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An Analysis of Desalination Process with The Variation of Basin Decker Type and Distance to Glass Cover Collector at Angle 25^{o}

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Abstract. The desalination process consists of changing form process and membrane process. This research applied the changing form process of desalination using solar energy. A solar collector is used to measure heat produced and collector efficiency from the desalination process. The angle of glass cover collector is 25o. The collector was made into the decker basin model with two and three levels. As for variations in the distance to glass cover are 10 cm, 10,5 cm, 11 cm, 11,5 cm and 12 cm. The data recorded for 5 consecutive days and was conducted in open space from 09.00 am to 03.00 pm with the interval time every 30 minutes. The result shows that heat energy resulting of 294,46 J/s from three levels basin with the distant to glass cover collector of 12 cm is 294,46 J/s, which is greater than others. While the highest collector efficiency, which is 70,27 %, was found in two levels basin at a distance to glass cover collector of 10 cm. Further more, three levels basin at a distance to glass of 11,5 cm was found to produce more fresh water than others, as many as 53,92 ml.

INTRODUCTION

Water is the main need to support the conclusions of human life. The World Food Agency (FAO) in its report in 2012 stated that the daily water needs per person between 2-4 liters and for the need to process food 2,000-5000 liters per subject [1]. But there is not enough water to meet daily needs. To overcome this problem, seawater can be a source of clean water through the desalination method [2]. The desalination process is the process of extracting dirty air into the clean air or removing salt from the sea air. Among several non-conventional desalination methods known for solar distillation. Distillation is the process of removing salt from the air by means of sea air heated until evaporation occurs, and until it is condensed [3, 4 and 5]. The process of using solar radiation is the radiation directly absorbed by the water in the basin and then converted into thermal energy which in turn will make the water evaporated [6]. The black basin is used as an absorber which use for evaporating water in a basin and condensing it on the surface of a basin cover made of transparent material such as glass or plastic [7, 8 and 9]. Basins are used to make a simple construction and to reduce manufacturing costs.

Nowadays, study on desalination using solar radiation has been carried out extensively, including investigating the effect of the glass basin angle [10 and 11]. Jamil et. al studied the effect of the height of the glass and basin on the solar desalination [12]. Variations in water depth in the sun type basin have also been studied [13 and 14]. However, the review of literature has not found study that examined the effect of the height of the basin cover glass on the multiple level of basin. This research was conducted to analyse the performance of the basin by measuring the amount of distilled water produced.

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EXPERIMENTAL METHODOLOGY

Basin Description

The basin used in this study use a cover made of glass with a thickness of 3 mm, a slope of 25^{o} and is made of two types of basins where one consists of 2 levels and the other 3 levels. The construction section of the basin base is made of wood which is coated with a plastic type of Polypropylene. Temperature data were measured using a thermocouple and the volume of water from the distillation process were measured using a measuring cup. Data were retrieved with a 30-minute interval and started from 09.00 - 15.00. The measured data are the temperature of the cover glass, the temperature in the basin, the base temperature of the basin, the ambient temperature, and the temperature of the water in the basin. Data of solar intensity were obtained from the Climatology and Geophysics Meteorology Agency, Lasiana Kupang Climatology Station.

In this study, each basin has difference in the distance between the glass cover of the basin to the base of the basin. The distance variation are 10 cm, 10.5 cm, 11 cm, 11.5 cm and 12 cm.

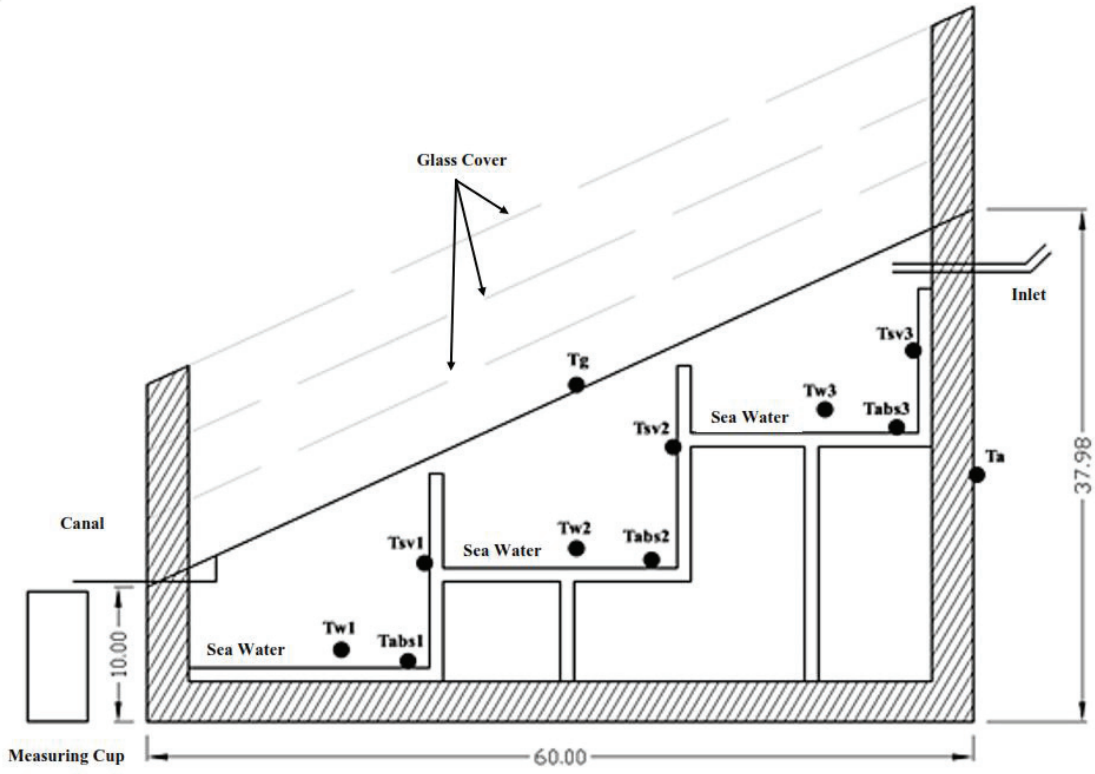

FIGURE 1. Schematic Drawing of The Solar Still

Performance of Solar Still

Randall investigated and correlated the data in Reynolds Numbers and Nusselt and form of equations as follows;

$$Nu = 1 + 1,44\left[1 - \frac{1708(\sin\ 1,8\ \beta)^{1,6}}{\mathrm{Ra}\cos\beta}\right]\left[1 - \frac{1708}{\mathrm{Ra}\cos\beta}\right] + \left[\left(\frac{\mathrm{Ra}\cos\beta}{5830}\right)^{1/3} - 1\right] \quad (1)$$

Calculation of Radiation Coefficients

$$h_{r,amb-cg} = \varepsilon_{cg}\sigma \frac{\left(T_{cg} + T_{sky}\right)\left(T_{cg}^2 + T_{sky}^2\right)\left(T_{cg} - T_{sky}\right)}{\left(T_{cg} - T_{amb}\right)} \quad (2)$$

The nature of the surface radiation (emissivity)

$$h_{r,cg-abs} = \frac{\sigma\left(T_{abs}{}^2 + T_{cg}{}^2\right)\left(\mathrm{T_{abs}} + \mathrm{T_{cg}}\right)}{\frac{1}{\varepsilon_{\mathrm{abs}}} + \frac{1}{\varepsilon_{\mathrm{cg}}} - 1} \quad (3)$$

Collector Efficiency

To find out how much collector efficiency, can be calculated by the following formula [7]

$$\eta = \frac{Qu}{AcIT} x100 \quad (4)$$

Distillation Efficiency

To calculate the efficiency of distillation, the equation used is as follows [7 and 9]

$$\eta_i = \frac{q_{ew}}{I_T} = \frac{h_{cw}\left(T_w - T_g\right)}{I_T} \times 100\ \% \quad (5)$$

RESULTS AND DISCUSSION

Data analysis used in this study is a mathematical analysis that obtained from the calculation formulas in the theoretical basis items, by investigating the influence of the multilevel basin shape and the variation of the cover glass distance to the collector efficiency, the amount of distilled water and heat energy produced. Results will be displayed in the graphs below

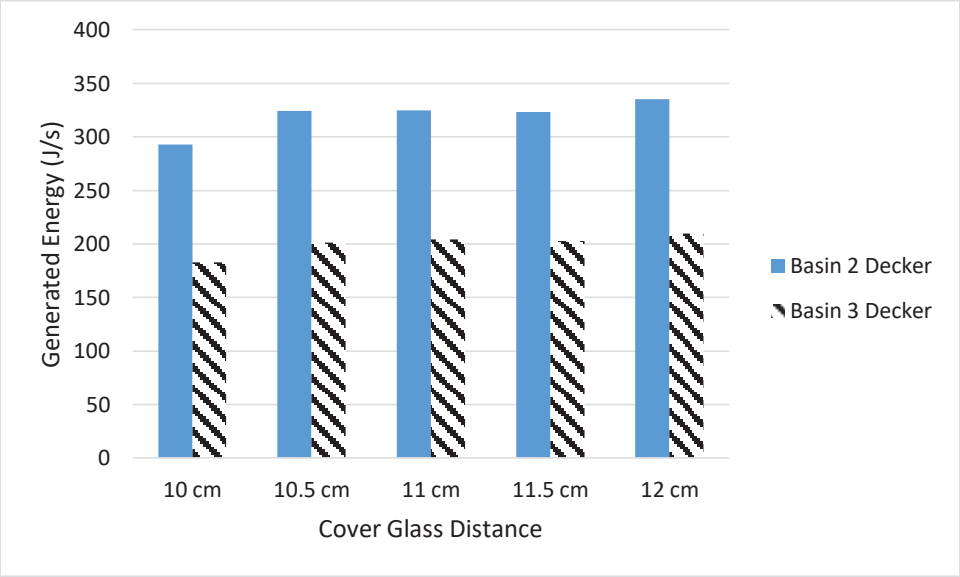

Figure 2. Generated Energy for Different Basin Decker and Distance

The graph above shows, a collector with a basin of 2 (two) decker produces more energy than a collector using a basin of 3 (three) decker. This is due to the different data retrieval times for each variation of the cover glass. Therefore, the heat of the sun which absorbed at each cover distance variation is different.

In relation to the increasing number of basins, it will affect the surface area of the water as a working fluid to absorb heat from the sun in the evaporation process. So, the energy produced (Qu) will be greater when the surface

area of the working fluid gets bigger and vice versa the value of the generated energy (Qu) will decrease when the working area of the fluid is reduced.

Based on Figure 2, it can be seen that the 12 cm distance of the cover glass to the absorber plate produces more energy than the other distances. This situation can be explained because with the closer of the distance of the cover glass to the absorber plate will increase the occurance of conduction during the heat transfer, which means there will be more heat lost to the environment.

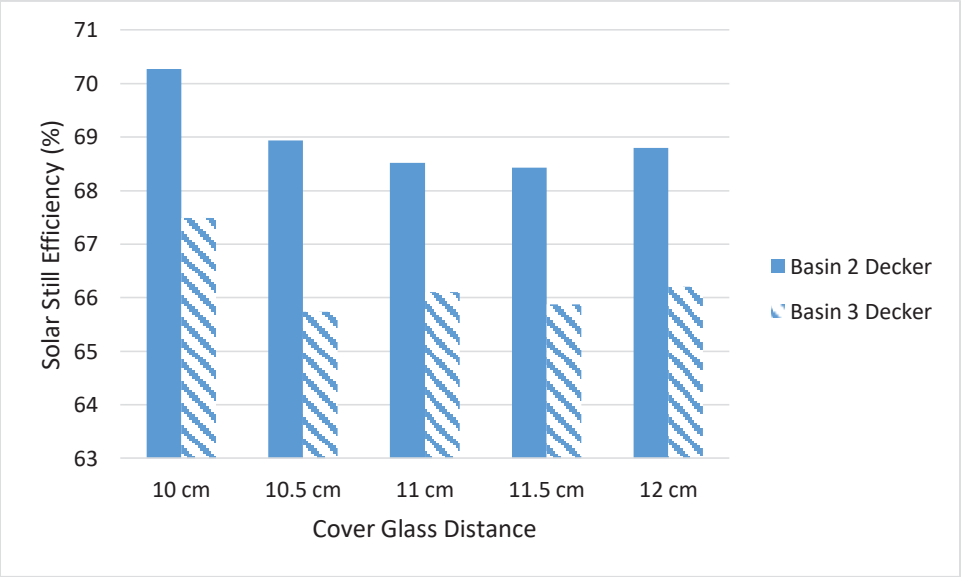

Figure 3. Solar Still Efficiency for Different Basin Decker and Distance

From the graph above, it can be seen that both collectors efficiency with all variations of the cover glass efficiency values that are not much different. However, the highest efficiency was found in the distance of the cover glass 10 cm, basin 2 (two) decker with a value of 70.27% and the distance of the glass cover 10 cm, basin 3 (three) decker with a value of 67.49%. This proves that the value of the heat energy generated by collector (Qu)is directly proportional to the collector efficiency (η).

However, the graph also shows contradictive result. In the two collectors with 10 cm distance of cover glass to an absorber plate has greater efficiency than the other distances. This finding is not in line with the resulting energy. From Figure 4, it can be seen that the collector peak point of the generated energy (Qu) is at a 12 cm distance of a glass cover, a basin of 2 (two) Decker and 3 (three) Decker. Therefore, it can tbe argue that theoretically, the collector efficiency is a characteristic that is influenced by the intensity of the sun, the heat energy produced and the heat absorbent area. It can be said that the peak point of the heat energy produced or the intensity of the sun is not necessarily the culmination of efficiency, because the peak point of its own efficiency is a condition where there is an increase in heat energy produced as much as possible with the smallest increase in solar intensity.

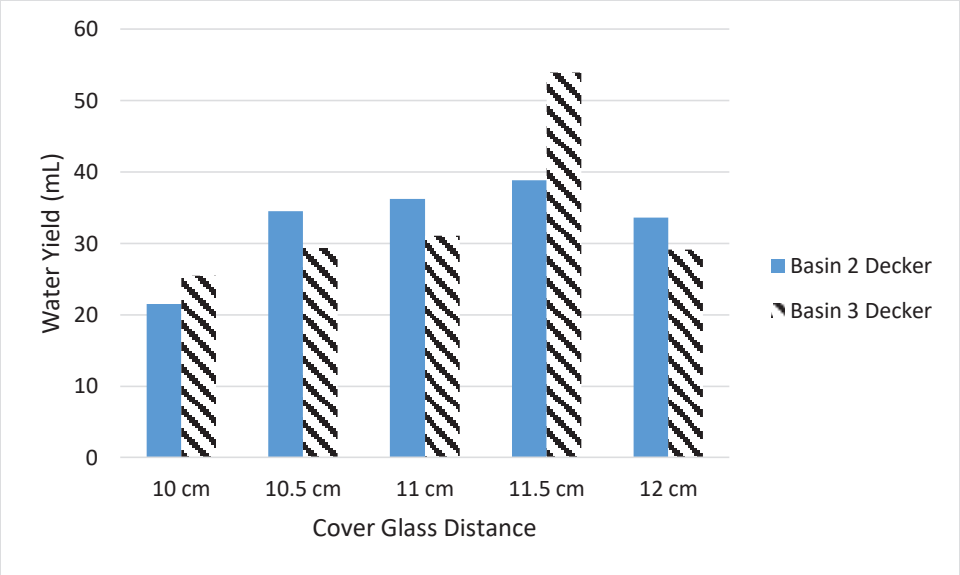

FIGURE 4. Water Yield for Different Basin Decker and Distance

The graph above shows that the collector with a basin of 2 (two) decker at a distance of 10.5 cm, 11 cm and 12 cm produces more distilled water compared to the collector basin 3 (three) decker at the same distance and this result is in line with the resulted energy. However, at a distance of 10 cm and 11.5 cm, the amount of distilled water is more produced by the collector with a basin of 3 (three) Decker and inversely proportional to the energy produced. In fact, the collector's basin 3 (three) decker with a 11,5 distance of cm cover glass produces more distilled water compare to others.

This result can be explained by the temperature difference.The 3 (three) level basin with a cover glass distance of 11.5 cm has an average temperature of the basin space, water temperature and absorber temperature higher than the others. In which the evaporation process willbe faster than the others. The distillation process that occurs also is supported by the type of cover glass used, in this case, the type of clear glass (transparent) has a high transmissivity value and low absorbtivity. Therefore, when solar radiation hits the glass, the radiation will be transmitted more to the working fluid , then to the absorber plate which in turn will be used in the evaporation process.

CONCLUSION

1. When the number of basins is multiplied, the number of bulkheads or collector walls will increase.Thus, when the solar radiation transmitted into the collector through reflection, the increasing number of collector wallwill tend to absorb more than the working fluid. Therefore the increase number of basins will decrease the energy produced.
2. Collector efficiency is a characteristic that is influenced by the heat energy produced, the heat absorbent area and the intensity of the sun. In this study, the highest efficiency was achieved at a distance of 10 cm by the collector with a basin of 2 (two) Decker of 70.27%.
3. The amount of distilled water is highly depend on the water temperature and the temperature of the basin. The higher of water temperature and basin temperature, the more distilled water will be produced. The highest amount of distilled water is produced by a 3 (three) level basin with a cover glass distance of 11.5 cm.

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