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Light Drop Resistor (LDR) as pH Sensor for Wastewater Treatment

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Abstract— **The electroplating industry generates acidic or wet liquid wastes when operating. Improper waste treatment will cause severe problems for the environment. Under Article 1 Paragraph 7 of the 1997 Law of the Republic of Indonesia, environmental pollution is the entry/inclusion of living things, substances, energy, or other components into the environment or changes in the environmental order by human activities or natural processes. So that the quality of the environment decreases to a certain level, causing the environment becomes less or no longer function according to its designation. A light Drop Sensor (LDR) sensor is used to read the level of acidic or wet liquid waste. The resistance value of the LDR sensor will change directly proportional to the conditions of acidity or level of wetness, and this value will then be the basis for the following control processing. The data were collected by installing a series of LDR sensors with resistance and obtained the results as follows: the wastewater, which was very cloudy, dark, of the first and second filters, and clear, each of these conditions emitted voltages of 4.4 volts, 3.45 volts, 3.10 volts, 2.6 volts, and 0.2 volts.**

Keywords — **Electroplating, wet waste, light drop resistor, sensor acid, clear**

I. Introduction

The electroplating concept is a chemical reaction produced by an electric current. The terminals that provide current in the solution are called electrodes. The cathode is the electrode that undergoes a chemical reduction process. At the same time, the anode is the electrode that undergoes a chemical oxidation process. There is an ion transfer at both electrodes: anion, from the cathode to the negative-charged anode, and cation, from the anode to the positive-charged cathode. The solution in which this process occurs is called an electrolyte.

Conduction can occur in two ways, namely electronic and electrolytic. Electronically, conduction is not accompanied by a chemical reaction or material transfer. In the meantime, conduction is accompanied by material transfer and chemical reactions at both electrodes in electrolytic conduction. [1]

Along with the increasing requests for high-aesthetic-value goods, the coating electroplating (coating) industry is also increasing rapidly. There is an electroplating industrial factory in almost every area. Also, there are positive and negative impacts along with the development of widely-spread electroplating industries. The electroplating process produces a hazardous-classified waste solvent to the environment, such as the metal Cr(VI). Some industries discharge this waste into sewers freely without knowing the safe waste limit to be released. Directly or indirectly, the waste pollution resulting from electroplating can cause either way damage to the existing ecosystem. For instance, if the electroplating waste is channeled directly into the river, it will kill many biota, beneficial bacteria, and fish. Heavy metal pollution is feared to harm health. Excessive content of chromium (Cr) and zinc (Zn) exposed to the human body will have a chronic impact on health that can last for years. [2]

Environmental problems are the relationship between living things, especially humans, and the environment. The environment is the unity of space with an object, power, condition, and living things, including humans, and their behavior that affects the continuity of life and the welfare of humans and other living creatures [3] (Bappedal, 1997:24). This hazardous liquid waste does not harm or damage the existing ecosystem. This waste must be processed first by adsorption of Cr(VI) before it can finally be released harmlessly into drains and rivers. Seeing that currently, there are still many processes of electroplating waste carried out manually. Such waste treatment is not carried out in a practical, safe, and efficient manner for the environment; a system that treats waste automatically and more efficiently than the old method is planned, classified as less effective, and takes a relatively long time.

Chemicals contained in water will determine the properties of the water in terms of the poisoning level and the danger they cause. The greater the concentration of pollutants in the water, the more limited the use of the water. Chemical characteristics consist of organic and inorganic chemistries. Chemical substances dissolved in water that can interfere with and even endanger human health include the acidity of water and heavy metals.

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The acidity of the water is measured with a pH meter. Acidity is determined based on the high and low concentrations of hydrogen ions in water. Wastewater containing high or low pH makes the water sterile and, as a result, kills the necessary water microorganisms. Likewise, for other living things, for example, fish cannot live in conditions of water pH that are too acidic or alkaline. Water with a low pH makes the water corrosive to construction materials, such as iron, steel, Etc. Alkaline waste comes from waste containing organic materials, such as carbonate, bicarbonate, and hydroxide compounds. Acid waste comes from acidic chemicals, such as waste containing hydrochloric acid, sulfuric acid, and others.[4].

Heavy metals are metals with high relative atomic masses. The term is usually applied to common transition metals such as copper and lead. Heavy metals cause pollution problems from several sources, including lead from gasoline, factory effluents, and the leaching of metal ions from soil into lakes and rivers by acid rain. [3].

The metal itself is a group of chemical elements in the form of a shiny solid, a good conductor of heat and electricity. However, not all metals have this property; mercury (Hg) is a liquid.

Heavy metals are still a metal group with the same criteria as other metals. The difference lies in the effects produced when these heavy metals bind to and-or enter the body of living things. It can be said that all heavy metals can be toxic materials that can poison living things. Examples are mercury (Hg), cadmium (Cd), lead (Pb), and chromium (Cr). However, even though all heavy metals can cause poisoning to live things, some of these heavy metals are still needed for living things, namely in tiny amounts. Moreover, if the need for these substances is not met in the body, it can be fatal for living things themselves. Because the level of need is fundamental, these metals are also called metals or essential minerals of the body. Later, when the amount of this essential metal enters the body in excessive amounts, it will change its function into a toxic material for the body. Examples of these essential metals are copper (Cu), zinc (Zn), and nickel (Ni). [4].

II. Theoretical Review

Several theoretical bases will be discussed based on the background above.

A. Chemical Characteristics of Water

The chemicals contained in the water will determine the properties of the water in terms of the poisoning level and the danger it causes. The greater the concentration of pollutants in the water, the more limited the use of the water. Chemical characteristics consist of organic chemistry and inorganic chemistry. Chemical substances dissolved in water that can interfere with and even endanger human health include the acidity of water and heavy metals. In general, Grid can be interpreted as an electrical network; the acidity of the water is measured by a pH meter. Acidity is determined based on the high and low concentrations of hydrogen ions in water. Wastewater containing high or low pH makes the water sterile and, as a result, kills the necessary water microorganisms. Likewise, other living things, such as fish, cannot live in conditions of water pH that are too acidic or alkaline. Water with a low pH makes the water corrosive to construction materials, such as iron, steel, Etc. Alkaline waste (alkaline) comes from waste containing organic materials, such as carbonate, bicarbonate, and hydroxide compounds. Acid waste comes from acidic chemicals, such as waste containing hydrochloric acid, sulfuric acid, and others. [4]

Heavy metals are metals with high relative atomic masses. The term is usually applied to common transition metals such as copper and lead. Heavy metals cause pollution problems from several sources, including lead from gasoline, factory effluents, and the leaching of metal ions from soil into lakes and rivers by acid rain. [3].

The metal itself is a group of chemical elements in the form of a shiny solid. It is a good conductor of heat and electricity. However, not all metals have this property; mercury (Hg) is a liquid.

Heavy metals are still a metal group with the same criteria as other metals. The difference lies in the effects produced when these heavy metals bind to and or enter the body of living things. Unlike ordinary metals, heavy metals usually cause special effects on living things. It can be said that all heavy metals can be toxic materials that can poison living things. Examples are mercury (Hg), cadmium (Cd), lead (Pb), and chromium (Cr). However, even though all heavy metals can cause poisoning to live things, some of these heavy metals are still needed for living things, namely in tiny amounts. Furthermore, if the need for these substances is not met in the body, it can be fatal for living things themselves. Because the level of need is critical, these metals are also called metals or essential minerals of the body. Later, when the amount of this essential metal enters the body in excessive amounts, it will change its function into a toxic material for the body. Examples of these essential metals are copper (Cu), zinc (Zn), and nickel (Ni). [4]. Changes caused based on physical parameters in wastewater include turbidity, solids, taste and odor, temperature, and color. Turbidity that occurs in wastewater indicates the optical properties of water that cause light to refract into the water. The cloudiness will limit the light in the water. Even if there is any effect of dissolved solids or particles floating in the water, the absorption of this light is influenced by its shape and size. This turbidity occurs due to the presence of floating material and the decomposition of certain substances, such as organic materials, microorganisms, mud, clay, and other objects that float or float and are very fine. Solids consist of organic and inorganic solids that dissolve, settle, or are suspended in the waste. This material will settle to the bottom of the water, which will eventually cause siltation at the bottom of the receiving body. Another consequence of these solids causes the growth of certain aquatic plants and can be toxic to living things. The amount of solids indicates the amount of mud contained in the water. The taste and odor resulting from the activities of microorganisms that decompose organic substances in wastewater will produce certain gases that are less pleasant. Besides, taste and smell also arise due to chemical reactions that cause gas. The strength of the odor produced depends on the type and amount of gas generated.

III. Research Method

The research method is experimental, namely, designing and making a prototype (Microcontroller Module) to automate processing and monitoring systems for electroplating industrial waste. In this case, the LDR sensor installed will read the parameters in the solution, and the microcontroller will process the data read. The block diagram of the system created can be seen in the figure below:

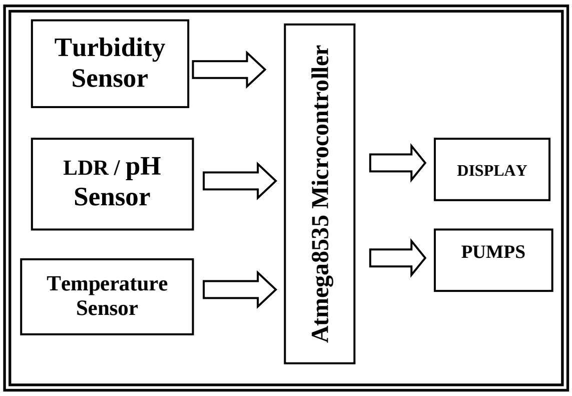

Figure 1. System block diagram

Functions per Block of Figure 1:

1. The turbidity sensor is used to detect the turbidity level in the liquid waste.
2. LDR functioned as a pH sensor used as a pH detector in liquid waste.
3. The temperature sensor detects the temperature of the solution.
4. The Atmega8535 microcontroller functions as a data processor and operating system control center.
5. Pumps are used to return wet or acidic solutions.
6. Display functions as a display of pH values before and after processing.

The flow of the work system from the control is as follows: after electroplating waste comes out of the electroplating process then, the turbidity will scatter if it is too cloudy, so there will be a moving process mixed with acidic or wet ingredients. After the stirring process is complete, this process runs simultaneously, namely reading turbidity and acid/wet. Hopefully, the waste follows the required requirements bypassing the first adsorption box (first reservoir); in this box, an adsorption process will occur, and from the first box, the electroplating waste will enter the second box. The process in this box is the same as the process in the first box, but it uses anion resin as a smaller filtrate in the second box. The hazardous materials contained in the electroplating waste are intended to experience a maximum adsorption process.

After the first and second processes are passed, the electroplating waste will enter the last box, namely the storage box. In this box, the sensor will detect variables that have been previously determined, namely those related to temperature, conductivity, turbidity, and pH variables. When the electroplating waste does not meet the predetermined standards, the pump will turn on to return the electroplating waste to the first box.

IV. Results and Discussion

LDR sensor is a detector of turbidity in liquid waste that has been emitted by the LED, for the more concentrated the waste, the more turbid the liquid. LED is used as the transmitter, and LDR is used as the receiver. In its placement, the sensor is packaged in a more light-resistant place so that it is not too affected by outside light.

The sensor circuit is shown in the figure below:

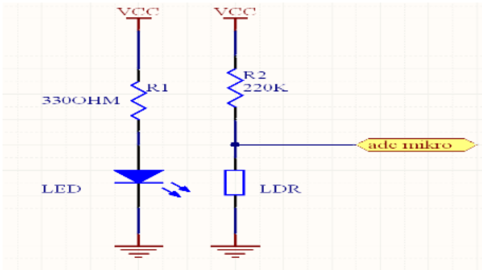

Figure 2. Turbidity Sensor Circuit

R1 calculation for LED

$$R1 = \frac{Vcc}{Id}$$

$$R1 = \frac{5V}{15mA}$$

$$R1 = 330\Omega \text{ on LED}$$

Changes in the LDR sensor from bright to dark are as follows:

Bright	⇒	R_{LDR}	= 10k
Clear	⇒	R_{LDR}	= 100k
Average	⇒	R_{LDR}	= 150k
Turbid	⇒	R_{LDR}	= 220k
Dark	⇒	R_{LDR}	= 500k

Calculations for the turbidity sensor:
The desired V_{out} when bright is 0.2 V, then to calculate the value of R2 is as follows:

$$\text{Bright } V_{out} = \frac{RLDR(\text{Bright})}{RLDR(\text{Bright})+R2} \times Vcc$$

$$0{,}2\ V = \frac{10K}{10K+R2} \times 5V$$

$$0{,}2V \times (10k+R2) = 10k \times 5V$$

$$2k + 0{,}2\ R2 = 50k$$

$$0{,}2\ R2 = 50k-2k$$

$$0{,}2\ R2 = 48k$$

$$R2 = \frac{48k}{0{,}2}$$

$$R2 = 240k \approx 220k$$

Thus, the R2 value is 220k

With the R2 value of 220k. then the V_{out} in the states of clear, average, turbid, and dark can be calculated as follows:

$$V_{out} \text{ at the clear state } = \frac{R_{LDR}(\text{Clear})}{R_{LDR}(\text{Clear})+R2} \times Vcc \Rightarrow$$
$$R_{LDR}=100\text{k}$$
$$= \frac{100k}{100k+220k} \times 5V$$
$$= \frac{100k}{320k} \times 5$$
$$= 1{,}56\text{V}$$

$$V_{out} \text{ at the average state } = \frac{R_{LDR}(\text{Average})}{R_{LDR}(\text{Clear})+R2} \times Vcc \Rightarrow$$
$$R_{LDR}=150\text{k}$$
$$= \frac{150k}{150k+220k} \times 5V$$
$$= \frac{150k}{370k} \times 5$$
$$= 2{,}02\text{V}$$

$$V_{out} \text{ at the turbid state } = \frac{R_{LDR}(\text{Turbid})}{R_{LDR}(\text{Turbid})+R2} \times Vcc \Rightarrow$$
$$R_{LDR}=220\text{k}$$
$$= \frac{220k}{220k+220k} \times 5V$$
$$= \frac{220k}{440k} \times 5$$
$$= 2{,}5\text{V}$$

$$V_{out} \text{ at the dark state } = \frac{R_{LDR}(\text{Dark})}{R_{LDR}(\text{Dark})+R2} \times Vcc \Rightarrow$$
$$R_{LDR}=500\text{k}$$
$$= \frac{500k}{500k+220k} \times 5V$$
$$= \frac{500k}{720k} \times 5$$
$$= 3{,}47\text{V}$$

Table 1. LDR Reading Results

NO	Parameter	V_{out} (V)
1	Dark	3.47
2	Turbid	2.5
3	Average	2.02
4	Clear	1.56
5	Bright	0.21

The relationship between the level of turbidity and the output voltage of the LDR sensor is shown.

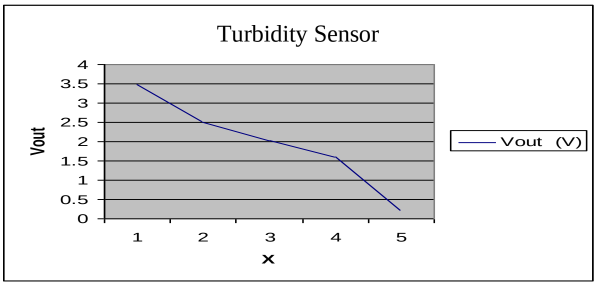

Figure 3. Voltage relationship curve and LDR condition value

V. Conclusion

Based on the results of planning and data collection, the conclusion is as follows: LDR can determine the turbidity of liquid waste by using a turbidity sensor, measuring the pH contained in liquid waste, and measuring the conductivity of the solution. The LDR sensor can only detect the level of turbidity of the liquid waste without detecting a color change. The conductivity sensor can also be used to detect levels of metal/electrolyte content from waste.

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