ISSN: 2633-4828 Vol. 4 No.2, September, 2022

International Journal of Applied Engineering & Technology

Modification of Micro Bubble Generator Type Orifice Porous Pipe with Distributor Pipe for Fish Water Pool

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Date of Submission: 15th May 2022 Revised: 29th September 2022 Accepted: 12th October 2022

How to Cite: Sulistyo Sidik Purnomo et.al.,(2022).Modification of micro bubble generator type orifice porous pipe with distributor pipe for fish water pool. International Journal of Applied Engineering &Technology 4(2), pp.94-100.

Abstract: **Micro bubble generators are capable of solving the dissolved oxygen (DO) problem in water. However, there are still some weaknesses of the spherical body type microbubble generator, including the difficulty of placing a solid ball or spherical body in the channel, besides that the process of making a hole in the channel wall is impractical. Therefore it is necessary to do research related to the design of the Orifice type Microbubble Generator with Porous Pipe for aeration of fish ponds as a solution to the problem of dissolved oxygen in fish farming because the system is simpler and is expected to produce micro-sized bubbles so that it can be applied to increase productivity. Before the tool was operated, the DO value of the test pool water was in the range of 9 ppm to 10 ppm. The increase in DO value was inversely proportional to the increase in the diameter of the orifice. In the running pump condition, the highest DO value is at 8 mm orifice diameter with a DO average value range of 18.128 ppm to 20,625 ppm, while the lowest DO average value is at 14 mm orifice diameter with a mean DO value range in the range of 11.15 ppm to 15.0 ppm. Whereas in the condition of the pump stop or off, the highest DO value is at an orifice diameter of 8 mm with a mean DO value range of 17,375 ppm to 18.90 ppm when the pump is running, while the lowest DO average value is at an orifice diameter of 12 mm with a range of DO mean values. in the range of 9.45 ppm to 12,575 and orifice diameter of 14 mm at a value of 13,375. The difference in the average DO value between the running pump and the stop pump is in the range of 1,968 ppm. So the average DO value in pond water with the Microbubble Generator tool is still above the expected target, which is in the range of 8.0 ppm, while the standard DO average value for pond water with fish is in the range of 5 ppm to 7 ppm**

Keywords: **Micro bubble generator, dissolved oxygen, increase productivity, pump, pond water**

1. INTRODUCTION

Indonesia is an archipelagic country consisting of: 75% marine area (including ZEEI) and 28% land area in the form of terrestrial public water ecosystems. This makes Indonesia the largest aquaculture production potential in the world (Henriksson et al., 2019; Rimmer et al., 2021). Currently, there are major challenges in aquaculture production that must be resolved, namely how to increase productivity for food supply, but with more efficient use of water and land sources (Kaini, 2020; Mozumdar, 2012). Research related to this has been carried out including the Micro Bubble Generator (MBG) swirl jet.

Microbubbles are formed due to turbulent flow that enters the channel and also as a result of shear stress which causes the air to split and turn into micro-sized bubbles. The working process of the swirl jet microbubble generator utilizes the centrifugal force on the water flow and the centripetal force on the air flow. With this process, swirling occurs, causing continuous cavitation. Discovered a type of MBG for producing micro air bubbles using the shape of the inner spherical body of the tube to form a gap (Hun et al., 2021; Jeon et al., 2018; M. Sadatomi et al., 2005). In the spherical type MBG, there are several weaknesses, including the difficulty of placing solid balls in the channel, besides that the process of making holes in the channel walls is not practical. Then Deendarlianto et al. (2017), Yao et al. (2013) and Sadatomi et al. (2012) created a new type of MBG namely multi-fluid mixer. The role of the spherical body and the hole in the channel wall is replaced by an orifice and a porous pipe.

Referring to some of these findings, in this study a modified Microbubble Generator (MBG) type orifice porous pipe with a distributor pipe was made for aeration of fish ponds. In this modification, the performance of the tool and the effect of the distributor pipe with various parameters are studied. Testing on the stability of the uniform value of Dissolved Oxygen (DO) in water in fish ponds. The results of the MBG modification are expected to increase the productivity of fish livestock better. MBG modification was carried out with the aim of knowing the volumetric mass transfer coefficient of oxygen.

2. LITERATURE REVIEW

Microbubble is a bubble that has a diameter in the order of micrometers. Until now there is no definite definition of the size of the diameter of the microbubble. Several previous researchers have defined different diameter sizes. Kawara & Sadatomi (2015) defined microbubble as a bubble with a diameter of 50-200 m. Tabei et al. (2007) and Rizaldi et al. (2019) define a micro bubble as a bubble with a diameter smaller than 100 m. Mawarni et al. (2021) define a micro bubble as a spherical gas bubble with a diameter between 1-100 m. Makuta et al. (2006) defines a microbubble as a bubble with a diameter between 10-40 m. Meanwhile, Devi & Kumar (2019) defines micro bubble as a micro-sized air bubble, which can be suspended evenly in a liquid. In general, the basis for the classification of bubbles that are categorized as microbubbles comes from the field of study of the researchers themselves. In biology, a bubble is classified as a microbubble if it has a diameter of 10-40 m. Meanwhile, in another field of study, classifying microbubble bubbles if they have a diameter of 100 m (Bhadran & Goharzadeh, 2020; Cleve, 2019).

Microbubble Generator is a tool that functions to produce air bubbles in water with a diameter of less than 200 m, this is what distinguishes it from ordinary size bubbles. The use of Microbubble Generators is very wide, in the field of fisheries Microbubble Generators are used to increase oxygen levels in ponds or ponds to the field of industrial wastewater treatment. Then, the Microbubble Generator in wastewater treatment plays a role in improving the quality of wastewater by maximizing the role of aerobic bacteria in wastewater treatment. According to Mawarni et al. (2020) micro bubble is classified into three, as follows: Pressurization type, Cavitation type and Rotating Flow Type.

The pressurization type is a Microbubble generator type which is based on Henry's law. Henry's law states that the concentration of dissolved gas in water at saturation conditions is proportional to the partial pressure of the dissolved gas above the water at a certain temperature. Henry's law also states that no chemical reaction occurs between gas and water. According to Henry's law, the amount of gas that enters increases with increasing water pressure. Then, Cavitation type, namely in this type of microbubble generator, high pressure water is injected into the environment under atmospheric pressure conditions through a nozzle, microbubbles will be formed as a result of a sudden drop in pressure. This microbubble generator is often used for microbubble applications in waste water treatment known as Dissolved Air Flotation (DAF). An example of this type of micro bubble generator is Sadatomi et al. (2005) spherical body micro bubble generator. Furthermore, the Rotating Flow Type, namely this type of Microbubble generator, works by flowing high-pressure water in a tangential direction from the outside into a conical pipe. The fluid flowing in a spiral motion (rotating flow) on the inside of the wall forms a vortex. The center of the vortex is the part that has a low pressure due to the centrifugal force that causes gas to be sucked into the microbubble generator, so that at the outlet of the microbubble generator, the air is split into microbubbles due to the high rotating flow velocity of the fluid (Ali & Jang, 2021; Nouri et al., 2009, 2007).

3. MATERIALS AND METHOD

In carrying out the modification, this study used an orifice diameter ratio of about 0.57 mm which corresponds to the type of MBG type LP-12.5, SF-4.0, MF-8.4 and LF-12.5. This diameter ratio is used, because the ratio of the rate of microbubble formation to the level of power consumption is higher at water depths <1.2 m and the maximum achievable bubble formation rate is higher. Saunter's mean bubble diameter and mean bubble diameter for MBG are about 0.12 mm and 0.63 mm at QG = 1.0 l/min if the mean water velocity through the orifice is higher than about 10 m/s.

Design of an Orifice Type Microbubble Generator with Porous Pipe for Aeration of Fish Ponds, with variations in depth and distance of bursts with DO prices in the range of 8.15 ppm, in the direction of the bursts (Budhijanto et al., 2017; Majid et al., 2018; Purnomo et al., 2021; Rofik, 2020). The dimensions of this tool are: (1) Overall size: 0.5 mx 0.5 mx 1.5 m, (2) Pipe size: 3/4 inch ; PVC material, (3) Valve size: 3/4 inch ; PVC material; ball valve, (4) Flowmeter size (air): 3/4 inch, (5) Flowmeter size (air): 3/4 inch, (6) Pressure gauge : 3/8 inch ; 2.5 bar, (7) Pump size: 0.25 mx 0.25 mx 0.5 m, (8) Orifice size: 8 mm, 10 mm, 12 mm, 14 mm, and (9) Porous pipe: 0.3 mm.

The capacity of the necessary tools such as: pumps and measuring instruments, determining the type of pipe and pipe material, until finally in the form of a drawing design. The following is a flowchart for the design process, shown in Figure 1. Based on this figure, the pump capacity is selected and adjusted to the microbubble production speed of 430 liters/minute with a pressure of 1.8 bar and the pump type is submersible pump, while the flow meter is selected rotameter type. Pipe with PVC material is strong to withstand a pump pressure of 1.8 bar, because the strength of the pipe is 4 bar.

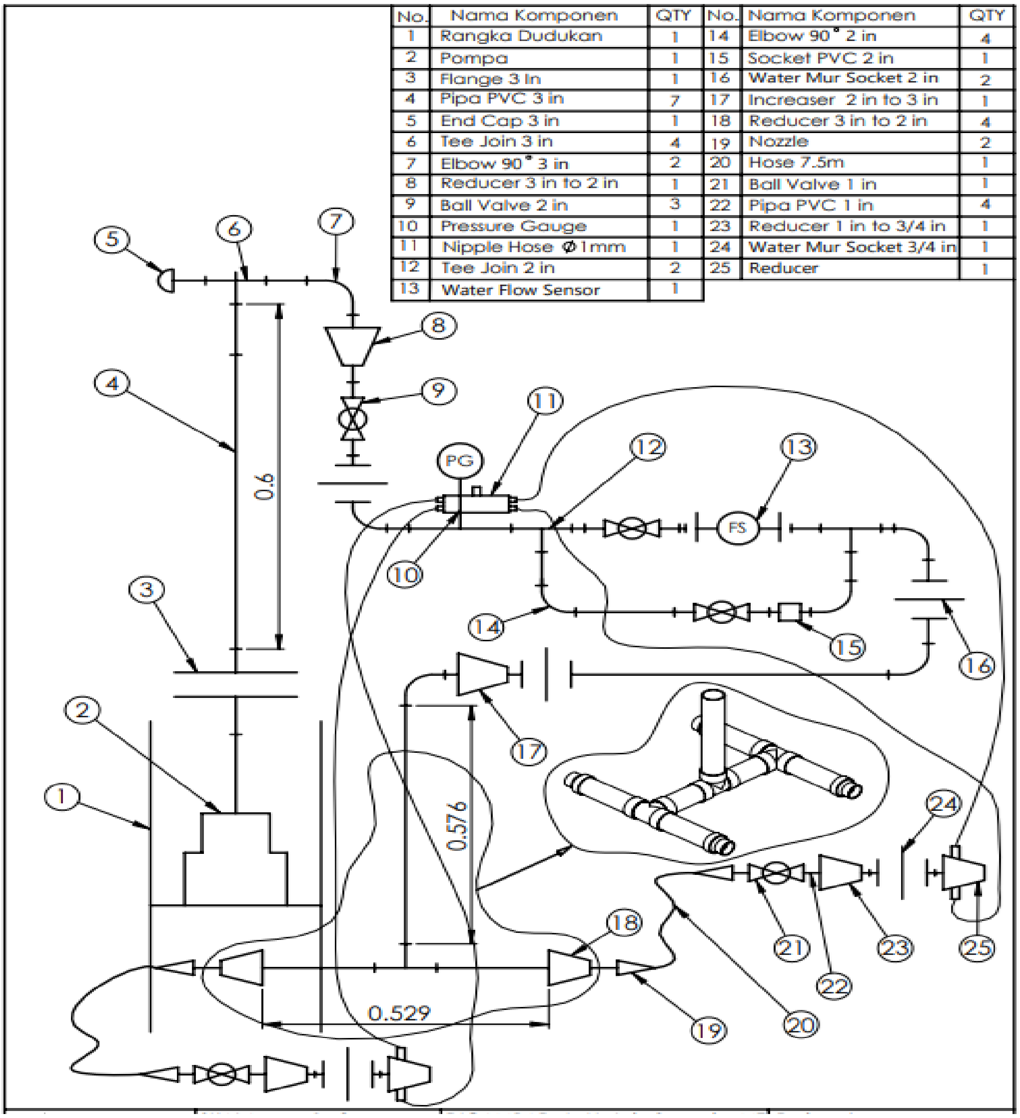

Figure 1: Design drawing of the Micro bubble generator

4. RESULT AND DISCUSSION

After total assembling, this tool is carried out a function test with the aim of whether this tool is functioning. This function test is carried out in a fish pond, this test is carried out for several hours, this tool is running with variations in water and wind valve openings, but because the water flowmeter is a rotameter type and when the adjustment is unstable, the test is carried out based on the water valve opening at 300 lpm and air valve opening at 14 lpm.

DATA FROM THE TEST RESULTS ARE AS FOLLOWS:

1) Temperature : 31 °C – 33 °C
2) Orifice inner diameter : 8mm, 10mm, 12mm, 14mm
3) Micro bubble generator
4) DO-meter type YK-2001PH brand Lutron
5) test pool size: 14m x 4m x 1 ,2 m (95 cm water height)
6) Water is standard koyi fish pond (there are 50 kg fish) with initial DO of 9 ppm – 10 ppm
7) Maximum water valve opening (Qw) with Qa (air flow rate)) of 14 lpm (constant)

The following table of test results:

1) D = 8 ; P = 1 bar; Qw = 300 lpm ; Qa = 14 lpm

	20.47 - 20.52	20.54 - 20.59	21.01 - 21.06	- 21.13	21.15 -	21.22 - 21.27 21.29	21.35	- 21.40	- 21.46	21.49 - 21.59
A	17.0	18.0	18.2	17.3	18.1	17	19.9	18.1	20.4	21.34
-	21.20	18.2	21.08	21.41	21.6	17.3	20.8	19.3	20.4	19.2
C	19.5	16.8	20.2	18.1	21.5	16.8	19.8	18.5	19.9	18
D	17.4	17.2	21.2	18.5	20.7	18.7	21.3	19.1	21.8	19.8
	ON	STOP	ON	STOP	ON	STOP	ON	STOP	ON	

2) D = 10 ; P = 1 bar; Qw = 300 lpm ; Q = 14 lpm

	19.36 - 19.41	19.44 - 19.49	19.51 - 19.56	19.59 - 20.04	20.05 - 20.10	20.13 - 20.18	20.20 - 20.25	20.27 - 20.32	- 20.38	- 20.45
A	15.3	14.3	17.5	15.3	16.3	16.4	17.9	16.1	17	16.4
B	16.5	14.5	16.4	16	16.5	20.33	20.40	14.5	16.6	16.7
C	15.4	15.0	16.0	14.6	17.7	16.5	18.9	16.3	17.8	16.1
D	15.0	14.3	16.0	15.6	17.7	17.1	17.1	16.5	15.6	16.5
	ON	STOP	ON	STOP	ON	STOP	ON	STOP	ON	STOP

3) D = 12 ; P = 1 bar; Qw = 300 lpm ; Q = 14 lpm

	15:30	15:35	15:45	15:52	15.56 - 16.01	16.05 - 16.10	16.14 - 16.19	16.27 - 16.32	16.38 - 16.43	16.46 - 16.51
A	17.4	9.0	3.4	10.0	15.4	13.0	14.1	10.5	14.0	13.0
B	14.0	8.7	18.3	10.5	22.0	12.3	17.6	11.5	15.8	13.0
C	13.2	10.0	14.0	10.0	13.5	12.3	14.0	11.0	14.1	13.1
D	16.5	10.1	14.3	10.0	12.8	13.2	13.7	10.4	12.4	10.0
	ON	STOP	ON	STOP	ON	STOP	ON	STOP	ON	

4) D = 14 ; P = 1 bar; Qw = 300 lpm ; Q = 14 lpm

	17.08 - 17.13	17.10 - 17.16	17.19 - 17.24	17.18 - 17.33 17.35	- 17.46	17.43 - 17.48	17.50 - 17.55	18:56	19.02 - 19.07	19.11 - 19.16	19.18 - 19.23	19.30
A	11.0	11.0	9.1	12.4	11.3	14.3	11.0	14.8	11.3	-	5.0	19.25
B	13.6	12.1	12.0	13.2	12.1	13.5	13.2	15.4	14.0	13.0	13.8	13.0
C	10.5	11.0	10.3	13.4	12.1	13.0	12.0	14.2	14.2	13.3	13.0	13.2
D	13.0	10.5	12.3	14.5	12.4	15.0	13.5	15.5	15.3	13.7	15.5	14.4
	STOP	ON	STOP	ON	STOP	_	STON	/ STOP	ON	STOP		

Information for the table above: ON is the condition of the pump running, STOP is the pump is not operating.

From the test data, the mean value of DO is shown in Figure 2 below.

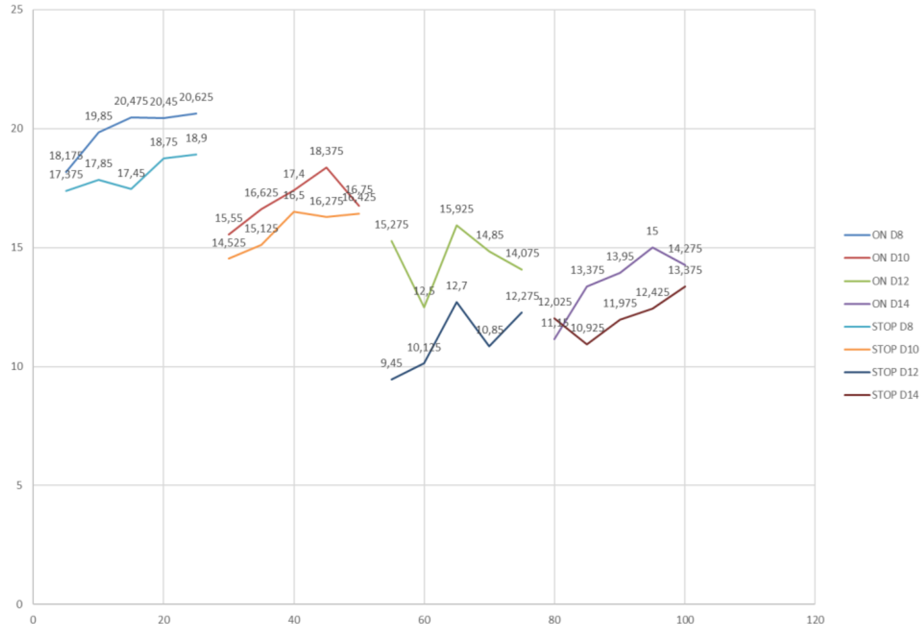

Figure 2: The test results of the mean DO value

Before the tool was operated The DO value of the test pond water was in the range of 9 ppm to 10 ppm. The graph above shows that from the test results, the size of the orifice diameter at the nozzle of the microbubble generator is very influential on increasing the DO value in the water in the fish pond. The increase in DO value is inversely proportional to the increase in orifice diameter size. In pump running conditions, the highest DO value is at orifice diameter of 8 mm with an average DO value range of 18.128 ppm to 20.625 ppm, while the lowest DO mean value is at orifice diameter of 14 mm with a range of DO average values in the range of 11.15 ppm to 15 0.0 ppm. Meanwhile, when the pump is stopped or off, the highest DO value is at an orifice diameter of 8 mm with an average DO value range of 17.375 ppm to 18.90 ppm under pump running conditions, while the lowest DO average value is at an orifice diameter of 12 mm with an average DO value range. in the range of 9.45 ppm to 12,575 and an orifice diameter of 14 mm at a value of 13,375. The difference in the mean DO value between the running pump and the stop pump is in the range of 1,968 ppm. So the average DO value in pond water with the Microbubble Generator tool is still above the expected target, which is in the range of 8.0 ppm, while the standard DO average value for pond water with fish is in the range of 5 ppm to 7 ppm.

5. CONCLUSION

Based on the results and discussion of research that has been done can be concluded that:

(1) A Porous Pipe Orifice Type Microbubble Generator test tool with a distributor pipe for fish pond aeration, with overall dimensions of 0.5mx 0.5m x 1.5m, porous hole diameter of 0.3 mm, nozzle diameter of 20 mm, inch PVC pipe, flow capacity 430 Liter/minute, maximum pressure head 18 meters.

(2) The size of the fish pond used is 14m x 4m x 1.2m (water height 95 cm) with standard water (containing about 50kg of fish), with 4 Microbubble Generator (MBG) nozzles, each nozzle attached to each side of the pond and located at a depth of 65 cm from the surface of the water with the direction of the flow of each MBG nozzle towards the center of the pond.

(3) When the pump is running / on, the highest DO value is obtained when using the smallest orifice diameter, which is 8 mm with a mean DO value of 18.128 ppm to 20,625 ppm, while the lowest DO value is at 14 mm orifice diameter with a mean DO value range in the range of 11, 15 ppm to 15.0 ppm

(4) When the pump stops, the highest DO value is obtained when using the smallest orifice diameter, which is 8 mm with a DO average value of 17,375 ppm to 18.90 ppm, while the lowest DO average value is 12 mm orifice diameter with a mean DO value range in the range of 9, 45 ppm up to 12,575 and orifice diameter of 14 mm at a value of 13.375.

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