Engineering of Automatically Controlled Energy Aeration Systems for Fisheries Cultivation Pools

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Abstract

Billi Rifa Kusumah, Asep Kostajaya, Dedi Supriadi, Eulis Hendra Nugraha, and Ridwan Siskandar. 2020. Engineering of Automatically Controlled Energy Aeration Systems for Fisheries Cultivation Pools. *Aquacultura Indonesiana*, 21 (2): 74-81. Fish need oxygen for metabolic processes, especially cultured fish. The high amount of dissolved oxygen (DO) in the water greatly affects the quality of life of the fish. A good aquaculture pond is a pond that uses an aerator machine, because the dissolved oxygen content will fulfill the life of all fish. The purpose of this research is to design an automatic controlled aeration device system and utilize solar panel technology as an energy source. This system uses a monitor feature for controlled oxygen levels using a DO sensor, the results of the monitoring are then displayed on the LCD. The data will be processed to make a decision, whether the aerator engine is on or off. The aerator engine activity is continuously controlled by a device connected to a sensor. The sensor will measure real-time dissolved oxygen levels and display it on the LCD. The test steps carried out on this tool are the automation response system test and power resistance test based on the load of the electronic circuit. In the automatic system setting, when the DO value exceeds 6.86 mg/L, the aerator engine will shut down, then restart when the DO level is below 5.20 mg/L. Solar Panel electrical devices with a capacity of 10 WP, 10 A controllers and a 12 V, 7 Ah battery, are sufficient for the energy needs of electronic circuit loads. System testing shows that the system is functioning properly as intended.

Keyword: Aerator; Automatic control; Energy saving; Solar panel

Introduction

Aeration is the process of adding oxygen to a medium until the dissolved oxygen concentration in the medium gets higher. The most common and easy to understand case example is the aeration process in a water medium. Dissolved oxygen content is one of the most important water quality parameters in the fish culture management system. The level of dissolved oxygen concentration greatly affects the success rate of the fish ecosystem to live. If the oxygen level is low, it indicates that there has been a decrease in the quality of pond water. One of the causes is the accumulation of organic compounds from food waste and manure which then decomposes to form high ammonia. (Salmin 2007).

In principle, the process of photosynthesis that occurs naturally will keep dissolved oxygen at optimal conditions. However, in a fish culture pond system, the content of oxygen concentration is very fluctuating, largely determined by the density of fish which are oxygen consumers and phytoplankton as well as other types of aquatic plants which are primary producers of oxygen.

Nowadays, almost every aquaculture pond has used an additional aeration system using a pump / dynamo machine or so-called an aerator. The use of this technology is very useful for maintaining the stability of the oxygen
concentration so that it remains above the minimum limit (Kuman et al. 2013). Initially, the source of electricity for the aerators was AC voltage, then developed aerators with DC voltage sources. This technology is increasingly sophisticated with the engineering of solar panel technology. The integration of aerator technology with solar panels has provided great benefits to the fish pond culture cycle. The cost of electricity for the daily component of cultivation pond farmer groups can be drastically reduced so that it can reduce total expenditure (Adiyana and Supriyono 2015). Aerator technology engineering still needs to be developed to be able to provide maximum positive output as developed by Siskandar and Kusumah 2019.

The purpose of this research is to design an automatic controlled aeration device system and utilize solar panel technology as an energy source. The principle applied to this engineering is that the aeration system can turn on and off automatically based on information on dissolved oxygen (DO) content which is measured in real-time and the measurement results are displayed on an LCD. In the automation control system, there is a microcontroller that instructs the sensor to measure DO. The results of the analysis of DO data measurements will then be processed and become the decision material for the microcontroller to order the aerator to turn on or off. The source of electrical energy used for all components is solar panel energy which is stored in the battery. This development will be very useful to reduce the waste of energy sources in the aeration system. This system will save more on spending on electricity sources.

**Materials and Methods**

The steps taken in this research are, the concept of tool engineering, the design concept of application, design and construction of hardware and software, testing automation systems, testing power.

**Tool concept**

In the scope of failure of fish farming, one of them is caused by decreased water quality. This reduction can be overcome by the aeration system. However, the addition of these machines will add to the routine expenses of the farmer group's electricity costs. An alternative energy device that can be controlled automatically can be a solution to solve this problem (Mardhiya et al. 2017).

The 10 WP solar panel device and a 10 A controller are used to capture solar energy and then store it in a 12 V, 7Ah battery. The battery is used as an energy source to run aerator machines and automation control devices (Subandi and Hani 2015). The working principle of the device is to monitor dissolved oxygen (DO) levels in fish ponds. If the DO level is 6.86 mg / L, the aerator engine will die. The aerator engine returns to life when the oxygen content is monitored below 5.20 mg / L. Arduino uno as a microcontroller controls the work of the DO sensor and orders the aerator engine to turn on or off.

**Design concept**

The illustration of the application of the tool is illustrated in Figure 1. The need for research is divided into three parts, namely; alternative energy source devices such as solar panels, controllers and batteries; automation control devices such as arduino uno, DO sensor, LCD; and testing equipment such as ponds, fish and aerator.
The focus of the study materials described in this paper are energy source devices and automation control devices. The electronic system of energy source devices and automation control devices is shown in Figure 2.

The electronic circuit schematic is shown in Figure 2. Solar panels have a power pin configuration, namely VCC and GND. The power pin is connected to the input pin of the controller component, then forwarded to the battery component via the 12 volt controller output pin. The battery energy will continuously be charged until the condition reaches its maximum point, then the controller component will cut the charging current automatically.

Automation control devices derive their resources from Accu. Through the Arduino Uno component, electrical power is supplied to almost all components such as the DO sensor and LCD, while the Aerator Motor power is supplied directly from the battery. The DO sensor data pin configuration is controlled by the Arduino A0 pin, the Aerator Motor data pin configuration is controlled by the Arduino pin 9, while the LCD data pin configuration is connected to the SDA-SCL pin Arduino uno because it uses I2C communication. Figure 3 is an explanatory diagram of the previous electronic schematic. Figure 3 describes the relationship between each component. The red arrow symbol represents the power route and the blue arrow symbol represents the data route.
Laboratory Tests and Performance Analysis

Laboratory tests are carried out after the engineering process to ensure the control device is working as expected. At this stage, the device automation system test is carried out and the power estimation test is carried out. Testing of the automation device system is needed to see the success rate of the automatic control device. The DO sensor is inserted into a container smaller than the pool, then the container is inserted into the aerator machine. The treatment observed was the automation pattern of the aerator engine on-off system based on measured DO sensor levels. At the same time, the researchers measured the consumption of electric current used when the aerator engine was turned on and when the aerator engine was off. Information on the consumption of electric current is a reference for calculating the range of power usage used. To consider that the cycle of electrical energy can be used continuously every day, the calculation of the power used is then compared with the calculation of the incoming power.

Results and Discussion

Test the program algorithm

The designed program algorithm is shown in Figure 4. When the control device starts getting power, the control device will start initializing the DO sensor and LCD module. DO sensors continuously monitor DO levels and display on the LCD. In designing the algorithm, when the measured DO value is more than equal to 6.86 mg / L, the aerator engine will shut down, and the monitoring system will rest for thirty minutes, then after that the sensor will actively monitor DO. If the measured DO value is less than 5.20 mg / L, the aerator will turn on again. The systematics of this algorithm continues until the power source is turned off.
The results obtained from testing the algorithm are shown in Table 1. The automation test of the device was carried out on a small container measuring 30 x 30 x 20 cm with four tilapia fish weighing a total of one kilogram. The use of a smaller size is done only to speed up the aeration filling process, so that success or failure can be seen in a faster time.

Table 1. Results of testing the algorithm for the automation control device program

<table>
<thead>
<tr>
<th>Time Trial</th>
<th>Initial DO (mg/L)</th>
<th>Initial Aerator</th>
<th>Final DO (mg/L)</th>
<th>Final Aerator</th>
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<tbody>
<tr>
<td>1</td>
<td>5.01</td>
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<td>6.87</td>
<td>Off</td>
</tr>
<tr>
<td>2</td>
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</tr>
<tr>
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<td>6.86</td>
<td>Off</td>
</tr>
<tr>
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<td>6.86</td>
<td>Off</td>
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<td>On</td>
</tr>
<tr>
<td>5</td>
<td>5.18</td>
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<td>Off</td>
</tr>
<tr>
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<td>6.87</td>
<td>Off</td>
<td>5.19</td>
<td>On</td>
</tr>
<tr>
<td>7</td>
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</tr>
<tr>
<td>8</td>
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<td>5.19</td>
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<tr>
<td>9</td>
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</tr>
<tr>
<td>10</td>
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<td>On</td>
</tr>
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<td>On</td>
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<td>6.87</td>
<td>Off</td>
</tr>
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<tr>
<td>20</td>
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Aerator machines and automation devices run simultaneously at 06.00 WIB, at which time the duration starts to be calculated in the 1st time experiment table. The automation process from the aerator engine to turn off works after 120 minutes. This means that the aerator machine has added the DO concentration in the water container beyond the specified standard limit, namely 6.98 mg / L. Then the automation device ordered the aerator machine to shut down. Furthermore, in the second time experiment table section, it shows that the automation process of the aerator engine turns off to work after 30 minutes. This means that the fish in the water container have taken advantage of the DO until it is reduced from the specified standard limit of 5.20 mg / L. Then the automation device instructs the aerator machine to turn back on. This experiment was repeated in the k-3 time trial until the 20 time trial. The total time required for this trial was 6 hours. Automation devices can control the work of the aerator machines as expected. The delay in response to the command to turn on or off in each time trial was caused by the speed rate of the microcontroller. However, this is still within reasonable limits, because overall the largest difference in delay response is 0.01 mg / L.

**Power test**

The main energy source of this tool is a battery with an output voltage of 12 V, a capacity of 7 Ah. Based on laboratory tests, it is found that the current consumption when the aerator is off is 61.7 mA, and when the aerator is on, it is 0.21 A (Figure 5).

Figure 5 Current measurement when the aerator on (left), aerator is off (right)

The use of current in a sustainable manner can be calculated by knowing the work pattern of the aerator. The start and stop of the aerator is influenced by the DO concentration in the water, so that the aerator's working pattern is inconsistent. The current consumption model of the automatic controlled energy-saving aeration system engineering is shown in Figure 7.
To find out the number of solar panels and battery capacity that can meet the minimum power requirements for the instrument, we use an example of a maximum current of 210 mA (0.21 A). By using the current value, the power used is 24.2 watts per day. To determine the number of solar panels that need to be used, namely multiplying the capacity of the WP solar panels used with the effective time the solar panels charge in one day (Equation 1) (Safrizal 2017).

\[
\text{Number of Solar Panels} = \text{WP} \times \text{effective fill time} \quad (1)
\]

In general, the effective filling time in tropical regions including Indonesia is 4 hours. If you use 20 WP solar panels, then the amount you need is 1 piece. Then, to determine the type and number of batteries that need to be used. A good type of battery for a solar panel system is a dry battery. If the capacity used is 12 V, 7 Ah, then the number of batteries needed can be calculated using equation 2.

\[
\text{Number of Batteries} = \frac{\text{total load day}}{\text{Battery Voltage}} \times \frac{1}{\text{Battery Ampere}} \quad (2)
\]

Based on calculations using Equation (2), the number of batteries needed is one. While the selection of the SCC (solar controll charge) specification is adjusted to the number of Isc values on the solar panels used.

**Conclusion**

The automation control device works according to the specified DO level setting. The aerator engine turns off when the DO sensor shows a level above 6.86 mg/L and turns back on when the DO sensor shows a level below 5.00 mg/L. The power source of the 12 V, 7 AH battery connected to the 10 WP Solar Panel with a 10 A controller can replenish the electrical energy used by the aerator engine and automation devices, so that the aerator engine and automatic control devices can continue to live.

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