Journal of Theoretical and Applied Information Technology
31st March 2018. Vol.96. No 6

ISSN: **1992-8645** www.jatit.org E-ISSN: **1817-3195**

DESIGN OF DISINFECTANT MANUFACTURING SYSTEM WITH AUTOMATIC CONCENTRATION CONTROL

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ABSTRACT

HACCP (Hazard Analysis and Critical Control Point) is a systematic preventive approach that has been first developed for astronaut food safety in the 1960s. Recognized as an effective tool to suppress food poisoning broken out by pathogens, toxins and chemicals, it has been adopted by many countries. Preventive procedures based on HACCP processes are becoming increasingly important since food poisoning accidents at large meal service stations, which can infect a large number of people at once, are not decreasing each year. The chemical disinfection is a common method to remove pathogens and the chlorine solution is mainly used. Since chlorine can harm not only the bacteria but also the human body, the concentration of the chlorine solution should be suitably adjusted. In addition, the disinfectant solution must be prepared immediately so that the disinfection process is carried out on the spot. Therefore, the chlorine solution should be able to accurately measure in a short time. The disinfectant management system proposed in this paper is a device that can prevent the contamination of tableware and food materials by manufacturing disinfectant of exact concentration and measuring its concentration in real time. The proposed system detects the inflection points of the ORP and pH changed by applying the reducing agent to the disinfectant and measures the concentration. Experimental results show that the average measurement accuracy is 97.42% and the measurement elapsed time is 97.9 seconds.

Keywords: *Measurement system, Disinfectant, Chlorine Concentration, ORP, pH*

1. INTRODUCTION

The World Health Organization defines food poisoning as "an infectious or poisonous disease that is thought to be caused or resulting from the ingestion of food or water" [1]. More than 250 food poisoning causes are known worldwide and classified as shown in Table 1 [2]. Most of them are pathogens (bacteria, viruses, parasites, etc.), toxins and chemicals such as mushrooms poison. HACCP is a systematic approach to prevent biological, chemical, and physical hazards in food production processes that can cause the finished product to be unsafe [3-6] Governments are increasingly beefing up its provisions on food hygiene regulations, such as the need to introduce HACCP to reduce food hygiene accidents. Nonetheless, the number of food poisoning accidents that occurred in Korea during the past 12 years from 2002 to 2014 shows that food hygiene accidents are rarely decreasing [7]. In particular, more than 60% of food poisoning cases occurred in the group food service (school, business). Also, if food materials are not washed sufficiently, there is a possibility of infection with infectious microorganisms.

Table 1: Classification of food poisoning factors.

	category
Microbial hazards	Bacteria
	Virus
	Parasite
Natural hazards	Animal
	Vegetable
	Mycotoxin
Chemical hazards	Food additive
	Metal compound
	Oxidation product

Disinfection is a method mainly used for the safety of food by killing various kinds of microorganisms such as bacteria, viruses, protozoa and parasites which can cause various diseases that may be contained in food materials and tableware [8]. In a group meal facility, large quantities of food are handled at one time, and many people serve meals, so food service machines and utensils are especially susceptible to contamination and microbial proliferation. Also, if the food materials are not washed sufficiently, there is a possibility of infection with infectious microorganisms. The chlorine solution used in the chemical disinfection process is generally prepared by diluting the raw solution by the on-site cooking personnel. However, it is not easy to produce a precise chlorine solution due to variations in the concentration of the raw solution and the produced chlorine solution. In addition, a sufficient reaction time is required for the disinfectant to inactivate food poisoning bacteria.

In this paper, we propose an automatic disinfectant concentration control system to increase the sterilization rate of tableware and food materials through chemical disinfection. The device automatically produces and maintains a precise and constant concentration of a disinfectant solution and ensures sufficient reaction time. Accurate concentration measurement of sterilization disinfectant is necessary for automatic preparation and maintenance of disinfection solution. Electrolysis method and reagent staining method have been mainly used for measuring the concentration of disinfectant [9]. The electrolysis method uses a characteristic curve of voltage and current that is proportional to the chlorine concentration during electrolysis. While it is likely to apply to the automatic measurement using the sensor, the electrolysis method has problems with complex analysis and low accuracy. The reagent staining method is a method of using the color change of the reagent which is colored in chlorine. The reagent staining method is relatively easy to measure and allows a trace amount of residual chlorine to be measured at a limit of 0.05 mg/L. However, there is a problem that waste liquid is generated and automation is difficult.

The automatic disinfectant management system proposed in this paper utilizes the characteristics of ORP (Oxidation Reduction Potential) and pH concentration which are varied by a chemical reaction between a chlorine-based disinfectant and a reducing agent. When the proper amount of the reducing agent reaches the equivalence point, the value of the ORP, which is kept constant, is rapidly decreased. The pH concentration reaches the inflection point, where it gradually decreases and then increases again. The proposed system keeps monitoring the change of ORP and pH concentration, finds the equivalence point, and calculates the concentration of disinfectant by using the amount of reducing agent. It can measure the concentration of all chlorine series by using ORP and pH change characteristics. Since using the relative value of the sensor, it does not need frequent sensor correction and is resistant to sensor errors. The system also provides automatic concentration control and accurate immersion time management which are inspection items of CCP/CP necessary for HACCP operation [10]. The proposed device is evaluated with the measurement accuracy and the time taken to measure concentration for a disinfectant solution. As a result of the performance evaluation, the designed device shows a measurement accuracy of 97.42%. The time taken for the measurement is analyzed within an average of 97.9 seconds.

This paper is composed of as follows. Section 2 examines the research results and technologies developed concerning the measurement of residual chlorine concentrations. In Section 3, we describe the structure of the automatic disinfectant control system proposed in this paper and the method of measuring the chlorine concentration according to the amount of reducing agent to be dosed. In Section 4, the performance results are analyzed, and conclusions are made in Section 5.

2. CONCENTRATION MEASUREMENT

Methods for measuring residual chlorine include electrolysis using current or voltage characteristic curves, reagent staining using the color change of reagents, ORP/pH analysis using solution oxidation/reduction features. In this section, the types and characteristics of reagent staining, and electrolysis methods are explained, and the ORP/pH analysis method used for the proposed system is examined in more detail.

2.1 Reagent Staining Method

Reagent staining methods include litmus staining and colorimetric methods. The litmus staining method is to measure the concentration by observing the degree of discoloration with the naked eye, using the characteristic of discoloring when a test paper called litmus is immersed in a sample solution [11]. Although this is a relatively simple and fast method of measurement, it has a low precision and has deformation problems such as discoloration of the test paper. In the colorimetric method to measure the concentration of a solution, a sample for coloring is added to an unknown solution and a known standard solution, and then the changed color, saturation, and hue of the two solutions are compared by using transmitted light or reflected light [12]. Comparison of color tones through the naked eye has a limitation in accurate concentration measurement. In order to overcome this problem, there is an absorption photometry for measuring the color density of a substance using the difference in the amount of light absorbed by each color. It irradiates the light source to the sample solution for measurement and calculating the concentration of light detected by the optical sensor installed on the opposite side. This method can obtain accurate concentration values, but it is difficult to measure the concentration repeatedly in a short time.

2.2 Electrolysis Method

The electrolysis method is a method of applying an electric energy to induce an involuntary oxidation-reduction reaction, and using the characteristic curve of voltage and current generated according to the chlorine concentration. Typical electrolysis methods include polarography, galvanic cell, and cyclic voltammetry [13]. Polarography, which is one of the most used methods for chlorine measurement, analyzes the current-voltage curve obtained by electrolyzing a solution using a mercury working electrode and a counter electrode to measure the concentration of a substance in a solution. In the galvanic electrode method, the concentration is measured using the difference in the electromotive force magnitude of the galvanic cell formed by immersing the different kinds of metals in the chlorine solution. The cyclic voltammetry is a method of measuring the concentration by acquiring a current potential curve at the solid electrode using the difference of the electric potential curve characteristics according to the concentration of chlorine contained in the solution.

2.3 ORP/pH Analysis Method

Oxidation Reduction Potential (ORP) is a measure of the tendency of a substance to be oxidized by the loss of electrons or to be reduced by the acquisition of electrons [14][15]. Thus, the chemical reaction can be predicted using the ORP. Since they are strong oxidants and different each other in the degree of oxidation of the surrounding materials, sanitizing agents have characteristics of unique ORP values depending on the ion species. Victorin et. al. have proposed a method to determine the amount of chlorine based on the fact that even with the same disinfectant, the ORP value changes according to the concentration [16]. However, at a certain concentration (about 2 ppm) or more, the ORP difference is very small, which makes it difficult to measure a high concentration solution. In addition, since it relies on the absolute value of the sensor, frequent sensor correction and management are required to maintain the sensitivity of the sensor.

Meanwhile, when the reducing agent is injected into the solution containing chlorine, it is observed that the measurement value of the ORP rapidly drops at a certain point as shown in Figure 1. That is, the reducing agent of sodium sulfite injected into a disinfectant solution, it reacts with a solution, consuming chlorine so that the value of ORP is falling. At the point when the chlorine is completely consumed, the ORP value is observed to increase inversely as the occupant is replaced with the reducing agent. Stoichiometry can determine the residual chlorine concentration based on the concentration and amount of reducing agent injected to this inflection point. The theoretical reaction formula of sulfite and chlorine is as follows.

$$SO_3^{2-} + Cl_2 + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2Cl^- \quad (1)$$

That is, the reaction between the reducing agent and chlorine at a ratio of one to one produces two units of H+, which causes the pH to decrease as the reducing agent is injected as observed in Figure 1. However, after all the chlorine in the solution has disappeared, the pH will no longer drop, after which the pH is reversed due to the alkaline of sulfite. Thus, the inflection point at which the slope change of the pH profile occurs gives a critical clue to determine whether chlorine is completely removed. That is, the concentration of residual chlorine in the solution can be determined based on the amount of reducing agent injected to that point. The ORP/pH analysis method is relatively accurate and reliable because it does not depend on the absolute value of the sensor but uses the inflection point on the ORP and pH profile when the reducing agent is added to the disinfectant. Since the mutual check is offered using two sensors, it makes more accurate and stable measurement possible.

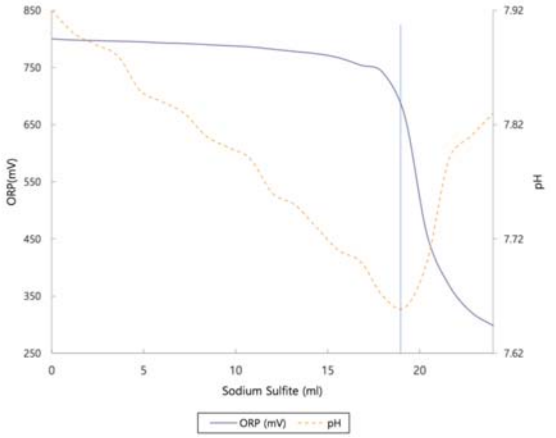


Figure 1: ORP and pH Curve for the Sulfite Infusion.

3. DISINFECTANT CONCENTRATION MANAGEMENT SYSTEM

In this chapter, the structure of a disinfectant management system is introduced that can manufacture the desired concentrations of disinfectant and measure chlorine concentration. In addition, a method of measuring the chlorine concentration by using the volume of the reducing agent introduced into the disinfectant will be described.

3.1 System Structure

The proposed system is a concentration maintenance system that adjusts the amount of water and disinfectant crude liquid to be added to the washing tank by calculating the amount of reducing agent dosed to the sample in real time. The sample refers to the diluted disinfectant contained in the washing tank. Depending on the type of food materials to be disinfected and cleaned, washing water is manufactured using crude liquids such as sodium hypochlorite, chlorine dioxide, and hypochlorous acid. Timers can be set to determine the immersion time of the ingredients.

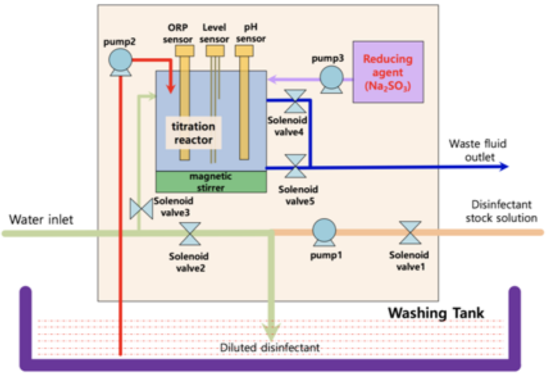


Figure 2: System Structure.

Figure 2 conceptually shows the structure of the concentration measurement part of the system. Valve 1 and valve 2 are devices for controlling the supply of disinfectant crude liquid and water to the washing tank, respectively. The peristaltic pump 1 is used to precisely control the crude liquid supply according to the desired concentration. At this time, the supply amount of the disinfecting crude liquid is determined by the following equation.

$$C = \frac{M_{solute}}{V_{solution}}$$

, where C is concentration value, M_{solute} is mass of solute (mg), and $V_{solution}$ is volume of solution. However, since crude liquid is volatilized over time as well as manufactured disinfectants, concentrations need to be measured frequently to maintain a constant level. The metering pump 2 is a device for extracting the disinfectant sample from the washing tank and supplying it to the titration reactor. While pump 2 is operating, valve 4 and valve 5 are closed so that the sample does not escape to the waste fluid outlet and is filled in the reactor. The amount of sample to be filled in the reactor is designed to keep constant level by using the level sensor and the valve 4 connected to the waste liquid discharge pipe. The magnetic stirrer at the bottom of the reactor is a device that allows the sample solution to be mixed well with the reducing agent precisely supplied by the metering pump 3. The reducing agent injected by the predetermined amount through the metering pump 3 sufficiently react with the sample solution through the operation of the stirrer for a period. Then, the ORP sensor and the pH sensor are used to read the value change and to find the equivalence point. Valve 3 is a device that allows water to be supplied to the reactor through an inlet pipe to clean the reactor. Once the reactor has been cleaned, or the concentration has been calculated by finding the equivalence point of the sample solution, valve 4 and valve 5 are open to drain the wash water or solution contained in the reactor.

Table 2: System Operation for Concentration Measurement.

Operation Flow
1. Activate the metering pump 2 to fill the reactor with the disinfectant to the full level.
2. Shortly operate valve 4 to turn off the level sensor.
3. Introduce the reducing agent through the metering pump 3, after operating the stirrer.
4. After reading a series of values with an ORP and a pH sensor, calculate the concentration by a measurement algorithm.
5. If greater than the desired concentration, operate valve 2 to supply the calculated amount of tap water.
6. If lower than the desired concentration, operate valve 1 and pump 1 to supply the calculated amount of crude liquid.
7. Open valve 4 to allow the reactor solution to drain.

Table 2 shows the overall system operating flow to perform a concentration measurement of a disinfectant. Figure 3 shows the concentration measuring algorithm. To reduce the time required for the measurement, the initial charge of the reducing agent is injected at a rate of about 70 to 90% of the calculated amount according to the theoretical formula. The closer the amount of the initial reducing agent is to the calculated amount, the more likely the concentration measurement time will be shortened, but the possibility of failing to find the equivalence point increases. Therefore, proper adjustment of the initial injection amount is required. Subsequent reductant injections will be injected with a very small amount (0.5~1% of the theoretical amount) so that an accurate equivalence point can be obtained. The ORP/pH measurement is made every 20 msec and is repeated until the reducing agent thoroughly being stirred with the disinfectant and it reaching a constant value. The process of dosing a trace amount of reducing agent and measuring the ORP / pH is repeated until the equivalence point is found.

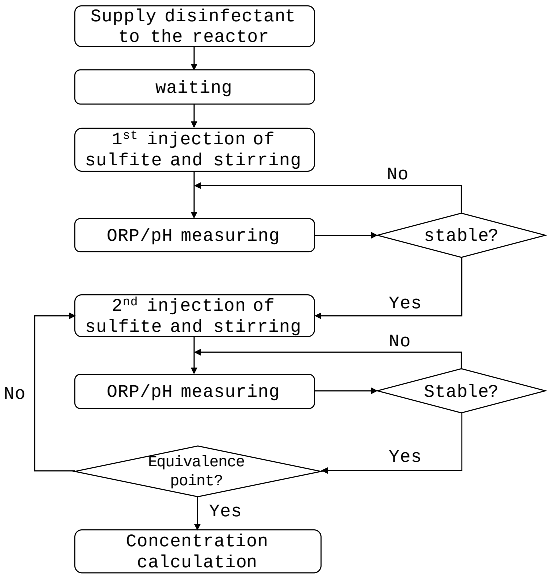


Figure 3: Concentration Measuring Algorithm.

Figure 4 shows a digital control unit that controls the overall system. It uses a high-performance, low-power 32-bit microcontroller, the ARM Cortex-M4 series 168MHz STM32F407, with 196KB of internal SRAM and 1MB of internal flash memory [17]. ORP and pH sensors and water level sensors are mounted via the ADC and GPIO interfaces, respectively. In order to eliminate malfunction due to noise in the control of the metering pump and the solenoid valve, photo coupler is used which transmits the electric signal using light. The disinfectant concentration management system is designed to be used as one of the components of the i-HACCP (intelligent HACCP) [18]. The i-HACCP records the check results for the eight CCPs (critical control points) and CPs (control points), where several digital devices including the disinfectant concentration management system are deployed in workspace and used to collect CCP data. Every device in the i-HACCP is connected via low power and low data rate wireless modem to form a mesh network and serve as a data transfer to the central database server. The Network/USN part in the digital control unit allows the disinfectant concentration management system to be a router as well as an end device in the i-HACCP.

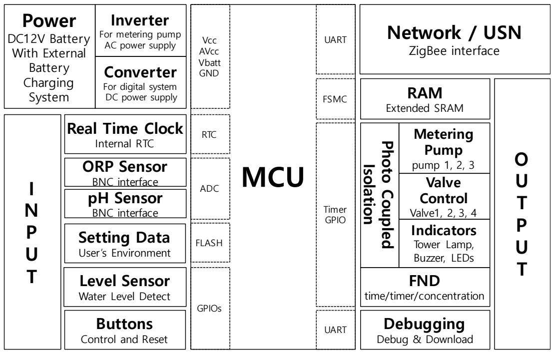
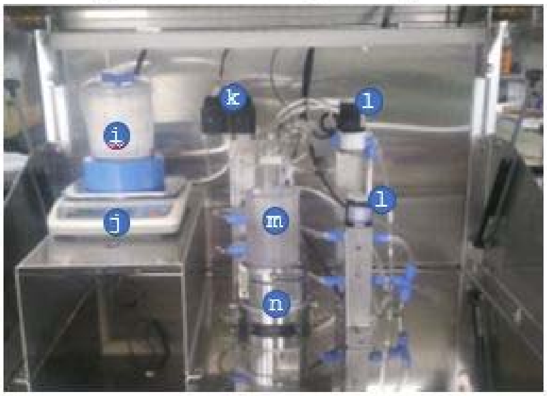


Figure 4: Block Diagram of Digital Control Unit.

Figure 5 shows the prototype of the disinfectant management system. The main body, of which specification is 1430h×800w×600d (mm^3), and the washing table are shown in Figure 5(1). The main body is divided into the upper and lower layer. The touch-type LCD control panel on the cover of the upper layer provides with a GUI interface for a disinfectant preparation, concentration measurement, and immersion control. The lower layer of the main body has a tank containing the disinfectant crude liquid, digital control box, and power supplier including battery and battery charger. There are two pumps and one solenoid valves equipped in it. The solenoid valve is to control the amount of tap water provided into the sink on the washing table and a pump is to withdraw the crude liquid from the tank to become mixed with it. The other pump is to put the diluted disinfectant solution in the washing table into the titration reactor for concentration measurement. The level sensor is used to measure the amount of water in the washing table and control the amount of the crude liquid to be added at initial time. The concentration measuring part shown in Figure 5(2) is located on the inner top of the main body. There are two metering pumps and two solenoid valves. The two pumps is used to precisely inject the reducing agent into the titration reactor. They are different each other in terms of the supply speed. The faster one operates first until it reaches 70~90% of the expected amount of reducing agent. Then, slower one runs until the equivalence point is found. This greatly reduces the time to find an equivalence point. One valve is used to keep the amount of the diluted disinfectant solution drawn from the washing table constant in the titration reactor, while the other is connected to the tap water pipe to wash the reactor. The stirrer causes the magnetic field to rotate the magnetic bar within the reactor so that it mixes the solution and the reducing agent together.

(1) Disinfectant Management System



(2) Concentration Measuring Part

a) LCD touch control panel	b) Power button
c) Disinfectant stock solution	d) Digital control box
e) Power supplier	f) Waste fluid bucket
g) Level sensor	h) Washing table
i) Reducing agent vessel	j) Scale
k) Metering pump	l) Solenoid valve
m) Titration reactor	n) stirrer

Figure 5: System Prototype

Figure 6 shows some of the major GUI screens that appear on the LCD touch panel. As shown in Figure 6 (1), four selection menus are displayed on the home screen. The menus include the preparation of the disinfectant solution, the concentration measurement of the disinfectant solution, the immersion time control for the food or tableware, and the preferences of configuration. The value in the washing table field indicates water level as a percentage. The one in the reducing agent field informs the remaining amount of the reducing agent in the vessel.

(1) Home Screen

(2) Disinfectant Preparation

(3) Concentration Measurement

(4) Immersion Control

Figure 6: GUI for Disinfectant Management.

Figure 6 (2) shows the disinfectant preparation screen. In the field (f), the volume of tap water to be supplied, which can be set by choosing the configuration menu in the home screen, is displayed and current amount of water in the sink is shown. The target concentration can be chosen by tapping the touch in the field (h). Each tapping on the LCD changes the concentration value in the order of 5, 100 and 200 ppm. The menu in the field (g) is provided to choose between sodium hypochlorite, chlorine dioxide, or hypochlorite, and the percentage on the right side indicates the concentration of a crude liquid that can be set in the configuration menu in the home screen. The amount of a crude liquid being added is displayed in real time in the field (e). The timer in the middle shows the elapsed time after pressing the start button.

Figure 6 (3) shows the disinfectant concentration measurement screen. Pressing the start button starts the concentration measurement according to the system operation flow in Table 1 and charts of ORP/pH are displayed in the middle. Field (i) displays current concentration of the disinfectant solution in the reactor and field (k) shows the amount of reducing agent dosed so far. Field (j) shows the elapsed time from the start of measurement to the present. If the measured concentration is different from the target one, the button of the correction should be selected to add crude liquid or tap water to the disinfectant in the washing tank.

Figure 6 (4) shows the immersion control screen. The crude liquid displayed at the left bottom on every screen indicates the remaining of the liquid in the tank as percentage. Field (m) is a timer that shows the time elapsed since food material or tableware has been immersed in the disinfectant. The target time for immersion is set in the field (o). Field (n) displays the concentration of the disinfectant. Field (p) indicates if the immersion timer automatically starts or not. If auto is selected, the timer begins to operate when the water level in the sink goes up to the determined point.

3.2 Concentration Calculation

According to the chemical reaction formula that one mole of SO_3^{2-} reacts with one mole of Cl_2, reaching the equivalence point means that the reducing agent has been injected at the same molar number as the disinfectant. That means since the amount of reducing agent introduced until the equivalence point is reached is equal to that of chlorine contained in the disinfectant, the concentration can be calculated using a reducing agent instead of chlorine. If the volume and concentration of sodium sulfite (Na_2SO_3) used as a reducing agent are $V_{Na_2SO_3}\ (ml)$ and $C_{Na_2SO_3}\ (mg/L)$, respectively, the molar number of SO_3 introduced can be calculated as follows.

$$\text{molar number of } SO_3^{2-} = \frac{V_{Na_2SO_3} \times C_{Na_2SO_3}}{M_{SO_3} \times 1000ml}$$

, where M_{SO_3} is a molar mass of SO_3 and $126g$. If the concentration of chlorine used as disinfectant is $C_{Cl_2}\ (mg/L)$ and the amount of chlorine solution is $V_{Cl_2}\ (ml)$, the molar number of Cl_2 can be calculated as follows.

$$\text{molar number of} = \frac{V_{Cl_2} \times C_{Cl_2}}{M_{Cl_2} \times 1000ml}$$

, where M_{cl_3} is a molar mass of Cl_2 and $71g$. Thus, the concentration of chlorine can be obtained by the following equation.

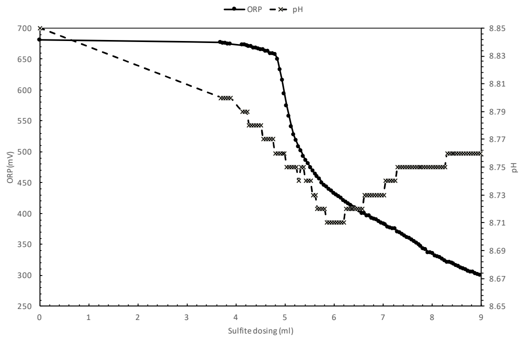
$$C_{cl_2} = \frac{V_{Na_2SO_3} \times C_{Na_2SO_3} \times M_{Cl_2}}{M_{SO_3} \times V_{Cl_2}} \qquad (2)$$

For example, assuming that 100 ml of 5 g / L of reducing agent is added to 10 L of disinfectant solution, the concentration of disinfectant solution can be calculated as follows.

$$C_{cl_2} = \frac{5000mg/L \times 71g \times 100ml}{126g \times 10000ml} = 28.17mg/L$$

4. PERFORMANCE EVALUATION

In this section, the experimental results conducted through the prototype of disinfectant management system are analyzed. Figure 7 graphically shows the change in ORP and pH measured in the prototype while dosing the reducing agent to four sample solutions of 100 ppm. The change range of ORP is as large as 300 ~ 690mV, while the pH range is 8.7 ~ 8.85. That is, it is essential that the amount of the reducing agent can be precisely controlled because the value can be sensitively changed even when a small amount of the reducing agent is dosed. Hence, our system uses boxer 9k, a high-performance peristaltic tubing pump [19]. It can flow 48 microliter solution per revolution at 260 rpm. In the experiment, 3.692 ml, which is the amount initially injected at a time, is 80% of the amount of reducing agent expected to reach the equivalence point, and then 0.048 ml will be dosed at every injection. The pH shows the stepwise change that its values are maintained until the amount of reducing agent dosed reaches to the threshold value, while the ORP is continuously decreasing at every dosing. When the pH reaches the low point, the ORP shows a gradual descent curve after a sharp decline. If it detects that the pH is on a rising curve past the falling curve, the system determines the midpoint of a series of reducing agents dosed at the lowest pH value as the equivalence point and the ORP measurement value is used as a reference for such determination. That is, the equivalence point obtained at the time when the pH is switched from downward to upward is assured by the fact that the ORP value deviates from the rapid descent.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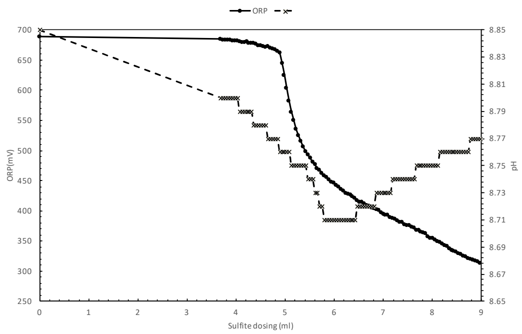
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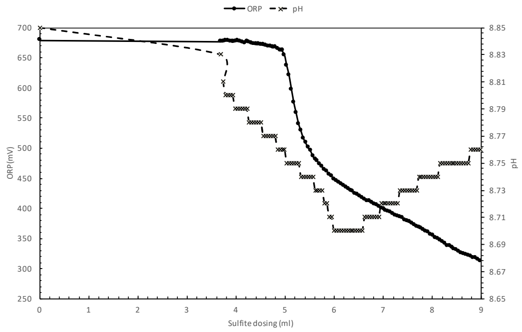
(c) Run3

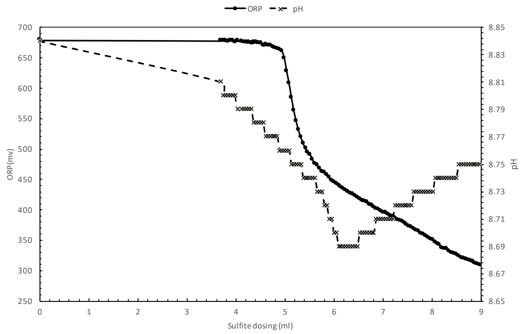
(d) Run4

Figure 7: Variations of ORP/pH based on Sulfite Dosing.

Table 3 shows the concentrations of the four disinfectant samples measured by accredited institution and prototype system, respectively. The disinfectant management system calculated the concentrations of the four sample disinfectants to a minimum of 98.3 ppm and a maximum of 104.8 ppm. It means that the accuracy of the system's concentration measurement is at least 93.7% and up to 99.9% when compared to accredited Institute's measurements.

Table 3: Measurement Accuracy.

		Accredited Inst. (ppm)	System (ppm)	Precision (%)
samples	1	98.163	104.785	93.68
	2	98.163	98.309	99.85
	3	99.239	100.615	98.63
	4	98.163	100.679	97.50
average		98.432	101.097	97.42

Table 4 shows the ORP and pH values at the equivalence point, the time taken to reach the equivalence point, and the total measurement time. The time is accumulated from the point the reducing agent is added to the reactor for the first time. To reduce the measuring time, the reducing agent is initially charged to 80% of the estimated amount at one time using a large peristatic pump (312 rpm, 566 $\mu l/r$). Since the equivalence point can be confirmed up to the point at which the pH value shows upward beyond the inflection point, the elapsed time for concentration measurement takes longer than the equivalence point reaching time. The average measurement time of the system is shown to be 97.9 seconds.

Table 4: Measurement Elapsed Time.

		Equivalence point			Elapsed Time(sec)
		ORP(mV)	pH	Time(sec)	
samples	1	431.85	8.71	69.9	95.4
	2	435.74	8.71	71.7	102.1
	3	431.78	8.7	71.5	98.6
	4	429.81	8.69	72.0	95.5
average		-	-	71.3	97.9

5. CONCLUSIONS

This paper discusses the design and manufacture of a disinfectant management system that can produce chlorine-based disinfectants at desired levels and accurately measure the concentration in a short time. The concentration measurement is performed by calculating the amount of the reducing agent which has been dosed until the values of the ORP and the pH reach the equivalent point. Since ORP and pH values are susceptible to the reducing agent and the pH range is not wide enough, it is necessary to be able to measure the values even with a trace of the reducing agent. The experimental results show that the accuracy and the elapsed time of the system for the concentration measurement are 97.42% and 97.9 seconds on the average, which are suitable for the disinfection of tableware in the large food service. For the low-level disinfectant which is as low as 5 ppm or less, it is not easy to find equivalence points due to a finer dose of the reducing agent and minute changes of ORP and pH.

The disinfectant management system is designed to be used in CP5 and CP8 of HACCP. Rinse and sterilization condition for fruits and vegetables are observed at CP5. Specifically, maintaining the concentration of the disinfectant to a specific level and the duration of soaking ingredients in chlorine water are so critical that the concentration and the time should be recorded at every rinsing and sterilizing process. At CP8, water temperature and the concentration of the disinfectant used in dish washing machine are inspected. The i-HACCP is a system for computer-assisted management such as record, collection and documentation of data inspecting CCPs. The disinfectant management system featured with wireless modem will be one of the components of the i-HACCP so that it would make HACCP help decreasing the food safety accidents effectively. Our future studies will focus on research on concentration measurement algorithms and system design to achieve high accuracy for the low-level disinfectants.

ACKNOWLEDGEMENT:

This research was supported by the Daegu University Research Grant, 2016.

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