Design Concept of Two Tank Reservoirs to Maintain pH Value for Tiger Prawn

Badrul Aisham Md Zain1,2, a, Muhammad Farhan Khasim2,b, Salihatun Md Salleh2, c and Md Saidin Wahab3,d

1Advance Control & Automation Research (ADCARe)
2Faculty of Mechanical Engineering & Manufacturing Universiti Tun Hussein Onn Malaysia (UTHM), 86400 Parit Raja, Batu Pahat, Johor, Malaysia
3Advanced Manufacturing and Material Center (AMMC) Universiti Tun Hussein Onn Malaysia (UTHM)
86400 Parit Raja, Batu Pahat, Johor, Malaysia

a aisham@uthm.edu.my, b planktonproject23@gmail.com, c saliha@uthm.edu.my, d saidin@uthm.edu.my

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Abstract: Shrimp culture is the fastest growing sector of the aquaculture industry in Malaysia. In culturing tiger prawn, the pH level needed for water is around 7.0-8.5. Currently, prawn farmer in Malaysia still using a manual method to control the water pH level by adding chemical (lime), in which, the process required constant monitoring and control by labor. Since the prawns are so sensitive on pH level, an automatic pH control system is required to maintain the water pH automatically and precisely. This research was conducted to design a system that can control and provide feedback on the changes of pH level and been implemented at the reservoir tank that can act as water storage tank and prawn pond. Control system and pH sensor are the important components in controlling the pH level. Input from pH sensor is processed by controller. Moreover, after an error is detected by controller, the correction will be delivered to the system as a feedback process. Nitric acid with concentration of 0.001M was added to 25 liter water in tank 1 so that the pH level is decreased to pH 3.00. Different concentrations were used for slaked lime; 0.5M, 0.4M, 0.3M, 0.2M and 0.1M, to increase the pH from acid to slightly alkaline in the range of pH value 7.00-8.50. Slaked lime is pumped to Tank by water pump and it will stop if the pH level reaches the setting level. The time for the system to recover from pH 3.00 to 7.00-8.50 were recorded. The results shows that slaked lime with the concentration 0.5M has the fastest recover time which is 29s follow by 0.4M in 69s, 0.3M in 92s, 0.2M in 151s and 0.1M in 252s, respectively.

Introduction

In culturing tiger prawn, there are no specific quantities or ratio of water and alkaline water inside the prawn pond [1]. Tiger prawn is the species that live in the pH water exactly same with sea water around 6.0 until 8.5. The optimum pH value to produce good quality of prawn is around 7.5 until 8.5 [2]. The current method that are applied by farmer in Malaysia is used a manual method to add chemical to control the pH level of water. This method is not efficient and accurate due to size of pond, level of water, quantity of prawn and type water where are not been considered during control the pH level of water in the pond. There are also no standard specification that been referred by farmer because the amount of chemical that are added to pond based on size, quality and quantity of prawn from previous harvest [1].

Lime is normally used by prawn farmer to control the level of pH in water. Consequently, it is increased the decomposition of organic and at the same time nourishing the pond, destroy the pathogenic organisms and encourage the process of prawn molt [3]. By developing and applying automation system, the precise amount of chemical can be added to the pond. Therefore, level of pH in water can be controlled automatically. The concept of automation system in prawn culture hopefully helps our farmer in aquaculture industry to reduce cost and increase productivity.
Literature review

A. pH sensor

pH sensors consist of two primary parts which are measuring electrode and reference electrode. Measuring electrode is referred to as a membrane or active electrode and it is sometimes called the glass electrode. Reference electrode is referred to as a standard electrode. The pH measurement is consisting of two half-cell or electrode. One half-cell is the pH sensitive glass measuring electrode and the other is reference electrode [4]. The measuring and reference electrodes can be in one of two forms which are two physically separate electrode known as electrode pair or the electrode can be joined together in a single glass body assembly known as a combination electrode [4]. The joined electrode is normally used as commercial pH sensor.

The galvanic voltage output produced by a measuring electrode will depend on the ionic activity of the species of ions for which the electrode was design to measure. In the case of pH electrodes, it is the hydrogen ion activity. At pH level of 7, it is isopotential point for a perfect electrode and gives output of 0 mV. While the pH of solution increase which is less acidic, the mV potential becomes more negative. Consequently, when the pH of solution is decrease which is more acidic, the mV potential becomes more positive [4].

B. Lime

Lime is an important chemical that has been used in prawn pond. By applying liming process to prawn pond it can increase the pH for mud. It is also can increase the availability of phosphorus added in fertilizer [1]. Lime has a lot of advantages in aquaculture such as to strengthen the base of water used in pond, to increase the light penetration of water inside the pond, to kill microorganism such as parasites, to rise the pH level of water from acidic to a neutral or slightly alkaline and to neutralize the harmful action of substance such as acid and sulphide.

There are few types of lime that been used for aquaculture purpose in calcify process such as limestone (CaCO3), quicklime (CaO) and slake or hydrated lime. Each of the type of the lime have varying in neutralising strength, solubility, ability to neutralise acidity and influence on pond chemistry. The ability to neutralise acidity is describe as their neutralising value. It can be determined by comparing the values to the pure calcium carbonate [5].

Methodology

A. Concept selection

Concept selection is important to select the best concept and meet all the criteria that are needed for the study. Selection of the concept was done by Pugh matrix method. All of the important criteria will be compared and evaluated from two concepts that have been proposed. Each concept is evaluated by using weigh method and the weigh score will be given based on priority of the criteria. Concept that has the highest score will be chosen [6]. The score will be given from 1-2 and will be multiplied with weight of the criteria, as shown in Table 1. Based on Table 1, Concept 1 has the highest score compared to Concept 2, where it meets all the criteria. It is better than concept 2 in terms of performance, prawn survival and system flexibility. Moreover, it control the pH of water without give any effect to the prawn because during the lime enters the tank, it takes time to react with water. So, during this process, prawn will not exposed to water that is still not stable in pH level. Concept 1 also react as the system flexibility when any source of water have different level of pH that are not suitable for the prawn can be easily control before supplied to the prawn tank. Figure 1 shows the layout between Concept 1 and Concept 2, respectively.
Table 1: Pugh matrix method

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weighting</th>
<th>Concept 1</th>
<th>Concept 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>0.3</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Environmental suitability</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Prawn survival</td>
<td>0.3</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>System flexibility</td>
<td>0.2</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>2</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Fig. 1: Concept of Tank Reservoir System [1]

B. Testing and finding result

An experiment was conducted to the pH sensor to determine whether it can measure the pH level in the tank and gave an output signal to the system. The pH sensor was immersed in the water and the output in the form of millivolt was converting into pH value. All data for the output given by sensor were recorded.

An experiment was conducted to the system to determine the feedback on change of pH level. Water was set to pH level 3.00 by adding 0.001M nitric acid to 25 liter water in Tank 1. Different concentration of slaked lime was used in these experiments which are 0.5M, 0.4M, 0.3M, 0.2M and 0.1M. In each experiment slaked lime were filled in the lime container. Water pump was used to pump the slaked lime into Tank 1. Time for the system to recover the level of pH from 3.00 to 7.00-8.50 were recorded

Result and discussion

There are two reservoirs tanks that were used in this project. The first tank noted as Tank 1 was used for water storage tank. This tank is considered as main tank for this project where the pH of water is controlled. Water from source was supplied to this tank by water pump. Control box and pH sensor are located at this tank. These two components are the main components to detect and control the pH of water. Tank 2 is acting as a prawn pond. Water that has been controlled from Tank 1 is supplied to this tank. Level of water in these two tanks was controlled by ball valve. The size of both tank are the same. Figure 2 shows the layout of Tank 1 and Tank 2, respectively.
Control box is the part that controls the level pH of water. Electronic circuit, controller and all electronic components are placed in this control box. The main purpose of controller is to control most of the other components in this system. It is used to make decision and gives an output based on parameter that been set. Parameter is setting through code that has been programmed to the controller. The advantages of the controller is used in this project are able to read both digital and analog signal. Even though the level of pH is display on LCD, controller that can read digital signal can allow us to monitor the system when it is running through a computer.

The use of LCD is to display the pH level that been measure by pH sensor while relay is used as a switch to turn on the water pump. When pH level is below than pH 6.5 controllers send an output signal to the relay to allow that pump to turn on. The function of AD-DC adapter is to supply power to the pump. Figure 3 shows the control box and the electronic circuit, respectively.

Based on the analysis of pH sensor, the relationship of pH value with the output in millivolt is an inverse proportional graph. In sequent, the pH value is increase; the value of output from sensor will decrease from positive 414.12 to negative 414.12.
Moreover, the value of output is 0mV so that the value of pH obtained is 7.00pH. This shows that the sensor was in good condition and the measurement were accurate. So, from the analysis is proved that sensor can measure the level of pH accurately.

Based on analysis on feedback of the system, all of the experiments were in a positive feedback. From experiment 1, the time for the system to recover the level of pH was 29s and Figure 4 shows the pH level is 7.29. Five experiments were conducted and the result is tabulated in Table 2. Table 2 shows time for the system to recover for all concentration of slaked lime. By referring to data from all experiment and graph, the concentration of the slaked lime will influenced the time for the system to recover the pH level. Slaked lime with concentration of 0.5M recover fastest followed by 0.4M, 0.3M, 0.2M and 0.1M. So, the relationship between the pH and time is inverse proportional where the concentration is increase whereas the time to recover the pH level will be decreased. Finally we can conclude that this system can gave a positive feedback on change of pH level as we want.

![Graph pH level vs time(s) for concentration 0.5M](image)

**Fig. 4:** Graph pH level vs time(s) for concentration 0.5M

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Concentration of slaked lime (M)</th>
<th>Time to recover (s)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5M</td>
<td>29</td>
<td>7.29</td>
</tr>
<tr>
<td>2</td>
<td>0.4M</td>
<td>69</td>
<td>7.37</td>
</tr>
<tr>
<td>3</td>
<td>0.3M</td>
<td>92</td>
<td>7.25</td>
</tr>
<tr>
<td>4</td>
<td>0.2M</td>
<td>151</td>
<td>7.18</td>
</tr>
<tr>
<td>5</td>
<td>0.1M</td>
<td>252</td>
<td>7.14</td>
</tr>
</tbody>
</table>

**Table 2:** Experiment for Concentration of slaked lime versus time and pH value.

**Conclusion**

Based on the analysis and collected data, it was proved that the pH sensor measured the level of pH accurately, where the outputs given by pH sensor in millivolt are exactly same with pH value of water after it was converted to pH value. It is also proved that this system can give a positive feedback after changing of pH level in the water. The time for this system to recover from an acid pH value to desire pH value is depends on the concentration of the slaked lime where the size of the tank and volume of the water are constant. So, the pH level in prawn tank can be controlled and maintained automatically within the optimum pH that is suitable for prawn.

In conclusion, it is proved that the pH sensor system was successfully control and maintains the level of pH in the water and accurately response on changing of the pH level.
Reference


