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SOLAR STILL: WATER FOR THE FUTURE

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ABSTRACT

Being an abundant natural resource that covers three quarters of the earth's surface, water still a major issue, as less than 1% of fresh water is actually within human reach. Solar energy, most recommended renewable energy source is widely used in desalination fields. Solar distillation, particularly solar still is expected to solve this fresh water production problem without causing any fossil energy depletion, hydrocarbon pollution and environmental degradation. However, the efficiency of the solar still is debatable. As the main reason of low productivity in a solar still is the low heat transfer inside the unit itself therefore, a thoroughly modification on solar still design is presented based on the scope of increasing the heat transfer process inside the unit. Significantly, introducing optical controlling techniques together with focused sunlight receiver and having the process to operate under low pressure have speed up the rate of production within 10 hours of day light. However, the presence of focused sunlight receiver is not seem to improve the production of the solar still yet an increase value is recorded.

Keywords: solar still, renewable energy, desalination, water, global issue, solar energy.

INTRODUCTION

Water is nature's gift and has been recognized as a basic human need for numerous purposes where it plays a key role in the development of an economy and for welfare of a nation. It is an abundant natural resource that covers three quarters of the earth's surface yet the available fresh water is limited on earth where less than 1% of fresh water is actually within human reach [1].

In order to tap this seemingly boundless resource, desalination processes should be the most promising process, as this process basically removed salt from brackish and seawater to produce purified water. It is one of the most important methods of getting potable water correspond to Earth's natural hydrologic cycle that continuously desalinates water. Besides of being inexhaustible, clean and universally available, the use of solar energy in renewable energy based-seawater desalination, particularly solar still, is moreover significantly more economical than the use of fossil fuels [2, 3, 4, 5]. To rationalize this controversy, new experimental techniques are required. This paper aimed to introduce a new method of desalinating seawater with simple principle at a low cost. But, before the design is introduced, the understanding of why solar still is not applicable for industrial scale must be understood.

Solar still

The very basic system for desalting water by using solar as driving source is called solar still [6]. Solar might seem an ideal energy source, as it is virtually limitless and can be used to produce fresh water directly in a solar still. A solar still operates similar to the natural hydrologic cycle of evaporation and condensation. Normally, the seawater will be exposed to solar radiation and vaporize. The vapor then, condensed on the inclined glazing cover before eventually being collected in a container as desalted water [7]. It is simple and have no moving parts, and can be used anywhere so that the operation of it, is very easy and no special skill is required. As a matter of fact, the only thing that differ solar still with other type of process to desalinate water is the source of energy and its operation where no solar energy is converted to electricity and no additional desalination unit is attached to the process except that only the main solar still unit [8].

However, the installations of large scale solar still require large installation areas which is why, the greatest issues of the small water production by solar stills is its efficiency. In addition to that, the experimental works towards this remained in the small scale i.e., laboratory stage because mainly, the cost of the producing desalted water in industrial scale are more complex [9]. Thus, the increased cost for the construction of a complex unit was not justified. Therefore, it is obligatory to know the different parameters affecting the solar desalination process and how that particular parameters influence the operation of the stills, and the production rate of desalted water [9]. Nonetheless, the effectiveness of solar still process depends on several factors like the materials of construction, the orientation, the inclined angle of the cover glass, climatic conditions, tightness, operating conditions and thermo-physical properties [10].

IMPROVEMENTS ON SOLAR STILL

Back in 1991, Maalej has concluded his experimental and mathematical model results that the best performance of solar still is achieved if and only if the high intensity of insolation, minimum wind velocity and full insulation is exist [11]. He added that under these conditions, approximately 50% efficiency of solar still can be obtained and it is then agreed by Kalogirou in 1997 followed by Delyannis et.al in 2001 [12, 13]. A number of efforts have been made to develop and improve the performance of solar desalination systems, particularly solar stills. The change of the design in solar still may not always improve water yield and still efficiency.

Nevertheless, there are numbers of designs that can be considered partially improve the unit efficiency. An article published in 2012 wrote by Arunkumar et.al after running a very detailed experiment on various solar still designs [14], presented the performance evaluation of seven different solar still designs. As a result, tubular solar still coupled pyramid solar still shows the maximum amount of productivity due to the concentrator effect. This shows that the production of the solar still are entirely depends on the climatic parameters as well as increasing the water temperature which then, leads to the rises of the evaporative and convective heat transfer coefficients in the solar still.

Apart of improving solar still, mechanical devices such as sun tracking [15, 16, 17], solar collectors, condenser, and fans have become a trend for recent researches upon solar still as it seems provide a major distinction in still efficiency. Practically, it has now been realized that solar distillation cannot compete with other methods of desalination unless and only if a major improvement is achieved [18, 19].

EXPERIMENTAL SETUP & PROCEDURE

The stills basin is a wooden box consist of two compartments with the external case, measured 80 cm long, 80 cm width with height of 80 cm. meanwhile the internal box fabricated smaller than the external to contain the seawater. The wooden parts is painted with black so that it could absorb the heat from surrounding. The still is 3 mm thick glass covered and fixed on an iron frame with an inclination angle of 45^o facing south and north. The distillate is collected in the vacuum pump that possess two functions, as a condenser and to create a vacuum condition in the unit.

There are several reasons behind the low temperature issue in solar still. One of all is that the heat received by the solar still itself is very low and is too small to be scattered inside the unit. Therefore, optical controlling instruments is introduce at the top of the glass cover to increase the ability of receiving solar radiation so that the unit have massive amount of heat to start the process. Focused Sunlight Receiver is fabricated together so that all the heat receive by the still could be gathered and distributed gradually throughout the seawater. To start the experiment, seawater is filled up inside the solar still manually. After that, solar still will be placed under an open area that exposed to the sunlight. All data required is measured by using sensors that has been fabricated together with solar still. Data for each 30 minutes then recorded and a graph of temperature versus time is prepared.

RESULT & DISCUSSION

The evaluated solar still unit has shown a different behavior with the addition of the two improvement, focused sunlight receiver (FSR) and with both FSR and optical controlling technique (OCT). Figure-1 show the production rate for solar still under vacuum pressure. Higher production rate was obtained with application of both the OCT and FSR where the production reach to 73.11 kg/m^{2}h, meanwhile lower result is recorded with the application of FSR alone, which is 37.63 kg/m^{2}h.Though it is quite low, yet the improved value is gained. The differences of production through two different condition, can be clearly seen in Figure-1. Production of water in solar still with FSR & OCT is rapidly increase by time, contrast with FSR, which took quite sometimes to increase the production slowly.

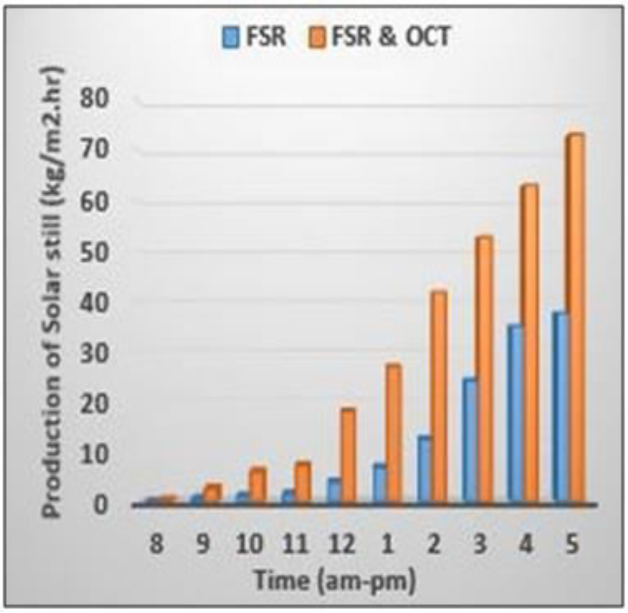

Figure-1. Production rate for solar still under vacuum pressure with focused sunlight receiver (FSR) and with both FSR and optical controlling technique (OCT).

Relatively, the production of the water from solar still, highly related to the temperature of the water itself which depends on the heat transfer. Figure-2 shows that the water temperature of each method in solar still. Although in the first three hours, it appears that water temperature for FSR & OCT a little bit lower than FSR, but the production of FSR & OCT remain higher. The fluctuated water temperature might probably cause by the intensity of the sunrays at the time experiment is running and since the presence of OCT is to highly focus the solar radiation onto FSR, even with lower heat, it can give higher temperature value compare to FSR. Additionally, though the highest temperature of water recorded is at noon, the recorded production of the water is not at its highest reading. This is due to the heat that is stored inside the solar still during the 10 hours which continuously allow the seawater to be kept heated up by the heat, thus the evaporation continued.

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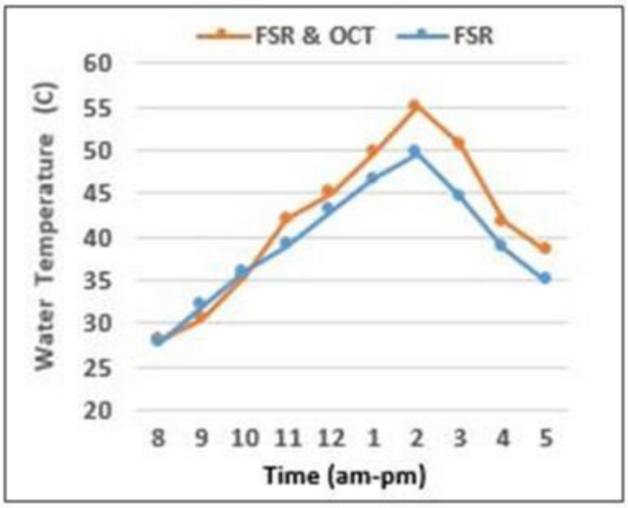

Figure-2. Water temperature for solar still under vacuum pressure with focused sunlight receiver (FSR) and with both FSR and optical controlling technique (OCT).

CONCLUSIONS

Due to the fact that world population keep growing, it is not impossible that sooner, the whole world would face fresh water scarcity. One of the methods to overcome this issue is by desalinating the seawater using solar still. This simple process however never been applied after the membrane and thermal technologies is being used due to some factors that affect its efficacy of desalting seawater. In this paper, new approached is introduced, where the solar still is running under vacuum condition together with the optical controlling techniques and focused sunlight receiver. Significantly, introducing optical controlling techniques together with focused sunlight receiver and having the process to operate under low pressure have speed up the rate of production within 10 hours of day light. However, the presence of focused sunlight receiver is not seem to improve the production of the solar still yet an increase value is recorded. It is desirable to fabricate solar still with the perfect low cost design, by introduce a method that can enriched the solar intensity onto the seawater without using solar tracking system (which is believed to be very costly).

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