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Analysis of The Performance Solar Desalination Proses With Spray in The Evapoarator Room

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ABSTRACT

The shortage of clean water sources on the earth's surface is a concern for the future. Utilization of solar thermal energy is something that can be done to get an environmentally friendly system. Desalination process is a method to produce clean water that is cheap and safe. With the experimental method, the desalination process is tested by providing a working system that considers the materials used and the addition of supporting work tools. The evaporator cover is designed to be made of clear glass with a thickness of 3 mm and an area of 1 m^2 with a double slope model with an angle of 15^o to the east and west, and was tested for 8 days. The result of the radiation heat transfer coefficient is that the highest convection coefficient outside the evaporator is 97.94 W/m^2 on the fourth day and the value of the radiation heat transfer coefficient from the glass surface to the environment is 83.85 W/m^2 on the second day. Meanwhile, the highest evaporative heat transfer coefficient was 20.30 W/m^2 on day four, the highest convection heat transfer coefficient was 3.08 W/m^2 on the first day, and the highest radiation heat transfer coefficient was 13.18 W/m^2

Keywords: *Solar Desalination, Solar Collector, spray evaporator*

INTRODUCTION

The development of water purification technology which is often referred to as the desalination process is growing. This is related to the demand for reduced sources of clean water reserves on the earth's surface [1]. The factors that cause it are all based on the increasing growth of the earth's population, the number of industries that use river water, global warming and many other factors that cause this [2]. Currently, the alt desalination model is still being developed by researchers, among which have been commercialized, namely, Reverse Osmosis (RO), Thermal Vapor Compression (TVC) Mechanical vapor compression (MVC), multi-stage flash distillation (MSF), multi effect distillation (MED) and Vacuum Desalination (VD) [3][4]. It is possible that in the future the latest models of the desalination process will appear and cannot be stopped [5].

The performance of the desalination device can be measured by calculating the absorption of heat energy that is absorbed when the test is carried out [6]. The energy absorbed is of course pure solar thermal energy and managed to enter until it is absorbed by the water. Before reaching the surface of the water and being absorbed by the water, the heat energy is inhibited which is called resistance to the layers on the surface of the water [7]. This layer is the evaporator glass, which serves as a place for sunlight to enter which carries heat energy to raise the temperature and evaporate the water. The resistance that occurs will reduce the amount of heat energy that will be absorbed by the water [8]. This model is often referred to as convection heat transfer from the glass surface to the environment, the process of conduction heat transfer from the outer glass surface to the inside, and the radiation process from sunlight to the water surface [9].

Research conducted so far has provided information regarding the amount of energy that can be absorbed by water during testing, including, D.B.Sing 2016 testing a seawater desalination tool with a single slope model of a passive system and the energy that can be absorbed reaches 1159.43 kW [10]. Continued in the following year D.B.Singh 2017 added additional heat-absorbing devices in the form of a collector made of copper pipes with a circulation system using an electric pump,

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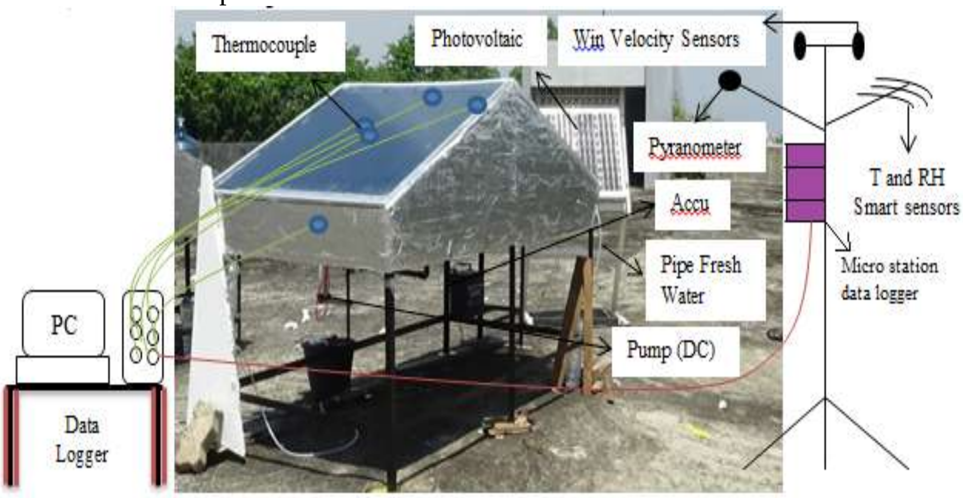
the test results obtained the amount of energy reaching 3389.0 kW [11]. This indicates that changes in the desalination device model will affect the amount of energy that can be absorbed when the test is carried out [12][13].
The amount of heat energy that enters the evaporator and is absorbed by water will depend on the heat transfer coefficient in the environment. This study aims to optimize the value of the heat transfer coefficient in order to produce maximum heat energy. The use of an evaporator material that is able to retain heat so that it does not convex into the environment, as well as the use of clear glass which has a small resistance value, so that solar thermal energy can enter easily and be absorbed by water. The factors that give the value of the heat transfer coefficient will be known in this study so that it can be avoided in further research.

METHODOLOGY

The method used in this research is to directly test the performance of the desalination equipment that has been designed, focusing on the value of the heat transfer coefficient. The test was carried out for 7 days starting at 08.00 AM and finished at 05.00 PM. The desalination tool is facing east so that direct sunlight enters when the sun rises. The slope of the evaporator glass is designed at 15^{O} with a glass thickness of 3 mm as many as 2 pieces which are on the east side and west side. The use of an electric pump that is useful for circulating water in the evaporator and fogging it back into the evaporator chamber.



Gambar 1. Experimental Set up Desalination Tool

Thermocouples are used as temperature measuring devices during research which are placed at certain points which are considered as areas where the temperature needs to be measured. Temperature data on the inside of the basin such as water temperature in the basin, temperature of the inner east side glass, inner west side glass and room temperature inside the basin are recorded every hour, and temperature data on the outside such as the east and west side glass temperature along with the temperature. The environment is recorded every hour using a thermocouple to be used in finding the value of the heat transfer coefficient on the outside and inside the amount of energy absorbed every hour and the energy efficiency of the solar detailing tool in seawater.

If seen in the picture, on the evaporator/basin there are 6 thermocouples placed on the evaporator, on the east side cover glass there are two thermocouples which aim to determine the temperature of the east side glass on the outer and inner surfaces, and so on the west side there are two thermocouple on the outer and inner surfaces. To determine the temperature of the water, one thermocouple is placed and one thermocouple is placed in the middle of the evaporator room with a hanging position to determine the temperature of the evaporator room. The data generated by the thermocouple and sensor will be received by a PC that has previously been calibrated and adjusted to the programming language by the data longer. While the DC pump is used to pump water in the evaporator to be injected through the nozzle installed in the evaporator room.

Mathematical Approach

The data obtained from the test results will be used to the next stage, namely the discussion of the data using the equations that have been determined. The energy received from the sun is not only received by the glass, but almost all surfaces that come into contact with free air get heat from the sun's rays either by convection, conduction or radiation. Then the radiation heat transfer coefficient from the water to the side glass surface is obtained in the following equation [14].

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

(1)

Convective heat transfer in the evaporator occurs in the moist air inside because of the difference in surface temperature of the water and the cover glass. For mathematical equations can use the following equation [15].

$$q_{cw} = h_{cw} (T_w - T_g)$$

(2)

Panas yang di serap air di dalam evaporator juga akan terpancar ke segala arah didalam evaporator yang disebut perpindahan panas radiasi [15].

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

(3)

Where, the large convection heat transfer coefficient can use the following equation [15],[16].

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

(4)

When the research was carried out there was a lot of heat loss during evaporation in the evaporator. Heat loss can affect the high and low speed of the water evaporation process related to the work efficiency of the tool and the results obtained. The value of the evaporation coefficient is a value that greatly affects the level of the results of the study, therefore this value must be known. The large convection heat transfer coefficient can use the following equation [15].

$$h_{ew} = 16.273 \times 10^{-3} \times h_{cw} \times \frac{(P_w - P_g)}{(T_w - T_g)}$$

(5)

The heat energy emitted by the sun is directly received by the evaporator cover glass which will then enter the evaporator and be absorbed by the water. The amount of heat received is not the same from the east and west sides. The value of the convection heat transfer coefficient is as follows [3].

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

(6)

On a large glass surface the radiation heat transfer coefficient on the east side occurs can be calculated using the following equation [3].

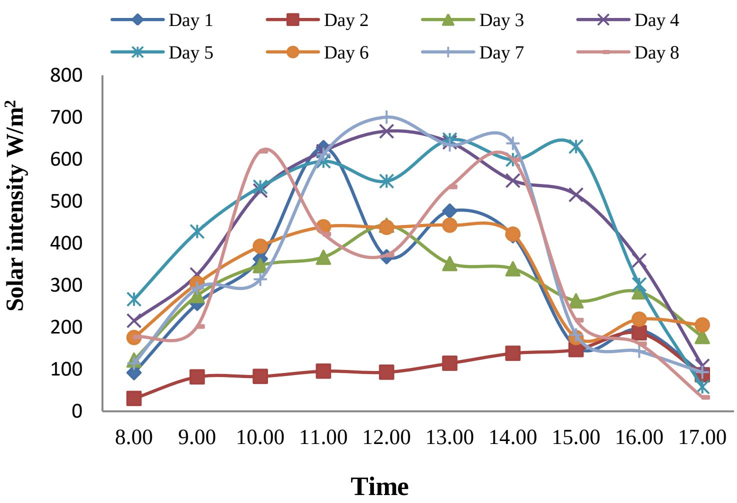
$$h_{rgaE} = \frac{\in_g \times \sigma \times \left(T_g^4 - T_{sky}^4\right)}{\left(T_g - T_a\right)}$$

(7)

Where on the west side of the glass with the following equation. The final results of this study will be used as the basis for further research to determine the effectiveness of using the single slope model desalination tool in regions, especially Indonesia

RESULT AND DISCUSSION

The intensity of the sun greatly affects the amount of heat energy that will be absorbed by the desalination tool during testing. The intensity of the sun greatly affects the amount of heat energy that will be absorbed by the water in the evaporator at the time of testing. Weather factors greatly determine the value of the intensity of the sun at the time of testing, this can change and cannot be predicted. The highest amount of energy at the time of testing will affect the amount of energy absorbed later.



Gambar 2. Solar intensity data

By looking at Figure 2, it is clear that the intensity of the sun is high and low every day and this greatly affects the heat transfer coefficient during testing. The highest solar intensity was seen on the seventh day to reach 700.60 W/m^2 and the lowest solar intensity was found on the second day, the highest was only up to 186.9 W/m^2. The heat received by the water will undergo a convection process to the air in the evaporator or basin, so that there will be heat transfer or the release of heat energy received by water from sunlight. These disadvantages must be known in order to get the effective work of the desalination tool.

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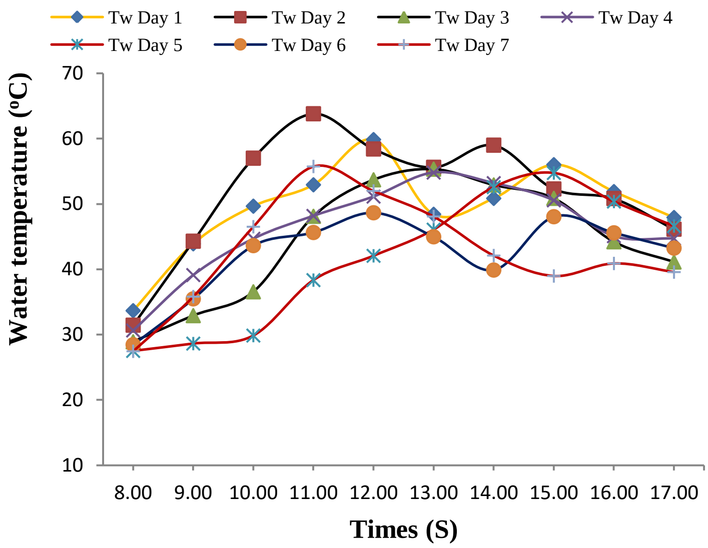
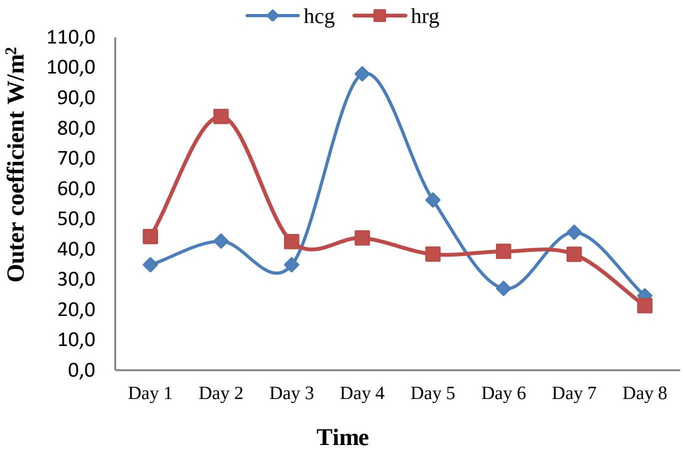


Gambar 3. Hourly variation of water temperature (Tw)

The environmental temperature when testing will be the basis and reference for water temperature, because in a pure environment there is no heat build-up which has the potential to increase the outside air temperature. The difference between the temperature of the water in the evaporator and the ambient temperature can be considered to represent the amount of energy absorbed by the water.

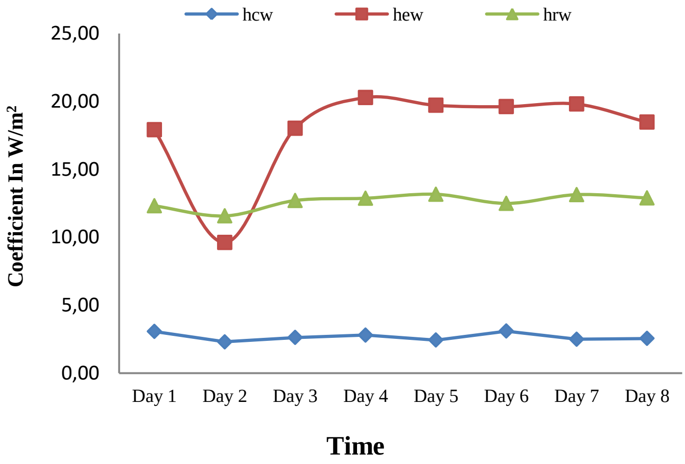


Gambar 4. Heat transfer coefficient data outside the evaporator

The heat transfer coefficient outside the evaporator occurs when heat from sunlight propagates and reaches the glass surface of the evaporator. The process of getting solar thermal energy to the glass surface is direct radiation and has a radiation heat transfer coefficient value of 97.94 W/m^2 on the fourth day of testing. Meanwhile, the lowest radiation heat transfer coefficient was 24.61 W/m^2 on the eighth day. The convection heat transfer coefficient from the glass surface to the environment was obtained 83.85 W/m^2 and the lowest gain was 21.33 W/m^2 on the eighth day.

Solar thermal energy that passes through the glass evaporator will enter and reach the surface of the glass and is absorbed by water. There are three types of heat transfer coefficient in the evaporator, namely evaporation, convection and radiation. Each has a different role, when the water evaporates due to this heat energy it produces the value of the evaporation heat transfer coefficient. While the condition of environmental radiation in the evaporator occurs when the heat energy from the surface of the water is reflected back into the air in the evaporator. Meanwhile, convection heat transfer is the difference in air temperature in the evaporator room with the water temperature, this results in air contact which simultaneously absorbs heat energy on the surface of the water.

In the picture above, it can be seen that the evaporation heat transfer coefficient is very dominant and the highest.



Gambar 5. Heat Transfer Coefficient Data Inside The Evaporator

The highest evaporative heat transfer coefficient is 20.30 W/m^2 on the fourth day and the highest radiation heat transfer coefficient is 13.18 W/m^2 on the fifth day, and the highest convection heat transfer coefficient is 3.08 W/m^2 on the first day. If we compare the heat transfer coefficient inside the evaporator and outside the evaporator, we can see that the heat transfer coefficient outside the evaporator is much higher. This is because the conditions outside the evaporator are very free, the conditions outside the evaporator have a large heat reduction factor because they directly touch the ambient temperature. It can be proven from Figure 3 that the convection coefficient nominates the highest due to the wind gusts that carry the heat energy received by the glass surface away so that the heat energy that enters is getting smaller.

CONCLUSION

The conclusion of this study is that the test with the same solar intensity value produces different heat transfer coefficients in each place. The highest convection coefficient outside the evaporator was on the fourth day 97.94 W/m^2 and the value of the radiation heat transfer coefficient from the glass surface to the environment was 83.85 W/m^2 on the second day. Meanwhile, the highest evaporative heat transfer coefficient is 20.30 W/m^2 on day four, the highest convection heat transfer in the evaporator is 3.08 W/m^2 on the first day, and the highest radiation heat transfer coefficient in the evaporator is 13.18 W/m^2 on the fifth day. From this data we can see that external conditions greatly affect the amount of energy that enters and is absorbed by water to convert it into steam.

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