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A review of design parameters and effect of Peltier module on output of a double basin solar still

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Abstract

Conventional desalination techniques involves the use of electricity generated from sources like coal. Solar still provides a suitable alternative to conventional techniques. But conventional single basin have low distillate output and high heat losses. This paper is a review of design of double basin solar still integrated with Peltier module for optimizing the heat transfer processes involved in solar desalination and also reducing the amount of heat losses. It also gives a study of natural parameters affecting output of a solar still and compares the output of single and double basin solar still.

Keywords: Desalination, Double Basin Solar still, solar energy

1. Introduction

Water is one of the most important constituent for the survival of mankind on earth. It is useful for many purposes like agriculture, irrigation and domestic purposes like cooking and so on. Availability of water is due to hydrological cycle. The same basic principle of hydrological cycle is involved in the production of rainfall, which occurs in nature is implemented in all the man-made desalination systems in order to produce fresh water from the salty resources. Removal of salt water is the need of the day as the demand of pure water is increasing day by day.The removal or separation of salts is achieved from the process called desalination..

Major desalination techniques like vapour compression distillation, reverse osmosis and electrolysis used electricity as input energy(Imad Al-Hayek, 2004).

Over dependence on conventional energy sources (coal power plants, fossil fuels, etc.) has led to energy crisis and has also adversely effected the environment. Since, the coal reserves in the world are not sufficient to provide the electricity required for functioning of desalination plants, the focus has now been shifting towards using non-conventional sources of electricity generation like solar, wind, tidal etc. Using thesesources, environmental and economic growth of the world can be improved significantly. However, non-conventionaltechnologies are not applicable for remote locations. To provide freshwater for the places where high intensity solar radiations are available, solar stills can be used(P.Vishwanath Kumar, 2015)

Solar stills can be broadly classified as: Passive solar stills and Active solar stills. Passive solar stills don't require external heat source for the evaporation process, while active stills require external sources, such as solar reflectors or waste heat or solar pond(P.Vishwanath Kumar, 2015)

In(T. Rajaseenivasan, 2013) this paper, we are going to discuss the effect of various design parameters (brine depth, inclination of cover, material of cover, thickness of insulation etc.) and climatic parameters (wind speed) on the output of double basin solar still.Besides this, the paper provides a comparison between output of single and double basin solar still. Also, it describes the effect of Peltier modules on the output of double basin solar still.

2. Effect of Design Parameters

The most significant problem which is an impediment for using a solar still for general purpose is the reduced output. To increase the output of solar still, various parameters are needed to be considered. The effect of every parameter on the output of solar still must be known before designing solar still. Parameters like depth of brine, inclination of cover, shape of cover, material of cover, thickness of insulation etc. play a significant role in functioning of a solar still. The importance and effect of these parameters for functioning of solar still is given below.

2.1. Depth of Brine

Depth of brine is an important parameter for design purpose of a solar still. It has been concluded that the output of solar still increases with decrease in depth of brine initially during the day(Abdul Jabbar N. Khalifa, 2009)(H. Al-Hinai, 2002)(Kianifar, 2011). But as the day progresses, the distillate output decreases with decrease in depth of brine. The nocturnal output of solar still can be increased by providing some brine depth.

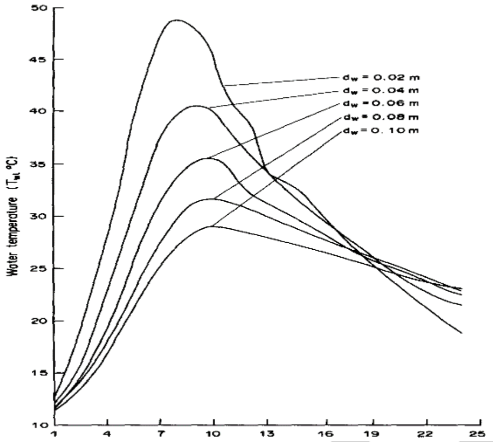

Figure1: Variation of still output with depth of brine for lower basin CITATION Abd09 \l 16393 (Abdul

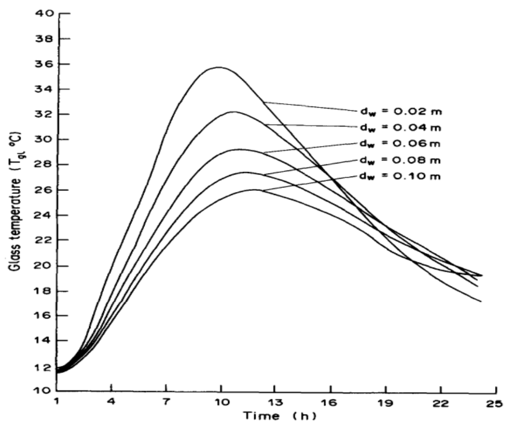

Figure2 Variation of still output with depth of brine for upper basin CITATION Abd09 \l 16393 (Abdul

Figure 1 and 2 show the variation in output of a double basin solar still with brine depth for each basin.

2.2. Thickness of Insulation

Radiation losses are reduced by providing insulation on the walls of still. As the thickness of insulation increases, the amount of heat lost due to radiation decreases. After attaining a certain thickness, if we continue to increase insulation thickness, the effect on output is very small but the cost increase is significant. Therefore, insulation thickness should exceed a certain value. Insulation of up to 9mm thickness is considered most suitable.(Kianifar, 2011).

2.3. Cover Inclination

Cover inclination is also an important parameter for optimizing the output of solar still. Cover inclination value should be chosen appropriately as higher value will lead to higher thermal losses and lower value of cover inclination will lead to hampered flow of condensate from the surface of cover.

Season, geographical location of still effect the selection of cover angle.General rule of thumb is that the cover inclination should be equal to the latitude of the geographical location of the still(Kianifar, 2011)(Khalifa, 2011). Also, cover inclination during summers should be smaller as compared to winters.

2.4. Material of Base

A significant amount of solar radiation is lost in the process of solar desalination. As shown in Figure 4, incident radiations fall on cover surface, from cover to base and then are subjected to surface.

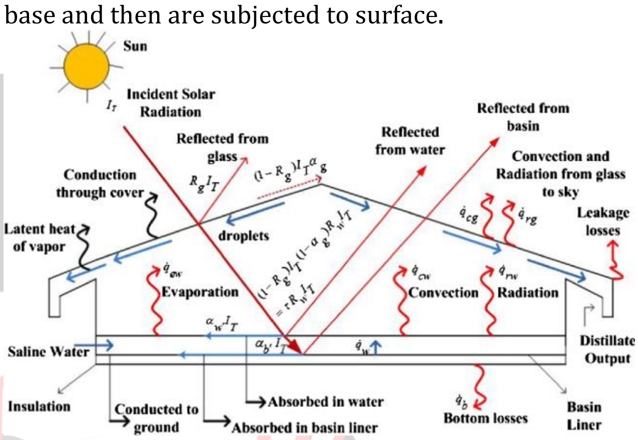

Figure 3: Heat Transfer Process Solar Desalination CITATION Lov16 \l 16393 (Lovedeep Sahota, 2016)

Material properties play a significant role in reducing the amount of heat lost during the process. Material having high absorptivity, low reflectivity, and low transmissivity are used for base as it will reduce the quantity of heat transferred to ground. Besides, material of cover should have high transmissivity to reduce reflection losses.

Recently, the use of Nano particle and water solution has increased due to higher thermal conductivity of the solution. The use of Phase Change Material has also increased. It has been observed that with Flaked Graphite Nano particle, Flaked Graphite Nano particleand Phase Change Material are 50.28%, 65% respectively (S.W. Sharshir, 2017)

2.5. Temperature of Cover

The temperature of cover should be as low as possible to increase the condensation rate.(K. Vinoth Kumar, 2008). Increased condensation rate leads to higher distillate output.

2.6. Shape of Cover

Shape of cover determines the amount of radiation which enters the still,condensation rate etc.. Cover may be pyramidal (double slope) (Imad Al-Hayek, 2004)(P.Vishwanath Kumar, 2015)(Kianifar, 2011), spherical(T. Arunkumar, 2012).Increasing the surface area of cover will increase the condensation rate and hence output will increase. Using hemispherical cover will do just that.(D. Dsilva Winfred Rufuss, 2016)(Imad

Al-Hayek, 2004)(P.Vishwanath Kumar, 2015)(T. Arunkumar, 2012).

3. Climate Parameters

Solar intensity, ambient temperature, relative humidity, wind velocity and cloud and dust cover, are climatic parameters which effect the output of still [6].

3.1. Wind Speed

The convective heat transfer co-efficient from glass cover to the surrounding must be high and temperature differencebetween water and inner side glass cover should be high to have high output of still. Higher wind speeds does just that.

3.2. Ambient Temperature

As Ambient Temperature increases the Output of still increases.

3.3. Relative Humidity

With increase in relative humidity the output of solar still increases.

4. Double Basin Solar Still

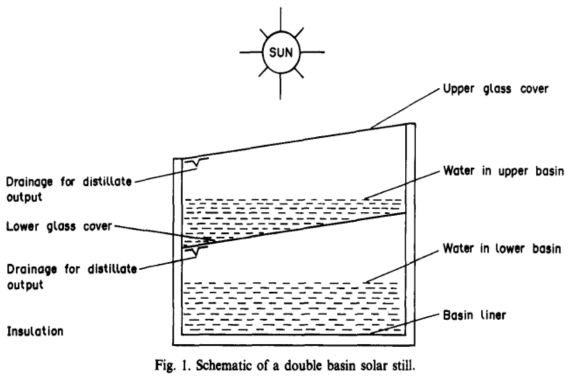

Figure 4: Layout of double basin solar stillCITATION GNT911 \l 16393 (G. N. Tiwari, 1991)

As shown in figure 4 a double basin solar still has two condensing surfaces so that the heat lost in the first basin is utilized for evaporating the water of second basin. Design Parameters for single and double basin solar still are identical.

The output of a double basin soar still is higher than that of single basin still. Under given conditions, a double basin still produces 85% more output than single basin still(T. Rajaseenivasan, 2013). But still there are some heat losses which should minimized to further increase the output.

5. Use of Thermoelectric module

A Peltier module comprises of semiconductor unions to achieve a high temperature difference between both sides. There are two ceramic substrates. Between them, the electric connections and thermoelectric elements are mounted. The substrates act as binding material as well as insulation.

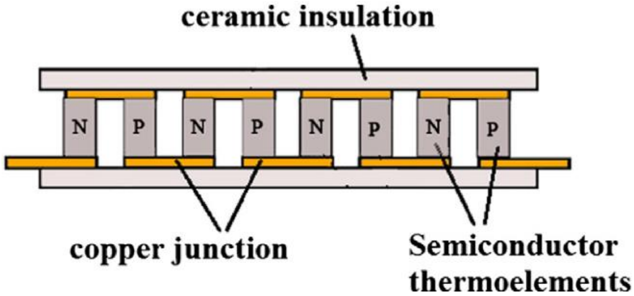

Figure 5: Layout of Peltier module CITATION Jav11 \l 16393 (Javad Abolfazli Esfahani, 2011)

Figure 5 shows the layout of a Peltier module. Using Peltier module, heat losses are minimized and output of still can be increased(Javad Abolfazli Esfahani, 2011).

6. Conclusion

- A double basin solar still has relatively higher output as compared to single basin solar still.
- Various parameters like Brine depth, Inclination and shape of cover, InsulationThickness have to be considered while designing solar still.
- The value of depth of brine, cover inclination, should be 6cm for upper basin and 4 cm for lower basin, latitude of the place.
- Climatic parameters like Ambient Temperature, Relative Humidity, and Wind speed also effect the output of solar still.
- Double basin still helps in reducing the heat losses.
- Using Peltier module, the heat losses are minimized and output is also increased.

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