Energy analysis of double slope aktive solar still

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Abstract. The technology of distilling seawater into fresh water has been carried out with various models and methods. The distillation process is one of the effective methods to get clean water by utilizing solar energy as the main energy source. The model is planned for a dual slope active system with a basin area of 1,932 m^2 wide with 1 m^2 glass surface with two pieces with 3 mm glass thickness and 15^o glass slope angle. The water level from the bottom of 20 mm is kept constant and given a fog that circulates the water in the basin. The lowest solar intensity was 186.9 SR,W/mA^2 with the amount of energy absorbed 20.9761 W/m^2, and the highest solar intensity 700.6 SR,W/mA^2 with the amount of absorbed energy 1813,667 W/m^2 ^{o}C. The energy efficiency obtained from the results of the discussion of the highest test results data on the seventh day reached 77.92 %, and the lowest efficiency on the second day was 66.1853 %.

1. Introduction

Water is a very important element for every organism to survive. The availability of drinking water from natural sources day after day is shrinking due to the rapid growth of the human population and the poor processing of water pollution caused by industries that use chemicals that pollute water sources and climate change that occur, [1]. According to United Nation Organization that by the year of 2025, almost 1800 million people around the world will be under severe water scarcity, [2]. This is a concern for many people because the impact of the reduction in clean water reserves is starting to be difficult. Solar energy can be used as a source of heat energy such as solar drying, absorption cooling and solar distillation process, [3]. Various water distillation technologies have been carried out by researchers in the world, such as Reverse Osmosis (RO), multi-stage flash destilation (MSF), multi effect distillation (MED), Thermal Vapor Compression (TVC) Mechanical vapor compression (MVC), distillation vacuum and others, [1,4]. But distillation of water by utilizing solar energy is a technology that is very efficient, economical, effective and environmentally friendly [1,4,5,6]. There are two solar distillation models that have been developed in the basin cover which are single slope and multiple slopes, and the work principle of solar distillation is also divided into two active and passive systems, [6]. The solar distillation method has been applied in the last 40 years, [7]. Lovedeep et al 2017 developed a passive dual slope system with a monthly clean water yield of 20 kg to 40 kg or about 1.3 kg, [6]. Where in the previous year lovedeep et al also developed solar distillation technology by adding AL203 chemicals and the amount of clean water produced 35 kg to 80 kg or 2.6 kg a day and these results indicate that the addition of chemicals to water can increase the productivity of clean water produced from the tool desalination of the sun, [7]. In the previous year, V, K.Dwivedi et al. Developed passive and active solar distillation devices with multiple slopes, and the results were obtained by the number of clean water in passive solar distillation devices as much as 1,838 kg/m2 [8]. The use of solar energy, wind and geothermal energy is also considered in salinity devices, increasing efficiency and reducing the use of fossil fuels, [9]. Among the three types of energy used in water distillation, solar energy distillation is most often used to reach 73% of other types of energy smelters, [9]. According to Kalogirou, around 10,000 tons of fuel is used for electricity distillation, [10]. The energy in the basin is very influential on the rate of evaporation of seawater. Even though the amount of energy given and absorbed by water is large, the water will evaporate faster. In this study, the energy received by the basin received a desalination system for the active slope system. There are some people who have researched the sun's double tilt system of active detillation. Love deep Sahota, Shyam, G.N. Tiwari 2017, Analytical characteristic equation of Nano fluid loaded active double slope solar still coupled with helically coiled heat exchanger.

2. Method and Equipment

Temperature data on the inside of the basin such as water temperature in the basin, inner glass temperature inside, west side glass inside and room temperature in the basin are recorded every hour, and temperature data on the outside such as glass temperature east and west side along with temperature the environment is recorded every hour by using a thermocouple to be used in search of the coefficient of heat transfer on the outside and in the amount of energy absorbed every hour and energy efficiency in the solar detillation device in sea water. The following are dimensions of the solar distillation device and the physical properties of the materials used.

Table 1. Physical properties of distillation equipment

Symbol	Value	Symbol	Value
AgE	1 m^2	M_w	38.64 Kg
AgW	1 m^2	Li	0.02 m
hbw/f	100	Ki	0.039 W/m °C
σ	5.67x 10^{-8} $W/m^2 K^4$	α_b	0.8
Cf	4241.0637 J/kg °C	α_w	0.6
Ab	1.932 x 1 m	α_g	0.05
L_g	0.003 m^2	ϵ_w	0.95
K_g	0.78 W/m^2 °C	ϵ_g	0.95

In table 1.you can see the specifications of the distillation tool and the dimensions of design.

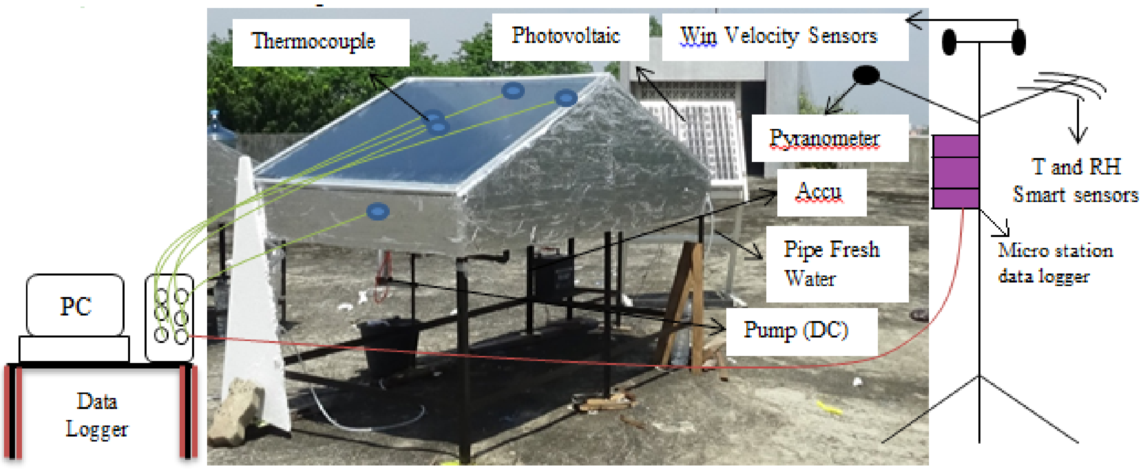

Figure 1. Double slope distillation scheme

The dimensions of the solar distillation apparatus have been adjusted to follow D.B.Singh 2016 and also as a comparison of the distillation results later. Picture of a solar distillation tool with multiple slopes can be seen in the following figure. When water testing is circulated using a DC pump, water temperature (Tf / Tw), the temperature of the inner glass (Tgi, TgiE and TgiW) temperature of the outer glass (Tgo, TgoE and TgoW) and ambient temperature (Ta) are recorded every hour by using 6 thermocouples. While the measurement data of solar intensity (I (t)) and wind speed (V) is obtained from a HOBO micro station Data Loggerr recorder which is connected to a computer to store recorded data. The test data is calculated using MS. Excel 2010.

The working method of this distillation is to open the seawater faucet and ensure the water level from the basin base surface 0.002 m, after the basin water filled with sea water can be turned on egilial thermocouple to record the water temperature in the basin air temperature in the basin and east glass temperature and the outer and inner west. The thermodynamic model used to calculate energy and the rate of production of clean water produced as follows.

2.1. Temperature and external coefficient of the basin.

The heat energy emitted by the sun is directly received by the Basin cover glass which will then enter the Basin and be absorbed by water by convection and radiation. The amount of heat received is not the same as the magnitude of the east and the west side. The convection heat transfer coefficient (h_{cg}) is as follows [13].

$$h_{cg} = \begin{bmatrix} [5.7 + 3.8 \times V] : \leq 5 m/s \\ [6.15 \times V^{0.8}] > 5 \text{ m/ s} \end{bmatrix} \tag{1}$$

On the glass surface a large radiation heat transfer coefficient (h_{rg}) occurs can be calculated using the following equation [11, 14].

$$h_{rg} = \frac{\in_g \times \sigma \times (T_g^4 - T_{sky}^4)}{(T_g - T_a)} \tag{2}$$

Total heat transfer coefficient $h_{og} Tot$ can use the following equation [11, 13].

$$h_{og}Tot = h_{cg} + h_{rgaE} + h_{rgaW} \tag{3}$$

2.2. Temperature and internal coefficient of the basin.

Previously known principle of radiation heat transfer will take place if between two objects have different temperatures. Radiation heat transfer coefficient from water to the glass side surface in the following equation h_{rw} [5, 11, and 17].

$$h_{rw} = \in_{eff} \times \sigma \times \left[(T_w + 273)^2 + (T_g + 273)^2 \times (T_w + T_g + 546) \right] \tag{4}$$

The convection heat transfer coefficient h_{cw} and the equation are used as follows [11, 12, 13, 17, and 18].

$$h_{cw} = 0.884 \left[(T_w + T_g) + \frac{(P_w - P_g) \times (T_w + 273)}{268.9 \times 10^3 - P_w} \right]^{\frac{1}{3}} \tag{5}$$

h_{EW} Evaporation heat transfer coefficients in Basin space can be calculated by the following equation [4, 7, 11, 12, 16, and 18].

$$h_{EW} = 0.034 \times 5.67 \times 10^{-8} \left[(T_{giE} + 273)^2 + (T_{giW} + 273^2) \right] \times \left[T_{giE} + T_{giW} + 5546 \right] \tag{6}$$

The total heat transfer coefficient $h_{ig}Tot$ can use the following equation, [11,13].

$$h_{ig}Tot = h_{rw} + h_{cw} + h_{EW} \tag{7}$$

2.3. Energy and energy efficiency from the basin.

To find the amount of energy received by a distillation device every hour can be with the following equation, [1, 6, and 17].

$$En_{hours} = \left[h_{ef,E} (T_{bf} - T_{giE}) + h_{ef,W} (T_{bf} - T_{giW}) \right] Ab \tag{8}$$

The overall energy efficiency of the process can be searched by the following equation [16].

$$\eta_{En} = \frac{(m_{ewE} + m_{ewW}) \times L}{(A_{gE} - I_{SE}(t)) + (A_{gW} - I_{SW}(t)) \times 3600} \times 100 \tag{9}$$

The above equation is used to find the amount and amount of energy and energy efficiency received by the Basin.

3. Results and Discussion

Data retrieval was carried out in the morning to evening for 8 days by observing from each temperature of each thermocouple attached to the specified sides. There are 6 points observed through the thermocouple. The difference in the temperature of the surface of the glass is clearly visible in the morning, the east side is the highest temperature side compared to the western side. Wind speed in the environment also influences the rise and fall of the glass surface temperature which affects the speed of the condensation rate.

3.1. Lowest coefficient and energy results

The lowest results of the coefficient and energy absorbed by the basin were obtained on the second day of testing.

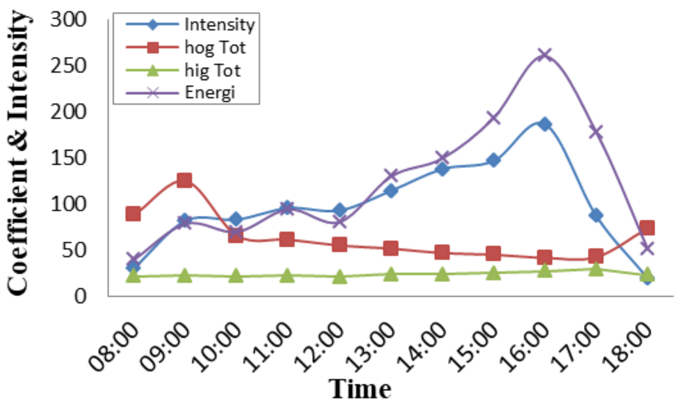

Figure 2. Graph of solar intensity and second day heat transfer coefficient

On the second day the highest solar intensity of 186.9 SR, W/mA^2, produced the energy absorbed by the highest distillation device 290.9761 W/m^2 ^{O}C, with the total heat transfer coefficient outside the basin (hog Tot) at 124.9968 W/m^2 ^{O}C and the total heat transfer coefficient in the basin (hig Tot) the highest is 29,194 W/m^2 ^{O}C. The high energy absorbed is directly proportional to the solar intensity.

3.2 Highest results of coefficient and energy

The highest coefficient and energy absorbed by the basin were obtained on the seventh day of testing. The heat transfer coefficient of the second day and the seventh is affected by the wind speed when doing the testing.

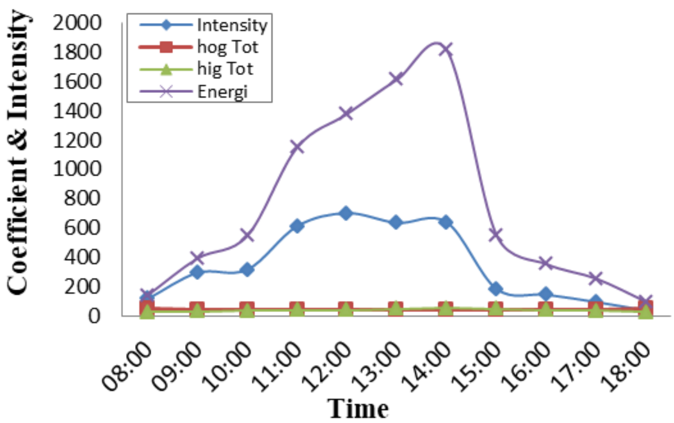

Figure 3. Graph of solar intensity and seventh day heat transfer coefficient

On the seventh day the highest solar intensity of 700.6 SR, W/mA^2, produces the energy absorbed by the highest distillation tool 1813,667 W/m^2 ^{o}C, with the total heat transfer coefficient outside the basin (hog Tot) of 50.96 W/m^2 ^{o}C and the total heat transfer coefficient in the highest basin (hig Tot) is 50.2769 W/m^2 ^{o}C.

3.3. Energy efficiency

The energy absorbed by the water distillation device is not entirely used to raise the temperature of the water in the basin, some of which is wasted back, the following is a graphical picture of the energy efficiency of a distillation device.

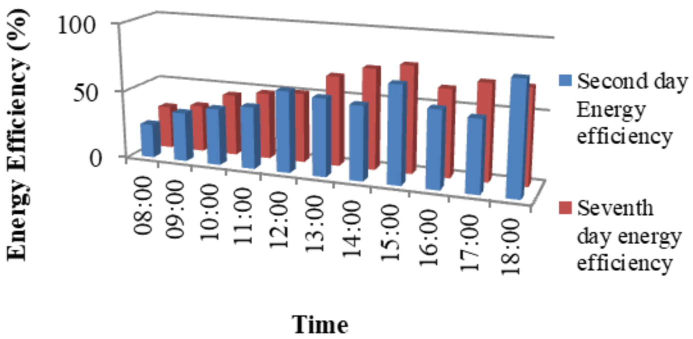

Figure 4. Graph of energy efficiency

Energy Efficiency obtained from the results of discussion of the highest test results data on day seven to reach 77.92%, and the lowest energy efficiency on the second day 66.1853%.

4. Conclusion

The solar intensity determines the amount of energy absorbed by distillation equipment, while the higher the solar intensity, the higher the heat energy that enters and is absorbed will be. This is evident on the second day of the test obtained solar intensity 186.9 SR, W/mA^2 with the amount of energy absorbed 20.9761 W/m^{2o}C, and on the seventh day the solar intensity 700.6 SR, W/mA^2 with the amount of energy absorbed 1813,667 W/m^{2o}C. The energy efficiency obtained from the results of the discussion of the highest test results data on the seventh day reached 77.92%, and the lowest efficiency on the second day was 66.1853%.

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