IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

The Ineffectiveness of Water Splash on Paddlewheel Aerator

To cite this article: Samsul Bahri *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **268** 012162

View the article online for updates and enhancements.

This content was downloaded from IP address 111.170.106.60 on 11/10/2019 at 15:58

The Ineffectiveness of Water Splash on Paddlewheel Aerator

Samsul Bahri, Jufriadi, Hamdani, Anwar

Mechanical Engineering Department, Lhokseumawe State Polytechnic, Lhokseumawe, 24301, Indonesia

E-mail: samsul@pnl.ac.id

Abstract. The successful of intensive aquaculture is strongly influenced by the ability of the farmers to overcome the deterioration of water quality. The problem is low dissolved oxygen through aeration process. The aerator device which widely used in pond farming is paddle wheel aerator because it is the best aerator in aeration mechanism and usable driven power. However, the paddlewheel has a slow aeration rate resulting in low aeration efficiency. The problem is caused by the backward water splash ineffectively. The backward water of the paddlewheel that is already aerated, but it is splashed again so it wastes the power. However, only the forward splash is effectively. The aim of this study was to determine the ineffectiveness of paddlewheel aerator based on the backward water splash. The paddlewheel used an 1 phase motor, 1 hp power, 1400 rpm motor speed, and 2 pieces of wheels. The treatment was carried out by varying the blade of 65, 85, and 105 mm submerged. The test was done by collecting the forward and backward water splash and calculating its volume. The normal position of the float on the blade submerged by 85 mm was obtained that the forward and backward splash volume of water was 17.99 and 13.74 m^3/hour. Only 56.70% the effectiveness of the water splash compared to 43.30% the backward water splash. In fact, the forward splash coverage volume of water was 47.83% compared to the forward was 52.17%. This result shown that the water splash of paddlewheel aerator was not effective, so the backward water splash need to optimize to the effectiveness of water splash.

Key words:
Paddlewheel aerator, aeration, ineffectiveness, forward water splash, backward water splash, volume

1. Introduction

Aeration is a mechanism of adding some amount of oxygen into water to provide sufficient amount of oxygen. Aeration is carried out by increasing water and air contact using aerator device. One type of aerator device which widely used in pond farming is paddle wheel aerator [1]. Paddlewheel aerator is considered as the most appropriate aerator device due to aeration mechanism and wide usable driven power [2]. Aerator based on Taiwan design is widely used by consumers due to affordable price, light in weight and corrosion-resistant but has low efficiency [1][3].

Standardized aeration efficiency is directly proportional to the standard oxygen transfer rate and inversely proportional to the power consumption. Aerator that was designed and fabricated by Taiwan has *SAE* (standard aeration efficiency) value of 1.063 kg O_2 kW h^{-1} [4]. Bhuyar *et al.* designed aerator with SAE value 2.269 kg O_2 kWh^{-1} [5]. The most appropriate paddle wheel aerator was designed by Moore and Boyd with *SAE* value 2.54 kg O_2 kWh^{-1}. Some of fabrications use aerator design with specification 2.25-7.5 kW and *SOTR* 17.4- 23.2 kg O_2 h^{-1} and average value of SAE was 2.2 kg O_2 kW h^{-1} [6]

Aeration rate is influenced by water and air surface contact, differential oxygen concentration, film surface coefficient and turbulence [7]. In the paddlewheel aerator, the contact of surface between water and air occurred by the splash of

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

water that produced by the wheel rotation. The splash is the water that have the process of aeration which is spread forward, also behind the wheel. The prior study has not conducted this aspect. Bahri *et al.* calculated these splash in the coverage volume of the splash itself, it was not distinguish them into forward and backward splash but only of total splash of water [8]. However, only forward splash was useful, while backward splash was less effective but cannot be avoided. It was caused by the power consumption of paddle aerator is used to reaeration of aerated water. Therefore, the aim study was to determine the rate of the ineffectiveness of paddlewheel aerator.

2. Materials and Methods

2.1. Materials

2.1.1. Blades. The blades are based on Taiwan design is widely used by consumers. The geometry of blade are the wheel diameter was 650 mm and the hole diameter was 20 mm. The blade consist of eight pieces with the width was 200 mm and the length 180 mm.

2.1.2. Paddlewheel test unit. Paddlewheel test is aerator based on Taiwan design. Motor used is 1 phase AC electric motor with a power of 1 HP at 1400 rpm rotational speed.

2.2. Procedure

2.2.1. Treatments variations. The tests was conducted on the freshwater pool with dimensions of length 10 m, 7 m width with a water depth of 1 m. Submerged variations blade is done by changing the height position paddlewheel support. The tests was the blade submerged 65, 85, and 105 mm.

2.2.2. Splash coverage volume measurement. Splash coverage volume was done by taking the recorded images used a digital camera from the front side and side the wheel at the time of testing. Then, the digital image was processed by using a CAD programs to create segments (grid), which the splash coverage volume was the number of multiply results of segments area at the front side water splash with the side of water splash.

2.2.3. Volume measurement. The splash volume was measured by containing the backward and forward splash water for 15 seconds. Based on the result of the test, it was measured the splash volume that produced per hour.

2.2.4. Power measurement. Paddlewheel power measurement was done by measuring the electrical power consumption of electric motors using Ammeter (DO2A) which was connected to an electrical outlet. Reading the power measurement value (Watt) was done by using a digital video camera recording on display Ammeter. Rated power was taken on the average value that often was showed from the reading video playback recording for each treatment testing.

3. Results and Discussion

The water splash produced visible from the front and side the wheel of the submerged blade 85 mm can be compared in Figure 1.

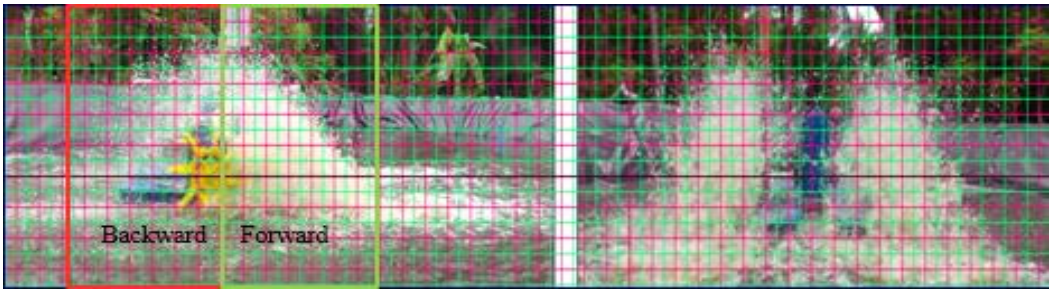


Figure 1. The image of water splash and calculation segment of splash coverage volume.

The splash coverage volume produced at different blade submerged are presented in Table 1.

Table 1. The splash coverage volume of water at different blade submerged

Blade submerged (mm)	Splash coverage volume of water (m^3)		
	Backward	Forward	Total
65	0.94	1.05	1.99
85	1.32	1.21	2.53
105	1.51	1.42	2.93

The results of the test shown of the dip of blade submerged increased the splash coverage volume of water, both of forward and backward water splash. The normal position of the float on the blade submerged by 85 mm was obtained that the backward splash coverage volume of water was 52.17% compared to the forward was 47.83%. The lift of blade submerged by 65 mm, it was obtained that the backward splash coverage volume of water was 47.24% compared to the forward was 52.76%. When the blade submerged dipped by 105 mm it was obtained that the backward splash coverage volume of water was 51.54% compared to the forward was 48.46%. The average of forward splash coverage volume of water was 50.32%, while the backward was 49.68% as shown in Figure 2.

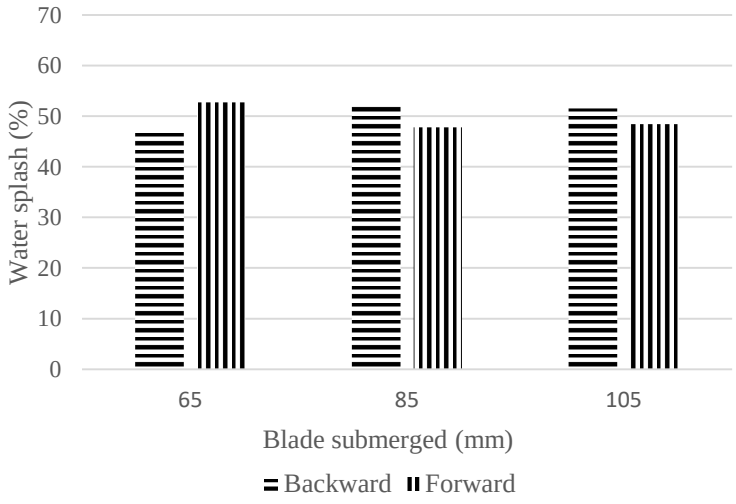


Figure 2. The backward and forward water splash based splash coverage volume.

The splash volume produced at different blade submerged for 15 second are presented in Table 2.

Table 2. The splash volume of water at different blade submerged

Blade submerged (mm)	Splash volume of water (m^3)		Power comsumption (Watt)
	Backward	Forward	
65	0.0223	0.0321	575
85	0.0286	0.0375	850
105	0.0318	0.0446	950

The results of the test shown of the dip of blade submerged increased the splash volume of water, both of forward and backward water splash. That increasing also gave influence to increase the power consumption. The normal position of the float on the blade submerged by 85 mm was obtained that the backward splash volume of water was 43.27% compared to the forward was 56.73%. The lift of blade submerged by 65 mm, it was obtained that the backward splash volume of water was 40.99% compared to the forward was 59.01%. When the blade submerged dipped by 105 mm it was obtained that the backward splash volume of water was 41.63% compared to the forward was 58.37%. The average of forward splash volume of water was 58.04%, while the backward was 41.96%. The calculation of two pieces the wheel, the volume per hour of forward water splash at the blade submerged in the 65, 85, and 105 cm were 15.42, 17.99 and 21.42 m^3, respectively, while the backward were 10.68, 13.74 and 15.27 m^3 as shown in Figure 3.

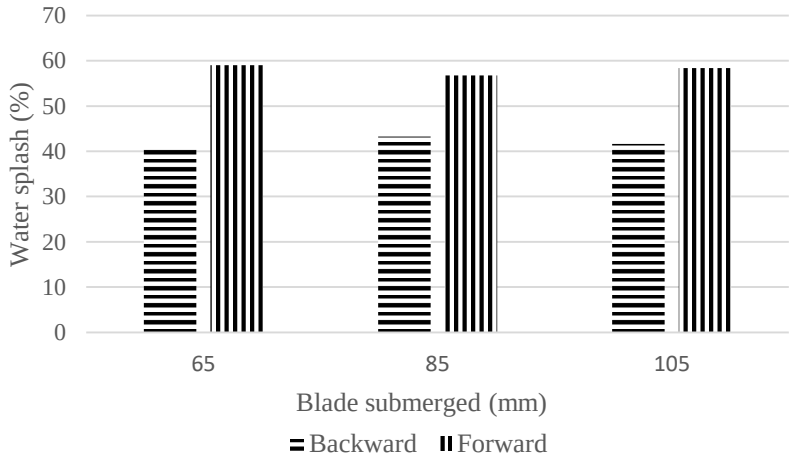


Figure 3. The backward and forward water splash based splash volume.

Although the backward splash volume of water was less, based on the splash coverage volume it can be concluded that the splash was rich oxygen. Based on the normal blade submerged (85 mm), if the usage of paddlewheel during a 12-hour night [7], it will produce the backward splash volume of water is 164.90 m^3. The volume is different for each aerator. It is depending on the operating conditions and aerator specifications. However, it is means that the paddlewheel re-aerated the aerated water. This indicates that the water splash by the paddlewheel aerator has not been effective.

4. Conclusions

The result of this study given that the forward and backward splash coverage volume of water of paddlewheel aerator at the normal blade submerged 85 mm was 2.64 and 2.42 m^3, the average percentage of each was 50.32% and 49.68%. The volume per hour of backward water splash at the blade submerged in the 65, 85, and 105 mm were 10.68, 13.74, and 15.27 m^3, respectively. The average of forward splash volume of water was 58.04%, while the backward was 41.96%. The dip of blade submerged increased the splash volume of water, both of forward and backward water splash. The backward water splash caused the ineffectiveness the production of paddlewheel aerator water splash. Therefore, it is clearly needed to minimize or utilize these splash for the effectiveness of paddlewheel aerator.

5. References

[1] Laksitanonta S, Sahdev S and Gajendra S 2003 A Review of Aerators and Aeration Practices in Thai Aquaculture *AMA Agr Mech ASIA AF* **34** 64-71
[2] Romaire RP and Merry GE 2007 Effect of Paddlewheel Aeration on Water Quality in Crawfish Pond *Appl Aquac* **19** 61-75
[3] Wyban JA, Pruder GD and Leber KM 1989 Paddle wheel effect on shrimp growth, production and crop value in commercial earthen ponds. *Journal of the World Aquaculture Society* **20** 18-23.
[4] Peterson EL and Walker MB 2002 Effect of speed on Taiwanese paddelwheel aeration. *Aquaculture Engineering* **26** 129-147.
[5] Bhuyar LB, Thakre SB and Ingole NW 2009 Design characteristics of curved blade aerator w.r.t. aeration efficiency and overall oxygen transfer coefficient and comparison with CFD modeling. *International Journal of Engineering,Science and Technology* **1** 1-15.
[6] Moore JM and Boyd CE 1992 Design of small paddle wheel aerators *Aquaculture Engineering* **11** 55-69.
[7] Boyd CE 1998 Pond Water Aeration Systems *Aquac Eng* **18** 9-40
[8] Bahri S 2015 Optimization of Blade Design and Operational Condition to Increase the Performance of Paddlewheel Aerator *PhD Dissertation* Dept. Of Agricultural Engineering Science Bogor Agricultural Univ chapter 5 p 53-54