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Parametric Study of Basic Items in the Solar Still

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Abstract

Fortunately, in regions of greater potable and drinking water shortage like Middle East, renewable energies such as solar energy is more abundant during the year. The desalination method in this solar desalination still is evaporation distillation. Basically this solar desalination still is a batch stage for every day operation with saline wastewater. This paper describes the solar desalination still, discusses the used method for distillation and represents the experimental results, finally. The results show the feasibility of using the solar still.

Keywords: still; saline; wastewater; operation; distillation.

Introduction

Water treatment is usually needed and desalination process is the most efficient for formation of drinking and fresh water from brackish and/or seawater, certainly [1 and 2]. However, desalination process is energy intensive and since of scarcity of wood, oil and generally fossil fuel resources also high capital, fixed and operational cost [3 and 4]. Among, solar desalination still is based on renewable, free; clean and safe solar energy is the promise for a cost beneficial solution [5 and 6]. These systems are environmental friendly and cost saving process competitive with the other desalination systems [7].

Published researches from 1986 to 1995 focused on the technical feasibility of solar systems such as solar stills or solar stills. Several papers show during 1995 to 2000 the researches have been focused on development of solar system especially solar stills. Since 2000, the published papers have been surveyed on the environmental problems and operating conditions which enhanced the yield percentage and also, economics in order to make it more cost beneficial and competitive with the other desalination systems such as multi stage flash, MSF, reverse osmosis, RO, electro dialysis, ED, multi effect distillation, MED, concentrating photovoltaic/thermal systems, CPVTS, and etc.

Fortunately, in regions of greater potable and drinking water shortage like Middle East, renewable energies such as solar energy is more abundant during the year. So, solar desalination systems have been applied for many generations especially production of sweet water [7]. According to many literatures the earliest documented work is related to an Arab alchemist in the 5th century. Several published papers have been stated that an Arab alchemist had applied polished Damascus mirrors for solar distillation. Some scientists especially the famous French chemist, Lavoisier (1892) applied the large glass lenses mounted on collaborating supporting structures to collect and also concentrate solar energy on the contents of distillation flasks. Apply of silver or aluminum coated glass reflectors to collect and concentrate solar energy for distillation is described by previous literatures [7]. In the last century application of the solar concentrators in solar distillation is reported by literatures. Scientists applied a concentrator to collect and finally focus solar rays on to a copper boiler containing water. The vapor generated from the boiler is piped to a conventional water cooled condenser in which distilled water is circulated and then accumulated. Renewal of interest in solar distillation happened soon after the First World War [7]. Many varieties of new apparatuses and stills such as the basin types, inclined-tray, tilted-wick type, roof type, flash type stills and inflated type systems has been developed and studied for solar desalination systems. But a very small number of processes put into practice since of the low yield and small level of production rate of potable and drinking water [7].

In this study an experimental solar desalination still with operating performance is discussed and evaluated. The experimental results show the performance of the solar desalination still depends on the meteorological conditions such as solar radiation, used material in solar still, atmospheric temperature, etc.

Materials and method

The principle of the solar still is quite simple. The air in the solar desalination still is evacuated and the water boils at low temperature. So, solar radiation can be applied for the distillation and the smaller temperature difference being only a few Kelvin between a glass roof and the brackish water makes it possible to get more potable water. The optimum solar desalination still would be constructed from a realization of an optimum heat by considering the second law of Thermodynamics and an optimum mass transfer process.

1 The study of used solar desalination still

The desalination method which is applied in the present work is evaporation distillation at low temperature. The process is batch, basically for every day operation with wastewater desalination. The Schematics of the solar desalination still is shown in Figure 1.

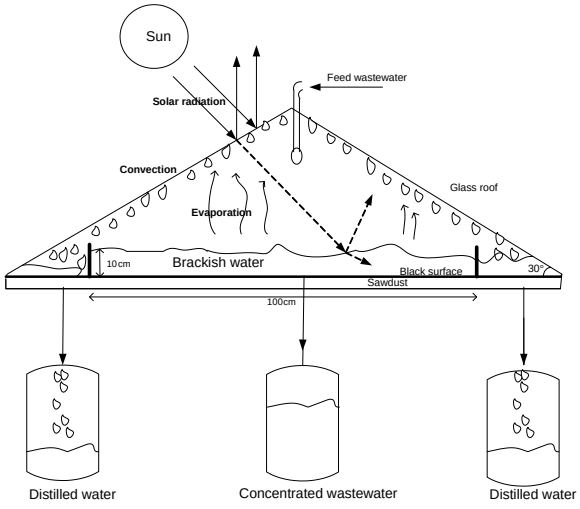

Figure 1. The Schematics of the solar desalination still.

Transferring of vapor is made by movement of steam from the solar desalination still (high pressure and temperature place) to the clean water collector vessel (low temperature and pressure place) and the storage tank. The storage tank is made from PVC contains remarkable volume of the brackish water and is placed in the shelter. So, this can be used as a condenser for the effluent steam from the solar desalination still. The temperature drop of steam in the cooling pipe line helps transferring of steam to the water collector vessel When the steam passing through the storage tank.

2 Description of procedure

One hour before sunrise, 100 kg of brackish water are prepared in the solar desalination still. Evaporated water filled solar desalination still is evacuated during day light. The temperature of the brackish water and potable water are measured by copper-nickel thermocouples and also, recorded at any time on chart paper.

After finishing the daily operations (at sunset) the condensate water in the collector vessels is recovered after the vacuum of the process is broken and the mentioned process is repeated every day.

Results and Discussion

The obtained results of experimental work are analyzed according to the below notes; Figure 2 shows the amount of insolation rates in 2013, monthly, the maximum and minimum solar radiation is in June and December, respectively. This is related to the inclination of solar radiation which is vertical nearly in the summer season and on June.

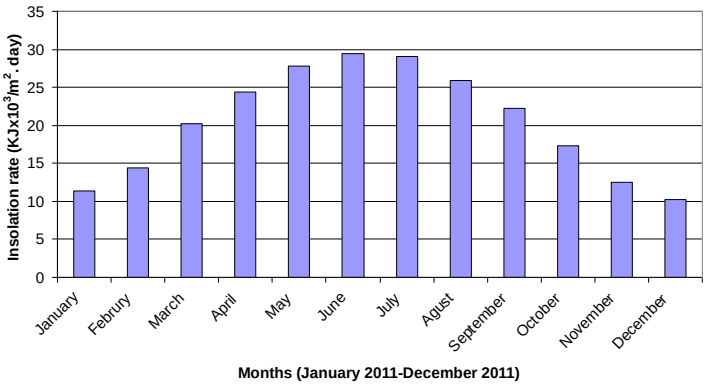

Figure 2. Investigation of insolation rate versus different months.

Correlations 1 and 2 show the highest and lowest production versus insolation rate for each month of 2013. Highest production is obtained in July and the minimum production of clean water is gained in December. Wind velocity is one effective factor in temperature difference between brackish water and glass roof so affects evaporation rate of water. In Shiraz due to the weather condition, wind velocity is higher in July than June with the approximate equal insolation rate, so in July the amount of water production is higher than June.

The highest production, HP (kg/m².day), of potable water is dependent on the solar radiation, s (kJ×10³/m².day), of the brackish waste water.

$$HP = -7.9\times10^{-3}s^2 + 2.9\times10^{-1}s - 3.3\times10^{-} \quad (1)$$

The value of the standard deviation 0.959 may show the high prediction accuracy of the correlation 1.

Related correlation which shows the variation of the lowest production, LP (kg/m².day), with the insolation rate is presented in Equation 2 with a relatively high accuracy according to Figure 5.

$$LP = -5.2\times10^{-6}s^4 + 8.1\times10^{-4}s^3 - 2.2\times10^{-3}s^2 + 9\times10^{-2}s - 4.7\times10^{-6} \quad (2)$$

Conclusion

According to the experiments, the maximum and minimum solar radiation is in June and December, respectively. Highest production is obtained in July and the minimum production of clean water is gained in December. Wind velocity affects the rate of production in July because of making the higher temperature difference between brackish water and glass roof.

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