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# Application of ozone treatment in cooling water systems for energy and chemical conservation

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**Abstract.** In this study, a complete set of recirculating cooling water system and the required instruments were built in a semi-industrial-scale and a 50 g/h ozone generation plant and a chlorine system were designed for cooling water treatment. Both chlorination and ozonation treatment methods were studied and the results were analyzed during two 45-days periods. The concentrations of ozone and chlorine in recirculating water were constant at 0.1 mg/lit and 0.6 mg/lit, respectively. In ozone treatment, by increasing the concentration cycle to 33%, the total water consumption decreased by 26% while 11.5% higher energy efficiency achieved thanks to a better elimination of bio-films. In case of Carbon Steel, the corrosion rate reached to 0.012 mm/yr and 0.025 mm/yr for the ozonation and chlorination processes, respectively. Furthermore, consumptions of the anti-corrosion and anti-sedimentation materials in the ozone cooling water treatment were reduced about 60% without using any oxidant and non-oxidant biocides. No significant changes in sediment load were seen in ozonation compared to chlorination. The Chemical Oxygen Demand of the blow-down in ozonation method decreased to one-sixth of that in the chlorination method. Moreover, the soluble iron and water turbidity in the ozonation method were reduced by 97.5% and 70%, respectively. Although no anaerobic bacteria were seen in the cooling water at the proper concentration range of ozone and chlorine, the aerobic bacteria in chlorine and ozone treatment methods were 900 and 200 CFU/ml, respectively. The results showed that the payback time for the ozone treatment is about 2.6 years.

**Keywords:** ozone treatment; cooling tower; corrosion; energy conservation; chemical conservation

## 1. Introduction

Once-through and re-circulating cooling water systems (RCWSs) are used for the rejection of waste heat into the environment. Of these methods, RCWSs are by far the most common method because they can conserve freshwater and reduce thermal pollution compared with Once-through systems (Ataei *et al*. 2009, Alawadhi 2011).

Ozone is a gas that acts as a powerful oxidant and disinfectant. When ozone is injected as tiny bubbles into water, it precipitates materials such as iron, sulfur and manganese, while destroying

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## Nomenclature

| Parameters | Description | Unit |
|---|---|---|
| A | Surface | $cm^2$ |
| | Area of heat | $m^2$ |
| B | Blow-down water | $m^3$/hr |
| C | Specific heat of water | J/kg. ℃ |
| CFU | Colony Formation Unit | CFU/ml |
| COD | Chemical Oxygen Demand | mg/lit |
| CR | Corrosion Rate (by weight loss) | mm/yr |
| d | Density | gr/$cm^3$ |
| DM | Dematerialized Water | - |
| HMI | Human Machine Interface | - |
| IP | Ingress Protection | - |
| K | Constant value (depending on measurement unit) | - |
| L/G | Liquid/Gas | - |
| LPR | Linear Polarization Resistance | - |
| M | Make up water | $m^3$/hr |
| m | Mass flow rate | kg/s |
| mpy | Corrosion Unit | min/yr |
| NTU | Nephlometric Turbidity Unit | - |
| ORP | Oxidation Reduction Potential | mv |
| Q | Heat transfer | J/s |
| SBR | Sulphate Reduction Bacteria | - |
| t | Time | yr |
| TBC | Total Bacterial Content | CFU/ml |
| $T_{in}$ | Cooling tower inlet water temperature | ℃ |
| $T_{out}$ | Cooling tower outlet water temperature | ℃ |
| T | Temperature difference | ℃ |
| U | Overall heat transfer coefficient | J/$m^2$.s.℃ |
| W | Weight loss (after cleaning) | g |
| $X_M$ | Concentration of a soluble component in make-up water | mg/lit |
| $X_B$ | Concentration of a soluble component in blow-down | mg/lit |

| Greek letters | Description |
|---|---|
| $\pi_c$ | Cycle of concentration |