Effect of Using Phase Change Material (PCM) Paraffin Wax and Lauric Acid as Heat Storage on Water Productivity in Solar Desalination

VINSENSIUS HENDRIK[1], RAUDHATUL FADHILAH[2,*], DODDY IRAWAN[1], EKO SARWONO [2]
[1] Department of Mechanical Engineering
[2] Department of Chemistry Education
Muhammadiyah University Pontianak
Jalan Jendral Ahmad Yani, No. 111, Pontianak
INDONESIA

Abstract :- Increasing levels of water pollution and depleting the availability of fresh and clean water that exists, as is the case in coastal areas (beaches) where it is still difficult to get clean water, make it better if sea water is used to be processed into clean water by eliminating The salt content contained in seawater has become one of the problems that must be solved, considering that water is one of the resources used to meet human needs. One solution to overcome the problem of the availability of fresh and clean water through distillers or converting existing seawater into fresh and clean water is a solar desalination device, which utilizes solar heat radiation to heat water in a desalination device. In this research, the solar desalination device will be added with phase change material (PCM) as a storage medium and heat release, the PCM used in this research is paraffin wax and lauric acid. The PCM will be inserted into a stainless-steel ball with a diameter of 3 inches. maximum total distillate occurred when using PCM paraffin wax compared to using lauric acid, and when not using PCM, namely for paraffin obtained 990ml/m^2 -day, lauric acid 928ml/m^2 -day, and when not using PCM 818ml /m^2 -day. So, it can be said that solar desalination with the addition of PCM, especially paraffin, can increase the required distillate water yield.

Key-Words: Solar Desalination, Phase Change Material, Paraffin Wax, Lauric Acid, Water.

Received: May 14, 2022. Revised: October 22, 2022. Accepted: December 5, 2022. Published: January 24, 2023.

1 introduction

Water is one of the natural resources used to meet human needs, especially drinking, washing, and so on, where the availability of water on this earth covers 71% of its surface. About 97% of the water on earth is found in the oceans as salt water, about 2% of the water is in the polar regions where it is still ice, and the remaining 1% is as fresh water in several lakes such as groundwater and rivers [1] . According to data obtained from WHO and UNICEF in 2019, it shows that in the world, there are nearly 900 million people who do not have access to clean water, such as those in local health centers, and they have to use unsanitary well water to continue their lives. Water has chemical compounds in liquid form with the chemical formula H_2O, where water has a very small molecular size, which is 0.3 nm or 3 x 10-8 cm. In seawater, there is a mixture of 96.5% pure water and 3.5% other materials, such as salts, dissolved gases, organic matter, and undissolved particles. Seawater has an average salt content of 3.5% [2]. The abundant amount of seawater and adequate brackish water would be better if used to be processed into clean water by removing the salt content contained in seawater [3]. Especially in coastal areas (beaches), where it is still difficult to get clean water, One method that can be used to convert seawater into fresh water is also known as the desalination method [4], which is a renewable energy source that utilizes solar power as a heating source. Solar desalination is a technology that is of global concern due to water scarcity in many places in the world, where solar desalination utilizes solar energy to obtain clean water by evaporating saltwater so that it can purify saltwater from pollutants, including salts, heavy metals, and microbes [5]. The desalination tool works in that the salt water in the holding container will be heated by solar energy, causing evaporation. The water vapor then condenses on the surface of the slanted glass cover, which allows the water to flow into the clean water storage container. The parameters that affect the productivity and efficiency of desalination are location, sun intensity, ambient temperature, the glass covering material and its thickness, water depth, and wind speed [6]. Whereas the use of solar desalination devices with single and double glass tilt models in desalination devices is very popular for converting salt water into fresh water at this time [7], The problem found in the productivity of water from the solar power desalination device at night from the slope model is zero, which is because it is very dependent on solar heat so that the heat loss that is inside the desalination device is from the glass cover and its surroundings. The method that can be applied to increase the productivity of solar desalination is by using a phase change material (PCM) as a latent heat storage medium [8]. Phase change materials are used to store solar energy during the day and to keep the heat from solar power constant at night [9] . According to Shalaby et al. (2016), who studied a single-basin v-corrugate, the productivity of water produced using PCM increased by 12% compared to not using it [10].

2 Problem Formulation

2.1Desalination

Desalination is a process used to remove excess salt content from seawater and create fresh water. The desalination process requires a large amount of solar heat energy for the expansion process; the higher the heat energy supplied, the faster the water will expand or evaporate. The evaporated water produces clean water vapor and salt contained in unrepavored water and forms salt crystals at the bottom of the evaporation chamber [11]. This process is used to obtain clean water that can be consumed by living things such as animals, plants, and humans. Through the distillation process, liquid substances are separated from the mixture based on differences in their boiling points [12]..

2.2 Sea water

Seawater is a liquid in which various solids and gases are dissolved. Seawater is also one of the abundant sources of water, but seawater cannot be consumed directly because it still contains about 3.5% salts, dissolved gases, organic materials, and undissolved particles. There are also dissolved substances, including organic salts derived from living organisms and dissolved gases, but the largest fraction of dissolved material consists of inorganic salts in the form of ions. The main salts contained in seawater are chloride (55%), sodium (31%), sulfate (8%), magnesium (4%), calcium (1%), and the remainder (less than 1%) consisting of bicarbonate, bromide, boric acid, strontium, and fluoride. The six inorganic ions found in seawater are chlorine, sulfur, magnesium, calcium, potassium, and sodium [2]. Seawater has a total dissolved solids (TDS) content that exceeds 3000 ppm. According to the WHO, water that is good for consumption must have a total dissolved solids (TDS) of less than 1000 ppm. So that the development of seawater desalination technology can be an alternative solution in making clean water [13] .

2.3 Solar energy

The sun is one of the main sources of energy needed by humans for various lighting or heating purposes, and the sun can emit extraordinary amounts of energy to the surface of the earth. In sunny conditions, the earth receives around 1000 watts per square meter of solar energy. For solar energy in Indonesia, it has an intensity value between 0.6 and 0.7 kW/m^2 [14], which is basically the area around the equator and also the tropics with more than six hours of sunshine. With so much solar energy, it would be better if it was utilized as well as possible, one of which is solar desalination which requires solar radiation as a process to produce clean water that can be used for various purposes.

2.4 Heat

The amount of heat needed to raise or lower the temperature of an object depends on the mass of the object, the specific heat of the object, and changes in temperature, while it can be formulated as follows:

$$Q = mc\,(T_2 - T_1) \qquad (1)$$

Where;

Q = heat (J)
m = object mass (kg)
c = specific heat (J/kgK)
ΔT = temperature change I

2.5 Heat Transfer

Heat transfer is one of the engineering sciences that studies heat. The heat transfer that occurs in the desalination device is influenced by the absorption of energy from the air in the basin, the cover glass, the type of phase change material used, and the intensity level of the sun. Heat transfer moves from a substance with a higher temperature to one with a lower temperature until it reaches an equilibrium state. [11]

2.5.1 Conduction

Convectional heat transfer is a heat transfer process in which a liquid or gas with a high temperature flow to an area with a lower temperature, providing surface heat at a lower temperature. The equation that can be used to calculate the conduction heat transfer rate is as follows:

$$q = -k\,A\,\frac{dT}{dx} \qquad (2)$$

Where:

q = heat transfer rate (watts)
-k = thermal conductivity (W/mk)
A = heat transfer area (m^2)
dT = temperature difference I
dx = distance (m)

2.5.2 Convection

Convectional heat transfer is the transfer of heat that occurs between a solid surface and the fluid flowing around it. The equations that can be used are as follows:

$$q = h \times A \times \Delta T \qquad (3)$$

Where ;

h = material convection coefficient ($W/m^2 C$)
A = cross-sectional area of the surface (m^2)
ΔT = temperature difference

2.5.3 Radiation

Radiation is the transfer of heat from high temperatures to lower temperatures without an intermediary substance through electromagnetic waves, where solar radiation is one of the heat radiations that has a special distribution of wavelengths. Radiant heat transfer does not require a medium, so heat transfer can take place in a vacuum. The intensity is very dependent on atmospheric conditions and the angle of incidence of the rays to the surface (angle of incidence) [12]. The basic equation for the concept of radiant heat transfer is the Stefan-Boltzman law. The Stefan-Boltzman law is expressed by:

$$q_r = \varepsilon\sigma A \Delta T^4 \qquad (4)$$

Where :

ε = surface emissivity
T = absolute temperature of the body, K (°R)
A = surface area, m2 (ft2)
qr= convection heat transfer rate, watts (Btu/h)
σ = Stefan-boltzman constant. 5.669 x 10-8 W/m2.K4 (0.1713 x 10-8 Btu/h.ft2.°R4)

2.6 Desalination Efficiency

The efficiency of the desalination device is determined by the ratio of the heat energy required to evaporate seawater, which is a clean water product, to the amount of solar radiation received by the device through the solar radiation absorbing plate in a certain time interval [15]. To calculate the efficiency of a solar seawater distillation device, the following equation can be used:

$$\eta_d = \frac{m_k \times h_{fg}}{A_c \times I_r \times t} \times 100\% \qquad (5)$$

where ;

m_k : Total Mass of Distillate Water (kg)
h_{fg} : Latent Heat of Vaporization (kj/kg)
A_c : Area of Absorbing Plate (m^2)
I_r : Intensity of Solar Radiation (W/m^2)
t : Length of Testing Time (s)

2.7 Phase Change Materials (PCM)

Phase change materials (PCM) utilize the latent heat of the phase change to control the temperature within a certain range. When the temperature rises above a certain point, the chemical bonds in the material will begin to break and the material will absorb heat in an endothermic process (internal heating) where the material will change from a solid to a liquid. When the temperature drops, the material releases energy and returns to a solid state. Therefore, the phase change material can provide an increase in heat storage capacity [16]. Based on their chemical composition, PCM materials can be divided into three categories: organic, inorganic, and eutectic.

2.7.1 Organic

Organic phase-changing materials are divided into paraffins and non-paraffins. In general, organic phase-changing materials do not undergo phase separation and crystallize without supercollimation. Organic phase change materials (PCM) utilize mass-based latent heat, which show no sign of phase separation after repeated passage through solid-liquid and have low vapor pressures. Phase-changing materials using praffin have several drawbacks, such as low thermal conductivity (about 0.2 W/(mK)), as well as being incompatible with plastic containers and flammable. PCM paraffin also has a low thermal conductivity, which ranges from 0.15 – 0.17 W/(m.K).

2.7.2 Inorganic

The most commonly known inorganic phase-changing materials consist of hydrated salts and metals. The hydrated salt consists of an alloy of inorganic salts and water, so the use of this type of phase change material (PCM) can save costs because of its easy availability and low cost. In transforming the phase change involving dehydration or hydration of the salt in a process such as melting and freezing, desirable properties of the hydrated salt used as a phase change material (PCM) include high latent heat per unit, higher thermal conductivity than the phase change material organic, small volume changes, easy availability, and a more affordable cost.

2.7.3 Eutectic mixture

A eutectic mixture is a mixture of several chemical compounds or elements that have a single chemical composition that freezes or melts at a lower temperature than the melting point of the mixed compound composition made from the same material. Eutectic can also be a mixture of organic and inorganic compounds. Several organic eutectics that have been studied include capric acid/myristic acid, lauric acid/stearic acid, myristic acid/palmitic acid, palmitic acid/stearic acid, and capric acid/lauric acid. The most common inorganic eutectics that have been studied consist of different hydrate salts.

3 Methodology

3.1 Place and Time of Implementation

A solar desalination test will be carried out for about one month starting in October 2022, from 8:00 a.m. to 2:00 p.m., at the Laboratory of the Faculty of Mechanical Engineering, University of Muhammadiyah Pontianak, which is located at Sui Ambawang Kuala, Kec. Ambawang River, Kubu Raya Regency, West Kalimantan.

3.2 Experimental Procedure

In this experimental procedure, a single-tilt solar still desalination device was designed as shown in Figure 1. Hollo aluminum (22 mm x 34 mm) was used for the frame of the desm for the front.alination device with dimensions of 1 m long, 1 m wide, 0 m for the frontal height, 2 m for the back, and 0.7 m. The basin or container to be used as a container for seawater and PCM, is designed with a size of 0.95 mx 0.92 m × 0.07 m, made of plywood with a thickness of 8mm and coated with resin and painted black. On the top cover of the solar still desalination device, a transparent glass with a length of 1012mm, a width of 934mm, a thickness of 3mm, with a slope of 25^{0} will be used in the desalination apparatus, which is used as a place for condensation of eandrating water250nd flows down the desalination channel to flow into a fresh water tank. , where the glass will be attached o the frame (frame) and silicone rubber.

Fig. 1. Solar desalination device with PCM

The PCM that will be used in this study, namely paraffin wax and lauric acid where each PCM will be stored in a ball made of stainless steel with a diameter of 76.2 mm (3 in) and a thickness of 0.5 mm. Each PCM that is inserted into the ball will be filled with the same weight and closed with bolts and rubber that is resistant to high temperatures.

Table 1. Physical Rhermo Properties Of PCM

Properties	Lauric Acid	Paraffin Wax
Chemical Formulas	(CH3(CH2) 10COOH)	(C31H64)
Melting Temperature	42-46 ˚C	52 ˚C
Heat Conductivity	0.16 W/m˚C	0.24 W/ M - ˚C
Latent Heat	180 Kj/Kg	143 Kj/Kg

Specific Heat	Specific	2.1 kj/kg.˚C	2 Kj/Kg.˚C

(a) (b)

Fig. 2. PCM used (a). lauric acid, (b). paraffin wax

3.3 Desalination Process

The way the solar-powered seawater desalination device works is that the seawater that is in the reservoir will flow into the basin (the water storage container in the desalination device) through a connecting pipe. The sea water that is already in the basin will be heated by solar energy that enters through the transparent glass (translucent) to the basin through the heat-absorbing medium at the bottom of the basin, so that the heat accumulated in the room will cause the water in the basin to evaporate, and then condensation will occur on the inner cover glass due to the difference in temperature with the air outside the desalination equipment room. The result of condensation in the form of condensate will flow downward following the slope of the transparent cover glass and enter the canal (condensate channel), and then flow into a clean water reservoir (distillate).

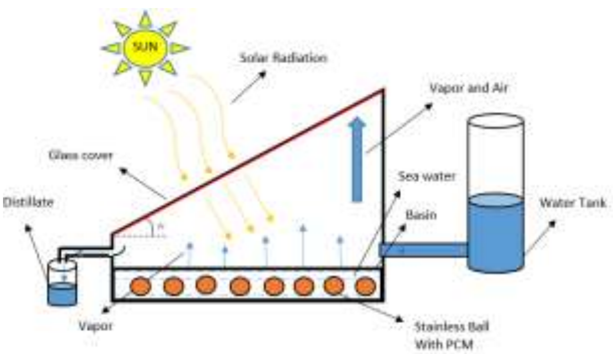


Fig. 3. Solar desalination diagram with PCM

In this research, tests will be carried out on a still desalination device using PCM (phase change material) as a heat storage medium, where testing will be carried out for each PCM (paraffin wax and lauric acid), and testing without using PCM with a water level recommendation of 3 cm. Measuring or collecting data on the desalination device is carried out once every hour, using a measuring instrument such as a thermocouple, which is used to determine glass temperature, water temperature, PCM temperature, and basin temperature. The hygrometer is used to determine the temperature inside and outside the desalination device. A LUX meter is used to measure the level of lighting around the desalination device.

3.4 Principle Of Operation

In the operation of the solar power desalination device with the addition of PCM (phase change material), 15 balls will be used, which will be filled with PCM of the types paraffin wax and lauric acid, with the same weight for each PCM, namely a total weight of 2,580 g. As can be seen in Figure 2, the filling process occurs in the PCM due to solar heat or solar radiation entering through the cover glass and being absorbed by the basin and the 15 balls containing the PCM, or where the PCM balls get hot due to solar radiation and convection heat transfer during the filling process. At first heat will be stored as sensible heat until PCM is at its melting point, for paraffin wax 52 ˚C, and lauric acid is at 42-46 ˚C, when PCM starts to melt, heat storage process will occur in the form of latent heat, and when the PCM melts completely, heat will be stored in the melted PCM as sensible heat. When the sun goes down and the solar radiation becomes zero, or there is no incoming sunlight, the room will start to cool, and the PCM inside the ball will transfer or give off heat by conduction to the water in the basin, until the PCM really becomes solid again. Here, PCM acts as a heat source for water when there is no solar intensity entering the desalination device. so that it can still produce clean water even though there is no solar radiation.

Fig . 4. The ball filled with PCM is placed in the basin

4 Results and Discussion

The research will be conducted for three days, starting from 8:00 to 20:00. by observing several temperatures, such as water temperature, glass temperature, indoor temperature, and outside and indoor temperature, with a hygrometer and thermocouple.

4.1Temperature Desaliansai

The temperature for each type of PCM is also measured using a thermocouple, where fifteen balls containing PCM will be placed in a basin of water. where sensors will be placed on each side to be observed to determine the resulting temperature. There is also light coming in from the sun, which is also measured using a lux meter, and the volume of clean water produced will be collected and measured using a measuring cup. where the data collection process will be carried out once every hour.

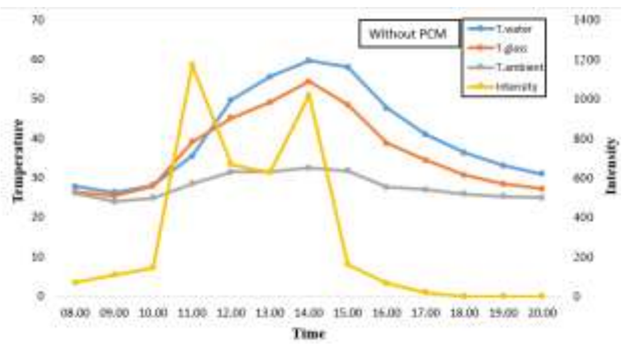


Fig. 5. Temperature variation with time without PCM

Figure 5 shows the variations in the temperature of the salt water (T.water), the temperature of the inner glass (T.glass), the ambient temperature (T.ambient), and the intensity of the sun (Intensity) when not using PCM. It can be seen that over time, all temperatures show an increasing trend until they reach a maximum value around 14 o'clock and then decrease gradually until sunset. The glass temperature and water temperature continue to fluctuate in the morning, until around 11 a.m. or 12 a.m., when the water temperature increases faster than the glass temperature due to the release of heat from the glass into the environment and the absorption of heat by the salt water. The maximum temperature values obtained from the temperature of the water, inner glass, and environment are 59.70°C, 54.40°C, and 32.50°C, and at the highest intensity value, which is 1169 W/m2,

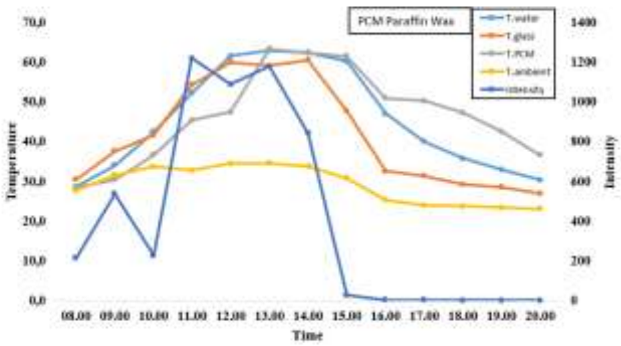


Fig. 6. Variation of temperature with time with PCM paraffin wax

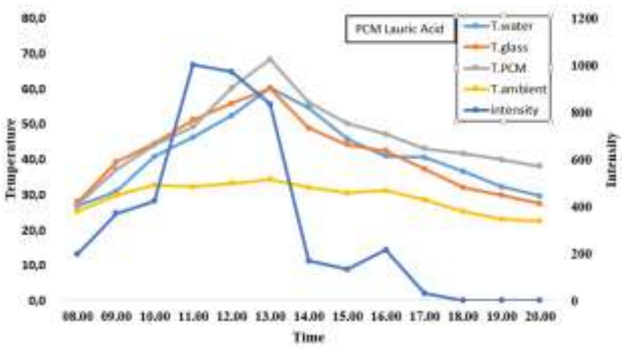


Fig. 7 Variation of temperature with time with PCM lauric acid.

Figure 6 shows the variations in the temperature of the salt water (T.water), the temperature of the inner glass (T.glass), the ambient temperature (T.ambient), and the intensity of the sun (Intensity) when using PCM paraffin wax. It can be seen that the increase in temperature continues to increase over time until during the day, around 12.00 a.m.–14.00 p.m., and then continues to decrease until the evening. It can also be seen that the temperature of the glass in the morning is higher than the temperature of salt water, this is caused by the difference in heat capacity between the glass and the water and the time it takes for the glass to heat up before the water gets hot. After that, there was a change in temperature in the water, which became hotter in the glass; this happened until the night. The maximum temperature obtained at the temperature of water, glass, and environment is 63.30C, 60.50C, and 34.50C, and the highest intensity value obtained is 1218W/m2. The PCM temperature increases progressively over time because the PCM receives heat from the water, where the heat is absorbed from the basin and the water is initially stored as sensible heat in the PCM until it reaches its melting point temperature of 520C, and then the PCM temperature becomes constant for a few moments, which indicates a process of phase change from solid to liquid. In PCM paraffin wax, the maximum temperature obtained is 63.30 °C, which is at around 13 o'clock. After the PCM melts, the temperature will continue to decrease constantly until nightfall, when the PCM becomes solid again. This is due to the process of releasing heat from the PCM to the basin water by changing the temperature. At the PCM temperature with water it can also be seen that at night the PCM temperature will be greater than the water temperature because during the day heat energy has been stored in the PCM. This shows that the release of heat from the PCM will continue even at night when there is no longer the intensity of the incoming sun. In Figure 6, it can be seen that the PCM temperature displays an almost flat trend around 13.00 p.m.–15.00 p.m., even though there is a decrease in intensity at 15.00; this indicates heat release occurring from the PCM to the water basin.

As can be seen in Figure 7, the parameters are the same as those in Figure 6, but what distinguishes them is the type of PCM, where Figure 7 will use PCM lauric acid as a heat storage medium. In Figure 7, it can be seen that the temperature increases over time until around 13:00 p.m., which is the maximum temperature shown at all temperatures, and then continues to decrease following the decreasing sun intensity value. It can be seen that the maximum temperature for water temperature, environmental glass is 60.3^0 C, 60.1^0 C, 34.3^0 C, and for the highest solar intensity value is at 1002W/m 2 . The maximum temperature of PCM lauric acid occurs at 13:00 p.m. with a temperature of 68.30 °C, while the melting point of luric acid itself is at a temperature of 42–46 °C. This indicates that PCM lauric acid has melted. In Figure 7, it can be seen that all temperatures decreased rapidly after 13:00 p.m. This was due to changes in weather that caused the value of the sun's intensity to decrease. At PCM temperature, it was revealed that at 14.00 p.m., when all temperatures were decreasing, PCM was still able to stabilize the decrease at all temperatures, which indicated that there was a heat release from the material changing phase from liquid to solid.

4.2 Comparison of glass and water

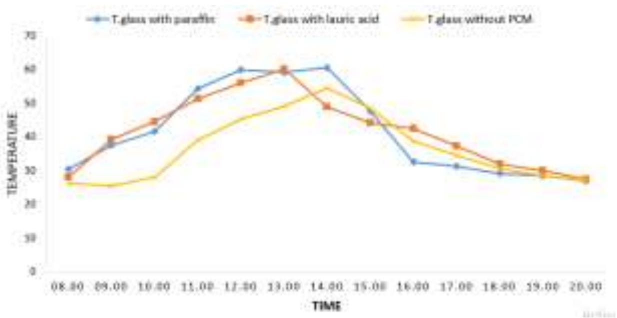


Fig. 8. Comparison of glass temperature versus time in the study of PCM paraffin, lauric acid, and without PCM

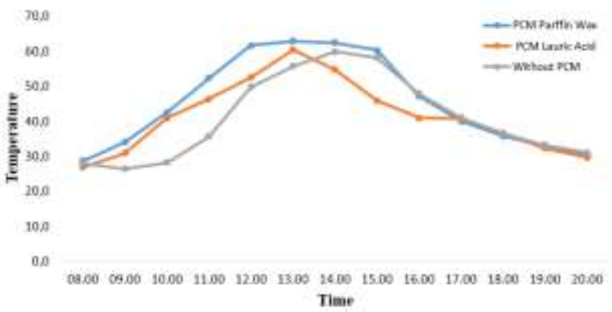


Fig. 9. Comparison of water temperature with time on PCM paraffin, PCM lauric acid, and without PCM

In Figure 4 it can be seen that the temperature variation graph that occurs on the cover glass of the desalination apparatus when testing on PCM paraffin, PCM lauric acid, and when not using PCM, that the glass temperature when usi14 p.m.ng both PCM is higher than when not using PCM. The maximum heat temperature for the cover glass when using PCM paraffin is 12 p.m.12.014 p.m.;4.00pm, for PCM acid, it isic acid 12 a.m.12.013 p.m.;3.00pm, and the cover glass temperature when not using PCM is 13 p.m.13.00pm to 14.00pm. On the cover glass is the place where solar radiation is channeled into the desalination device room to heat water and PCM in the basin, and the cover glass here is also the place where fresh water condensation occurs and also drains condensate water into canals and collects it in a reservoir. On the cover glass temperature in Figure 4, it can be seen that the temperature drop occurred at 15 p.m., while for the cover glass temperature on PCM paraffin, it decreased significantly at 16 p.m. due to changes in weather to rain, which caused the glass temperature to drop faster than glass on lauric acid or when not using PCM.

In figure 7, there is a comparison of the water temperature with PCM paraffin, PCM lauric acid, and without using PCM. As can be seen in Figure 7, the temperature value of the water combined with paraffin is more stable for a longer time from 12.00 a.m. to 15.00 p.m. when compared to when using lauric acid and when not using PCM. Due to weather changes at or 17.00 p.m.13.00 p.m., when using PCM lauric acid, the temperature in the water immediately drops until 16.00 p.m. 17.00pm the water temperature is still maintained at 41^0 C and then drops again, the water temperature when not using PCM where the temperature rises along wi410Cncoming solar radiati.nWhenarts If the wa,lue decreases, the water value will immediately dradiation,this is due to the absence of , eat release that occurs in the PCM to the water which causes the water p. for the maximum water value obtained by using paraffin Pandh is at 63^0 C, the maximum temperature for water that can be obtained at 13.00pm at a tempera13.00pm, 60^0 C, and630Cta collection when not using PCM the maximum temperature value is obisi600C00pm .

4.3 PCM Temperature Variation

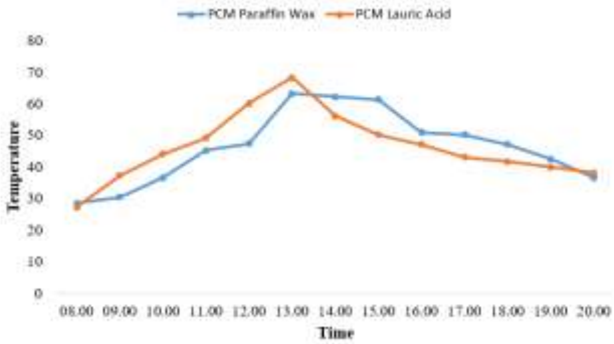
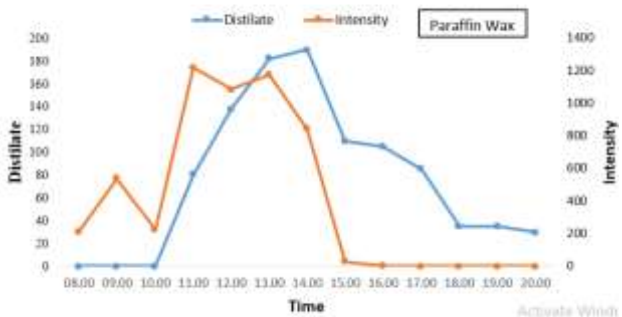


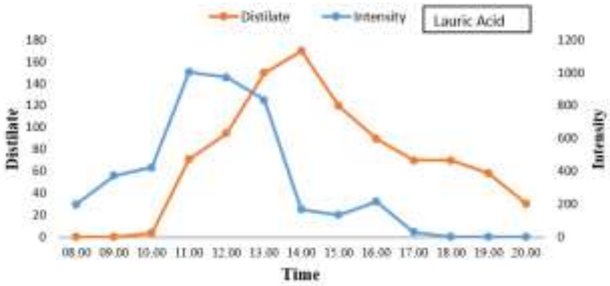
Fig. 10. Comparison of PCM, paraffin, and lauric acid temperatures against time

As can be seen in Figure 7, a graph of the temperature of PCM paraffin and lauric acid is used as a heat storage medium in order to maximize the performance of the desalination device, especially at night. Where the heat required for PCM to melt depends on the type of PCM used, for paraffin a temperature of 520 °C is required, while for lauric acid a temperature of 42–46 °C is required. As can be seen in Figure 7, PCM's heat rises constantly until 13 o'clock, which is the highest temperature received by PCM; at that time it has melted because it has exceeded its melting temperature; then, after melting, a heat release process will occur due to changes in outside temperature in the room, which happened to the PCM ball in the water. The heat dissipation process that occurs in PCM balls occurs constantly and takes longer compared to using PCM lauric acid, which releases heat more quickly.

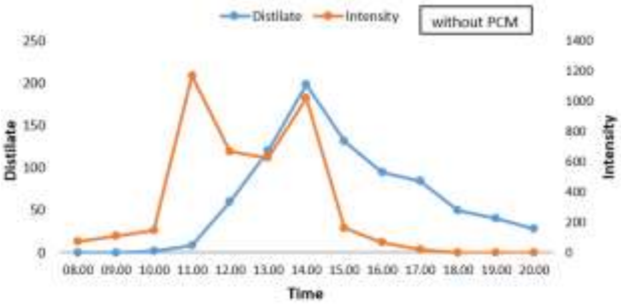
4.4 Freshwater Production



(a)



(b)



(c)

Fig. 11. Comparison of fresh water production to hourly intensity in testing with (a) PCM paraffin (b). PCM lauric acid, (d). No PCM

As can be seen in Figure 8, there is a comparison of the production of fresh water (the distillate) and the intensity of the sun when tested using PCM paraffin (a) and lauric acid (b) and when no14 p.m.t using PCM (c). As can be seen in figure (a), distillate water begins to increase at 11 a.m., when the intensity of the sun is at its highest, while for distillate water producers, the highest is at 14.00pm. then the weather immediately changed which indicated the intensity value dropped dramatically at 15.00pm, which lasted until 18.00pm where there was no more sun intensity coming in, but the distillate water continued to fall slowchanged,to the previous weather change, because the PCM had previously stored heat began to slowly releaswhent into the water and the environment around the room so that the process of producing water could continue until 20.00pm. in figre (b) in thePCM, whichst using PCM lauric aciheat,he distillate begins to increase at 11.00pm which is accompanied by an increase in the intensity of the sun which is the highest value of the intensity of the sun, the increase in distillate water continues to rise until 14.00 is the time that produces the most distillate water, although at that time the intensity of the sun had fallen, the decline started from 12.00pm to 14.00 it had decreased drastically, but the production of distillate water was still maintained until 20.00pm the water was still able to produce water. In figure (c) it can be seen that at 11.00am the intensity value was at its highest value, accompanied by an increase in the yield of distillate water until 14.00pm the distillate water was at its highest production, and at 15.00pm the weather began to change which was marked by the loss of intensity. the sun that enters until 18.00pm the intensity value becomes zero, and in the process of producing distillate water the decrease occurs from 15.00pm because there is no incoming sunlight and there is no heat storage medium used the distillate water continues to fall, using room temperature until it becomes cold, until 20.00pm less water is produced than using PCM.

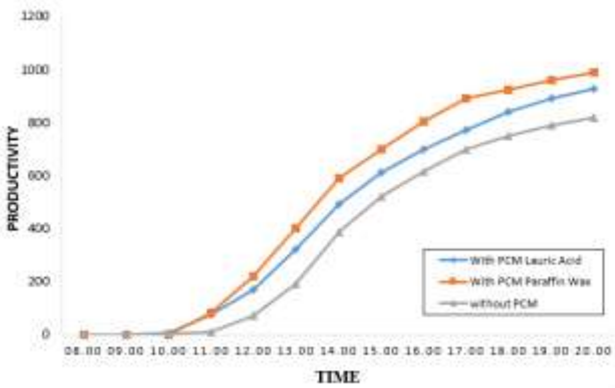


Fig. 12. Accumulated productivity water production

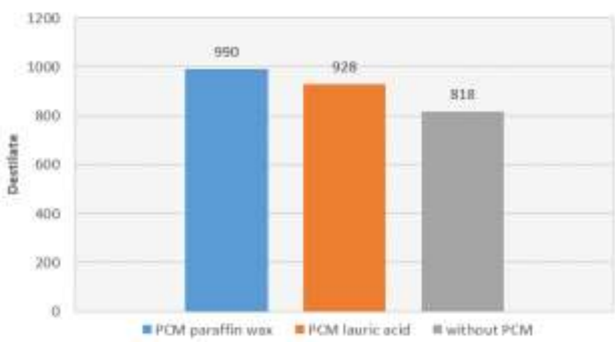


Fig. 13. Variation in the number of destilae in tests with PCM paraffin, lauric acid, and without PCM

As can be seen in Figure 9, there is a comparison of variations in the amount of distillate water collected from the desalination process when using PCM paraffin, lauric acid, and when not using PCM, starting at 18.00 am and ending at 20.00 pm. As can be seen in the data above, the highest amount of distillate production was obtained when using PCM paraffin with a production volume of 990 ml, followed by using PCM lauric acid with a distillate amount of 928 ml, and when testing without using

PCM, the distillate produced was 818, which is the least amount of distillate. This can happen because there is no PCM used. When using PCM, heat from solar radiation will be stored when it reaches its melting point and released when the temperature around the PCM is lower than the PCM melting temperature. This can help the heating process when the sun's intensity begins to decrease, especially in the evening. Therefore, in testing using PCM, it can produce more distillate water.

5 Conclusion

In producing fresh water from salt water, this research was carried out using a laboratory-scale solar desalination tool. This tool utilizes solar energy as a source of heating the salt water in the tool to make fresh water and is one of the solutions as a supplier of water in various remote areas, especially during a water supply crisis. In the tests carried out on a solar seawater desalination device by looking at comparisons when using additional different phase change materials, and when not using PCM in the dealianation device, the productivity of the desalination device with PCM can increase. Variations of the type of PCM used are paraffin wax and lauric acid. The test results show that PCM paraffin is more able to maintain hot temperatures due to a higher heat storage capacity compared to PCM lauric acid, which releases heat more quickly. The temperature that occurs in the tool decreases linearly when using PCM paraffin and PCM lauric acid, and drastic changes occur when you don't add PCM. This is because PCM can store heat when it reaches its melting point and release it again when the temperature decreases, so that the temperature drop can be kept gradual. The maximum distillate production when using PCM paraffin was 990 ml, compared to 928 ml when using PCM lauric acid and 818 ml when not using PCM.

6 References :

[1] M. Fathy, H. Hassan, and M. Salem Ahmed, "Experimental study on the effect of coupling parabolic trough collector with double slope solar still on its performance," *Sol. Energy* , vol. 163, no. August 2017, pp. 54–61, 2018, doi: 10.1016/j.solener.2018.01.043.

[2] T. Susana, "Water as a Source of Life," *Oceana* , vol. 28, no. 3, pp. 17–25, 2003, [Online]. Available: www.oceanography.lipi.go.id.

[3] LA Yoshi, IN Widiasa, P. Studi, T. Kimia, and JP Soedarto, "Reverse Osmosis (RO) Membrane Desalination System for Clean Water Supply," pp. 1–7, 2016.

[4] P. Di and K. Makassar, "Design of sea water purification equipment into drinking water using a water pyramid system (green house effect) for island and coastal communities in the city of Makassar," pp. 300–310, 2010.

[5] H. Mousa, J. Naser, AM Gujarathi, and S. Al-Sawafi, “Experimental study and analysis of solar still desalination using phase change materials,” *J. Energy Storage* , vol. 26, no. September, 2019, doi: 10.1016/j.est.2019.100959.

[6] M. Al-harahsheh, M. Abu-Arabi, H. Mousa, and Z. Alzghoul, “Solar desalination using solar still enhanced by external solar collector and PCM,” *Appl. Therm. Eng.* , vol. 128, pp. 1030–1040, 2018, doi: 10.1016/j.applthermaleng.2017.09.073.

[7] P. Kulkarni, “Water Desalination Using PCM to Store Solar Energy,” *Store Sol. Energy* , pp. 0–18, 2020.

[8] M. Dashtban and FF Tabrizi, “Thermal analysis of a weir-type cascade solar still integrated with PCM storage,” *Desalination* , vol. 279, no. 1–3, pp. 415–422, 2011, doi: 10.1016/j.desal.2011.06.044.

[9] B. Sutanto, YD Herlambang, Bono, AS Alfauzi, and DA Munawwaroh, "EFFECT OF MASS PHASE CHANGE MATERIAL (PCM) ON PRODUCTIVITY AND EFFICIENCY OF SOLAR DISTILLATION EQUIPMENT USING PCM TYPE LAURIC ACID AS HEAT STORAGE," *J. Tek. Energy* , vol. 17, no. 1, pp. 15–24, 2021.

[10] SM Shalaby, E. El-Bialy, and AA El-Sebaii, “An experimental investigation of a v-corrugated absorber single-basin solar still using PCM,” *Desalination* , vol. 398, pp. 247–255, 2016, doi: 10.1016/j.desal.2016.07.042.

[11] P. Fundamentals and P. Composting, "STUDY OF DUAL Slope ACTIVE SOLAR SEAWATER DESALINATION DEVICE WITH THE ADDITION OF SOLAR COLLECTORS," pp. 14–55, 2014.

[12] M. Syahri, "Design of a Solar Energy Desalination System Using a Transverse Half Elliptical Absorber," *Pros. Monday. Tech. Kim. Struggle* , 2011.

[13] W. Regency, D. Nur, U. Agustina, S. Sudarti, and Y. Yushardi, "Analysis of Potential Development of Seawater Desalination Technology as a Clean Water Provider," vol.

2, no. 2, pp. 7–14, 2021.
[14] S. Manan, "Solar Energy, an Alternative Energy Source that is Efficient, Reliable and Environmentally Friendly in Indonesia," *Solar Energy Altern Energy Sources. Efficient, Reliable And Environmentally Friendly. In Indonesia.* , pp. 31–35, 2009, [Online]. Available: http://eprints.undip.ac.id/1722.
[15] Mulyanef, "Solar Seawater Distillation System Using a Flat Plate Collector with a Type of Tilt Cover Glass," no. October, pp. 1–7, 2014.
[16] R. Baetens, BP Jelle, and A. Gustavsen, "Phase change materials for building applications: A state-of-the-art review," *Energy Build.* , vol. 42, no. 9, pp. 1361–1368, 2010, doi: 10.1016/j.enbuild.2010.03.026.