Discussion on the design of solar aerator for fish pond

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Abstract. The solar energy is used as the power of the aerator in the solar aerator for fish pond to provide sufficient oxygen for fishes in pond, which meets the needs of general aquaculture. In this paper, solar energy is used as the power source of aerator, and weak current DC aerator replaces the traditional existing strong alternating aerator. The system comprises of a polycrystalline solar panel square array, solar panel bracket, controller, colloidal battery, DC aeration blower, micro-porous aeration coil, DC-DC regulated adjustable power supply module, DC brushless water spray aerator, etc. The experimental results show that the solar aerator can work for 6.5 hours per day on average. Furthermore, after adding the DC-DC regulated and adjustable power supply module, the voltage and the current of the solar aerator are relatively stable. Therefore, the aerator has a noticeable effect on the dissolved oxygen in the water, and it can effectively and stably provide the necessary oxygen for the fish pond.

1. Introduction

China is one of the largest agricultural countries in the world. Fishery occupies a large proportion of the national economy, and the culture and consumption of aquatic products play important roles among them[1]. The aquaculture of aquatic products needs to seek the maximum benefit in the limited land resources, which results in the aquaculture practitioners increasing the density of aquaculture ponds. It is very easy to cause anoxia of fish when the weather changes suddenly, and even cause the death of fish. At the same time, the fish pond aerator provides sufficient oxygen for high-density aquaculture ponds and makes full use of the water to promote the speed of material circulation in the pond. These can effectively avoid the death of fish caused by insufficient oxygen supply for high-density aquaculture. Moreover, it can improve and stabilize the water quality at the same time. The rapid development of the fishery is inseparable from the contribution of natural energy. Taking solar energy as the power source of agricultural appliances can ensure the regular operation of agriculture. It has a good application prospect[2].

The traditional fish pond aerator uses municipal electricity as its power source, which needs to be connected to the power grid. However, aquaculture is mainly located in the outskirts of the sparsely populated field ponds or lakes, which brings a lot of trouble to the power supply of fish pond aerator[3]. The traditional fish pond oxygen supply device not only consumes more electricity and costs more, but also has the disadvantages of trouble accessing the power grid and unsafe electricity consumption. Using solar energy as the power source of aerator for fish pond and designing suitable aerators for fish pond can improve the mechanization level of fishery and increase the economic benefit of fishers. The design of solar aerator for fish pond can expand the application of solar energy...
in agricultural production, furthermore, improve the economic benefit and market competitiveness of fishery.

2. Design scheme

In most areas of China, there is abundant sunshine in summer. In sunny days, the surface temperature of fish ponds is relatively high at noon, and the activities of plankton and microorganisms in the water are quite frequent, which requires a large amount of oxygen. Meanwhile, the high-temperature weather also causes a sharp drop in the oxygen content in the water. Therefore, in order to make the fish move normally, it is necessary to provide 2-3 hours of dissolved oxygen for the fish pond at noon. Giving a full play to the oxygen-increasing and cooling function of the aerator can cool the surface of the fish pond and increase the dissolved oxygen in the water, at the same time, it can accelerate the material circulation of the fish pond, improve the water quality and reduce the occurrence of hypoxia in the fish population[4].

Plankton gathers downwind for aerobic respiration at night, resulting in a gradual decrease in dissolved oxygen in the water below. In addition, on rainy days, the photosynthesis of plankton is weak, which also leads to a lack of dissolved oxygen in the water. Therefore, it needs to start the aerator of the fish pond in order to prevent the occurrence of hypoxia promptly in this case[5].

The dissolved oxygen of fish pond can be influenced by time, seasons, solar illumination intensity, wind direction and water layer position of fish pond, which will impact the design of solar aerator. In addition, the design of the solar aerator is required to provide sufficient dissolved oxygen in the downwind area of the fish pond for three consecutive rainy days.

The system sets a DC micro-porous aeration coil oxygen supply in the middle of the downwind direction and a DC brushless water spray oxygen supply in the middle of upwind direction. In the downwind direction, the solar power generation system uses the controller to charge and discharge the colloid battery, and provides electric energy to the DC micro-porous aerated coil oxygen supply unit. The DC micro-porous aerated coil oxygen supply unit can supply the dissolved oxygen for the lower layer of the fish pond at noon on sunny days, and it can also provide enough dissolved oxygen for the fish pond on cloudy days. In the upwind direction, the solar power generation system provides electric energy to the DC brushless water spray oxygen supply through the DC-DC regulated adjustable power supply module. The DC brushless water spray oxygen supply cools the surface of the fish pond and provides the necessary dissolved oxygen during sunny days[6]. The distribution of the solar aerator system is shown in Figure 1.

![Figure 1. Distribution diagram of solar aerator system](image-url)
In this design, a relatively safe weak current DC oxygen supply device driven by solar energy is used to provide oxygen and cool the fish pond. The solar power generation system can constantly adjust and switch the charge and discharge of the colloidal battery group according to the solar radiation intensity and oxygen supply load. The adjusted electric energy is released to the DC aeration blower in the downwind direction. The DC aeration blower drives the micro-porous aeration coil laid in the lower area of the water to supply oxygen. In the upper area of the water in the upwind direction, the DC-DC regulated adjustable power supply module provides electric energy for the DC brushless water spraying oxygen supply device. The colloid battery pack can also store the excess electric energy of the photovoltaic power generation system to provide the necessary power for the system through the controller when the light intensity is weak or on cloudy days, to realize the continuous and stable work of the system.

3. Experimental equipment
The system comprises a polycrystalline solar panel square array, solar panel bracket, controller, colloidal battery, DC aeration blower, micro-porous aeration coil, DC-DC regulated adjustable power supply module, DC brushless water spray oxygen supply device, etc. The experimental equipment is shown in Figure 2.

3.1. Solar cell
The polycrystalline solar photovoltaic panel model used in the system is SFP-275W, with a conversion efficiency of 20%. It has A peak voltage (VMP) of 30V and A peak current (IMP) of 9.17A. It is calculated that the daily power generation of a single solar panel assembly is 41.96Ah. The number of parallel solar modules used in the system is 4. The design output power of the solar cell array is 1100kW and the current is 40.36A.

3.2. DC Brushless water spray type oxygen supply
The traditional oxygen supply device needs the strong alternating current of the grid to provide electricity, which consumes high electricity and costs a lot, and it is easy to cause safety accidents in bad weather or improper operation. The solar aerator using a safe and reliable DC weak current oxygen supply and a DC brushless motor oxygen supply can reduce the electric spark generated by the brushed motor in operation, and it is more favorable to the growth and development of fish with the lower noises.

3.3. DC aeration blower
Aeration blower is the equipment that pumps the air with a certain volume and pressure into the water through the fan and the conveying pipe. The purpose of aeration blower is keeping enough dissolved oxygen in the water to meet the oxygen demand of aerobic organisms. In order to thoroughly stir and
dissolve oxygen in the liquid and achieve a good effect of increasing oxygen, the system uses high-pressure aeration blower.

3.4. *Micro-porous aerated coil*

The DC aeration blower is connected to a micro-porous aeration coil laid in the lower area. It produces a lot of bubbles in the water. Because the micro-porous aerated coil is submerged in the lower water body, the contact surface with the water body is very large. The floating velocity of gas is significantly reduced due to the resistance of water when it is working, which can increase the contact time between air and water. Therefore, it can achieve a full and efficient oxygen supply effect and improve water quality and fish pond environment at the same time.

3.5. *Photovoltaic controller*

In order to achieve a good charge and discharge control of the colloidal battery, a 24V50Ah photovoltaic controller is selected in this design. The controller rated charging current is 30A, rated power generation current is 10A. The working current of the high-pressure aeration blower is 8.3A. The photovoltaic controller can meet the charging requirements of photovoltaic panel for battery and the discharge requirements of battery for aeration blower.

3.6. *DC-DC regulated adjustable power supply module*

The function of the DC-DC regulated and adjustable power supply module is to convert the variable DC voltage into a fixed DC voltage. It can effectively stabilize the solar panel’s irregular current and voltage output in the solar aerator system. It can make the oxygen supply device work stably and efficiently.

3.7. *Colloidal battery*

The colloidal lead-acid battery is used to provide sufficient electrical energy for the system at night or on continuous rainy days. After calculation, the system selects two 12V, 300Ah colloidal battery series. It is used as an energy storage device for the solar aerator.

3.8. *Solar power panel bracket*

The solar panels are fixed with brackets. The bracket is made of stainless steel with double plate angle, and the two sides of the bracket are connected by movable hinge. It can change the installation angle of solar panels according to the requirements of different geographical environment. The bracket is fixed on the base of the fish pond with expansion screws.

4. **Experimental test and results analysis**

Different comparative experiments were carried out on the oxygen supply system of the solar pond. The design can be further refined by testing different factors that affect solar power generation. It also can provide some experience and adjusting methods for solar aerator in fish pond in the future.

4.1. *Variation of voltage with tilt Angle in the same period*

In order to make the system work efficiently and stably, the system was tested on the top floor where there were no other objects around during the period of maximum solar illumination intensity at noon (13:00-14:00). Set the azimuth to 16.5 degrees, changing the angle of the solar panel to the horizontal plane. The test voltage (open circuit voltage) varies with the tilt Angle. To reduce experimental error, a series of tests were carried out within ten minutes. The test results are shown in Figure 3.
4.2. Variation of the installation voltage with time at the same Angle

In order to test the effect of system operation at different intervals, the system was tested between 9 am and 10 am. The azimuth angle was fixed at 16.5° and the inclination angle of 22°. The open circuit voltage of the system is measured 13 times in one hour with a multimeter. The test results are shown in line figure 4.

4.3. The influence of regulated and adjustable power supply module on the system

After several times of testing and analysis, it is found that although the oxygen supply directly connected to the solar power generation array can work, but due to the light intensity, temperature, wind speed or installation angle changes, the output voltage of the system is not very stable. Therefore, a DC-DC regulated and adjustable power supply module is added to the oxygen supply and generator board. During the test, the azimuth angle was fixed at 16.5° and the inclination angle was 22°. To reduce experimental error, a set of data should be measured within three minutes. The test results are shown in Figure 5.
4.4. Effect of time on oxygen supply power
To test whether the solar aerator can work normally, when the azimuth angle and inclination angle are fixed, several sets of data of the solar aerator system are tested at different times. The results are shown in Figure 6.

![Figure 6. Variation of oxygen supply power over time](image)

4.5. Effect of oxygen supply on dissolved oxygen in the water
In order to test whether the dissolved oxygen in the water can achieve the expected effect after the oxygen supply has been running for a while, the dissolved oxygen in the water was tested at different time after the system start-up. The test results are shown in Figure 7.

![Figure 7. Influence of oxygenator on dissolved oxygen in the water](image)

5. System improvement
By analyzing dissolved oxygen changes in different water layers at different times, the system laid micro-porous aeration coils in the lower waters and set water-jet oxygen supply in the upper waters. It can provide enough dissolved oxygen for the fish pond and effectively improve the water quality and the environment of the fish pond. To optimize the oxygen supply mode of the fish pond, the system can still be improved.

For the purpose of making the system work quickly, stably and efficiently, a set of automatic detection and monitoring feedback system of dissolved oxygen in water can be added on the basis of the original design. The work of DC aeration blower is controlled by real-time monitoring of dissolved oxygen, temperature and PH value of fish pond, hence the solar aerator becoming truly automated and intelligent can be achieved.

6. Conclusion
The system set up 4, 275W polysilicon solar power panels in parallel and two 12V300AH colloid battery series in this design. To achieve a good charge and discharge control of the colloidal battery,
the system is equipped with a 24V50Ah photovoltaic controller. It set up a 200W24VD DC high-pressure aeration blower and a 400W power and 24V DC brushless water-jet oxygen supply device. In sunny days or continuous cloudy and rainy days the system can provide fish pond daily growth and development of dissolved oxygen.

The solar aerator system can work 6.5 hours a day on average after testing for one week. After DC-DC regulated and adjustable power supply module is added to the system, the voltage and current of the oxygenator are relatively stable, and the oxygenator has an obvious effect on the dissolved oxygen in the water. The experimental results show that the system can effectively and stably provide the necessary oxygen for the fish pond.

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