SOLAR ENERGY PADDLE WHEEL AERATOR.

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ABSTRACT

Oxygen was vital to all livelihoods and lives. A life required oxygen to maintain various processes in the body for growth. If oxygen did not exist or existed too little, a life was unable to continue. Amount of oxygen dissolved in water was necessary to aquatic animals' beings. Moreover, it was also an indication of water condition. As the amount of oxygen dissolved in water was diminished, the water became polluted. Therefore, it was essential to increase the oxygen level in water by using paddle wheel. In general, such paddle wheel used power supply by electricity. Nonetheless, the research had designed the one worked by solar energy. Electricity generated from the solar energy was utilized to supply the paddle wheel. According to the test result obtained from the invented paddle wheel, 24 volts 250 watts solar cell generated electricity for the paddle wheel gave electric power to DC brushless motor as well as an electricity charge to a battery to efficiently supply while there was no sunlight. The solar cell generated average electricity 27 volts 8.5 amperes approximately 6-8 hours per day. The best time that the maximum output was produced was between 10.30 AM till 2.30 PM. From the initial use, the paddle wheel using the power from the solar cell increased oxygen amount dissolved in water for about 0.16 mg/L in an hour.

Keywords: Solar energy paddle wheel, Solar energy, Solar cell and Paddle wheel aerator

INTRODUCTION

Waste water in community area and agricultural water-supply like fish pond, shrimp pond, etc. are one of the major problems that cause water pollution. Then, prevention and treatment of water sources are extremely important. The general principal of waste water treatment is to dissolve more oxygen in the water, therefore, the aerator used for supplementing oxygen level in water is designed and widely developed. However, it consumes a lot of electricity power when compared to the oxygen dissolved in water. This causes more expense on electricity power consumption as our region, Thailand, is located in tropical area which is the zone that solar energy is high potentially used. The concept of designing and developing aerator consuming electricity power from solar cells in place of electric transmission line is issued. Like solar energy paddle wheel aerator, it is used widely as it uses electricity from solar cells and directly to paddle driving motor. The paddle will accelerate water movement speed. There will be a vacuum in the middle of paddle area. Air on water surface will be flown through axle and whipped into small bubbles which are well mixed in water. This increases oxygen in water more quickly.

Types of aerator

1. Low speed surface aerator. It is a vertical aerator with large diameter paddle that whips water from bottom to top to exchange oxygen in the air. With 1 – 100 horse power motor, it works well with a large pond with 1 – 5 meters deep and can increase oxygen level in water approximately 1.2 – 1.5 KgO_2 / Hp-hour.

Fig.1. Low speed surface aerator

2. Jet aerator. It is an aerator with 1 – 30 horse power electrical motor which is installed on the float connected to paddle shaft to whip water. This makes turbulent flow in water. Air will be vacuumed to shaft area and a lot of bubbles are produced. It is suitable for adding oxygen level and increases flow of water with 1.5 depth above. It can increase oxygen level in water approximately 0.8 – 1.5 KgO_2 / Hp-hour.

Fig.2. Jet aerator

3. Paddle wheel aerator. It is a water-surface aerator that uses 1 – 3 horse power to drive the paddle to whip water on surface. This causes oxygen increasing in horizontal level and water movement. Small bubbles whipped by paddle will increase more oxygen level. It is suitable for facultative pond with 1 – 2 depth and can increase oxygen level in water approximately 0.8 – 1.2 KgO_2 / Hp-hour.

Fig.3. Paddle wheel aerator

Paddle wheel aerator components

1. Float. It is used for carrying components of the aerator to be able to float on water. This is mostly made from light plastic. There are various shapes of the float illustrated with figure 4.

Fig.4. Float

2. Electric motor. It is used as initial power to drive the paddle. There are both direct current motor (DC motor) and alternating current motor (AC motor) with 1 – 3 horse power of electric power as shown in figure 5.

Fig.5. Electric motor

3. Reduction gear. It is used to reduce electric motor speed connected to paddle axle. This makes the paddle has proper round speed for whipping. Generally, round speed of the paddle is about 90 – 100 rpm as shown in figure 6.

Fig.6. Reduction gear

4. Paddle wheel. It is used for whipping to make bubbles to increase oxygen level in water. It is mostly made from plastic. The paddle has various shapes with 6 or 8 blades as shown in figure 7.

Fig.7. Paddle wheel

5. Power supply. This is used for supplying power to the motor. There are both used direct current (DC) and alternative current (AC) depending on the motor used in aerator. If the aerator uses direct current, electricity from battery and solar cells will be used. And, if it uses alternative current, the electricity from electric transmission line will be used.

As the aerator is widely used because its size is not too big, inexpensive and easy to use, there are many inventors designing and developing the aerator using electricity from electric line and solar cells as followings:

Happy Farm Kerdphol Co., Ltd. has produced solar-cells aerator. Its structure composes of 3 floats to support 25 inches aerator with 8 four-blade paddles and 24 volt, 270watt solar cells for producing electricity to 24 volt, 270 watt brushless DC motor driving the paddle. The motor speed is about 30 – 90 rpm depending on electricity produced from solar cells. The weight of the aerator is 70 kilograms that is suitable for 100 – 200 m^2 pond [1].

From: http://www.happyfarm.co.th, 2019

Fig.8. Solar energy paddle wheel aerator model 9DD

Paradon Thongsen and Yodchai Tiaple from Naval Architecture and Marine Engineering, Kasetsart University, have developed solar-cells aerator for waste water treatment by increasing oxygen level in water with solar energy. Two solar cells with 24 volt and 270 watts are connected by parallel circuit to make 300 watts of electric power for supplying electricity to 24-volt 500-watt DC motor. This is to drive the 20-centimeter paddle and suitable for shrimp pond and fish or natural water resource [2].

From: https://mgronline.com, 2019

Fig.9. Paddle wheel energy system

Tinnakorn Musika, Kittisak Pluem-arom, Peerapong Kosaipat, Tinnakorn Kheowree and Naphat Watchanathepin have developed 3-bouy water mill machine driven by the photovoltaic energy system. This uses solar cells with 290 watts, 44.4 volt and 6.5 ampere to produce electric charge past through charge controller with 20 ampere and 24 volt to 2 batteries with 12 volt and 18 ampere by series circuit. This battery voltage will be supplied to 250 watts and 24 volt DC motor to drive the paddle, of which speed with 60 rpm. For these 3 buoys, each one's dimension is 240 centimeters long, 40 centimeters wide and 35 centimeters high and can be loaded 336 kilograms [3].

From: http://www.rdi.rmutsb.ac.th, 2019

Fig.10. 3-buoy water machine driven by the photovoltaic energy system

Besides, there is development of aerator in other designs. For example, Chonmapat et al. has designed and invented aerator. 12 volt, 80 watts solar-cells to supplying electricity to DC motor to pump water into the sieve on top of the aerator. The water will spray down the bottom. From the examination, it can increase oxygen in water about 9.5 mg/L [4].

RESEARCH METHODOLOGYS

Research methodology of solar energy paddle wheel aerator is as follows:

1. There are 2 parts of solar paddle wheel aerator design:

1.1For solar paddle wheel aerator structure design, the base of the aerator is made from light fiberglass with 25 centimeters wide, 170 centimeters long and 25 centimeters high with the amount of 3 bases stuck together so their length is 165 centimeters. These bases will be carried all the aerator structure and other components to be floated in the water. The metal structure dimension is 162 centimeters long, 94 centimeters wide, 85 centimeters high and 110 centimeters high at the back to make the angle of 15 degree for installing solar cells. Overall dimension of the aerator including buoys is 162 centimeters wide, 170 centimeters long and 135 centimeters high as shown in figure 11.

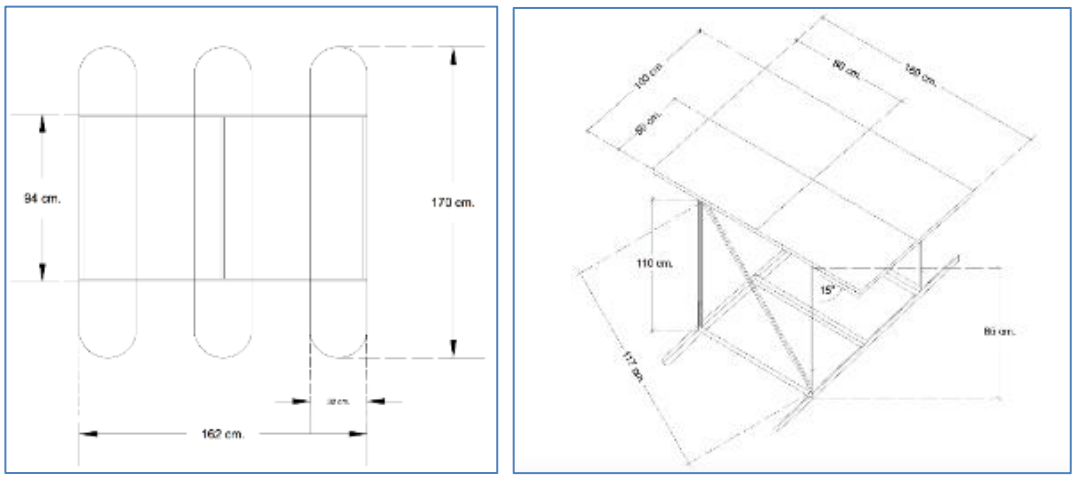

Fig.11. Solar energy paddle wheel aerator structure design

1.2 The solar energy paddle wheel structure is composed of 24 volt, 250 watts solar cells for producing electricity to DC motor and 2 batteries by using charge controller with 24 volt and 20 amperes. It produces charge to batteries 12 volt 100 ampere-hour with series circuit, so this produces batteries voltage 24 volt 100 ampere-hour. Current from batteries that supply charge to motor 24 volt and 750 watts with 3,000 rpm will be controlled by time controller for not working overload and causing overheat. This prevents motor from damaging. The DC motor shaft will be connected to gear reducer with 1:3 round to reduce paddle shaft speed to 1,000 rpm. The solar energy paddle wheel system diagram will be shown in figure 12.

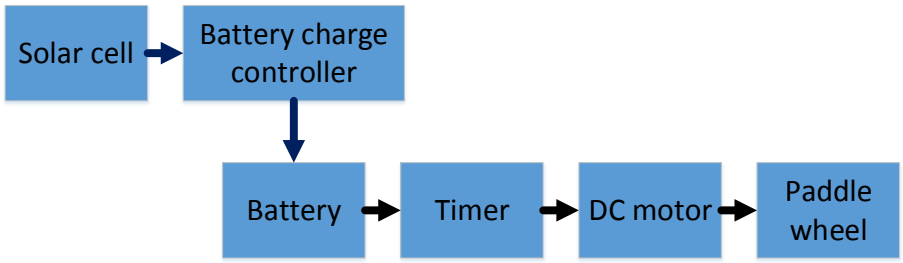

Fig.12. Solar energy paddle wheel aerator system diagram

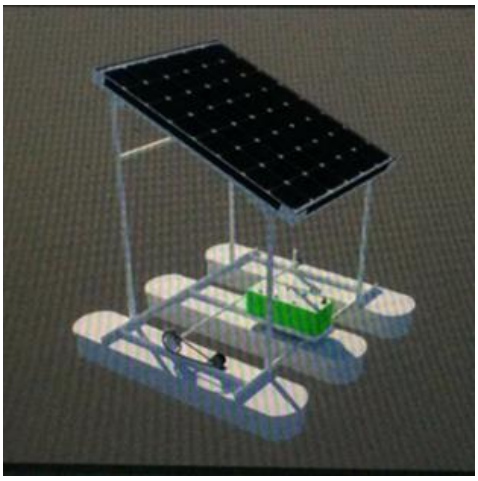

Fig.13. Solar energy paddle wheel aerator design

2. Solar energy paddle wheel constructing will stick 3 buoys referring to figure 11 and install paddle shaft on the top of the buoys with 2 set of bladed installed between the buoys as shown in figure 14

Fig.14. Paddle wheel installation on the floats

DC motor and reduction gear will be connected to paddle shaft as shown in figure 15 and solar cells will be installed on the top of aerator as show in figure 16. When the structure is finished, electric system for solar energy paddle wheel will be set up as shown in diagram figure 12.

Fig.15. DC motor and reduction gear installation

Fig.16. Solar energy paddle wheel aerator

RESEARCH RESULTS

1. Test round speed by using round speed measurement DT-2236B to measure the paddle shaft speed. It is found that the paddle shaft speed is about 1,180 rpm when not whipping water and consume electricity current about 4.8 amperes. Yet, when whipping water, the paddle shaft speed will decrease to 880 rpm and consume more electricity current about 17 amperes.

2. Test electricity producing from solar cells by using volt meter to measure voltage at anode and cathode of solar cells through each day. It is found that the solar cells are able to produce electricity on the average of 27 volt and average current of 8.5 amperes as shown in figure 17.

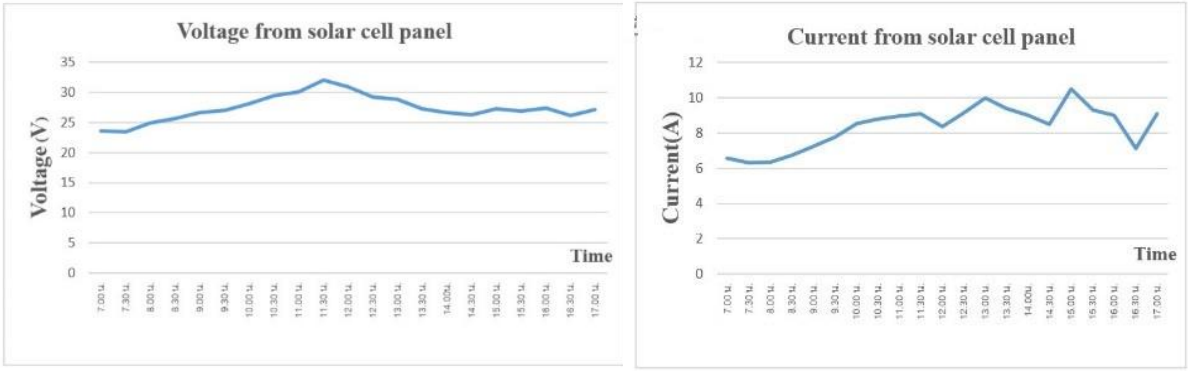

Fig.17. Solar energy paddle wheel aerator

3. Test oxygen dissolved in water measurement by using Dissolved Oxygen Meters 8403 to measure oxygen dissolved in the pond in 3 positions as shown in figure 18. Record oxygen value in water every 10 minutes in 1 hour and the result is shown in table 1.

Table 1. Oxygen dissolved in water at the determined positions

Dissolved Oxygen (mg/L)	Time)minute)						
	0	**10**	**20**	**30**	**40**	**50**	**60**
TP 1	1.83	1.86	1.92	1.96	2.03	2.12	2.15
TP 2	2.02	2.05	2.10	2.16	2.22	2.31	2.34
TP 3	1.79	1.81	1.85	1.89	1.92	2.01	2.06

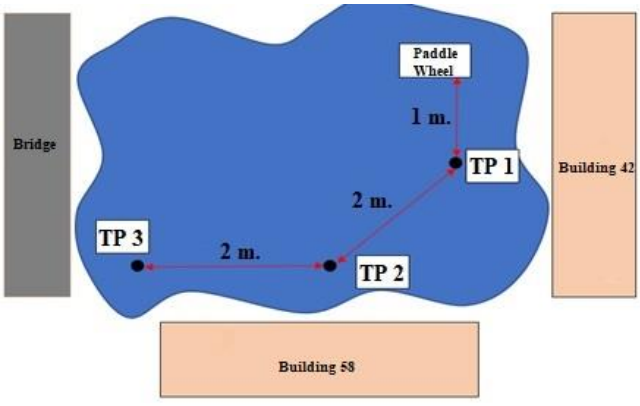

Fig.18. The positions of oxygen dissolved in water measurement test

CONCLUSION

From designing and building solar energy paddle wheel, it is found that the paddle wheel can be adapted to increase oxygen dissolved in water by using electricity from solar cells and electricity line is not necessary that is able to save electricity consumption cost. Electricity producing from solar cells for the aerator test is found that this can produce voltage on the average of 27 volt and average current 8.5 amperes which are average electricity power 230 watts. As the aerator consumes 400 watts of electricity power, this cannot produce electricity to DC motor driving the paddle directly, so it is necessary to use electricity from batteries to help supply the motor. In case there is no sun light, the batteries can produce 100 ampere-hour charge for the aerator about 2 – 3 hours. The solar cells can produce electricity for 6 – 8 hours per day and highly produce from 10:30 am to 02:30 pm. The solar energy paddle wheel can increase oxygen level dissolved in water about 0.16 mg/L in one hour.

RECOMMENDATIONS

1. The weight of solar energy paddle wheel is still heavy so it is difficult to move or relocate. It should be reduced its materials gross weight and altered to flexible solar cells which are significantly light.
2. Materials used should not be easily rusty such as aluminum, dipped metals, zinc, etc.
3. Add more sets of paddles so that these can help increase more oxygen level dissolved in water
4. In case of adding more working time for each day, the solar cells should be extended more electricity power by installing more solar cells at the bank of the pond near the aerator.
5. The paddle shaft speed should be reduced to 90 – 120 rpm to decrease electricity power of motor so that it is not overheated.

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