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Solar still with condenser – A detailed review

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ABSTRACT

Access to potable water to the people is narrowing down day after day all over the world. Most of the human diseases are caused by polluted or non-purified water resources. Water purification without affecting the ecosystem is the necessity of the hour. Solar distillation is one of the water purification techniques producing ultrapure distilled water. Solar still distillation systems offer sustainable tools for freshwater production. Numerous environmental and operational parameters attribute to optimize the still design. Different designs were tested by researchers to improve the productivity of solar still. In their experimentations, the solar still integrated with external or internal condenser is deemed to be effective and efficient design. In this detailed survey, we are seeking to introduce, explain and discuss the status of different solar stills integrated with different condensers arrangements.

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1. Introduction

Water is a gift from God and it plays a key role in the development of an economy and in turn for the welfare of a nation. The available freshwater in the earth is fixed. The demand for freshwater is increased rapidly due to population growth and rapid industrialization. Non-availability of drinking water is one of the major problems faced by both developed and developing countries. Today, most of the health issues are owing to the non-availability of clean drinking water. In the recent decades, various parts of the world receive insufficient rainfall resulting in increase in the water salinity. The pollution of water resources is increasing drastically owing to several factors including growth in population, industrialization, urbanization, etc. These activities adversely affected the water quality in rural areas and agriculture. Globally, 200 million h are spent a day, mostly by females, to collect water from distant, often polluted sources. In the world, 3.575 million people die every year because of water related diseases. Basic medical facilities were not spotted in numerous villages in the developing and underdeveloped countries. Most of the rural people are still unaware of the consequences of drinking untreated water.

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People living together in remote areas or islands, where freshwater supply by transport is expensive, face the problem of water shortage every day. Solar still presents definite advantages to be used in these areas due to its easier construction using locally available materials, minimum operation and maintenance requirements and friendliness to the environment. It is quite fortunate that, in times of high water demand, solar radiation is also intense. It is thus beneficial to exploit solar energy directly by installing solar stills. Two majored merits that favor the use of solar stills. The first one is the clean and free energy. While the second advantage would be the friendliness to the environment. Where, sunlight (green energy) has the advantage of zero fuel cost. Moreover, using solar energy reduces fossil fuel consumptions and pollutants. The main disadvantage, however, is the lower output of distilled water in comparison with other desalination systems. The production capacity for a simple type still is only between 2 and 5 l/m^2 a day. This makes the system highly uneconomical. In solar desalination processes, the productivity of solar still is very low compared to other conventional desalination systems [1].

Major desalination techniques like vapor compression distillation, reverse osmosis and electrolysis used electricity as input energy. Nevertheless in recent years, most of the countries in the world have been significantly affected by energy crisis because of heavy dependency on conventional energy sources (coal power plants, fossil fuels, etc.). Hence, the environment and economic growth of these countries is affected significantly. However, these technologies are not appropriate for remote villages and small islands. To provide freshwater for these places, solar stills may be potentially applicable.

2. Working of a conventional solar still

The conventional solar still is a box having a shallow pool of water at the bottom and an inclined glass cover at the top, Fig. 1. The solar insolations are absorbed at the blackened bottom of the pool. The water evaporates and condenses on the underside of the glass cover plate from where it would be collected. The condensation heat raises the glass temperature considerably. Consequently, the yield during the period of maximum solar insolation is much below what is anticipated. Among the solar insolation curve and the still yield curve, there is a definite time lag which can be ascribed to high glass temperatures. For one-hour periods after proceeding the insolation peaks, although saturated vapors are produced inside the still, condensation does not occur because the glass temperature is well above the dew point of the air-vapor mixture. The glass cover, at relatively high temperatures, also loses more energy to the ambient. The overall output of the still is thus low, causing a decrease in the overall efficiency. To overcome the problem posed by high temperatures of the glass cover, several improvements are suggested. One of them is to flow water over the glass plate. Some of the heat are then taken away by the water, thereby lowering the glass temperature. However, the increase in yield is not large because part of the incoming solar radiation is reflected by the ripple formed in the flowing water film. Another suggestion is to use a condenser. Because the condensation takes place in the condenser, the glass temperature is significantly reduced [2].

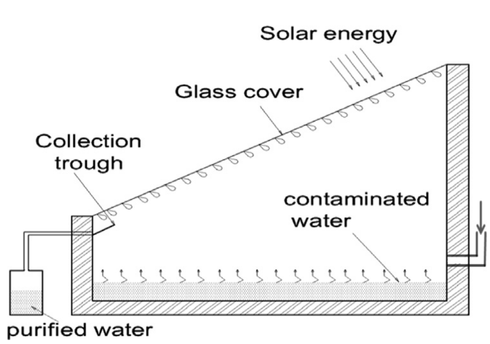

Fig. 1. Schematic diagram of the single basin solar still.

The various factors affecting the solar still productivity [1] are solar intensity, wind velocity, ambient temperature, water–glass temperature difference, free surface area of water, absorber plate area, temperature of inlet water, glass tilt angle and depth of water. The solar intensity, wind velocity and ambient temperature are factors cannot be controlled as they are metrological limitations, whereas the remaining parameters can be varied to enhance the productivity of the solar stills.

Although solar stills have low productivities, they are being a sustainable water production method. Solar stills continue to attract wide research attention that is targeted to improve their yield. Many experimental and theoretical studies are being carried out to improve the performance of solar stills [3]. Numerous researchers have reviewed, thoroughly, the work on solar distillation system [4–6]. They have described the design, affecting parameters and the performance of different types of solar stills.

3. Working of a conventional solar still with condenser

The temperature difference between evaporating and condensing areas in the solar still affects its productivity. Investigations determined that increasing the water–glass temperature difference improves the output distillate yield of solar still. To maintain this temperature difference high, condensers, fans, reflectors, storing materials and cooling of the glass cover were used. The solar still integrated with condenser has the same construction of conventional still with an external or internal condensation unit added to the system as shown in Fig. 2.

A good condensation conditions can make the evaporation rate of brine water in the still faster. The values of glass temperature and basin water temperature of solar still integrated with external condenser are less than that of conventional one. Consequently, the difference in temperatures of the glass cover is higher than that of basin water temperatures when integrating an external condenser through a fan with a solar still as compared to a conventional type. This is mainly due to the small fan power that is used to exhaust the water vapor from the still to the external

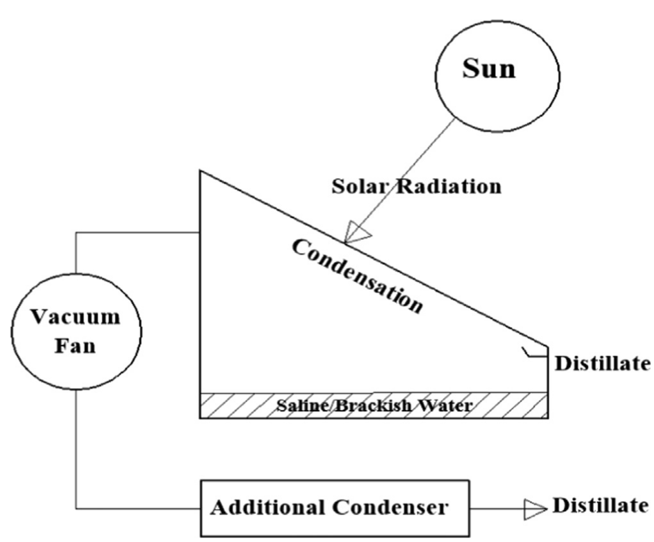

Fig. 2. Solar still with condenser.