



SOLAR WATER SEA DISTILLATION USING CONDENSER

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Abstract:

Water is one of the main needs of living things, especially humans who need clean water for drinking, bathing, washing and other purposes. However, many regions have difficulties to get clean water, especially people who live on the beach, thus many experts try to process seawater into clean water which is worth drinking. One of the ways to process salt water into fresh water is by distillation. In this research, the author tries to distill water with the help of condenser. In this research, the author made an evaporation chamber of 80 cm x 100 cm x 30 cm. Through the use of solar-powered blower, vapor is inhaled from the evaporation chamber, therefore the pressure on the evaporation chamber will fall, so that the evaporation will occur much faster and the resulting vapor can be supplied to the condenser for cooling. From the test result using variation of blower rotation of 2800 rpm, 2200 rpm, and 1200 rpm, each condensate water produced from the distillation process are 215 ml/h, 410 ml/h, and 250 ml/hr. The condensate resulted from the highest rotation (2800 rpm) produces less condensate, thus based on our observation, we temporarily conclude that it occurs because there is water vapor coming out from the condensate, but more accurate research is needed to confirm it. Condensate of 410 ml/hour is still not as expected, thus this research will be continued in order to reach the expected result.

Keywords: Water Distillation; Condenser; Solar Power; Blower.

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1. Introduction

Water is the source of life and a primary need for humans other than air and food. Thus, water is something that cannot be separated from humans. Water is abundant in nature and is one of the main constituents of the earth, though only a small part of it which can be exploited by humans since most of the water on the earth is seawater. Seawater is salt-containing water that tastes salty so it is less suitable for human consumption. From such small portion of water that can be consumed, it slowly began to diminish due to environmental pollution that recently becomes increasingly rampant.

In some areas on the earth, there are several places where it is difficult to get pure water because of unsustainable environmental factors such as prolonged drought or environmental pollution. A

residential area around a beach also sometimes difficult getting pure water due to the seepage of seawater into the land (intrusion), thus the groundwater becomes salty like seawater.

Efforts have been made to obtain pure water such as boiling, filtering, distillation and others, all of which have their respective advantages and disadvantages. Boiling is done to kill the germs but it does not remove the impurities (small solids). Filtration is done only to remove the small solids but it does not remove the germs. Meanwhile, distillation is done to take condensate water while the germs will die by itself due to the heat and the dirt (small solids) as well as salts contained in the seawater will be left at the base since it has a different steam point.

Another substance needed is energy. Distillation process also requires an energy source to evaporate the liquid to be distilled in the form of heat energy. There is a lot of energy in nature that is not fully utilized until now, for example, solar energy. Solar energy is energy in the form of heat, therefore in the process of distillation which requires heat energy, a tool to convert energy sources is no longer needed. Thus, solar energy is very suitable to be used in this process. Solar energy continues to flow through the entire surface of the earth and is able to evaporate water during the day which can be seen in the process of evaporation of seawater into clouds. Although solar energy is very small at night or in a cloudy weather, solar energy is an ideal energy economically.

Research Objective

This research aims to overcome the problems above through designing an appropriate prototype so that the problem can be resolved and clean water can be obtained through an energy-efficient process.

Problem Limitations

The limitation of this research is only to the study to find out how much result (pure water) is obtained in every hour and to know the equipment and materials which meet the expected needs. Obstacles such as friction which occurs in the pipe, the smoothness of the workpiece surface, and others are considered absent (not counted) in this research.

2. Literature Review

Kinds of Distillation

There are several kinds of distillation including simple distillation, fractionation distillation, steam distillation, vacuum distillation and others.

This research uses the type of vacuum distillation of which theoretically the evaporation will occur faster at lower pressures. If the blower sucks the vapor from the distillation chamber, then the pressure on the distillation chamber will fall, and if the distillation chamber is heated by the sunlight then the evaporation will happen more quickly.

Various studies have been done by applying distillation process. Research conducted on experiments with a collection area of 0.68 m² yields a maximum condensate of 2.3 liters at a maximum temperature of 54°C (Ugwoke E. C et al, 2015). In addition, distillation is also used in the process of purifying sugar and molasses by the use of yeast (G. Thamilvanan¹ and R.

SenthamilSelvi, 2013). The result of the molasses sugar induced by the fermentation process is used to determine the significant amount of ethanol produced.

In addition, distillation is also used to separate the water-ethanol mixture using the micro bubble distillation technology (Atheer Al-yaqoobi, et al, 2016) which can produce better biofuel.

3. Basic Theory

Seawater

Seawater is water from the ocean. Seawater has an average salinity of 3.5%. This means that in 1 liter (1000 mL) of seawater, there is 35 grams of salt (but not entirely, kitchen salt/NaCl). Although most seawater in the world has a salinity of about 3.5%, seawater also has different salt content. The most tasteless one is in the eastern of Finland bay and in the northern of Bothnia bay, both are the parts of the Baltic Sea. The most salty one is in the Red Sea in which the temperature is high and the circulation is limited, producing high evaporation and little water input from the rivers. The salinity in some lakes can be even higher.

Seawater has salt content because the earth is filled with mineral salts contained in rocks and soil. For example sodium, potassium, calcium, and others. When the river water flows into the ocean, it brings salt. The sea waves that hit the beach can also produce salt contained in the rocks. As time goes by, the seawater becomes salty because it contains lots of salt.

Solar Energy

According to Abdul Kadir (1987), solar energy which enters the Earth's atmosphere has an estimated density of 1 kW/m²-1.4 kW/m² in a direction perpendicular to the axis of light. From that amount, 34% is reflected into space, 19% is absorbed by the atmosphere (dust, gas, and clouds), and 47% reaches the earth. If the average solar radiation entering the earth is estimated at 1.2 kW/m², the average energy absorbed by the earth from 47% with the perpendicular state (1.3x10⁸ km²) is 0.564 kW/m², using PV which has a 15% efficiency, the panel of 0.63 m² will produce 53 Watt, therefore that energy can move the equipment of 40 Watt power.

Evaporation

Evaporation is the process of changing the shape of a liquid (water) into vapor and enters the atmosphere. In hydrology, evaporation can be distinguished into two kinds, those are evaporation and transpiration. Evaporation (given E₀ notation) is evaporation which occurs from the water surface (such as the sea, lake, and river), the soil surface (puddle on the ground and evaporation from the groundwater surface), and the plant surface (interception). If the groundwater level is deep enough, the evaporation of groundwater is small and can be neglected.

Some Reasons Which Affect the Evaporation

Solar Radiation

On any change of substance form; from ice to water (melting), from liquid to gas (evaporation) and from ice to vapor (sublimation), latent heat is required. The latent heat for evaporation comes from the radiation of solar and ground. Solar radiation is the main source of heat and affects the amount of evaporation above the earth's surface, which depends on the latitude and season.

Solar radiation at a site varies throughout the year depends on the location (latitude) and sun declination. In December, the position of the sun is the furthest which is in the south, while in June the position of the sun is far in the north. Areas in the southern hemisphere receive maximum solar radiation in December, while the smallest radiation is in June, and vice versa. The solar radiation that reaches the earth surface is also affected by the cloud. The closure by the clouds is expressed as the percentage of the actual duration of sun exposure to the expected duration of solar irradiation.

Temperature

Air temperature on the evaporative surface greatly affects the evaporation. The higher the temperature, the greater the air's ability to absorb the vapor. In addition, the higher the temperature, the more increase the kinetic energy of the water molecule thus more and more water molecules are moved to the upper air layer in the form of vapor. Therefore, the amount of evaporation in tropical climates regions is higher than in the polar regions (cold climates). For daily and monthly variations, the air temperature in Indonesia is relatively small.

Pressure

In the process of evaporation, the air pressure at the air layer is just above the water level and is lower than the pressure on the water surface. The difference in pressure causes evaporation. When evaporation occurs, vapor joins the air above the water surface, thus the air contains vapor.

Table 1: The Temperature and Pressure of Saturated Vapor of Water

No	Temperature °C	Saturated Vapor Pressure (N/m ²)	mm Hg = 13.6 mm H ₂ O
1	20	2.33 x 1000	1.75 = 238.0
2	25	3.17 x 1000	23.8 = 323.7
3	30	4.24 x 1000	31.8 = 432.5
4	40	7.37 x 1000	55.3 = 752.1
5	50	1.23 x 10,000	92.5 = 1258.0
6	60	1.99 x 10,000	149 = 2026.4
7	70	3.12 x 10,000	234 = 3182.4
8	80	4.73 x 10,000	355 = 4828.0

Condenser

The heat transfer rate of the condenser is a function of the refrigeration capacity and the evaporation temperature as well as the condensation temperature. The condenser must be able to remove the heat absorbed in the evaporator. A common term used to indicate the heat transfer rate from the condenser to the evaporator is the heat rejection ratio which occurs.

$$\text{heat rejection ratio} = \frac{\text{heat released in the condenser}}{\text{heat absorbed in the evaporator}}$$

However, this heat transfer ratio is less precise because it does not count the compression work. The value of this heat transfer ratio can also be calculated with the help of the chart below.

In the condenser, condensation occurs on the vapor which condenses outside the pipe. The condensation coefficient which occurs outside the pipe is calculated through the equation below:

$$hct = 0.725 \left(\frac{g \rho^2 hfg k^3}{\mu \Delta t N D} \right)^{1/4}$$

Of which:

Hct	= condensation coefficient (W/m ² K)
g	= gravity acceleration m/s ²)
ρ	= fluid mass density fluida (kg/m ³)
hfg	= evaporation latent heat (J/kg)
μ	= condensate viscosity (Pa.second)
Δt	= temperature difference between condensate and pipe (K)
N	= number of pipes in vertical row
D	= the diameter of outer pipe (m)

Processes on the Heat Transfer

1) Conduction

Conduction is a heat conduction which is not accompanied by the displacement of intermediate particles.

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Of which:

H	=	Heat flow rate (J/s or watt)
Q	=	Heat transferred (joule)
t	=	Time (s)
k	=	Thermal conductivity of substances (W/mK)
A	=	Cross sectional area (m ²)
Δt	=	Temperature changes (°C atau K)
l	=	Carrier thickness (m)

2) Convection

Convection is the heat conduction accompanied by the displacement of the intermediate particles.

$$H = \frac{Q}{t} = h.A.\Delta t$$

Of which:

H	=	Convection Coefficient (W/m ² K)
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3) Radiation

Radiation is a heat conduction that does not require an intermediate medium such as the heat from the sun that reaches the earth.

Of which:

e	=	Emissivity of the object (without unit) (e is 1 for perfect black object, and 0 for no black objects at all)
σ	=	Stefan-Boltzman Constanta = 5.67 x 10 ⁻⁸ W/mK ⁴

Research Materials and Method

Equipment used

- 1) Control bucket and buoy, to set the water level inside the distillation bin.
- 2) Evaporation chamber, to evaporate the seawater.
- 3) Solar Panel, to produce the electric current as the blower driver.
- 4) Manometer H₂O, to measure the difference in pressure in the distillation bin and outside air.
- 5) Blower, to absorb the vapor in the distillation chamber.
- 6) Condenser, made of 3 car radiator serves to cool the vapor to change into condensate.
- 7) Battery, to stabilize the DC electric current produced by the solar panels and also as the more current storage produced by the solar panels.
- 8) Thermometer, to monitor the temperature inside the evaporation chamber.

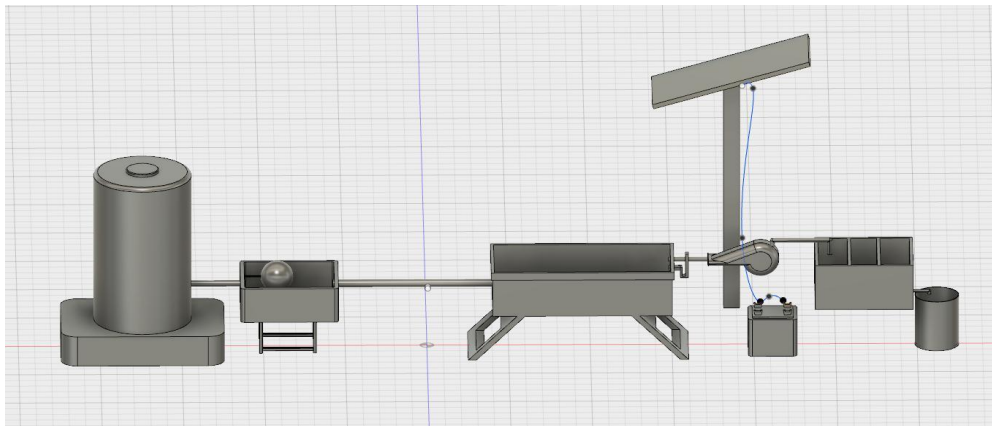


Figure 1: Seawater Distillation Installation Sketch

4. Result and Discussion

After all the distillation equipment is installed, the following test is conducted

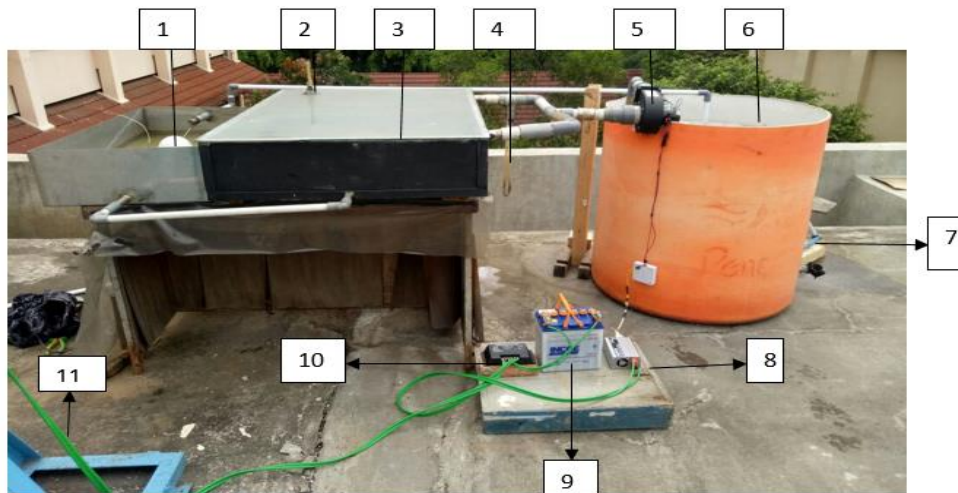


Figure 2: Distillation Test and Equipment Used

- 1) Buoy and water surface regulating vessel
- 2) Manometer (to measure temperature in the vapor chamber)
- 3) Evaporation chamber
- 4) Manometer H₂O (to measure the pressure difference)
- 5) Blower
- 6) Condenser (located in a cooling basin)
- 7) Condensate outlet
- 8) Inverter
- 9) Battery
- 10) Controller
- 11) Cable carrier of PV

In this experiment, the evaporation chamber size is 80 cm x 100 cm x 30 cm. Dimmer tool is used to help control the spin in order that the rotation can be changed as desired.

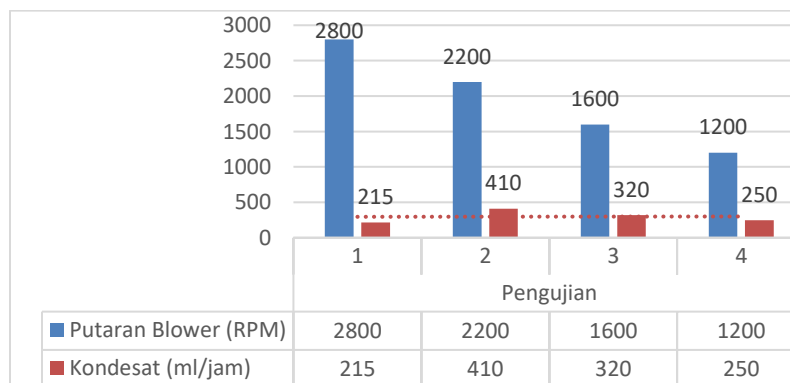
Research Result and Discussion

Table 2: Condensate produce in Evaporation Chamber With the dimension of 80 cm x 100 cm x 30 cm

No	Blower Rotation (RPM)	Temperature of Distillation Chamber (°C)	Δh Water on pipe U	Q Condensate (ml/jam)
1	2800 rpm	42°C	2.0 cm	215 ml/hour
2	2200 rpm	42°C	1.7 cm	410 ml/hour
3	1600 rpm	42°C	1.4 cm	320 ml/hour
4	1200 rpm	42°C	1.0 cm	250 ml/hour

Through the use of solar-powered blower, vapor is absorbed from the evaporation chamber, then the pressure on the evaporation chamber will fall, thus the evaporation will occur faster and the resulting vapor is transferred to the condenser for cooling.

From the test result with variation of blower rotation of 2800 rpm, 2200 rpm, and 1200 rpm, each condensate water produced within 60 minutes from the distillation process are 215 ml/h, 410 ml/h, and 250 ml/hr. The resulting condensate at the highest rotation (2800 rpm) produces less condensate.



Graph 1: The Relationship between the Blower Rotation Variation and Condensate Produced

5. Conclusion

Condensate water is not in accordance with the expected results. From the observed results, it can be concluded for a while that the least condensate produced occurs because there is vapor coming out of the condensate channel. Therefore, we need more accurate research to ensure it. Condensate result of 410 l/h is still not as expected, thus this study will be continued to achieve the expected results.

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