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Simulation and Control of Flexible Link Aerator with PID Using Ziegler Nichol's Method

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Abstract: The failure to maintain prawn alive in a pond has resulted in a significant loss of investment for the prawn farmer. It is well recognized that one of the problems in prawn habitat is a shortage of oxygen delivered to the pond. Water is a mixture of Oxygen and Hydrogen. As a result, oxygen exists within the water, which is required for the shrimp to breathe. By implementing this project in the prawn pond, the oxygen concentration inside the pond may be improved while decreasing the pawn's death rate. By combining the PID controller with the Ziegler Nichols method, the death rate of prawns may be further reduced, and the effectiveness of the controller used to control the rate of concentrated oxygen inside the pond can be raised. The results indicate that the value acquired prior to and following implementation of the Ziegler Nichols approach is successful, and that the system's performance has improved. Peak response is decreased to 1 O_2 % from 1.28 O_2 %, and overshoot is decreased to zero from 28.1. The time required is reduced from 3 to 1.75 seconds. The settling time value is reduced from 8.91 to 2 seconds, while the rise time is increased from 1.19 to 1.5 seconds.

Keywords: Ziegler Nichols, Flexible Link Aerator, Oxygen Concentration, PID Controller

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1. Introduction

Aeration is the introduction of oxygen or pure hydrogen to the surrounding water. There are several factors in this process to understand the aerator equipment, which is the combination of volume, pressure, and friction [1]. Agriculture has now become one of the incentives that inspire youth generation to pursue it more and use the sector for various types of applications. The important aspect for Agriculture sector involvement is to understand what aquatic life needs. Knowledge of living aquatic element such as knowing the value of aquatic life liquid [2]. The aerator also known as the oxygen exchange system which converts oxygen from gas to liquid phase [3]. In the agricultural sector, the most aerators are gravity aerators, pool aerators, injection or spray aerators and hydraulic aerators [4].

Aquatic life relies on the preservation of dissolved oxygen [5]. It will harm the aquatic life due to the lack of dissolved oxygen. Either it risks destruction, or it exits the area to find a better place to live [6]. The process involved in the dissolved oxygen transfers oxygen from the phase of gasses to the phase of liquid. The water will be measured by dissolved oxygen to ensure the survival of aquatic life [7]. Water temperature and atmospheric pressure effect water's ability to hold dissolved oxygen may decrease due to weather and dissolved oxygen may increase during rainy weather and night [8]. Artificially reduced dissolved oxygen will increase the staying power of Trichomonas Gallian in water [9]. Optimizing land control techniques for optimum enhancements in lake dissolved oxygen concentrations. Eutrophication and anoxia are unresolved problems in lots of huge waterbodies [10].

The Arduino controller proposed to introduce this project is a simple implementation control system compared to another controller [11]. Arduino is a USB connector for attaching the power supply or a laptop adapter to attach the code to the deck [12]. The methods of Zeigler Nichols, also known as hand tuning techniques, are usually used by professional control engineers based on the rules [13].

A paddle wheel is a form of waterwheel or impeller in which a number of paddles are set around the periphery of the wheel. Nathan Smith, of Berwick City, La., has invented a paddle wheel that's supposed for stern-wheel boats, and the discovery is composed in becoming the 2 hubs sporting the 2 units of fingers of a paddle wheel to their shaft, and the attachment of the buckets to the fingers of the wheel [14].

2. Software and Methods

The software that are being used in this project is MATLAB. MATLAB is a programming and numeric computing platform used by millions of engineers and scientists to analyses data, develop algorithms, and create models.

2.1 Developing the concept

Developing of concept will examine about structuring for controlling the flexible link aerator [15]. The structuring the controller flexible link aerator it will comprise of Arduino framework with PID and Ziegler Nichol’s controller technique.

2.2 Generate the transfer function

Based on the information that are given by the supplier. A transfer function is generated with the technique of identification where’s.

2.3 Analysis of Step Response

Analyzing the step response from the transfer function obtain from the system identification. Based on the system identification we can obtain the transfer function of this equation in the Equation 1 below. Based on the transfer function the graph obtain from it is in the Table 4.1 as shown below.

$$G(s) = 0.9704 / (0.9704S^2 + 1.126s + 0.07445) \quad \text{Eq.1}$$

Table 1: Characteristic and the value of it

Item	Characteristic	Value	Unit or Dimension
1	Peak response	13	O_2 %
2	Overshoot	0	O_2 %
3	Time taken	90	second
4	Settling time	56.4	second
5	Rise Time	31.2	second
6	Final value	13	O_2 %

Table 1 shows the performance of the system determined from an open loop system. The result that obtain shows that the response time taken for the value of the rising time is 31.2 sec which delay the response time for the system to achieve it maximum value without overshoot. It can be seen that the time taken for the settling time is quite high at 56.4 sec when the system without oscillation. The peak performance that obtain is 13 O_2 % .

2.4 Implementing the Ziegler Nichols 1st method in the Close Response Model System

Based on the step response obtained above, which is derived from the transfer function formed from the specification provided by the item's supplier and depicted in Figure 1, the graph derived from this transfer function is implemented using the Ziegler Nichols method as shown below.

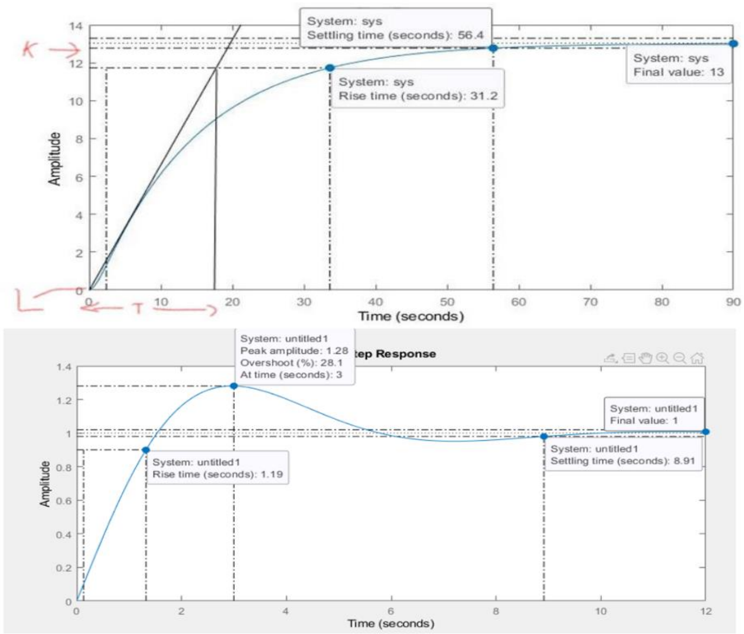

Figure 1: The step response before and after implemented with Ziegler Nichols method

By drawing the tangent line on the graph, the value of K, T and L can be obtaining based on the Ziegler Nichols method.

Table 2: Characteristic value that obtain from the Ziegler Nichols method.

Item	Characteristic	Value	Unit or Dimension
1	K	13	O_2 %
2	L	1	O_2 %
3	T	18-L	second

Based on the value received from the graph using the Ziegler Nichols method, we now have all the unknowns required to be entered into the Ziegler Nichols method, as seen below.

Table 3: Ziegler-Nichols Tuning Formula for Step Response Method

Controller	Kp	Ti	Td
P	1/a	-	-
PI	0.9/a	3L	-
PID	1.2/a	2L	L/2

Based on Table 3, the tuning formula above the equation that need to be used to obtain the unknown value in the table is by using both of this equation $C(s) = K_p + K_i \frac{1}{s} + K_d s$ and $C(s) = K_p(1 + \frac{1}{T_i s} + T_d s)$ which also used as reference for the tuning that will be done in MATLAB. Based on the tuning formula and the equation the equation of a, Ti and Td can be obtained alongside the equation of Kp, Ki and Kd can be obtain.

Table 4: Equation of a, Ti and Td

Item	Characteristic
a	K*L/T
Ti	2*L
Td	L/2

Table 5: Equation of Kp, Ki and Kd

Item	Characteristic
Kp	1.2/a
Ki	Kp/Ti
Kd	Kp*Td

Table 4 shows the equation that are needed to be used to obtain the unknown value of a, Ti and Td and when the equation of Table 3 is obtain now it can proceed to Table 5 which need to obtain the value of Kp, Ki and Kd. The value needed to find the value of a, Ti and Td is based on the value that obtain from the tangent graph that have done at above.so after obtaining the all the equation needed for the tuning now inserted it into the MATLAB as shown below.

```
s=tf('s')
sys=0.9704/(s^2+1.126*s+0.07445)
figure
%step(sys)
K=13;
L=1;
T=18-L;
```

```
a=K*L/T;
Ti=2*L;
Td=L/2;
Kp=1.2/a
Ki=Kp/Ti
Kd=Kp*Td
cont=pid(Kp,Ki,Kd)
step(feedback(cont*sys,1))
```

The figure illustrates the coding required to produce the step response. We can see that it incorporates all of the tables and figures above without omitting any, as each is necessary for obtaining the step response when utilizing the Ziegler Nichols approach.

3. Results and Discussion

From the transfer function that obtain from specification that provided by the supplier and used the system identification technique to design a conventional PID controller system. The cause of use PID controller in the closed loop system is that to let the motor run very near the reference pace that obtained. A fast response and small overshoot detected with zero steady state error with the response of PID all of this is achieved. Figure 2 shows that the response of PID controller to the BLDC motor control speed with open response of modelled BLDC motor system. The PID controller have been tuned using the Ziegler Nichols method that are done manually with a lot of trials and errors to obtain the best parameters with less settling time, rise time, overshoot, and steady state errors than the first one. To obtain that, the value of Kp need increase periodically from zero till the final value is reached, while others value remains zero. The final value obtained for Kp is 35 and it shown at figure below.

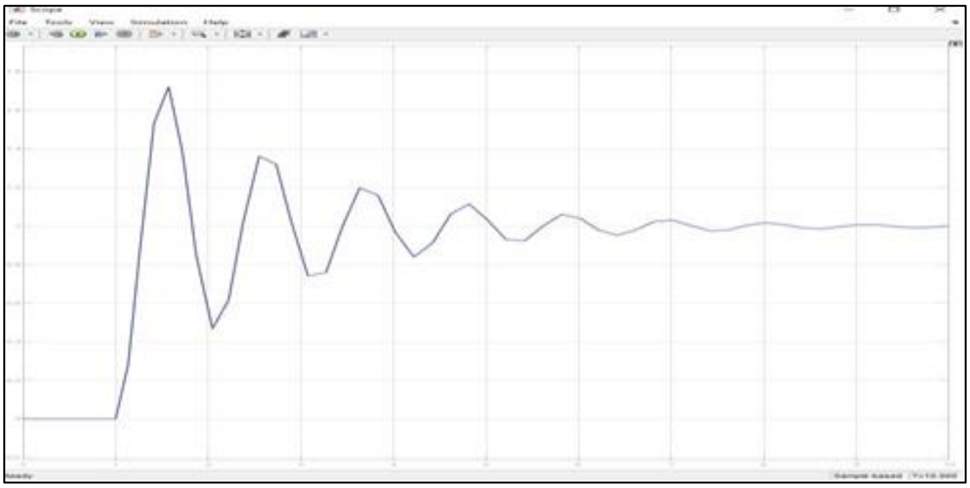

Figure 2: Kp Step Response

After completing the first step, the second step can be completed by increasing the coefficient of derivate Kd from zero to the response, increasing the settling time and overshoot and decreasing the rising time. The optimal value for Ki is 0.1. The graph is displayed in Figure 3.

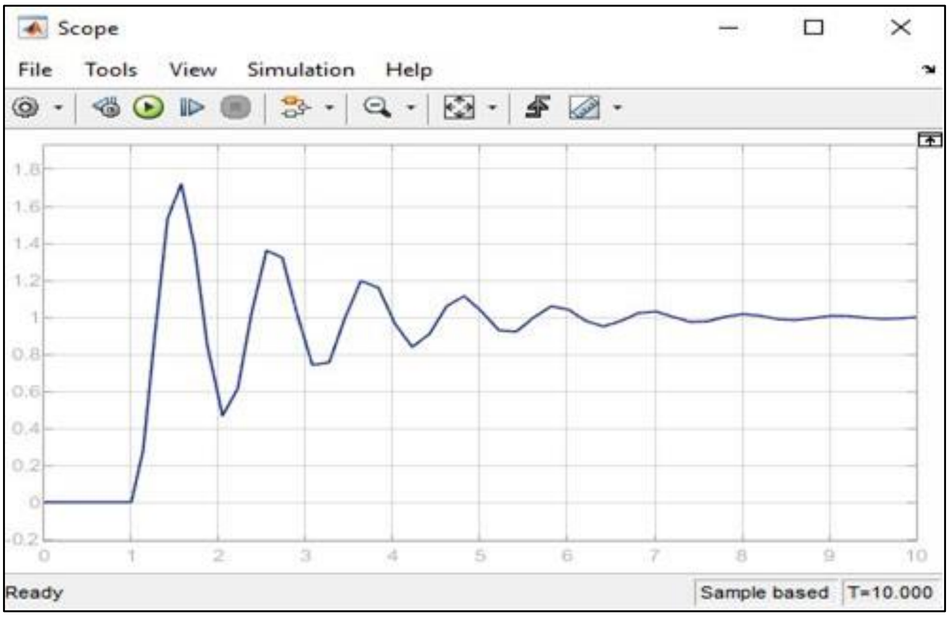

Figure 3: Kp and Ki Step Response

The last step which the integral gain for Kd where the value is increase from null to a certain value that able to eliminate overshoot and reducing settling time to its minimum capabilities. The gains are of the proportional and derivative which obtained from the final response of the PID controller that is shown in Figure 4. The value that obtains after the elimination of overshoot and reducing settling time is 8. The value of each Kp, Ki and Kd is shown in Table 6 below.

Table 6: Tuned PID Controller Parameter

Parameter of PID Controller	Kp	Ki	Kd
	35	0.1	8

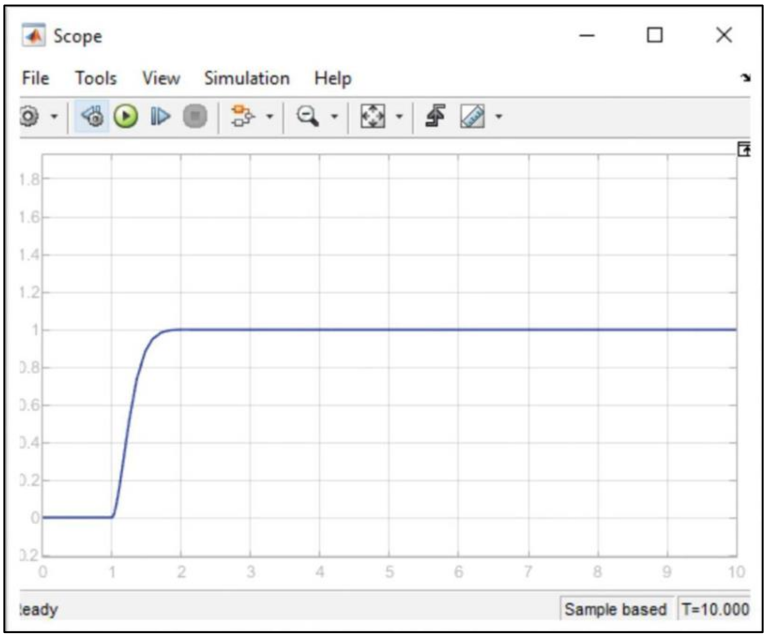

Figure 4: Tuned PID Response of System

Table 7 shows the new parameter which obtain after putting all the value of Kp, Ki and Kd into the MATLAB. The value of peak response is reduced to 1 O_2 % from 1.28 O_2 %, while the value of overshoot is reduced to zero from 28.1 O_2 %. The time taken is reduce from 3 sec to 1.75 sec. Settling time value decrease from 8.91 sec to 2 sec. While the value that increasing the rise time where its increase from 1.19 sec to 1.5 sec. Final value for both is still the same.

Table 7: Parameters Value After Tune

Item	Characteristic	Value	Unit or Dimension
1	Peak Response	1	O_2 %
2	Overshoot	0	O_2 %
3	Time Taken	1.75	second
4	Settling Time	56.4	second
5	Rise Time	31.2	second
6	Final Value	1	O_2 %

4. Conclusion

In conclusion this project able to achieve the objective that have been presented at above with the use of flexible link aerator as ref device. By using MATLAB or Simulink, the movement speed of flexible link aerator is controlled. The maximum speed of the motor can move is up to 3000 rpm based on the specification that are provided by the supplier. Based on the transfer function that provided the supplier or factory the controller system is being applied to the flexible link aerator using the PID controller with the Ziegler Nichols method for the tuning the controller. With the application of Ziegler Nichols method, the response time overshoot and also the settling time able to reduce using the try an error method where's the method is used to tuned one by one until obtain the desired results which reducing the overshoot and settling time.

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