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Preliminary design of shrimp pond paddle wheel powered by solar energy

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Abstrak

The level of oxygen solubility in shrimp ponds is crucial for the success of shrimp farming. Hence, the farmers need waterwheels to increase levels of dissolved oxygen in the pond. In general, shrimp farmers are still relying on the wheels powered by electricity, which is supplied from the national grid and diesel engines. To overcome these problems, an alternative solution is needed by utilizing solar energy. This work aims to develop a simple design of paddle-wheel powered by solar energy for shrimp farming waterwheels. The design of this equipment used a 50 Wp photovoltaic panel to turn a 250-Watt electric motor. The electricity generated in the form of DC, stored in a 50 Ah battery, then the DC current was converted into AC by 1000-Watt inverter. Dissolved oxygen (DO) sensor digital data that is connected to a computer via Arduino Uno was recorded and displayed on the serial monitor and LCD. This equipment has been successfully tested by running directly using solar energy sources for 35 minutes.

Keywords: waterwheel, inverter, oxygen content, Arduino, solar panel, relay, LCD

1. Introduction

Shrimp ponds as an artificial and closed aquatic ecosystem are in dire need of technical cultivation treatment that can stimulate physical, chemical, and biological processes towards the balance of these aquatic ecosystems. The balance of the pond water ecosystem is expected to create a comfortable and safe environment for shrimps like its natural ecosystem. One of the facilities that has a very important role in creating the condition of pond waters as mentioned above is by conducting aeration. Aeration is the addition of air into water to make the oxygen content in the water becomes sufficient with the help of aeration equipment or aerators. According to Jayanthi, et. al, one of the ways to increase contact with water is by using mechanical equipment that serves to increase the value of oxygen entering the water [1]. One of the most popular aeration tools used is the paddle wheel aerator [2]. One type of aeration device is the paddle wheel aerator which is the most common aerator used for aquaculture ponds. This is because the aerator windmill type is the best aeration method in terms of aeration mechanism and driving force [3].

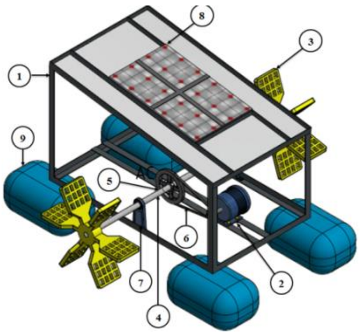
The application of SPP (Solar Power Plant) system for the windmill drive system in shrimp ponds is needed by shrimp farmers to increase shrimp production. During this time, the technique of operating a waterwheel on a shrimp pond, on average, uses electrical energy whose resources come from PLN and diesel engines that run on diesel fuel. However, the use of waterwheels driven by electricity from PLN and diesel engines require high operational costs, and makes the sustainability of the waterwheel business in its current utilization is hard to maintain. Therefore, we need a waterwheel for the operation of shrimp ponds whose source of energy comes from the sun.

In this case, to detect dissolved oxygen levels in pond water a dissolved oxygen (DO) sensor is needed. The dissolved oxygen sensor is part of an electrochemical sensor in which the reaction of oxygen gas with an electrolyte solution produces an electrical signal with a magnitude proportional to the amount of oxygen concentration [4]. According to Dien, et. al, one of the important things in shrimp farming in ponds is the source of DO (Dissolved Oxygen) which is sufficient in water [5]. This means that the amount of oxygen content is sufficient to fulfill the shrimp oxygen supply. Reduced pond water quality due to low oxygen levels can cause disease outbreaks for shrimp ponds [6].

In this research, a solar-powered aerator was designed. This equipment was then fabricated, assembled and tested to find out how long the paddle wheel aerator can operate. The design of this aerator was equipped with an automatic start-up system based on DO levels in order to save the power consumption.

2. Methodology

This research was carried out by using of solar energy as the main source of power to drive an aerator. This research begun with the design of equipment. The process included the design of fabricating tool, materials and estimated costs needed in making tools. During equipment design stage, prudent planning is needed in order to get accurate data. In addition to the design stages, it also needs to be prepared the paddle wheel design. After completing the design, then do the assembly of tool components. The component assembly must be in accordance with the frame of reference made to minimize errors in the manufacture of tools. Component assembly was divided into two stages, namely engine assembly and solar panel component assembly, in order to facilitate workmanship. The design of shrimp ponds using solar power can be seen in Figure 1.



No	Description
1	Angle bar Structure
2	Electric motor
3	Wheel blades
4	Shaft
5	Pulley
6	V-Belt
7	Bearing
8	PV panel
9	Floats

Figure 1. Design of shrimp pond wheels using solar power

In Figure 1, it can be seen that shrimp pond wheels have several components. The solar panel used has a type, namely polycrystalline Model: GH50M-18 with a power of 50 Wp. The battery used is the GS Premium 12 Volt 50 Ah. The inverter used is 1000 Watt. The electric motor used has AC current with a power of 250 Watt. Arduino used is Arduino UNO.

The process works the same as shrimp pond water wheels in general. But the difference is how to utilize solar energy by using photovoltaic panels. When the solar panel is exposed to sunlight, the solar panel generates electrical energy which is controlled by the solar charger controller and makes the output voltage of the solar panel is stable. The solar charger controller will insert solar panel energy into the battery when the engine is not working, which is often called charging or charging the battery. When the engine is working, the electric motor energy will take energy through the battery. The battery output voltage is a DC voltage while the motor requires an AC voltage to work. Consequently, an inverter is used to convert DC voltage to AC voltage. Once the motor rotates, the rotation is then forwarded to the shaft by using a pulley and v-belt. The water in the pond is stirred by using a propeller to increase the dissolved oxygen content in the pond.

The process of data retrieval in this study was divided into four parts, namely the first collection of battery charging data. Battery charging data is needed to find out how long the battery charging process uses solar panels. Measurements are made using a multi-meter to measure the voltage and current. The power is estimated by multiplying the voltage and current. Secondly, data collection on the pond wheel is done by measuring the battery. Tests carried out to determine the current and voltage that flows before finally entering the DC to AC inverter. Measurements were carried out the same as charging data collection using digital multi-meters. The third is measuring the rotation of the paddle wheels shaft. This is done to find out how much influence the spinning wheel on power consumed. Retrieval of speed data is carried out using a tachometer. Fourth, measure DO levels by using a DO sensor, which is to find out how much dissolved oxygen levels are in the water then it can be adjusted to an automation system.

3. Results and discussion

3.1. Battery Charge Test

Data collected in this experiment was aimed to find out how long it takes to charge 12 Volt 50 Ah battery capacity using a 50 Wp solar panel with a solar panel tilting angle of 25º. Charging data collection was carried out on July 15 2019 - July 17 2019, at the Bukit Indah Campus. Found that the right angle of the solar panel for the rainy season is 1º while for the dry season, it is 24º [7]. Whereas Gharakhani, et. al, explained that the tilt angle of solar panels that produce higher amounts of voltage and current is at an angle of 25º [8]. At the angle of the slope, it produces the most maximum power value leads to optimum efficiency. Table 1 is the observation data on charging during the daytime, starting at 09.00 until the battery is fully charged from the empty battery condition. The observation was carried out for three days.

Table 1. Battery charging data using solar panels

Time (Hour)	Voltage and Current Measurement					
	Day First		Day Second		Day Third	
	Volt. (V)	Curr. (A)	Volt. (V)	Curr. (A)	Volt. (V)	Curr. (A)
09.00	11.88	0.25	11.85	0.25	11.96	0.30
10.00	12.10	0.9	12.24	1.00	12.19	1.00
11.00	12.86	1.50	12.62	1.50	12.92	1.5
12.00	13.22	1.60	13.29	1.68	13.17	1.55
13.00	13.24	1.65	13.27	1.65	13.26	1.65
14.00	13.13	1.55	13.18	1.55	13.22	1.6
15.00	13.18	1.55	13.24	1.60	13.15	1.50
16.00	12.97	1.50	12.97	1.55	12.48	1.50
17.00	12.37	1.49	13.39	1.25	12.33	1.45

Then from the data in Table 1 above to get power, a multiplication of voltage (Volt) and current (Ampere) is performed. By using the same equation, you will get a power calculation done for three days. Table 2 is the data of the results of power calculations performed for three days.

Table 2. Power calculations

Time (Hour)	Calculation of Power (Watt)			Average
	Day First	Day Second	Day Third	(Watt)
09.00	2.97	2.96	3.58	3.17
10.00	10.89	12.24	12.19	11.77
11.00	19.29	18.93	19.38	19.2
12.00	21.15	22.32	20.41	19.98
13.00	21.84	21.89	21.87	20.89
14.00	20.35	21.42	21.15	21.86
15.00	20.42	21.18	19.72	20.73
16.00	19.45	20.10	18.72	19.75
17.00	18.43	16.72	17.80	14.76

The data in Table 2 then made into a graph that is useful for knowing the graph of power generated during the three-day charging process. The power generated during charging can be seen in Figure 2.

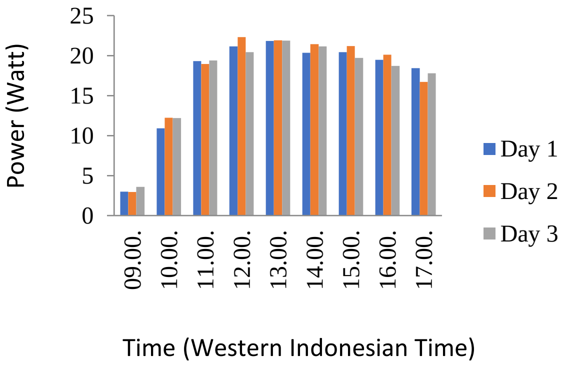


Figure 2. Power comparison graph during the charging process

From Figure 2 above, it can be explained that during the charging process of 12 Volt 50Ah batteries using 50 Wp solar panels is not constant from day to day. The increase and decrease in power produced occurs in three times observations. The most significant power supplied occurs during charging on the second day, where the highest time occurs at 12.00 with the power supplied at 22.32 Watt. While the lowest power supply occurs when charging the second day at 09.00 with a power supply of 2.96 Watts.

3.2. Paddle Wheel Performance Testing

In testing the instrument, it must be placed in a location that has sufficient volume of water and an adequate area to work optimally. Data is collected at 12.00 when the maximum sun. Furthermore, for the installation of paddle wheels according to Prasetyaningsari, et. al, that the blades owned by the windmills were submerged as deep as 3 cm into the surface of the water previously installed by a float [9]. The height of the wheel is adjustable on the water surface. Tests carried out with a 250 Watt paddle wheel load using 50 WP solar panels and 50 AH batteries. The observation is to find out how long the paddle wheel can be lit and how much power is produced by the paddle wheel. Data on testing shrimp ponds using solar power during the day can be seen in Table 3.

Table 3. Daytime testing data

No.	Weather	Time (minute)	Power (Watt)	Shaft Rotation (rpm)
1	Sunny	Start	423.15	-
2	Sunny	5	407.40	53.73
3	Sunny	10	403.90	52.24
4	Sunny	15	400.05	50.04
5	Sunny	20	396.20	48.21
6	Sunny	25	392.00	45.19
7	Sunny	30	387.80	41.27
8	Sunny	35	381,85	39,27

The data in Table 3 is then made into a graph, as in Figure 3.

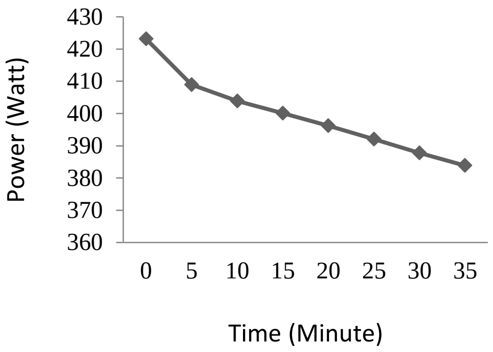


Figure 3. Power consumed by the wheel

From Figure 3, it can be concluded that the greatest power consumed when the start of the paddle wheel is turned on. This happens because of a large power jump when the electric motor is first turned on. When the paddle wheel is turned on, it starts to produce waves on the surface of the water. The time needed for the battery to turn on the wheel is about 35 minutes. The initial power produced by the wheel is 423.15 Watt after the wheel turns on for 5 minutes and the minimum power produced by the wheel is 381.85 Watt.

From Table 3, it can also be seen that the highest rotation of the shaft produced by 53.73 rpm has decreased to reach the slowest rotation, which is equal to 39.27 rpm. This is because the power consumed by the wheels decreases hence the rotation of the paddle wheels is also decreased.

3.3. Automation System Testing

The automatic system testing scheme can be seen in Figure 4.

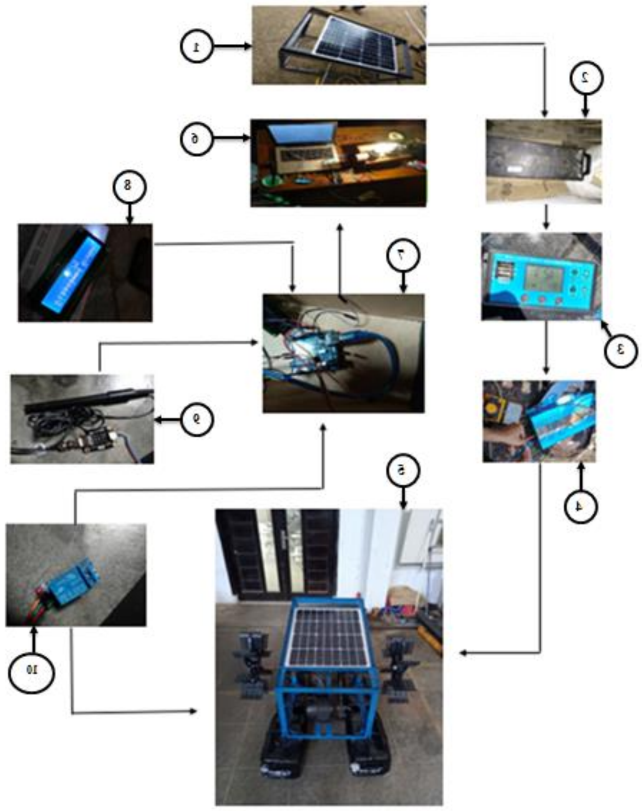


Figure 4. Schematic flow testing process pond automation system

No.	Section Name
1	Solar panel
2	Accumulator
3	Solar charger controller
4	Inverter
5	Paddle wheel
6	PC (Personal Computer)
7	Arduino UNO
8	LCD
9	Dissolved oxygen sensor
10	Relay

In Figure 4 it can be explained that in the initial stages solar panels exposed to sunlight store electrical energy into batteries which had been previously stabilized by the solar charger controller energy. The current in the battery which was originally in the form of DC is changed to AC current using an inverter and the battery is ready to be used to work the paddle wheel. In the automation system Arduino is connected to the computer then Arduino becomes the main center for LCD, DO and Relay Sensors, after the Relay is connected to Arduino then the electric motor cable that has been cut is connected to the relay to make it ON - OFF automatically.

This test aims to determine the level of accuracy of the sensor in making measurements on an object. This test is carried out during the day from 11:00 to 16:00. This is performed until the necessary data is collected completely and repeated three times, the data obtained are shown seen in Table 4.

Table 4. Test result data

Observation Schedule (Hour)	DO beginning (ppm)	DO End (ppm)
11.00 - 12.00	6.21 (On)	9.43 (Off)
14.00 - 15.00	6.00 (On)	8.72 (Off)
16.00	6.60 (On)	8.79 (Off)

From Table 4 above obtained different DO values and the results of observations made on dissolved oxygen obtained the lowest that is equal to 6 ppm and the paddle wheel alive (on) indicates the quality of dissolved oxygen in water is not enough while the highest is equal to 9.47 ppm paddle wheel off (off) indicates the quality of dissolved oxygen in water is sufficient.

Based on the Conservation Research Commission, stated that the content of dissolved oxygen in water suitable for life and growth of aquatic biota is at least 4 ppm and a maximum of 8 ppm [10]. Further explained by Brasil, et. al, who stated that shrimp is still able to survive at oxygen concentration as low as 4 ppm, but this condition can lead to shrimp appetite decrease and slow down the shrimp growth [11].

4. Conclusions

Solar power generator for shrimp pond water system has been designed which consists of several components including a 50 Wp solar panel, solar charger controller, inverter, 50 Ah battery, and also a 250 Watt electric motor. Testing of this equipment shows that waterwheel can operate for approximately 35 minutes using solar energy only. The waterwheel automation system based on DO levels was successfully run with a reference range of DO levels of 6.00 ppm - 9.29 ppm. Further investigation is needed on the depth of dip on the pedals and transmission system.

Acknowledgment

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