Journal of Engineering and Applied Technology
Vol. 4, No. 1, March 2023, pp. 33-39

Online ISSN 2716-2265
Printed ISSN 2716-2257

Experimental test analysis of hydram flow rate using L9 Taguchi at fish pond aquaculture

Joko Yunianto Prihatin [1,*], Brillian Adjie Pangestu [2], Roedy Kristiyono [3], Sulistyadi [4]

[1,2]Departement of Mechanical Engineering, Sekolah Tinggi Teknologi "Warga" Surakarta, Surakarta, Indonesia
[3] Departement of Electronical Engineering, Sekolah Tinggi Teknologi "Warga" Surakarta, Surakarta, Indonesia
[4] Departement of Textile Chemical Engineering, Sekolah Tinggi Teknologi "Warga" Surakarta, Surakarta, Indonesia
E-mail: jokoyp.sttw@gmail.com*
* Corresponding Author

ABSTRACT

Good water quality in fish nursery cultivation greatly influences the harvest quality. Temperature and Ph can be maintained properly with proper air circulation. The main problem is that the best flow rate quality in fish ponds of 0.123m^3/second is only achieved through the flow from the dam. In this study, the installation of hydram pumps in fish ponds was carried out with the angle of assessing the inflow and discharge to adjust to variations in the diameter of the inlet and outlet pipes, the height of the inlet pipe, and the height of the tank. The experimental design used L9 orthogonal array Taguchi with four replicas. The result of this study was that the maximum value of the input flow rate was 305.73 cm^3/second, and the discharge flow rate was 40.35 cm^3/second. The maximum value was in the 8th composition; namely, the variation of the inlet pipe height was 200 in, the outlet pipe height was 350 cm, the inlet pipe diameter was 1 in, and the outlet pipe diameter was ½ in.

ARTICLE INFO

Article history
Received:
03 February 2023
Revised:
11 March 2023
Accepted:
31 March 2023

Keywords
aquaculture
fishpond
flowrate
hydram
Taguchi

1. Introduction

Indonesia is the largest archipelago in the world located between two oceans, the Pacific Ocean and the Indian Ocean, consisting of 17,504 islands with a total land area of 1.922.570 km^2. The fisheries sector in Indonesia consists of marine and inland capture fisheries and aquaculture and has an important role in supporting the national economy and food security. In terms of production, in 2019 Indonesia ranked second among countries in the world in total capture fisheries production and third in total aquaculture production in the world [1].

Good irrigation affects the quality of fish farming in ponds. Weather changes have an impact on the success rate of fish farming. Continuous rainy conditions can affect the pH condition of pond water, temperature changes that occur in pond water, changes in salinity and acidity, and the hardness of pond water [2]–[4]. Erratic weather conditions in the morning, afternoon, evening, and night should be safe for the temperature and pH of the fish pond water [5], [6].

The problem is to achieve an effective and comfortable flow rate for fish pond water; an average of 0.123 m^3/sec is only achieved from the dam. As such, fish farmers without dams must use water pumps with high electrical power [7]. Irrigation aims to circulate the water so that the pond's water temperature can stabilize and dissolve fish waste through the drain pipe [8].

A hydram pump is a pump that works by utilizing the gravitational force of water from a certain height flowing into the pipe and causing a dynamic force on the hydram pump valve [9], [10]. In this study, the hydram pump was tested for irrigation in fish breeding businesses in ponds. Thus, this study aimed to apply hydram pump installations that are effective in fish farming in ponds. There are several ways to find the maximum flow rate and the composition of the hydram pump installation that gets the largest discharge based on test data and calculations using the continuity equation.

2. Method

This experimental research was conducted at Taman Kulon, Wiroko Village, Tirtomoyo Sub District, Wonogiri Regency, starting on July 20, 2022. The testing stage began with preparing tools and materials such as a 2-valve hydram pump, PVC pipe, pipe joints, water tanks, stopwatch measuring devices and measuring cups, and a pump installation framework. The height of the hydram pump outlet pipe varied between 300 cm, 350 cm, and 375 cm. The diameter of the hydram pump was 1 inch, and the height of the tank varied between 100 cm, 150 cm, and 200 cm. The diameter of the pipe exiting the air tube was varied between ½ inch, ¾ inch, and 1 inch, and the diameter of the inlet pipe to the hydram pump was varied between 1 inch, 2 inches, and 3 inches at an air tube diameter of 2 inches. The hydram pump construction is depicted in Fig. 1

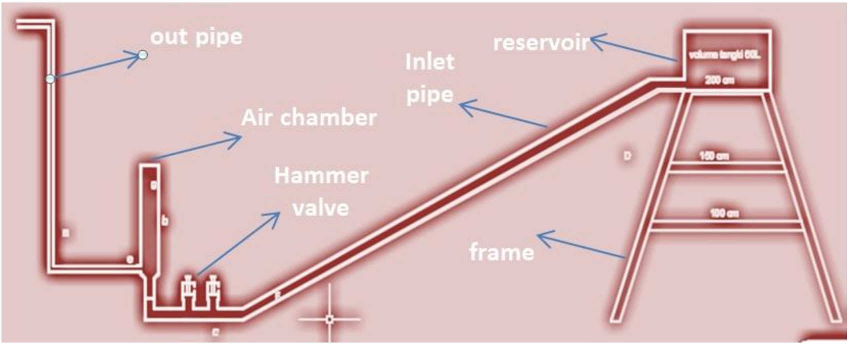

Fig. 1. Double-valve hydram pump construction

In determining the experimental design, the Taguchi system was applied to an L9 orthogonal array with a total of 4 factors and 3 levels. As shown in Table 1, the test consisted of 9 compositions with 4 replicas of data collected.

Table 1. Experimental design of L9 hydram pump

Composition	Tank height	Exhaust pipe hight	Inlet pipe diameter	Outlet pipe diameter	1	2	3	4
1	100	300	1	½	?	?	?	?
2	100	350	2	¾	?	?	?	?
3	100	375	3	1	?	?	?	?
4	150	300	2	1	?	?	?	?
5	150	350	3	½	?	?	?	?
6	150	375	1	¾	?	?	?	?
7	200	300	3	¾	?	?	?	?
8	200	350	1	½	?	?	?	?
9	200	375	2	1	?	?	?	?

At the testing and data collection stage, the flow rate value was obtained at the outlet pipe using a measuring cup and a stopwatch. Tables of flow rate data in and out of the pump test results were analyzed by applying the average and maximum value approaches. Then the confirmation analysis was carried out using a graphical approach that aimed to compare the effectiveness of the data between the test results and the calculation results between incoming and outgoing flowrate.

3. Results and Discussion

Based on the research, data on the volume generated by the pump and the time needed to drain the water from a full tank volume to the end was obtained, as shown in Table 2.

Table 2. The discharge flow rate generated by the hydram pump

Composition	Discharge flow rate (cm³/second)				Sum	Average
	X1	X2	X3	X4		(cm³/second)
1	33.8	30.5	26.4	30.95	121.65	30.41
2	15.2	14.8	8.3	13	51.3	12.83
3	2.1	1.4	1.5	2	7	1.75
4	15.7	30.5	28.7	28.8	103.7	25.93
5	14.4	12.6	10	9.6	46.6	11.65
6	47.3	32	34.2	46.4	159.9	39.98
7	19	16.9	12.5	16	64.4	16.10
8	57.1	27.9	33.4	43	161.4	40.35
9	40	42.1	41.6	36.6	160.3	40.08

The maximum flow rate value was obtained at the composition of 8, with an average of 40.35 cm^3/s. While the minimum flow rate value was achieved in composition 3 with an average discharge of 1.75 cm^3/s. The research results related to the analysis of two hydraulic ram pumps in parallel can pump more water than when operating with one hydram. However, the flow delivery rate was lower than the sum of the flows pumped by each ram when operating independently. The application of a single vertical flow installation is not effective enough [11].

Table 3 explains that the results of the value of the flow rate into the pump were obtained from taking data using a stopwatch measuring instrument when the pump was working from the volume of the tank filled with water until it ran out. The maximum time value data was achieved in composition 9, resulting in an average of 288.75 seconds. At the same time, the minimum value was obtained on composition 8, which achieved an average pumping time of 196 seconds.

Table 3. Pumping time

Composition	Pumping time (second)				Sum	Average
	X1	X2	X3	X4		(Second)
1	210	270	240	210	930	232.5
2	210	290	300	260	1060	265
3	285	280	265	250	1080	270
4	280	265	285	270	1100	275
5	260	245	290	250	1045	261.25
6	280	250	270	280	1080	270
7	250	280	260	265	1055	263.75
8	210	170	190	215	785	196.25
9	300	285	270	300	1155	288.75

In line with the results of research related to the application of hydram pumps that used sources from artesian water by using a large enough flow energy of water at a low place, the water would flow to a higher place with less water flow capacity. The capacity of water flowing to a higher place depends on the pressure difference between the inlet pipe and the discharge pipe pump [12].

The water tank was filled with 60 litres or 60,000 cm^3, then divided by the average time obtained until the tank's volume was used up according to Table 3. Table 4 is the result value of the input flow rate of the pump based on the average time of each variation obtained from the calculation results of the continuity equation.

$$Q_{in} = Volume/ Time \quad (1)$$

For example, Q_{in1} = 60.000/ 232.5 = 258.06 cm^3/second

Table 4. Input flow rate the pump at a tank volume of 60,000 cm^3

Composition	Time of tank volume runs out (second)	Input flowrate (cm^3/ second)
1	232.5	258.06
2	265	226.42
3	270	222.22
4	275	218.18
5	261.25	229.67
6	270	222.22
7	263.75	227.49
8	196.25	305.73
9	288.75	207.79

Table 4 is in line with the test results regarding the performance of the hydram pump based on variations in the angle of the waterfall. The best flow rate value was obtained by force of 11.18 N at an angle of 31°. Meanwhile, the best input flow rate was obtained by force 12.42 N at an angle of 22°. The suction force obtained was almost the same on average, namely 156.5 N for all variations of the waterfall inlet angle [13].

Following research into the optimization of the discharge volume on hydram pump installations, with the main addition of creating a threaded waste valve system, capable of controlling the opening and closing of the valve. So, the goal was to reduce the time needed to create an effective hammering momentum and effect. The water loss in the waste valve was reduced by about 20-30 % compared to the existing design at a mass flow rate of 0.10 kg/second. The result was that hydraulic ram pumps generate a lot of wastewater in the waste and delivery valves. As much as 90% of the incoming water would be wasted, and only 10% would be pumped to higher ground. Additional threaded control valves for both valves would help control any water loss [14].

Based on the results of testing the discharge in and out of the hydram pump in the research, a comparison of data was obtained, as shown in Fig. 2. According to the research results related to estimating the power and efficiency of the hydraulic ram pump with a recirculation system using a discharge calculation, the results were validated in standard fluid mechanics calculations to prevent water wastage [15].

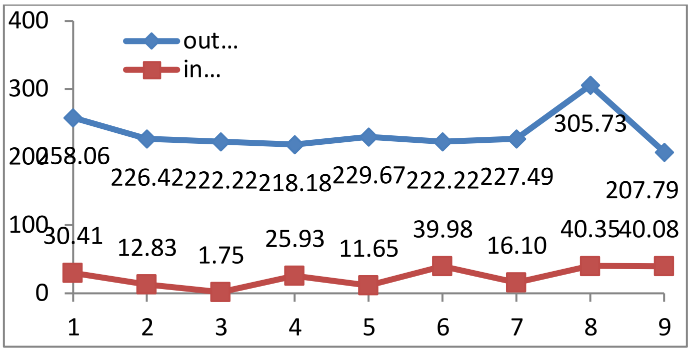

Fig. 2. Comparison of the hydram pump input and discharge flow rate value

The effectiveness of the hydram pump in flowing water in fish ponds is described in Table 5. The best percentage of effective flow rate is achieved if the difference between the incoming and outgoing flow rates is the smallest. It means that not much liquid is discharged that cannot be pumped. The 9th composition was able to achieve the highest percentage of 23.89 %, and the 3rd composition was the smallest, which was only able to reach 0.79 %.

Table 5. The percentage of effectiveness of hydram pump flowrate

Composition	Input flowrate (cm^3/ second)	discharge flowrate (cm^3/ second)	The difference in input and discharge flowrate (cm^3/ second)	The effectiveness of flowrate (%)
1	258.06	30.41	227.85	13.36
2	226.42	12.83	213.59	6.00
3	222.22	1.75	220.47	0.79
4	218.18	25.93	192.26	13.48
5	229.67	11.65	218.02	5.34
6	222.22	39.98	182.25	21.93
7	227.49	16.10	211.39	7.62
8	305.73	40.35	265.38	15.20
9	207.79	40.08	167.72	23.89

Table 5 shows that the 8th composition achieved the 3rd highest percentage of 15.20 %. Then, compared with the curves of the input and discharge test results, it explains that the 8th composition produced the highest flow rate values of 305.73 cm^3/second and 40.35 cm^3/second.

Slightly different from the results of the study on the suitability of water quality, it is necessary to consider the composition of the timing and amount of feeding of these fish. The application of a timer was used to control the amount of time to eat at an interval so that the feedback system that feeds the volume remaining in storage would provide a warning to the user via SMS (Short Messaging Service) remotely [16].

Thus, the correlation with the main problems above is that the best flow rate quality in fish ponds 0.123m^3/second is only achieved in the flow from the dam, so in this study, it was quite capable of reaching 305.73cm^3/second.

4. Conclusion

The conclusion of this study is that the maximum value of the input flow rate is 305.73 cm^3/second, and the discharge flow rate is 40.35 cm^3/second. The maximum value is in the 8^{th} composition; namely, the variation of the inlet pipe height is 200 in, the outlet pipe height is 350 cm, the inlet pipe diameter is 1in, and the outlet pipe diameter is ½ in.

References

[1] SEAFDEC, "Fisheries Country Profile: Indonesia (2022)," 2022. http://www.seafdec.org/fisheries-country-profile-indonesia-2022/ (accessed Jan. 01, 2022).

[2] V. A. Wardhany, H. Yuliandoko, Subono, M. U. Harun, and I. G. P. Astawa, "Smart System and Monitoring of Vanammei Shrimp Ponds," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 11, no. 4, pp. 1366–1372, 2021, doi: 10.18517/ijaseit.11.4.8557.

[3] H. Amiri, B. Hadizadeh, M. G. Mooselu, S. Azadi, and A. H. Sayyahzadeh, "Evaluating the water quality index in dam lake for cold water fish farming," *Environ. Challenges*, vol. 5, no. August, p. 100378, 2021, doi: 10.1016/j.envc.2021.100378.

[4] C. S. M. Figueiró, D. Bastos de Oliveira, M. R. Russo, A. R. L. Caires, and S. S. Rojas, "Fish farming water quality monitored by optical analysis: The potential application of UV–Vis absorption and fluorescence spectroscopy," *Aquaculture*, vol. 490, no. February, pp. 91–97, 2018, doi: 10.1016/j.aquaculture.2018.02.027.

[5] M. Besson *et al.*, "Influence of water temperature on the economic value of growth rate in fish farming: The case of sea bass (Dicentrarchus labrax) cage farming in the Mediterranean," *Aquaculture*, vol. 462, pp. 47–55, 2016, doi: 10.1016/j.aquaculture.2016.04.030.

[6] S. A.M. *et al.*, "Influence of cage farming and environmental parameters on spatio-temporal variability of fish assemblage structure in a tropical reservoir of Peninsular India," *Limnologica*, vol. 91, no. October, p. 125925, 2021, doi: 10.1016/j.limno.2021.125925.

[7] S. Kaimal, A. H. Haukenes, N. N. Renukdas, and A. M. Kelly, "Effects of Crowding and Water Flow on Golden Shiners Notemigonus crysoleucas, Held in a Flow Tank," *Front. Physiol.*, vol. 13, no. April, pp. 1–8, 2022, doi: 10.3389/fphys.2022.875898.

[8] P. Mahbub and A. Sharma, "Investigation of alternative water sources for fish farming using life cycle costing approach: A case study in North West Tasmania," *J. Hydrol.*, vol. 579, no. October, p. 124215, 2019, doi: 10.1016/j.jhydrol.2019.124215.

[9] Z. Yussupov, A. Yakovlev, Y. Sarkynov, B. Zulpykharov, and A. Nietalieva, "Results of the study of the hydraulic ram technology of water lifting from watercourses," *Int. J. Eng. Sci.*, vol. 177, no. May, p. 103713, 2022, doi: 10.1016/j.ijengsci.2022.103713.

[10] M. Inthachot, S. Saehaeng, J. F. J. Max, J. Müller, and W. Spreer, "Hydraulic Ram Pumps for Irrigation in Northern Thailand," *Agric. Agric. Sci. Procedia*, vol. 5, pp. 107–114, 2015, doi: 10.1016/j.aaspro.2015.08.015.

[11] E. del Risco Moreno, R. D. Muelas-Hurtado, and E. A. Acosta-Porras, "Analysis of two hydraulic ram pumps in parallel operating with single-vertical supply," in *Journal of Physics: Conference Series*, 2021, vol. 2022, no. 1, pp. 1–5, doi: 10.1088/1742-6596/2022/1/012028.

[12] B. Ulum, S. Arifin, and M. Fathuddin Nur, "Experimental Test of Hydram Pump Model in Utilization of Artesian Well Water Flow Gending 1 Probolinggo State Vocational High School," vol. 05, no. 1, p. 2022, 2022.

[13] R. Sutanto and Sujita, "ANALYSIS OF HYDRAM PUMP PERFORMANCE ON VARIA-

TION OF WATERFALL ANGLES," *Glob. Sci. Journals*, vol. 9, no. 8, pp. 2982–2985, 2021.

[14] M. N. Harith, R. A. Bakar, D. Ramasamy, and M. Quanjin, "A significant effect on flow analysis & simulation study of improve design hydraulic pump," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 257, no. 1, 2017, doi: 10.1088/1757-899X/257/1/012076.

[15] S. S. S, S. Shetty, A. M. Pendanathu, W. Javaid, and C. P. S. M, "Estimation of Power and Efficiency of Hydraulic Ram Pump with Re-circulation System," *Int. J. Comput. Mech. Des. Implement.*, vol. 1, no. 1, pp. 7–18, 2015, doi: 10.21742/ijcmdi.2015.1.1.02.

[16] M. Nasir Uddin *et al.*, "Development of an automatic fish feeder," *Glob. J. Res. Eng. A Mech. Mech. Eng.*, vol. 16, no. 2, p. 11, 2016.