IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

SMALL SCALE SOLAR STILL – A REVIEW

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ABSTRACT
In this communication an attempt has been made to review, in brief, work on small scale solar still. The review includes purification methods including the state of art and historical background. The classification of distillation units has been done on the basis of literature survey. Over the past three decades, there have been numerous designs of solar still system developed worldwide. However the technology is not commercialized and standardized because of its lower yield. This article provides a comprehensive review of the some designs of solar stills used at domestic level. Though solar still have not been successfully commercialized as yet, with the ongoing research efforts, they can be modified and improved for future domestic applications.

KEYWORDS: Solar Still

INTRODUCTION
The fresh water crisis is already evident in many parts of India, varying in scale and intensity at different times of the year. The fresh water crisis is not the result of natural factors, but has been caused by human actions. India's rapidly rising population and changing lifestyles also increases the need for fresh water. Intense competition among competing user's agriculture, industry and domestic sector is driving the ground water table deeper and deeper. Widespread pollution of surface and groundwater is reducing the quality of fresh water resources. Fresh water is increasingly taking centre stage on the economic and political agenda, as more and more disputes between and within states, districts, regions, and even at the community level arises. Nearly One million children in India die of diarrhea diseases each year directly because of drinking unsafe water and living in unhygienic conditions. Some 45 million people are affected by water quality problems caused by pollution, by excess fluoride, arsenic, iron or by the ingress of salt water. Millions do not have adequate quantities of safe water, particularly during the summer months. In rural areas, women and girls still have to walk long distances and spend up to four hours every single day to provide the household with water [1]. Scarcity of fresh water problems are facing many arid zones of Gujarat and Rajasthan, luckily these places are getting more amount of solar energy, apart Gujarat and Rajasthan that in western India, which face water shortage and have huge underground saline water sources, certain regions in Haryana state and Maharashtra states also have underground saline water in spite of high rain fall [2]. The village peoples are facing lot of difficulties to get fresh water for their family needs. All families the women and children are responsible for collecting and storage of water. The quality of drinking water also not suitable for human health, it was found by tested the village water samples at Guru Kripa test house at Ajmer district. After analyzing in all the aspects authors concluded that, the village peoples are expecting suitable low cost purification devices for getting pure drinking water [3]. Desalination of brackish water and seawater to provide the needed drinking water fulfill a basic social need and it does this without any serious impact on the environment. The conventional desalination technologies like multi stage .ash, multiple effect, vapor compression, iron exchange, reverse osmosis, electro dialysis are expensive for the production of small amount of fresh water, also use of conventional energy sources has a negative impact on the environment. Solar distillation provides partially support humanity's needs for fresh water with free energy, simple technology and clean environment. Solar stills have a good chance of success in India for lower capacities which are more than 20 km away from the source of fresh water and where the TDS of saline water is over 10,000 ppm or where seawater is to be desalted [4]. India, being a tropical country, is blessed with plenty of sunshine. The average daily solar radiation varies between 4 and\ 7 KWh per square meter for different parts of the country. There are on an average 250–300 clear sunny days a year. Thus, it receives about 5000 trillion kWh of solar energy in a year. The annual global radiation varies from 1600-220 kW/m^2. The highest annual global radiation is received in Rajasthan and northern Gujarat. In spite of the limitations of being a dilute source and intermittent in nature, solar energy has the potential for meeting

and supplementing various energy requirements Solar energy systems being modular in nature could be installed in any capacity as per the requirement. This paper presents of an overall review and technical assessments of various passive and active solar distillation systems in India. The assessment also recommended some research areas in the field of solar distillation, leading to high efficiency are highlighted and finally expressed the economic analysis of solar stills briefly.

HISTORICAL BACKGROUND OF SOLAR DISTILLATION

Distillation has long been considered a way of making salt water drinkable and purifying water in remote locations. As early as the fourth century B.C., Aristotle described a method to evaporate impure water and then condense it for potable use. Arabian alchemists were the earliest known people to use solar distillation to produce potable water in the sixteenth century. However, the first documented reference for a device was made in 1742 by Nicolo Ghezzi of Italy, although it is not known whether he went beyond the conceptual stage and actually built it. The first modern solar still was built in Las Salinas, Chile, in 1872, by Charles Wilson. It consisted of 64 water basins (a total of 4459 square meters) made of blackened wood with sloping glass covers. This installation was used to supply water (20,000 L/day) to animals working mining operations. After this area was opened to the outside by railroad, the installation was allowed to deteriorate but was still in operation as late as 1912-40 years after its initial construction. This design has formed the basis for the majority of stills built since that time [5].

During the 1950s, interest in solar distillation was revived, and in virtually all cases, the objective was to develop large centralized distillation plants. In California, the goal was to develop plants capable of producing 1 million gallons, or 3775 cubic meters of water per day. However, after about 10 years, researchers around the world concluded that large solar distillation plants were too much expensive to compete with fuel-.red ones. Therefore, research shifted to smaller solar distillation plants. In the 1960s and 1970s, 38 plants were built in 14 countries, with capacities ranging from a few hundred to around 30,000 L of water per day. Of these, about one third have since been dismantled or abandoned due to materials failures. None in this size range is reported to have been built in the last 7 years. Despite the growing discouragement over community-size plants, McCracken Solar Company in California continued its efforts to market solar stills for residential use. Worldwide interest in small residential-units is growing, and now that the price of oil is ten times what it was in the 1960s, interest in the larger units may be revived. Although solar distillation at present cannot compete with oil-.red desalination in large central plants, it will surely become a viable technology within the next 100 years, when oil supplies will have approached exhaustion [6].

CLASSIFICATION OF SOLAR DISTILLATION SYSTEMS

On the basis of various modifications and mode of operations introduced in conventional solar stills, these solar distillation systems are classified as passive and active solar stills. In the case of active solar stills, an extra-thermal energy by external mode is fed into the basin of passive solar still for faster evaporation. The external mode may be collector/concentrator panel waste thermal energy from any chemical/industrial plant etc. If no such external mode is used then that type of solar still is known as passive solar still [7, 8, 9].

Different types of solar still available in the literature are conventional Solar Stills, Single-slope Solar Still with Passive Condenser, Double Condensing Chamber Solar Still, Vertical Solar Still, Conical Solar Still, Inverted Absorber Solar Still, Multi-Wick Solar Still, and Multiple Effect Solar Still [10. 11, 12].

Passive solar still

Passive system in which solar energy collected by structure elements (basin liner) itself for evaporation of saline water. The simple single slope solar still is shown in fig 1. The sun’s energy in the form of short electromagnetic waves passes through a clear glazing surface such as glass. Upon striking a darkened surface, this light changes wavelength, becoming long waves of heat, which is added to the water in a shallow basin below the glazing. As the water heats up, it begins to evaporate. The warmed vapor rises to a cooler area. Almost all impurities are left behind on the basin.

ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

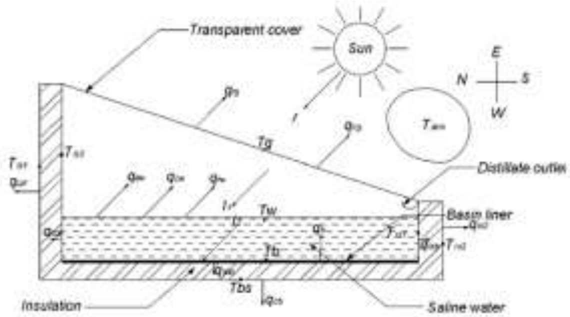

Fig.1. Passive solar still [12]

The vapor condenses onto the underside of the cooler glazing and accumulates in to water droplets or sheets of water. The combination of gravity and the tilted glazing surfaces allows the water to run down the cover and into a collection trough, where it is channeled in to storage [12].

A single basin double slope solar sill, tested with a layer of water and different sensible heat storage materials like quartzite rock, red brick pieces, cement concrete pieces, washed stones and iron scraps. They focused on the study to find the best heat storage material for increasing yield and found that ¾ in. sized quartzite rock is the effective basin material fig 3 [13].

Fig.2. Different storage material and sill [13]

Basin water temperature is one of the parameters to increasing the productivity of the still. By providing heat exchanger inside still and flowing waste hot water from various power plants, industries, etc., through the heat exchanger, can increase the basin water temperature. The effect of inlet temperature of waste hot fluid, temperature dependence of internal heat transfer in a double slope single basin solar still with heat exchanger is shown in fig 3 [14].

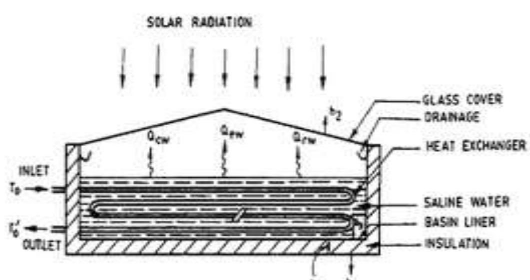

Fig.3. Double slope single basin solar still with heat exchanger

The thermal efficiency of a solar distillation unit in terms of daily production per square meter can be increased by the utilization of the latent heat of condensation. The re-utilization of latent heat in two or more basins is generally known as a multi basin solar still. A schematic of a double basin solar still is shown in Fig 4.

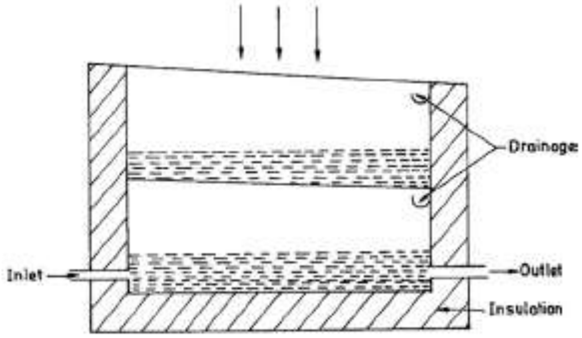

Fig 4: Double basin solar still with constant flow rate [15]

In a double basin solar still, another glass sheet is fixed in between the basin liner and the glass cover. This glass sheet serves as the base of an extra basin for the saline water, and the whole assembly behaves as two simple basin solar stills placed one above the other. The water in the upper basin makes use of the upward heat loss by the water in the lower basin [15].

Active solar still

The productivity of the solar still also improved through active methods of integrating the still with a solar heater, solar concentrator or other heating devices.

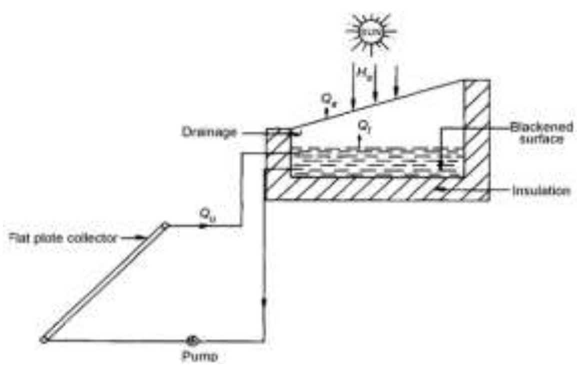

Fig.2. Active solar still [16]

The blackened surface of the flat-plate collector absorbs solar radiation, and the liquid in contact with it gets heated. This heated liquid is circulated through the heat exchanger and it gives its heat to water in the still. The blackened bottom of the still also absorbs solar radiation that heats the water. The evaporation of water in the still starts, and when the air inside the still is saturated, the water vapor condenses on the relatively cooler surface of the glass cover. The water droplets slide down under gravity to the drainage. The circulation of water through the .at-plate collector obtain either using pump (active mode) or by thermo siphon operation (natural circulation mode) active still is shown in fig 2. The average daily production of distilled water has been found to be 24% higher than for a simple single basin solar still [16].

the best performance will be the single basin still coupled with a flat-plate collector having forced circulation and blackened jute cloth floating over the basin water and a small quantity of black dye added to the water and from the economy point of view, the circulating pump should be used in the morning and evening when thermo siphon stops during sunshine hours.

The performance of a solar still integrated with a flat-plate collector using a thermo siphon mode of operation and compared with forced circulation mode. It was found that the system using the forced circulation mode give 5–10% higher yield than that of the thermo siphon mode. A 30–35% enhancement in the yield is observed with the proposed system as compared to the conventional system. It was concluded that the optimum collector inclination is 20° and the still glass-cover inclination is 15°, for maximum annual yield of the solar still [17].

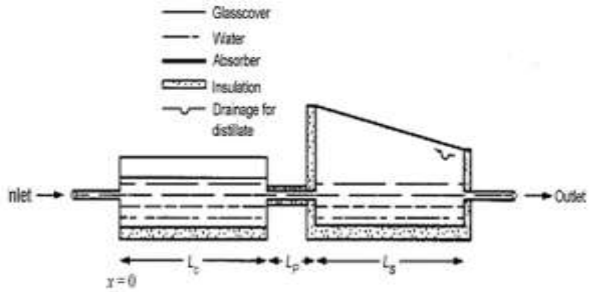

Fig.5. Single basin solar still coupled to parallel plate solar collector [17]

The effect of bubbling of ambient air and cooling of the glass cover is shown in fig 6.

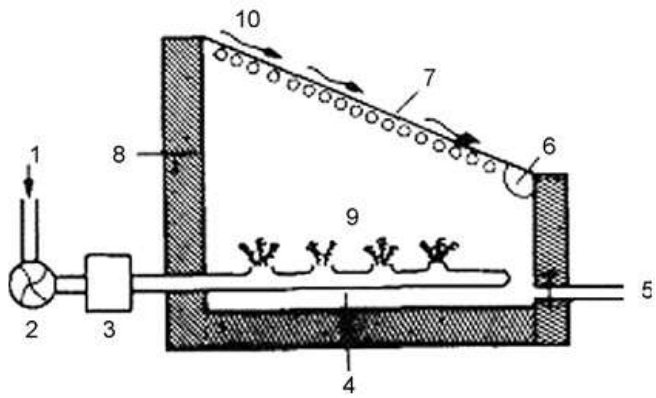

Fig.6. Schematic diagram of air bubbled solar still [18]

The author concluded that the efficiency of the still increased by dry air bubbling and glass cooling [18].

CONCLUSION

Various designs of solar still concepts were reviewed in this work. There view will help to understand the previously developed designs of solar still. This will facilitate to the researchers to fabricate an optimum design with better performance. The selection of a particular solar still design is based on several factors, such as location, type and quality of saline water, availability of efficient material and economics. The performance of solar still were affected by the various metrological parameter likes solar radiation, wind velocity, and ambient temperature and other designed parameter like area of still, inlet water temperature, orientation of the still, depth of the water and water glass temperature difference. These factors have to be optimized to enhance the productivity of the solar still. The maximum thermal efficiency obtained from the solar still varies from 17.4–45%. Efficient and optimized domestic designs of solar still with higher distillate output must be developed for solving future water scarcity problems.

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