

Effect of Rotation on the Performance of Paddle Wheel Type Pond Waterwheel

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ABSTRAK

Kincir air tambak merupakan suatu peralatan yang sangat penting dalam budidaya perikanan. Ketersediaan oksigen yang cukup dalam air sangat mempengaruhi pertumbuhan ikan atau udang yang dibudidayakan. Selain itu Penggunaan energi dalam membangkitkan atau menghasilkan oksigen terlarut dalam tambak harus se efisien mungkin agar biaya operasi tidak boros. Tujuan Penelitian ini adalah mendapatkan performa terbaik dari kincir air tambak dalam meningkatkan kandungan oksigen terlarut dalam air tambak dengan konsumsi energi yang digunakan paling rendah dalam menghasilkan atau meningkatkan kandungan oksigen dalam tambak. Metode penelitian yaitu secara eksperimen pada kincir air tipe dayung (paddle wheel) dengan jumlah bilah (sudu) delapan, serta jumlah lubang pada setiap bilah sebanyak 16. Dilakukan empat variasi kondisi kecepatan Putar (RPM) yaitu: 80, 100, 120, dan 140. Hasil penelitian menunjukkan bahwa pada kondisi kecepatan putar 120 RPM memberikan performa paling optimal yaitu penggunaan energi paling efisien untuk meningkatkan kandungan oksigen terlarut (dissolved Oxygen) dibanding pada kecepatan putar (RPM) lainnya.

Kata kunci: Energi; kecepatan putar, oksigen terlarut; roda dayung; tambak.

ABSTRACT

Aerator is a very important equipment in fish farming. The availability of sufficient oxygen in the water greatly affects the growth of fish or shrimp in pond cultivation. Besides that, the use of energy in generating or producing dissolved oxygen in ponds cultivation must be as efficient as possible decreasing that cost perations. The purpose of this research was to obtain the best performance of the Paddle wheel type aerator to increasing the dissolved oxygen in pond water with the lowest energy consumption used in producing or increasing the dissolved oxygen in ponds cultivation. The research method was experimentally for the aerator paddle wheel type with eight blades, and 16 holes on each the blade. There were four variations of rotation on the blades or rotors, namely: Rotation per minutes (RPM): 80, 100, 120, and 140. The results of the research showed that at a rotation speed of 120 RPM it provided the most optimal performance, the most efficient use of energy to increase the dissolved oxygen content compared the others RPM.

Keywords: Energy; rotation speed; dissolved oxygent; paddle whell; pond.

INTRODUCTION

According to the 2024 Performance Report of the Directorate General of Aquaculture Fisheries, the potential of aquaculture land nationally is estimated at 17.92 million ha, consisting of 2.83 million ha of freshwater aquaculture potential, 2.96 million ha of brackish water cultivation, and 12.12 million ha of marine aquaculture. Its utilization to date is only 10.26 percent for freshwater cultivation, 22.48 percent for brackish water cultivation and 1.39 percent for marine cultivation [1]. This utilization rate is still low, especially for marine cultivation, so efforts are needed to utilize it so that aquaculture production can continue to be increased.

The fisheries potential mentioned above is expected to improve the national economy and absorb jobs. To achieve this, it is necessary to develop, especially in terms of technology so that

national fisheries cultivation can be more efficient and able to compete globally.

Shrimp is Indonesia's leading fishery commodity which is an export commodity. However, shrimp productivity is one of which is highly dependent on the quality of water in ponds [2]. Low levels of dissolved oxygen in pond water can cause disease outbreaks and decreased shrimp immunity, so it is necessary to have an aerator system that has an important role in increasing the content of dissolved oxygen in the water[3].

Indonesia is one of the largest shrimp producers in the world, with a global market share of 8.7%. Major export markets include the European Union, Japan, and the United States. Vannamei shrimp, with its high productivity and tolerance to environmental changes, are a favorite in the global market. [4]. Shrimp is known to have high protein and nutrition, so it is in great demand

by consumers who want to maintain health so that it provides opportunities to be cultivated[5].

Energy conservation and diversification in supporting national development and job creation, is very important and urgent to be implemented [6]. Energy conservation is essentially energy saving in all fields, while diversification is directed to support the energy transition towards the use of renewable energy [7].

Pond waterwheel is one of the technologies used in fisheries cultivation that functions as pond aeration. Aeration technology to increase the dissolved oxygen content in pond water is very important because it affects the growth of fish or shrimp in the pond. Numerical (simulated) CFD research has been conducted by MA. Ariyuda, et al. concluded that the pond waterwheel with a number of holes as many as 16 holes provides the best performance compared to the variation in the number of other holes. [8]

The purpose of this study is to analyze the effect of rotational speed on the performance of a paddle wheel type aerator.

RESEARCH METHODS

The research was carried out experimentally/field test in the form of a paddle wheel-type pond waterwheel, with a total of eight spoons (blades). Each blade (spoon) has 16 holes, as seen in Figure 1.



Figure 1. 8-blade and 16-hole aerator per blade (Private Document, 2025)

The research was carried out with the help of several measuring instruments, including Dissolved Oxygen (DO) measuring instruments, to measure the content of dissolved oxygen in pond/pond water. Tachometer, to measure the rotation of the shaft or the rotation of the rotor of the spoon. Dimmer, to regulate the voltage entering the electric motor so that the rotational speed (RPM) of the electric motor can be regulated, and digital Watt Meter to measure the

consumption of electric power when the waterwheel is operated.



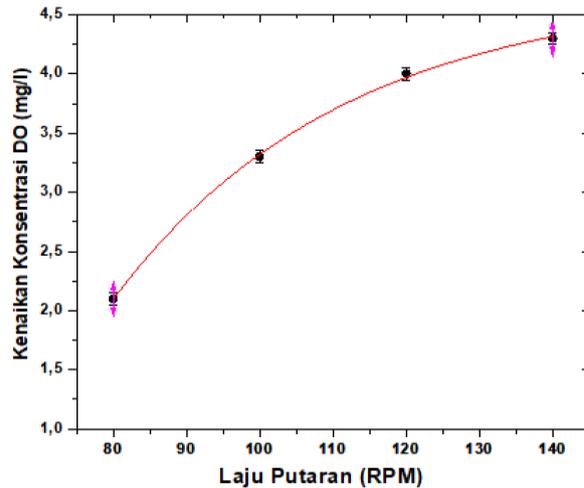
Figure 2. Aerator testing (Private document, 2025)

In Figure 2, you can see the testing of paddle wheel type aerators. The blade (spoon) of the Wheel is connected to the shaft/rotor of the wheel. The rotation of the wheel or the speed of the wheel is expressed in units of rotation per minute (RPM). Tests were carried out on variations in rotary speed as many as four categories, namely: Rotary speed 80 RPM, 100 RPM, 120 RPM and 140 RPM.

Tests were carried out on each speed variation by repeating the test three times each, then the results were averaged. When testing each variation of rotary speed (RPM), data is collected in the form of the amount of addition or increase in dissolved oxygen content (dissolved oxygen), DO in the pool water, and the power consumption (Watt) required/consumed by the electric motor to be able to rotate the shaft or rotor where the blades (spoons) of the pond waterwheel blades are installed.

RESULTS AND DISCUSSION

The results of the research/test are made graphic, as shown in Figures 3, 4, and 5.



Gambar 3. Dampak laju putaran bilah (sudu) aerator terhadap kenaikan DO

In Figure 3, the impact or effect of the rotation speed of the aerator blade (spoon) can be seen on the increase or addition of dissolved oxygen in pond water. The higher the speed or rotational speed of the wheel (wheel/blade), it will cause an increase in the concentration of oxygen dissolved in water.

When the rotor rotates where this rotor is where the blade is attached, the faster the rotor rotates, the faster the blade rotates. Increasing the speed of the spoon can also increase or increase the oxygen content that enters or dissolves in the cultivation pond. This happens because of the water that is lifted from the pond, due to the spinning of the waterwheel [9].

If the rotation speed of the spoon/blade is larger/higher, the number or volume of the grains will also increase, and the surface and contact between the water grains and the air will be wider, so that the ability of the water particles lifted from the pond to absorb the oxygen contained in the air will also increase, so that the addition of oxygen entering the pond water will also increase.

The addition of dissolved oxygen in the aquaculture pond, occurs when the water lifted from the pond due to the rotation of the (spoon), while in the air forms bubbles and water droplets, so that there is contact with the air, then the air which contains 21% oxygen, most of it is carried into the water, at the same time when the water bubbles fall or re-enter the pond, and this condition will be repeated as long as the wheel or spoon rotates, and this condition is affected by the rotational speed (RPM) of the blade rotor. This is in accordance with [7][8], which states that the ability of water granules or bubbles to absorb oxygen in the air is influenced by the volume and length of contact between water and air.

The increase or increase in the concentration of dissolved oxygen (Do) in the cultivation pond is not linear, in other words the increase in the rotation speed of the water turbine spoon is not directly proportional to the addition of dissolved oxygen (Do) produced. At the rotation speed of the spoon of 80 RPM to 100 RPM, there is an increase in the Do value or difference of 1.2 mg/L, but at the rotation speed of 120 RPM to 140 RPM the increase in the Do tilapia is only 0.2 mg/L.

This occurs at a fairly high rotational speed, the condition of water droplets (bubbles) has a reduction in the ability to absorb oxygen in the air. [11] Because the higher the rotational speed of feeding water droplets, many water droplets collide with each other, and there is saturation in the air above the pond and the oxygen condition in the pond has increased.

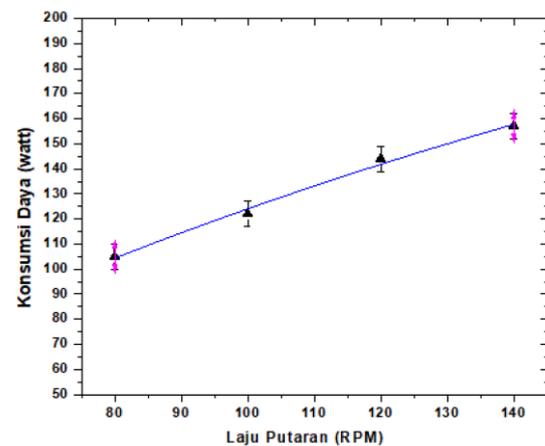


Figure 4. Increase in the rotation rate of the aerator propeller increases electricity consumption

In Figure 4, you can see the graph of the effect of rotational rate (RPM) on power consumption. The speed of the blade rotation greatly affects power consumption. In the image, it can be seen that the higher the rotation rate (RPM) of the rotor or wheel, the higher the power consumption. This occurs due to the drag force that occurs between the spoon and the water in the pond, where the higher the rotation rate of the blade (spoon), the greater the drag force that occurs so that the need/power consumption will also increase. This is in accordance with, stating that the shape/model of the wheel affects the drag or drag that occurs. [12]

The good performance or performance of the turbine is not only determined by the increase or increase of DO from the turbine, but also the low or efficient energy consumption in generating or

adding the value of DO. The performance of the turbine is good if the use or consumption of energy compared to the increase in dissolved oxygen (DO) is also higher. So that more efficient energy consumption is obtained in increasing or adding DO. In the research/testing of the four speed conditions, it was found that the highest increase in DO occurred at a rotary speed of 120 RPM, followed by a rotary speed of 100 RPM, 140 RPM, and 80 RPM.

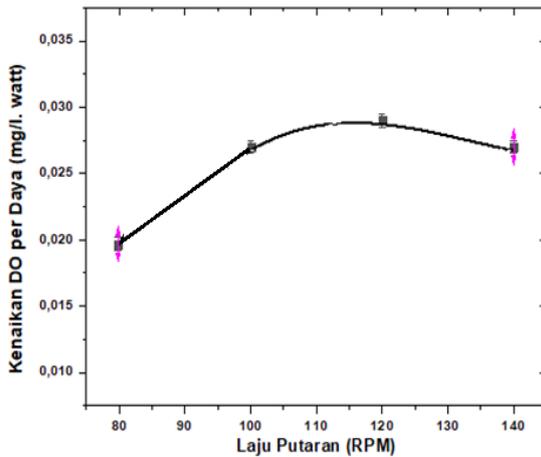


Figure 5. The effectiveness of the increase in the rotation rate on the energy use to raise the DO

In Figure 5 and Table 1, it can be seen the effect of rotation variation on the increase in dissolved oxygen content on power consumption. The highest consumption or consumption of power to the addition of oxygen content was seen to occur at the 120 RPM turbine blade rotation, followed by the rotor/spoon rotation of 100 RPM and 140 RPM.

The increase in the value of DO per Power used is very important to know because this greatly affects the operational costs of fisheries/pond cultivation, the operating costs of aquaculture ponds must be made as sparing or efficient as possible in order to provide profits for pond farmers. The higher the power used to raise oxygen, it will result in increased operational costs.

Table. 1 Effect of Rotation (RPM) on DO increase and Power Consumption

RPM	DO (mg/L)	Daya (Watt)	DO (mg/L)/Watt
80	2,1	105	0,020
100	3,3	122	0,027
120	4,1	143	0,029
140	4,3	160	0,027

The lowest increase in DO value to power consumption is at 80 RPM. This is because when the rotation of the rotor connected to the turbine blade (spoon) is lower, the ability of water particles lifted into the air has lower oxygen absorption, on the other hand if the rotor rotation speed is too high, the ability of water bubbles to capture/carry oxygen in AI is also reduced because too much water is lifted so that the ability to absorb oxygen also decreases.

CONCLUSION

The rotation speed (RPM) of the blade/blade greatly affects the increase in the dissolved oxygen content in the pond water. And power consumption/consumption. Of the four variations of rotor rotational speed, it shows that at the rotational speed of the blade/blade 120 RPM produces the most optimal performance, where the most efficient use of energy to increase/increase the content of dissolved oxygen (dissolved Oxygen) per Power (Watt) used compared to other rotational speeds/rates.

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