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Wastewater Treatment in Galvanizing Plants by Ozone in High Pressure Plasma System

Mongkol Jongsuphanphong
School of Energy and Environment
Siam Technology College, Bangkok, Thailand
Email: mongkol.phong@gmail.com

Abstract

Since the wastewater treatment process in a galvanizing plant requires expensive chemicals purchased from foreign countries, a plant owner tends to avoid the treatment of wastewater before releasing it into public water sources. This study reports the experimental results of implementing wastewater treatment in a galvanizing plant by ozone in high pressure plasma system that (1) 100% of zinc ions could be reduced with treatment efficiency at 98.00 %, and (2) the pH could be increased up to 99.00 % with the highest value of 9.95 in 100 minutes in100 liters of wastewater.

Keywords: *Wastewater treatment, galvanizing plant, high pressure plasma system, ozone technology*

1. Background and significance of study

At present, the rapid increase of galvanizing plants caused wastewater treatment problems. This incident includes both large and small plants, as the cost of wastewater treatment is high. As a result, some irresponsible galvanizing plants have released their toxic wastewater directly into the environment. The toxicity of wastewater released from the galvanizing plants caused contamination by cyanide and galvanize metal solution, such as chromium, zinc, and copper. The released amount is evidently higher than the standard set by the Department of Industrial Works, Thailand. In such a situation, it is necessary for galvanizing plants to treat their wastewater before releasing it to the public waterways. The required treatment definitely requires a high amount of chemical imported from foreign countries (American Society of Civil Engineers, 1985; Eilbeck & Mattock, 1987).

From the study on chemical properties of ozone by Hill (1991), a strong oxidizer can be used to dissolve cyanide and other solutions as well as metals. The study on wastewater treatment in galvanizing plants reports selected ozone created in the plasma system mixed with the wastewater in the high-pressure system, based on the design derived from the principles of physics and engineering (Hill, 1991).

The factors accounted for treating wastewater from the galvanizing plants include the intensity of ozone and the most effective duration in dissolving cyanide and zinc ions. The dissolving process takes place when ozone has come in contact with the wastewater, and then changes pH of wastewater from the galvanizing plants using ozone produced from plasma mixed with the wastewater in the high-pressure system (Baltpurvins et al., 1997; Hill, 1991).

2. Research Objective

The researcher conducted this study to determine the effectiveness of mixing ozone produced from plasma with the wastewater in the high-pressure system and use the result of the experiment as the prototype of wastewater treatment in galvanizing plants.

3. Related Theories

Ozone (O_3) is a natural gas existing in the stratosphere. It was produced naturally from lightning strikes or UV rays and was synthesized using the corona discharge method. Ozone (O_3) is an unstable gas that would transform into oxygen (O_2) quickly. It is a strong oxidizer that reacts with ions of metals, cyanide, and formalin rapidly (Sugimitsu & Okazaki, 1982; Baltpurvins et al., 1997).

Ozone reactions with some metal ions are shown as follows:

$2Fe^{2+} + O_3 + \longrightarrow 2Fe(OH)_3 + O_2 + 4H^+$
$5H_2O$
$2Mn^{2+} + O_3 + \longrightarrow 2MnO + O_2 + 2H^+$
H_2O
$2Zn^2 + O_3 + H_2O \longrightarrow 2ZnO + O_2 + 2H^+$

Ozone reactions with cyanide are shown below.

$CN + O_3 \longrightarrow CNO + O_2$
$CN + H_2 + \longrightarrow 2HCO_3 + N_2 + 3O_2$
O_3

4. Materials and Method

The researcher used the materials and method reported in this section.

4.1 Materials

The researcher used high pressure plasma ozone generator 500 mg hr, high pressure ozone wastewater treatment machine, sedimentation testing machine (jar test), spectrophotometer (Model DR / 4000 U), pH meter (Model 510 PC).

Figure 1: Ozonizer Circuit

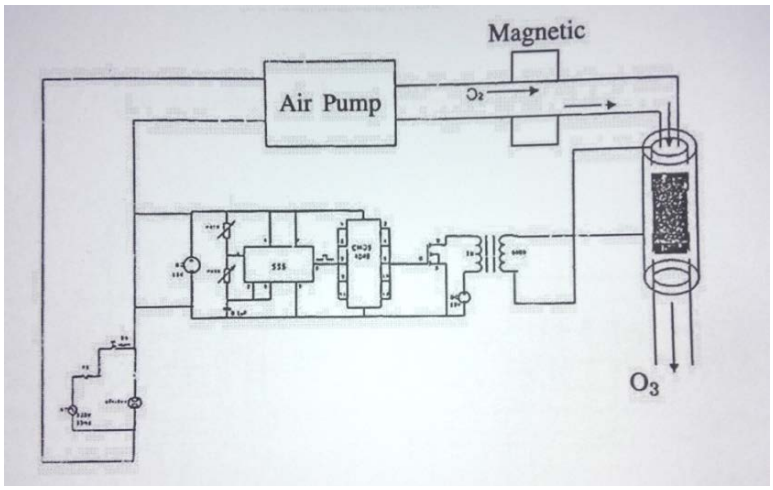


Figure 2: High Pressure Ozone and Wastewater Mixer

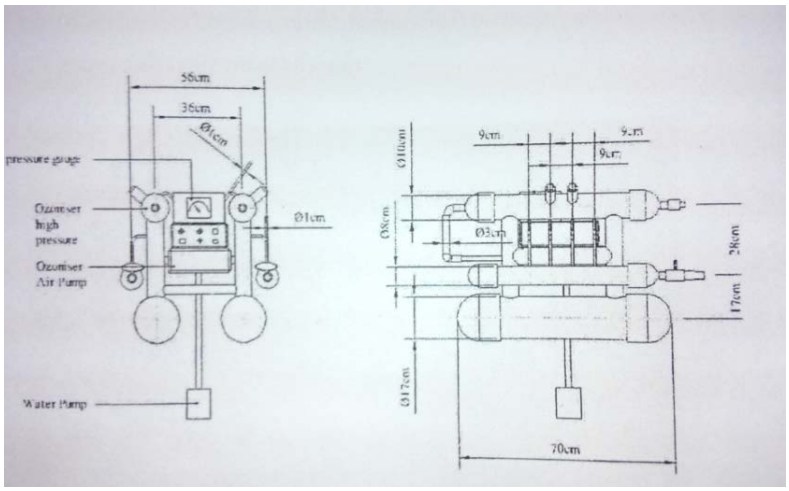


Figure 3: Testing of Wastewater Treatment in a Galvanizing Plant (Front)

Figure 4: Testing of Wastewater Treatment in a Galvanizing Plant (Side)

4.2 Method

The samples used in this research were collected from wastewater produced from the production of 5 galvanizing plants, 100 liters each, in the total of 500 liters. The samples then were analyzed with jar tests to find the intensity of zinc ions to identify the pH value. The samples were divided into 5 parts, 100 liters each, and tested with the high pressure ozone wastewater treatment machine. The wastewater samples were collected every 20 minutes for 120 minutes during the process; they were tested with the sedimentation testing machine to obtain pH level at the wastewater speed 10L/min through a high pressure ozone wastewater treatment machine. The experiment was run 5 times to obtain the average result.

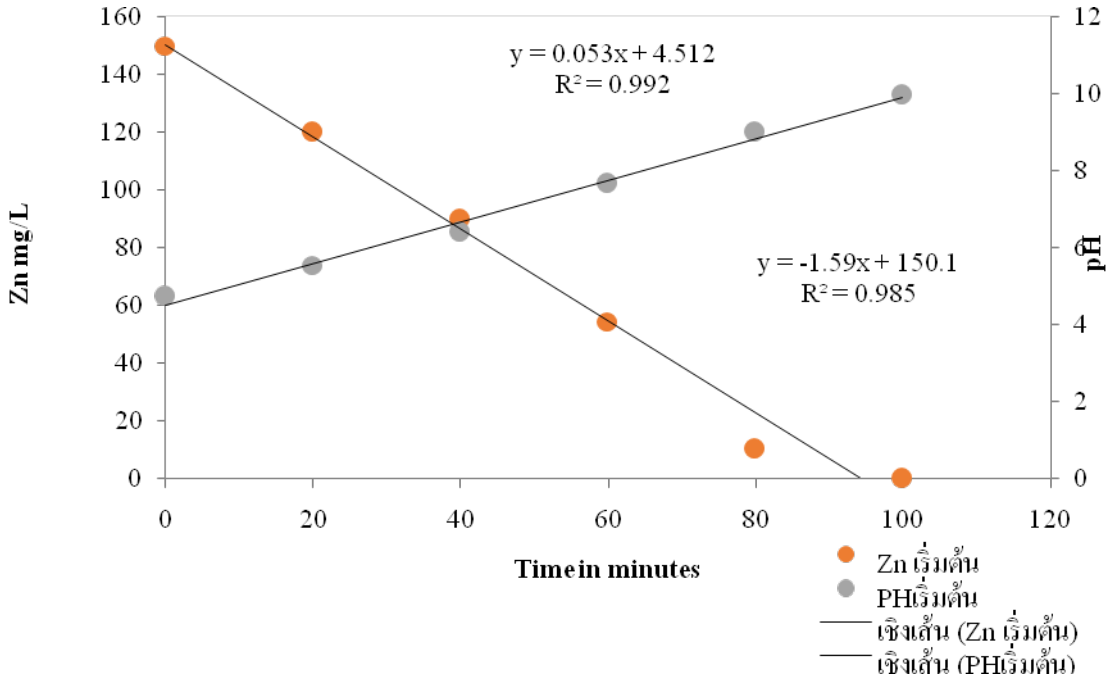
5. Results of the Study

The researcher reports the results in Table 1 and Diagram 1, as shown below.

Table 1: Results

Time minute	Zn mgZn/L	pH	Sediment mg/L
0	149.8	4.72	0
20	119.8	5.54	30.0
40	89.6	6.40	61.2
60	54.4	7.65	96.6
80	10.2	8.98	143.1
100	0.00	9.95	156.4

Diagram 1: Results



6. Major Findings

The analysis of slope value output 1.59 and R^2 is 0.958. This means the relationship between the reductions of zinc ions in the wastewater of galvanizing plants is very high. The pH of the wastewater of galvanizing plants shows the slope value at 0.053 and R^2 at 0.992. The increase of pH level is highly related to time (Honda & Naito, 1955). From the experiment, the high pressure ozone wastewater treatment machine could reduce zinc for 98.00% and could increase pH level at 99.00%. From the comparison in Table 1, the sedimentation level is higher than the zinc ions in the wastewater, which means that there are iron ions and other metal ions in the solution as well Barrado et al., 1998; Von Sonntag & Von Gunten, 2012; Honda & Naito, 1955).

7. Conclusion

The researcher showed in this study that galvanizing plans can use the treatment of wastewater before releasing it into public water sources by using the prototype of treatment experimented in the study. As proved, the experimental results of implementing wastewater treatment in a galvanizing plant by ozone in high pressure plasma system turned out as 100% of zinc ions being reduced with treatment efficiency at 98.00 %. In particular, the pH could be increased up to 99.00 % with the highest value of 9.95 in 100 minutes in 100 liters of wastewater.

8. The Author

Dr Mongkol Jongsuphanphongis an Assistant Professor in Alternative Energy and Environmental Engineering at the School of Energy and Environmental, Faculty of Engineering and Technology, Siam Technology College, Bangkok, Thailand. He has been well recognized for his work and local/ international awards in alternative energy and wastewater treatment with the use of ozone in high pressure plasma systems.

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