpose.

Sources from Indian ministry of water resources, United Nations, UNICEF reported that nearly 90% of the water discharged from rivers does not meet the environmental norms. And nearly 65% of rainfall goes into the sea as waste [1]. Beyond domestic and industrial sector, the next major user of water is the agricultural sector [2]. Several techniques are available for getting fresh water. Major techniques include thermal and membrane process. As the name implies, thermal desalination process requires heat to convert the saline water into steam, and the steam or vapour is condensed to get fresh water. Fossil fuels are used in the thermal process, and this makes the system uneconomical [3]. Solar desalination is subdivided into two major categories namely direct and indirect desalination. Direct desalination system collects the solar energy and converts the saline water into distillate water directly, whereas, in indirect desalination system, energy will be collected by additional solar thermal collectors integrated to a solar still [4]. Desalination through the membrane is a process of getting freshwater from waste or salt water and filtering into useful one by using electrical energy. Fouling effect and salt deposition on the membrane surface makes the maintenance of the process complicated. Almost it consumes 20% of electrical energy for the conversion of salt water to drinking water by pumping water into the perforated membrane. The evolution of using renewable energy has been identified during the 19th century and thus basin type solar stills were designed and fabricated to get fresh water from saline water using solar energy. Solar desalination appears to be the easiest and cheapest method of producing potable water.

For a very small scale of getting fresh potable water, solar desalination appears to the best method. Majorly many review papers have concentrated only on the prospective design configuration. Basin type solar still is one of the breakthroughs of the 20th century where many types of research are carried out to augment the fresh water production. For augmentation purpose, many used coupling methodologies with solar ponds which is an economical thermal energy storage unit [5]. Basin type solar still is the most traditional and conventional method of getting fresh water utilizing solar energy. Saline water washed into the basin, and an inclined glass cover is placed over the basin. Solar radiation heats up the water inside the basin to make it evaporate from the top layer. The evaporated vapour inside the still rejects its latent heat through the cover for condensation to attain thermal equilibrium with surroundings. Since the cover is inclined, the condensed water making a droplet on the cover, the droplets slides through it to the distillate collector due to the smooth cover surface [2]. Also, there is a fact that the water forming larger droplets falls back into the basin itself due to its weight and gravity.

II. CLASSIFICATION OF SOLAR STILL



A. Active Solar Still

Active solar systems use external sources of energy like power blowers, pumps and other types of equipment to collect store and convert solar energy. Once energy from the sun is absorbed, it is stored for later use.

While small systems are used to furnish electricity for heating and cooling systems in homes and other buildings, large systems can furnish power for entire communities.

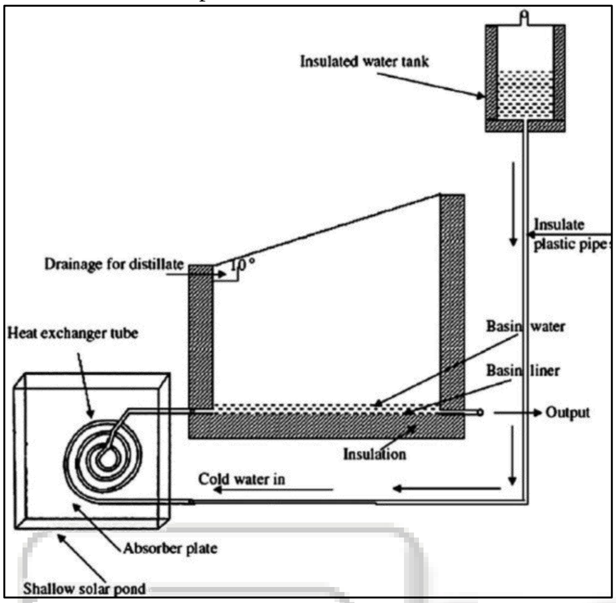


Fig. 1: Schematic diagram of single basin solar still coupled with the shallow solar

1) Active Solar Collectors

Solar collectors are complex than passive collectors in both design and mechanism. It consists of flat-plate PV panels that are usually mounted and remain stationary, although some are designed to track the sun throughout the course of the day. In some active solar still designs, multiple panels are connected together to form modules. Active solar collectors contain either air or a liquid as a conductor. In active system, those that use air are referred to as Air Collectors, while liquid based types are called Hydronic Collectors. The advanced design of these collectors makes an active solar heating system the most effective in terms of reducing reliance on traditional energy resources.

B. Passive Solar Still

A passive solar system always does not involve mechanical devices or the use of conventional energy sources, beyond that it controls the needs to regulate dampers and other controls if any. Classic examples of basic passive solar still structures are greenhouses and solariums as the sun's rays pass through the glass windows where the interior absorbs and retains the heat. Modelling this concept in your home can cut heating costs by half compared to heating the same home by traditional means without the use of passive solar.

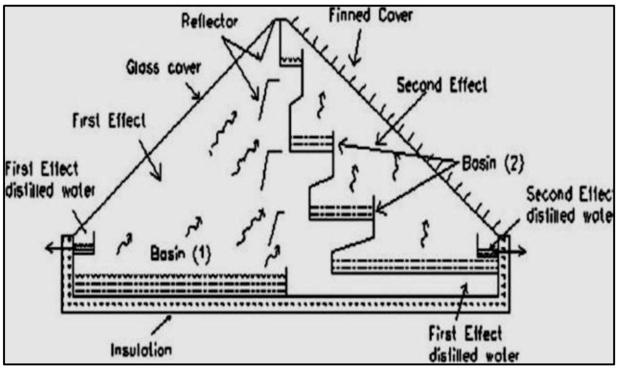


Fig. 2: Schematic diagram of passive solar still

1) Passive Solar Collectors

The passive solar system relies on south-facing windows as collectors to capture maximum solar energy, although some systems may also use supplemental PV panels. In most case, the goal system of this is to redistribute the energy collected according to a fundamental law of thermodynamics, which states that heat moves from warm to cool areas and surfaces. The simplest method of transferring the heat from passive solar collectors is through convection. To illustrate, think of a sunroom with windows on a southern wall. As the sun's rays travel through the glass, the heat is directed into that room. The heat then rises to area where the air is cooler, including others rooms beyond and above.

III. FACTORS INFLUENCING THE PERFORMANCE OF THE STILL

A. Water Capacity and Inclusion of Dyes

It is a well-known fact that the distillate output decreases significantly with the increase in water depth of the solar still. Many researchers have investigated the effects of climatic, operational and design parameters on the performance of a basin type solar still to improve the output. Malik et al (1982) have reviewed the work on solar distillation that includes various designs of solar stills, like single basin still, multiple effect still, inclined solar stills, solar still greenhouse and effect of meteorological and still parameters, etc. In their studies, it is concluded that there is a variation of 30% in daily yield for variation in depth from 12.7 mm to 305 mm. Effect on the heat capacity of basin water on the output of solar stills was investigated by many authors (Lawrence et al 1990, Yadav and Prasad 1995) and they have concluded that the output decreases with an increase in water depth. Further, in a previous work, it has been found that the overnight output of single basin solar still increases with an increase in the basin water depth and it represents a great part of the daily output of solar stills (Okeke et al 1990, El-Bassuoni 1986). However, a detailed study on the effect of heat capacity of basin water on the solar still performance is still of considerable interest due to some difficulties associated with experimental measurements of the still output overnight (Aboul-Enein et al 1998).

B. Cooling of Condensing Cover and Water Flow in the Basin

The productivity of the still is mainly dependent on the temperature difference between water and condensing cover. The higher this difference the more will be the output. This can be achieved by either increasing the basin water temperature or decreasing the cover temperature or both. These techniques are summarized below. Tiwari and Bapeshwara Rao (1984) studied the effect of cool water flowing over the glass (Figure 2.18) and its velocity. The result shows that, when water flows over the glass cover at a uniform velocity, the daily distillate production of the system is almost doubled.

C. *Effect of Condensing Chambers*

Tiwari et al (1997) conducted an experimental analysis of a new design of double condensing chamber single basin single slope solar still.

The authors concluded that,

1) significant enhancement in daily output was obtained due to a maximum vapor pressure difference between the two condensing chamber on a clear day and
2) the performance of double condenser chamber solar still gives a higher daily output of about 35% - 77% over the conventional solar still.

D. *Surface Treatment of the Glass Cover*

Bahadori and Edlin (1973) studied the effect of surface treatment of glass on the performance of simple solar still. In their experiments, still glazings are treated with sodium silicate or hydrofluoric acid to make them more wettable. Consequently, the angle of inclination can be reduced by 1°-5°. They found that, the treatment of glass glazing with either sodium metasilicate or hydrofluoric acid reduces the permissible glazing slope and increase water production.

E. *Effect of Condensing Surface Area*

Tayeb (1992) conducted an experimental study on four different designs of basin-type stills (Figure 2.22) to find the effect of condensation area on the efficiency and performance. The stills ave the same area of evaporation, but different shapes and thus different areas of condensation. The effects of these design factors as well as the effects of materials of construction and some operating factors such as basin temperature, cover temperature, ambient temperature and solar intensity is examined and analyzed. The results show that a higher ratio of condensation area (A_c) to evaporation area (A_e) leads to a higher productivity, if not contradicted by another effect such as shading.

A.A.El-Sebaii et al. Single basin solar still with baffle suspended absorber (SBSSBA) was designed and fabricated using locally available materials. Various investigators have studied the effect of baffle plates on the performance of solar water heaters and shallow solar ponds and an improvement in performance has been achieved. Recently, Kaushik et al. have studied the effect of a baffle plate on the performance of a built-in solar water heater, and they outlined that the water mass ratio, thickness and thermal conductivity of the baffle plate do not affect the performance of the system. Very few papers have appeared concerning the usage of a suspended absorber inside the single basin solar still. Szulmayer has investigated experimentally the conventional sun still with a floating absorber at some stage in daytime time simplest. Riera et al. have concluded that the output of the still provided with a floating absorber is set four% better than that received from the conventional nonetheless. Therefore, the SBSS with a baffle suspended absorber requires similarly experimental and theoretical studies. The authors of this study investigated the performance of a single-slope single basin solar still (SBSS), and they concluded that the overnight productivity of the still increases with an increase of the mass of basin water.

Hiroshi Tanaka et al. Many attempts have been made to increase the distillate productiveness of the tilted wick sun nevertheless among the modifications, an outside reflector may be a useful one to boom the distillate productivity for the tilted wick nevertheless as indicated by means of Malik et al. Tsumura et al. and Al-Karaghouli and Minasian however an in depth and quantitative evaluation of the impact of reflector on the sun radiation absorbed on the basin liner of the basin nevertheless. The impact of vertical flat plate external reflector for the tilted wick nonetheless at the sun radiation absorbed on the evaporating wick in addition to the distillate productiveness of the nonetheless at 30EN latitude, and the effects of this work are summarized as follows: 1. The averaged day by day amount of distillate for 4 days (spring and autumn equinox and summer and iciness solstice days) peaks while the attitude of the still θ is 20E for the nonetheless with the reflector, and peaks at θ = 30E for the nonetheless without the reflector. 2. The average daily amount of distillate of the still with the reflector is predicted to be about 9% larger than that of the still without the reflector, and the vertical flat plate external reflector would be less effective for the tilted wick still than for the basin still.

IV. CONCLUSION

The following results are made from the different research papers study:

1) Single slope, single basin solar still with baffle suspended absorber improves the productivity of solar still.
2) Use of evacuated tube collector with integration of single slope solar still helps to improve the productivity by preheating the water.
3) "V" type solar still with charcoal absorber is an efficient technique to improve the efficiency of solar still.
4) Double slope single basin solar still using phase change material likes (paraffin wax) and sensible heat storage element like (black pebbles) in efficient technique to improve efficiency of solar still.
5) Solar still of double exposure also helps to improve efficiency of solar still.
6) The glass cover inclination of solar still is also affect the efficiency of solar still.
7) A tube type networked solar still is also improves the effectiveness of solar still.

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