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Analysis of The Effectiveness of Ozonation on Corrosion and Bacteria on Closed System Cooling Towers

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Abstract. Cooling towers are used to increase productivity and efficiency in industrial machinery. The formation of corrosion and humid grass inhibits the heat transfer system thus affecting the efficiency level of the cooling tower. This study aims to determine the effect of ozone usage on corrosion and bacteria in a closed cooling tower system. The method used in this study is to inject ozone into the cooling tower basin and conduct water quality testing in the laboratory using AAS, Titrimetric and TPC tests for bacteria. The results obtained from this study show that the use of ozone with a productivity rate of 0.5 g / hour builds up corrosion, as can be seen from the iron content in water that increased from 0,04 mgFe/l to 0.07 mgFe /l. In addition, sulfate ions increased from 11 $mgSO_4^{2-}$/l to 20 $mgSO_4^{2-}$/l. The number of bacteria decreased from $2x10^5$ CFU/ml to $3x10^4$ CFU/ml.

INTRODUCTION

A cooling tower is utilized to optimize the productivity and efficiency of industrial machines and power generator system [1]. Water from the cooling the condenser, plays an integral role in shifting heat. In order for a cooling tower to work efficiently the quality of the water must be controlled. Without proper water treatment, corrosion and scaling occurs in the pipes and basin which results in poor heat transfer and renders the cooling tower inefficient. Corrosion occurs because of material interaction, chemically or electro-chemically, with the environment. Not only does corrosion escalate in the cooling tower when it comes into contact with untreated water but bacteria in the water encourages the growth of moss. Biofouling from cooling tower water is responsible for poor efficiency and increased corrosion [2,3].

Research on water treatment in cooling towers has been conducted using clorine, bromine and iodine but unfortunately there is still no consensus on the usage of these methods [4,5]. One other solution is to use ozone. Ozone is the strongest biocside to be used widely in Europe for treating water in cooling towers and has been proven to control bacteria. Ozone actually stimulates corrosion instead of inhibiting it, but it can still be used in certain situations [6-9]. In principle it is easier to clean up corrosion from the system than to clean up biological and mineral substances. It is expected that this research will show how ozone usage effects corrosion and sediment – causing bacteria in the cooling tower and how cooling tower efficiency can be optimized [10-11].

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EXPERIMENTAL METHOD

In this stage, the experiment setup is as follows:

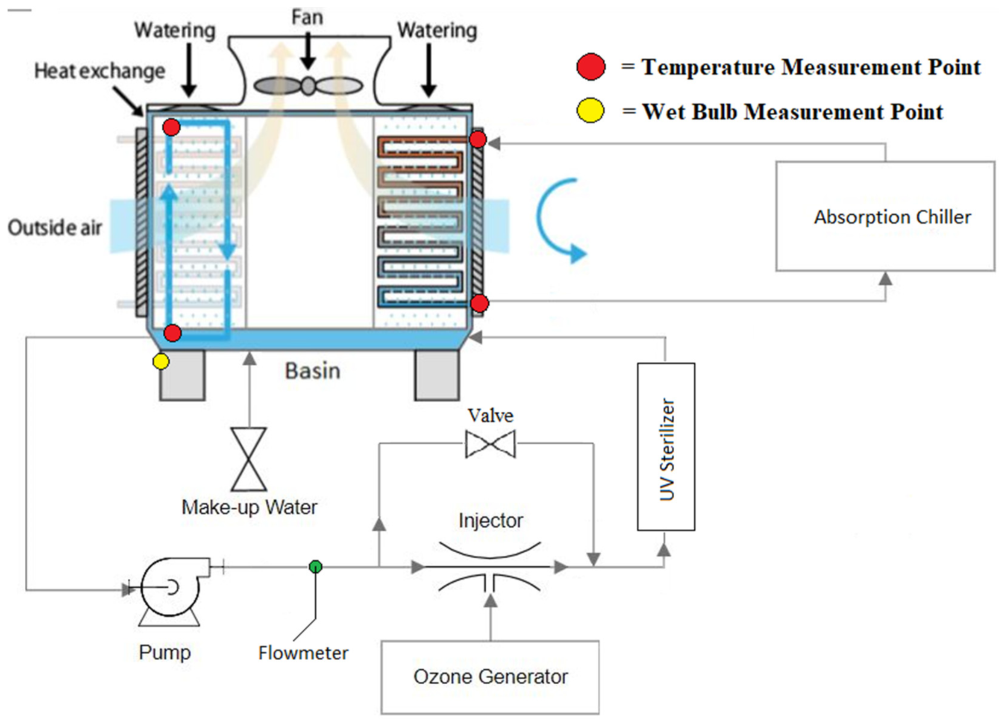

FIGURE 1. Experimental Schematic Diagram

The main circulation water flow in the closed circuit cooling tower system is injected with ozone. Pumps are used to channel water through the pipes and then it flows by the flowmeter to acquire the water flow rate. After that, ozone is sprayed into the water through the injector. The valve in this scheme functions to lower the water pressure. The ozonized water then flows to the UV sterilizer. UV sterilizer is used for increasing the duration of the ozone resistance. Finally, the water returns to the basin and is re-circulated.

RESULT AND DISCUSSION

The early sampling, before the ozone is injected, total bacteria was 2 x 10^5 CFU/mL. When ozone productivity rate is at 0.4 mg/hr, the total bacteria amount drops significantly. This is because the ozone in the water dissolves and reacts with the water molecule, producing OH which kills the bacteria's enzyme and DNA and destroys the bacteria by boosts their wall's permeability so that they die. The longer the bacteria is in contact with ozone-mixed water, the more hydroxil ions enter. As more ozone is oxydized, more bacteria dies.

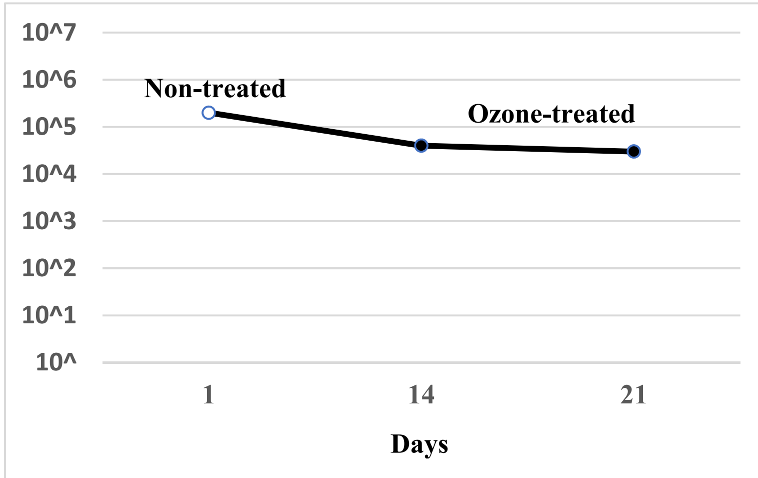

FIGURE 2. Total Bacteria

Ozone-influenced analysis on corrosion

Electric conductivity

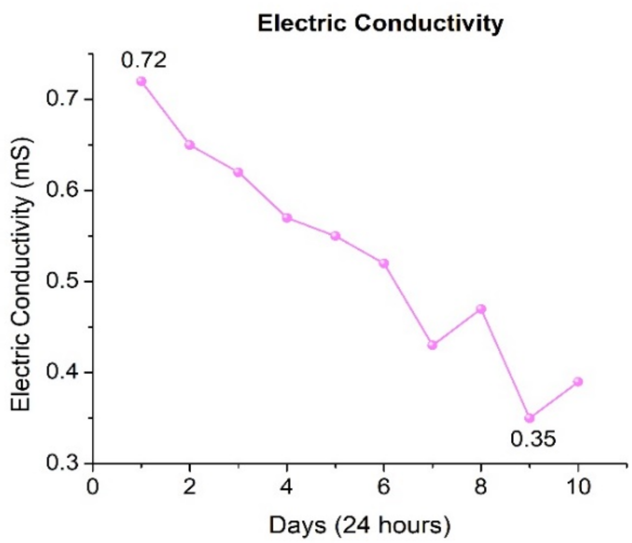

FIGURE 3. Electric conductivity rate

The graphic shows the absolving rate on ionized salts. It can be said that although corrosive ion, like ferro, only oxidates in a small measure it can still affect the corrosion rate. The conductivity rate is obtained when the cooling tower is inactive or has blowdown and water is sprayed into the cooling tower to dissolve the salt in the basin. This process is repeated over.

Iron (Fe)

TABLE 1. Iron composition of cooling tower water

Item	Cooling Tower Standard	Before ozonisation	After ozonisation
Iron (mgFe/l)	**1.00 or less**	**0.04**	**0.07**

The increase of iron (Fe) level is due to the reaction of ozone is so selective that only organic contaminants and some of anorganic contaminants that are preferred by ozone is previously oxidated to simpler substances. The escalation is still below the normal limit of the cooling tower standard so it indicates that the corrosion rate is low.

PH-dependant

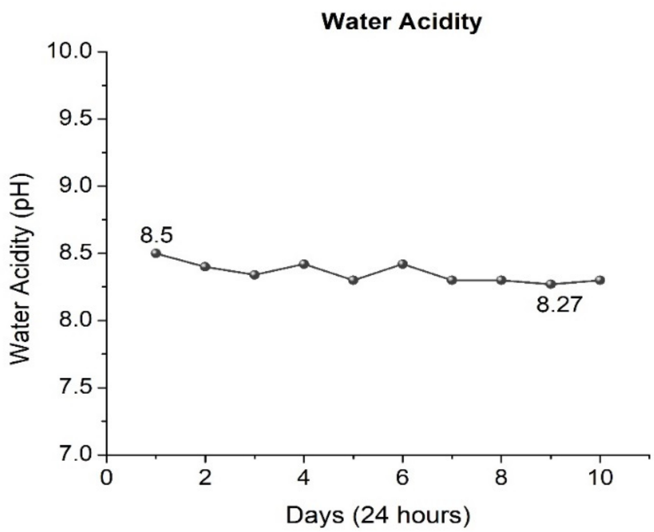

FIGURE 4. pH of cooling tower water

From Figure 4, it can be seen that the pH of cooling tower water is stable at the range of 8.3 to 8.5 when there is a balance between OH- and H+ ion. The fluctuating rate of pH can be caused by the segregation of acid organic compound in the ozonised water. Initially, it occurs from the oxidation process within the water, but after time it becomes CO_2 and H_2O.

Ion Sulphate

Ozone plays role on changes sulphur oxidation to elemental (So) which in advance becomes sulphate ion (SO_4^{2-}). It bonds with metal to make a solvable substance. On the Table 2 it shows the ozone usage is useful to the development of sulphate ion.

TABLE 2. Sulphate ion level on cooling tower

Item	Cooling Tower Standard	Before ozonisation	After ozonisation
Ion Sulphate (mgSO_4^{2-}/l)	50 or less	11	20

From the Table 2 it can be seen that there is an increase in corrosion. This phenomena happens because ozone forms a destructive ion in alkali solution. With an aggressive ion such as sulphate ion, the oxide layer on metal is suffocating so there is more iron dissolvement and the corrosion rate escalates.

CONCLUSION

Ozone application results in an increase in corrosion value this can be proven by Sulphate ion increased the iron content to 0.03 mgFe/L and SO_4^{2-}/L to 9 mg. Testing of ozone usage on the cooling tower water demonstrated a decline in total bacteria from $2x10^5$ CFU/mL to $3x10^4$ CFU/mL. It can be concluded that ozone usage is effective in destroying bacteria in closed circuit cooling tower water.

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REFERENCES

1. El–Wakil, M. and E. Jasjfi, *Instalasi Pembangkit Daya.* Power Plant Technology, 1992.
2. Handbook, A., *Fundamentals.* American Society of Heating, Refrigerating and Air Conditioning Engineers, Atlanta, 2001. 111.
3. Bott, T.R., *Fouling of heat exchangers*. 1995: Elsevier.
4. Pope, D.H., et al., *The effect of ozone on Legionella pneumophila and other bacterial populations in cooling towers.* Current Microbiology, 1984. 10(2): p. 89-94.
5. John, H., *Cooling Towers System Guidance for Energy Operations.* Kelcroft E & M Limited, 1988: p. 1-6.
6. Am Water Works Res, F., et al., *Ozone in water treatment: application and engineering*. 1991: CRC press.
7. Agency., U.E.P., *Wastewater technology fact sheet: ozone disinfection*. 1999, Washington DC,, USA.
8. Bitton, G., *Wastewater microbiology*. 2005: John Wiley & Sons.
9. Lezcano, I., et al., *Ozone inactivation of microorganisms in water: gram positive bacteria and yeast.* Ozone: science & engineering, 2001. 23(2): p. 183-187.
10. Rizqa, M., *Penurunan Kadar COD, TSS dan Warna Limbah Cair Industri Tekstil Sasirangan dengan Metode Ozonisasi.* STTL. Yogyakarta, 2009.
11. Deininger, R.A., et al., *Ozone and Water Treatment.* Web Of Science.