ISSN: 2633-4828 Vol. 5 No.4, December, 2023

International Journal of Applied Engineering & Technology

PERFORMANCE OF SOLAR WATER DESALINATION SYSTEM FOR THE SOLAR STILL DESIGN

Patel Hiralben Shileshbhai*, Dr. Mohan Nathulal Giriya and Dr. Ritesh Yadav
Department of Physics, Dr. A.P.J. Abdul Kalam University, Indore (M.P.) – 452010
*hiralpatel2191995@gmail.com

ABSTRATCT

Water and energy are the two fundamental resources necessary for the continuation of life. The demand for potable water is seeing a fast growth, although the availability of this resource has been declining over the last several decades. The scarcity of portable drinking water may be alleviated by desalinating saltwater. Existing methods for desalination are conventional, but they need a significant amount of energy, mostly derived from fossil fuels, which contribute to environmental deterioration. Solar desalination systems provide the optimal answer to this issue, since they cheaply and environmentally desalinate fresh water. A solar still is a basic solar desalination system that can generate 3 litres of drinkable water per day with a collection area of 1 square metre. Solar stills have been widely used in locations with water shortage, but their primary drawback is their poor production. The majority of research conducted in the area of solar desalination focuses on enhancing the efficiency of solar stills and increasing their yield of distilled water. In a basin still, water remains still on the absorber surface, whereas in an inclined still, water moves downward from the top to the bottom of the absorber surface.

Keywords: *Heat energy,distill water, solar energy, Sustainable Development, high-efficiency*

INTRODUCTION

Distillation is one of the numerous procedures that may be used to produce fresh water from salty, brackish, or polluted water. Sunlight is one of the many kinds of heat energy that can be utilised to fuel the distillation process. The use of sunlight has the benefit of not requiring any fuel, but it does need more area (for its gathering) and, in general, more expensive equipment in order to achieve high temperatures. However, contrary to popular opinion, it is not essential to bring water to a boil in order to distil it. The rate of evaporation may be effectively increased by simply raising its temperature to levels that are lower than its boiling point without any further effort. In point of fact, strong boiling speeds up the distillation process; but, it also has the potential to introduce undesired residue into the distillate, which would negate the purpose of purifying. In addition, the gear required to distil water in a little slower manner without boiling it is quite a bit more expensive than the apparatus required to boil water using sunlight.

SOLAR STILLS

On a worldwide scale, water shortage is a significant problem. By the year 2025, it is anticipated that an estimated one-fourth of the world's population would be impacted by water shortages, and that two-thirds of the population will be experiencing conditions of water stress. By the year 2030, fifty percent of the world's population will be under severe water stress. At the moment, areas in Africa are suffering severe water stress, which is impacting as much as 31% of the population. This is followed by regions in Asia, America, and Europe, which are experiencing high water stress at a rate of 25%, 7%, and 2% correspondingly. A rising number of people are turning to desalination as a means of satisfying their need for fresh water. Desalinating seawater and brackish water may be accomplished by a variety of techniques. These include flash distillation, multi-effect distillation, membrane distillation, reverse osmosis, forward osmosis, ion exchange, capacitive deionization, electrodialysis, and seawater greenhouse technology. Seawater greenhouse technology is also included in this category. Obtaining the energy necessary for desalination may be accomplished via the use of fossil fuels or other energy sources such as biomass, wind, solar, geothermal energy, or waste heat from industrial processes. Solar stills are one of the many techniques of solar desalination, and they provide a number of benefits, including their ease of use, ease of maintenance, cheap cost, and little influence on the environment. Nevertheless, they are not without drawbacks,

such as poor performance, which prevents them from being widely used in commercial settings. The solar energy system is still primarily based on the evaporation and condensation processes. When solar energy is used to evaporate the brine contained inside the solar still, the condensate that is produced is collected and used as the output of the distillation process. The process of condensation is repeated in a solar still with a double or multiple effect, so that the heat generated by the condensation process may be utilised to fuel the succeeding evaporation process.

CONFIGURATIONS, CAPABILITIES, AND CUTTING-EDGE OPTIONS FOR MULTISTAGE SOLAR STILLS IN WATER DESALINATION

The most serious threat to the expansion of civilization that comes with an increase in the human population is the shortage of water. To ensure that there is a continuous supply of clean water that can be used for any purpose is the most important factor that must be present in each location on the planet, even desert locations. Now, industrial activity is growing in developing countries, which is accompanied by insufficient management of wastewater and rising levels of water pollution. The construction of dams, cloud seeding, the reuse of sewage water, and the development of distillation technologies are just few of the numerous solutions that have been proposed in order to satisfy the need for freshwater. Desalination of water has become an attractive and ecologically benign means of delivering fresh water in the Gulf Cooperation Council (GCC) region because of the little amount of rainfall that occurs in this region. In this context, the desalination processes that are utilised the most often include reverse osmosis, multistage flash, and multiple-effect desalination, either with or without vapour compression. Desalination, which is the process of removing salt and other minerals from saltwater or brackish water to provide drinkable water, is relevant to a number of the Sustainable Development Goals (SDGs) that have been established by the United Nations via its Sustainable Development Agenda. The first benefit of desalination is that it may help achieve Sustainable Development Goal 6, which seeks to ensure that everyone has access to clean water and sanitation via sustainable management. The process of desalination may be helpful in increasing the amount of freshwater supplies that are available in locations that have restricted access to fresh water, such as coastal and dry regions. Water shortages might be reduced and access to clean water could be increased because of this. The Sustainable Development Goal 13 (SDG 13), which calls for rapid action to mitigate climate change and its repercussions, may also be helped by desalination.

LITERATURE REVIEW

Mohammed Ali, Hussein & Yawoz, Sahar (2023): The current water supplies are not adequate to meet the increasing demand in the future. Humans are capable of going days, weeks, or months without eating or drinking, but they cannot spend more than a week without doing so. The use of water by homes and businesses is expected to increase. In a number of nations, the production of drinkable water involves the filtration of brackish water, sewage water, and saltwater. Some nations place a higher emphasis on the production of drinking water. This article takes a look at the heat exchange techniques that scientists have used in order to boost the amount of solar still water produced. Solar stills, both fundamental and sophisticated, have been generated and analysed by many academics. These authors investigated what occurs when the chemical and physical qualities of the container, collector, and water undergo a change. The use of a cylindrical collector is one method that may be used to boost the yield of solar distillation. The total surface area of the system will increase. In this study, we investigate the many methods that have been used to improve the efficiency of solar stills.

Abdullah, A.s & Panchal, Hitesh (2023): The need for clean water is an essential component of day-to-day life. One of the most important issues that developing countries are now facing is the persistent lack of access to clean water. In many respects, the solar still is an excellent source of freshwater that can be used for domestic use as well as for agricultural purposes. It is also one of the most widely used vital and technically feasible applications of solar energy. To provide a comprehensive picture of the most recent scientific developments, this research compiles a list of studies on solar stills that experiment with various techniques for generating turbulence in order to improve the productivity of solar stills. The purpose of these strategies is to increase the rate of evaporation by causing turbulence in the water of the basin and breaking the thermal boundary layer that exists between the still

surface and the water. Free evaporation is transformed into forced evaporation using turbulence devices, which results in an increase in the rate of evaporation. Spraying unit, air bubbles, vibratory harmonic effect, stirring turbulence, revolving components, and ultrasonic fogger were the many methods that were used in order to generate water turbulence. The findings from several studies (productivity and enhancement) have shown that the spraying unit (5400 mL/m2/day - 56%), air bubbles (5490 mL/m2/day - 21.96%), stirring turbulence (5400 mL/m2/day - 39.49%), and ultrasonic fogger (6270 mL/m2/day - 83.87%) are of great significance. This study will allow for a systematic knowledge of the function and effect of each thermal-methods on the daily production rate utilising a variety of turbulence techniques, which is one of the benefits of this review.

Yuvaperiyasamy, Mayilsamy & Senthilkumar, N. (2023): It is possible for a simple solar still with a single basin to produce a small quantity of distilled water daily, but this is dependent on the specifics of the situation. Fin-type solar stills, fin-type solar ponds, and integrated fin-type solar stills with finned ponds are all being explored as potential solar energy storage systems. A place with a latitude of 10 degrees north, Pongalur, which is located close to Tirupur (10.9729 degrees North, 77.3698 degrees East), was the location where the theoretical performance and experimental research on the suggested systems were conducted. There are many types of solar stills that have been produced, including the single basin solar still (SBSS), the single basin solar still with fin, the single basin solar still with pond, the single basin solar still with finned pond, and the integrated single basin fin-type sun still with a finned solar pond. To improve the thermal performance of the SBSS, fins were added to the tiny solar pond. This resulted in an increase in the amount of water collected daily. As a result of the fins, the rate at which heat is transferred from the basin to the water has increased. This research found that the volume of water collected by a single basin solar still with fin, a single basin sun still with a finned pond, and an integrated single basin solar still with fins and a finned pond increased by 46, 48, and 52% respectively for each of these systems.

Shivhare, Maneesh & Samsher (2023): Evaluating and appreciating the many design factors for basic solar stills that have an influence on the yielding rate and heat transmission characteristics is the purpose of the present research. Indicators and performance comparisons made between a number of different solar stills have also been developed with the purpose of improving utility. When it comes to the increased wick, the majority of studies utilise wick on water surfaces in order to increase the pace at which water evaporates. The solar stills that have wet wicks attached to the side walls have been discovered to have a high porosity, which allows for thin film evaporation, which ultimately results in improved distillation. When compared to other kinds of solar desalination systems, solar stills with wick integration were shown to be better. These systems make use of wicking materials to improve the evaporation and condensation processes. During this research, the interpretations were carried out to a substantial degree, and various suggestions for future enhancements as well as the production of fresh ideas to work around practical limits were also made.

Chfat, Duaa & Hameed, Hassanain (2023): The use of water distillation methods is an effective method for addressing the issue of a lack of freshwater. The solar water still is one of these methods, and it may be used to remove dangerous compounds from polluted water by using free solar energy. This makes the water safe to drink before it is utilised. Using a solar still has a number of challenges, the most significant of which is the limited volume of water that can be generated. Therefore, there is a need to enhance the performance of solar stills in order to bring about an increase in the amount of water that can be produced. In most rural locations, there are not all that many sites where one may get clean and safe drinking water. In most of these locations, water is obtained mostly from rivers and shallow wells. On the other hand, it is possible that this water is tainted with hazardous chemicals, such as germs that cause disease, and is thus not suitable for consumption. Considering this, it is permissible to use this method in circumstances like these. Several researchers have concentrated their efforts on boosting the productivity and efficiency of Single Slope Solar Stills (SSSS) by implementing a broad variety of improvements. This paper provides an overview of the numerous approaches that have been researched to enhance the effectiveness of SSSS and the amount of clean water produced.

Elgendi, Mahmoud & Almallahi, Maryam (2023): Using solar stills, salty water may be desalinated in a cost-effective and easy manner. The present research suggests a novel design for a solar still that makes use of thermoelectric generators and phase change material in order to maximise the efficiency of a passive inclined solar still to achieve optimal performance. Using phase change material, the heat that has been dissipated is retained and then used for distillation throughout the evening and nighttime hours in order to maximise the output of the solar still. The solar still that is being developed, which is equipped with thermoelectric generator modules, has the capability of producing potable water from groundwater while simultaneously producing energy. In order to create electricity, thermoelectric generators are used to take advantage of the temperature differential that exists between the solar still and the phase change material. It is possible to implement the adjustment that has been suggested for both passive and active solar still systems.

Al-Mezeini, Saif & Siddiqui, Mohd (2023): There is a significant imbalance between the supply of water and the demand for water in Gulf nations, which results in a notable decrease in the volume of groundwater supplies. For the purpose of water desalination, solar energy is an appealing choice in this location since the climate is sunny throughout the whole year. It is usual practice to make use of a solar gadget known as a single basin solar still in order to transform accessible saltwater into water that may be consumed comfortably. It is possible that this method might be utilised to tackle the problem of generating drinking water; nevertheless, since it has a poor productivity, it is not used very often. During the months of October and November 2022, the tests were conducted on a solar still that had a single slope and faced south. The condensing cover was inclined at a right angle of 23 degrees. The trials were conducted on several days for varied water depths. The data indicated that the solar still with a depth of 4 centimetres (in comparison to those with depths of 5, 6, and 7 centimetres) had the highest water production (2.680 litres per day) with an efficiency of thirty percent. The temperature in the basin was boosted when the solar still was fitted with an exterior mirror, which resulted in an increase in water production to 3.075 litres per day and an improvement in efficiency of 35%. In addition, research has been conducted to investigate how daily production is affected by factors such as the speed of the wind, the temperature of the surrounding environment, the temperature of the glass within, and the amount of solar radiation.

Huan, Liu & Ji, Dongxu & An, Meng (2023): The water scarcity situation has received a lot of attention, and a lot of attempts have been made to discover appropriate and relevant solutions to it via the development of desalination technologies. It is common practice to produce sun stills (SSs) in order to satisfy the need for freshwater, particularly in dry regions, because of their simple construction and straightforward operation. Nevertheless, there is still a problem to be faced in terms of improving their production and efficiency. Consequently, the purpose of the present study was to improve the thermo-economic performance of a pyramid SS (PSS) by enhancing the processes of evaporation and condensation. For the purpose of achieving a high level of vapour production, evacuated tubes and ultrasonic foggers were included into the PSS that was built (DPSS) as a first case (DPSS-I). In this example, various fogger operating periods were evaluated. Following that, a basin fluid consisting of 1.5 weight percent of Co3O4 nanofluid was introduced in the second example (DPSS-II). An increase in the condensation rate was achieved by the use of a glass cooling system in the third and final case (DPSS-III). A comprehensive thermo-economic performance study was carried out in addition to the trials. This was accomplished by calculating the energy and exergetic efficiency as well as the cost of freshwater (per litre). The conventional PSS (TPSS) was used as a benchmark against which all of these DPSS performance metrics were evaluated. Because of this, including all of the additions that were recommended (DPSS-III) has the potential to improve the efficiency of freshwater production, energy efficiency, and exergy efficiency by 83.87 percent, 18.29 percent, and 38.86 percent, respectively. Furthermore, there was a reduction of 11.61% in the production cost per litre of freshwater. In the realm of solar desalination, notably SSs, these findings demonstrated the application, sustainability, and practicality of the additives that were suggested.

DISTILLATION BY SOLAR STILL

An instrument known as a solar still is used to remove salt from unclean water, such as brackish or salty water. It is a simple apparatus that may convert dirty water into drinkable and fresh distilled water by using solar energy as the source of fuel. This device has a wide range of uses in both the residential and industrial sectors. When it comes to obtaining consumable fresh water from salty, brackish, or polluted water, the fundamental principle of utilising solar energy to do this is really fairly straightforward. It is inevitable that water will evaporate into the air if it is left in an open container in an open place. In order to collect the water that has evaporated (or been distilled), a solar still is designed to condense the water onto a surface that is at a lower temperature.

Principles of a Solar Still

Accelerating the rate of evaporation may be accomplished by increasing both the temperature of the water and the area of the water that is in contact with the air. The water would be perfectly contained in a pan that is both large and shallow and is painted black. To remove any volatile toxicants from the paint, which may otherwise evaporate and condense along with the drinking water, it is recommended that it be baked in the sun for a period before it is used. This will allow the paint to be uncontaminated. To maximizing the quantity of solar radiation that is absorbed, the pan is painted black (or another dark colour altogether).

Water Quality

In theory, the water that is produced by a solar still ought to be of a superior quality. Using a slow distillation process, only water that is free of any impurities is able to evaporate from the pan and gather on the cover, leaving behind any particle pollutants. The catch basin, also known as the trough, continues to be the possible source of direct contamination. This is because a clean glass cover plate and storage vessel should not create any contaminants. If the design allows for catchments of rain, then air pollutants that are present in the rain might also be considered a type of contamination. Even at temperatures that are significantly higher than average, the catch trough needs to be constructed out of a material that is not likely to deteriorate the water that is running through it.

Types of Solar Still

Passive and active sun stills are the two categories that are used to categories solar distillation systems according to the energy source they provide. Both passive solar still systems and conventional solar still systems are examples of solar still systems that rely only on solar energy as their source of thermal energy. With active sun stills, on the other hand, additional thermal energy is sent to the passive solar still in order to speed up the evaporation process. It is possible to get this additional thermal energy from a solar collector or from any waste thermal energy that is accessible from any industrial operation, such as a power plant. Different kinds of basin-type solar still systems may be discovered in the literature. These systems are characterised by their structure, which is similar to that of the conventional solar still (see Figure 1). The single-slope double-basin solar still, the single-slope triple-basin solar still, the pyramid-shaped solar still, the standard solar still with sponge cubes in the basin, and the double-slope single-basin solar still are some examples of these types of energy storage devices.

SOLAR STILL WITH ENHANCED CONDENSATION

About 97 percent of the water on the planet is found in the seas, about two percent of the water on the planet is now frozen in the polar ice, and just one percent of the water on the planet is fresh water that can be used to meet the requirements of living things, including plants, animals, and people. In many regions of the globe, the issue of overexploitation of the fresh water resources that are already available is growing more prevalent. The United States of America is experiencing water shortages in a number of states, which has led to the preparation of long-term plans for an increase in the use of desalination of saltwater as a means of supplementing the supply of drinking water. It is estimated that there are over 15,000 desalination units located in over 120 different countries. An increase of one hundred percent in the operational installed capacity of desalination plants is anticipated to take place between the years 2005 and 2015, according to research and projections.

The sun, the wind, geothermal energy, and ocean energy are the most frequent types of renewable energy sources. Now, there are just a few instances in which renewable energy sources are used for desalination. The proportion

of total renewable energy sources that are used for desalination at the global level is just approximately 0.02% of the total energy that is utilised. It is possible that desalination that is driven by renewable energy might be the perfect option for some tiny towns who do not have access to an inexpensive supply of fossil fuels accessible for desalination. In the realm of thermal applications that capture solar energy, one of the practical and cost-effective uses is the utilization of solar stills for the purpose of obtaining drinkable water. At least eighty percent of the world's population lives in arid and semi-arid nations like India, and among those countries, around forty percent are experiencing severe droughts. Examples of such countries include India. A variety of desalination procedures have been used in a number of nations in order to find a solution to the situation that is now occurring. Solar distillation is one of these processes. In this method, solar energy is used to extract freshwater from salty or brackish water for the purpose of drinking and other applications.

CONCLUSION

Based on the findings of both experimental and theoretical study, it was discovered that specific research techniques and results may increase the performance of inclined solar stills. The following conclusions can be drawn from these findings:

The most ideal wicking material for greater productive inclined solar stills is water coral fleece material, which has a porosity of 69.67%, an absorbency of 2 seconds, a capillary rise of 10 millimeters per hour, and a heat transfer coefficient of 34.21 watts per square metre at 70 degrees Celsius

The production of distillate may be increased from 3.77 litres per day to 4.27 litres per day by using iron pieces, which are the materials that store the most sensible energy among all the basin materials. According to the meteorological circumstances in Kovilpatti, Tamil Nadu, India, the preferred collector inclination angle for inclined solar stills is thirty degrees. This allows for the greatest amount of solar radiation to be received. In order to analyse the crucial wicking characteristics of wick materials that are going to be employed in inclined stills, new testing methodologies have been created.

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