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Cooling Tower Ozonization

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Ozone Introduction:

Ozone is a molecule that consists of three negatively charged oxygen atoms. The ozone molecule is very unstable and has a short half-live, causing it to fall back into its original form after a while, according to the following reaction mechanism:

$$2O_3 \leftrightarrow 3O_2$$

Ozone is one of the strongest known oxidants. It can be used to technically burn dissolved compounds (oxidation). The extra oxygen radical in an ozone molecule quickly binds to each component that comes in contact with ozone molecules. This is because of the instability of ozone and its inclination to return to its original form (O_2). Both organic and inorganic substances may be oxidized by ozone (oxidation), but also microorganisms such as viruses, bacteria and fungi (disinfection). This causes the extra oxygen radical to be released from the ozone molecule and to bind to other materials, so that only pure and stable oxygen molecules (O_2) are left.

Problems associated in cooling Tower water treatment

Water that is applied in cooling towers, even when this concerns tap water, often contains salts (such as chlorine, sulphates and carbonates), dissolved gases (such as oxygen and carbon dioxide) and metal ions (such as iron and manganese ions). The presence of these pollutants can cause a series of problems. The main problems that are caused are fouling, limestone formation, corrosion and biological growth. The pollutants also affects cooling tower building material such as concrete, wood, plastic or metal.

During cooling tower water treatment, three main factors must be controlled:

- Corrosion of pipes and heat exchanger units
- Scaling in pipes and (mainly) in heat exchangers
- Microbial growth (bacteria, algae)

Biofilm

A bio film can be formed in the cooling water system, consequentially to clogging of microorganisms, such as algae. A bio film takes up ions that normally form micro crystals, which increases scaling. In time, inorganic and organic matter will thicken this core.

The warm temperature of the water and the addition of nutrients from the scrubbed air flowing through the tower provide a virtual nirvana for all sorts of microbes and algae. In turn, these organisms multiply at fantastic rates. The result is degraded system efficiency due to blockage of flow, shortened equipment life due to corrosion, increased operating cost due to higher pumping power requirements, and the spread of disease or even death. This was brought home and reinforced during the first recorded outbreak of Legionnaire's Disease in 1976 in Philadelphia and since that time.

Scaling

Scale forms as a result of calcium and magnesium ion deposits on the units of a cooling system. This causes the formation of a core, which forms an isolation layer in heat exchangers. This negatively influences heat transport. At a certain point, the saturation rate for these salts is reached, causing them to precipitate. This limits the number of times the cooling water can be recycled.

Microorganisms

Bacteria and other pathogenic microorganisms are present everywhere throughout the environment. They can often be found in cooling tower water. When cooling towers contain an open recirculation system, microorganisms can spread from air to water. Microorganisms can rapidly multiply, when a substrate is present and a number of conditions are ideal for microbial growth.

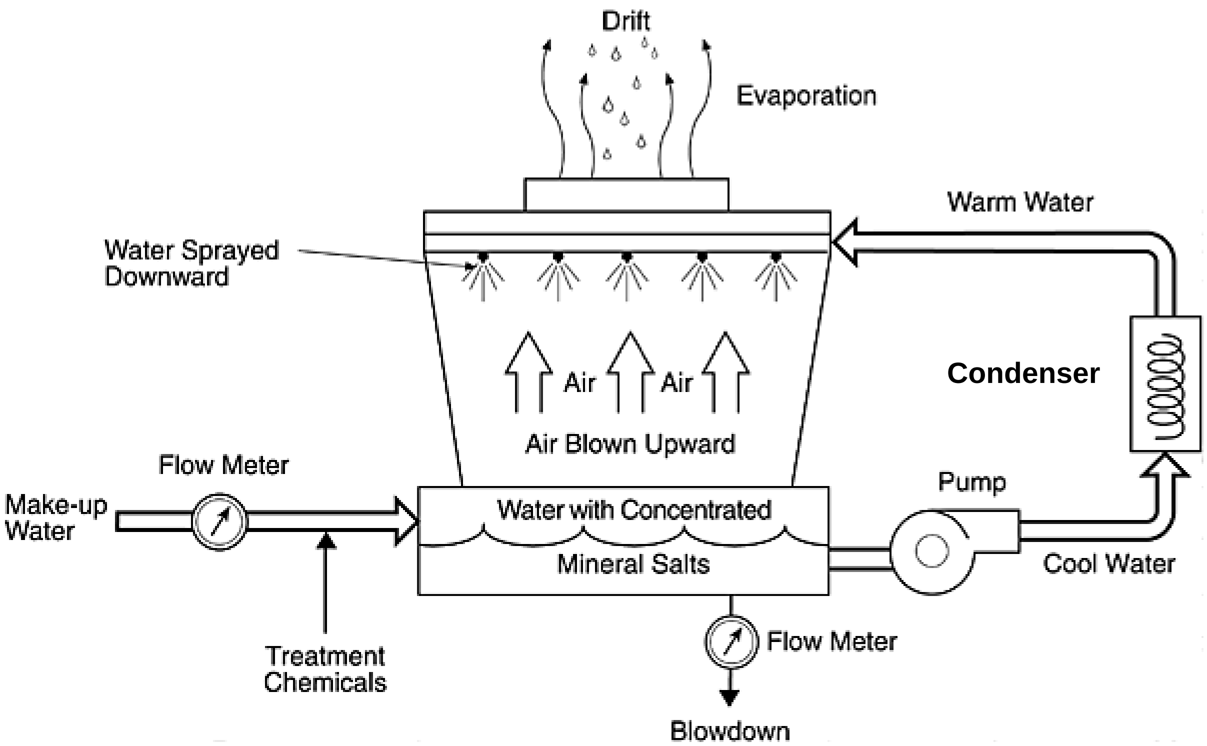

Fig. 1. Typical Cooling Tower Operation

Cooling Tower Water Treatment with Ozone

In the distant past, there was a wide range of products used for cooling tower water treatment. These compounds, which included both oxidizing and non-oxidizing chemicals, were very effective biocides, and included quaternary ammonia compounds, isothiazolin, chlorinated phenolics and glutaraldehydes. Some of these chemicals are still available today, but many of them have been banned due to environmental concerns and pressures. Oxidizing biocides in use today are generally chlorine or bromine based, but these formulations are also coming under increased environmental scrutiny, even to the point that some local municipalities have outlawed their use.

Typical treatment involves the application of chemicals such as chlorine, sulfuric acid, phosphorous, and zinc compounds. As traditional chemical water treatments are being restricted because of environmental concerns, **ozone** is gaining acceptance as a viable biocide alternative.

Ozone treatment of a cooling tower can reduce the quantity of blowdown. Ozone decomposes into oxygen, and therefore imparts no undesirable chemical residue into the system. Therefore, blowdown from cooling towers treated with ozone only will be free of biocide, scale, or corrosion control, chemical Control.

Ozone will disinfect more rapidly than any other commercially available oxidant. This feature makes ozone a viable technique for biofilm control and to attack organic binders holding scaling materials to cooling water surfaces. Ozone will destroy many organics commonly encountered in recirculated cooling systems, some rapidly, some slowly, and some no reaction.

Algae are readily oxidized by ozone. However, algae will reappear on exposure to sunlight unless small ozone residual is left in the system. Ozone levels in the 0.01 to 0.05-mg/l range, maintained for a few minutes, are usually sufficient for algae control.

Ozone treatment limits scaling. Ozone is a disinfectant that decomposes bio film, causing ions to no longer be able to attach to it. This causes a decrease in scale formation. Even water with high dissolved solids content can now be recycled, causing cooling water discharges to be decreased.

Corrosion is mainly caused by microorganisms, which enhance corrosion forming conditions. Ozone limits microbial growth. Little ozone is required to form a corrosion-preventing film on metals. In practice, about 0.1 g/m^3 of ozone are dosed to recirculating water. The ozone that does not react with organic matter decomposes to oxygen. There will be no toxic residues.

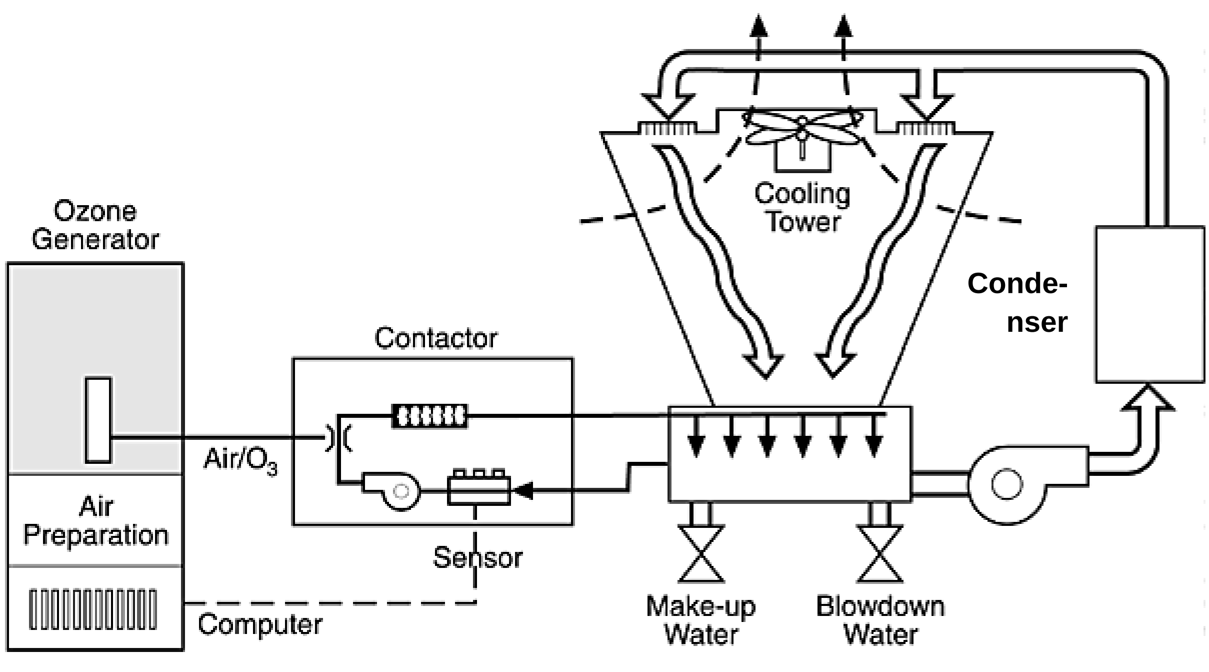

Fig. 2. Process for Ozone Treatment of Cooling Tower Water

The advantages of ozone in cooling tower are:

- Safe and easy in use.
- Low maintenance costs.
- Ozone is produced on-site and requires no storage of dangerous chemicals.
- Ozone requires no additional disinfectants.
- No cocktail of disinfectants necessary. Micro-organism can not get resistant to ozone after prolonged use of ozone.
- High efficiency as disinfectant.
- Very effective in removing biofilms.
- Higher efficiency of heat exchangers due to reduced biofilm formation.
- Due to good biofilm removal capacities very effective against Legionella.
- No chlorinated compounds.
- No persistent chemicals or disinfectants in bleed. Ozone breaks down to oxygen.
- In some cases ozone can replace disinfectants and also dispergents and inhibitors.
- In many cases a higher concentration factor is possible.
- Lower operational costs and in many cases a lower overall costs.
- Ozone is effective in a wide pH range.
- Conventional treatment techniques are mainly applications of chemical biocides, corrosion inhibitors and scale inhibitors. Ozone is a reliable alternative that controls the above-mentioned factors sufficiently.

CONCLUSIONS

Field tests have demonstrated that the use of ozone in place of chemicals for water treatment will reduce the blow down rate. As a result, cost savings accrue from decreased chemical use and make up water requirements, from a reduction of waste water volume, and from avoidance of waste water disposal surcharges due to residual chemicals in the blow down. There are also environmental benefits, as fewer chlorine or chlorinated compounds and other chemicals are discharged. When ozone oxidizes the biofilm that serves as a binding agent adhering scale to heat exchange surfaces, scale buildup on heat exchange surfaces is reduced, and higher heat transfer rates are achieved.

Ozone technology appears to be a reliable and effective method for cooling tower water treatment. Much excitement has been generated around this technology due to the possibilities it affords. Cooling tower system owners and operators see potential costs savings, environmental benefits, and reductions in maintenance and health hazards. Finally, with a reduction in biological growth, scale, corrosion, and chemical use, the issue of liability decreases as well. From a human resources perspective, reduced risk to personnel health enhances the working environment and makes a positive public statement.

Khaperkheda TPS ozonisation system performance:

Case study by Ozone Research & Applications (I) Pvt. Ltd.

ORAIPL successfully commissioned an ozonisation treatment plant (capacity 6kg/hr) for **Cooling Tower recirculating water flow 30,000 m3/hr at MSPGCL, Khaperkheda TPS, for a 210 MW unit**, eliminating total chlorine use.

ORAIPL is also executing an ozonisation treatment plant for cooling tower recirculating water at Paras & Parli Thermal Power Station for a 250 MW unit respectively.

Status of Ozonization after 6 months

1. The performance guarantee parameter in respect to KMnO4 value is within limit.
2. E. Coli found to be zero and no algae growth in water is seen.
3. The required vacuum is maintained.

Parameters	**Optimum**	**Before Ozonization**	**After Ozonization**
Vacuum in mm of Hg	657	662	677

4. The Cleanliness factor is improved

Parameters	**Optimum**	**Before Ozonization**	**After Ozonization**
Cleanliness factor L	0.85	0.53	0.69
Cleanliness factor R	0.85	0.54	0.71

5. The Log Mean Temperature Difference (LMTD) factor improved.

Parameters	**Optimum**	**Before Ozonization**	**After Ozonization**
LMTD L	8.03	10.74	8.13
LMTD R	8.03	10.62	8.01

6. The comparison of corrosion coupons of Unit. No. 2 where Chlorination is in practice & corrosion coupons of unit No. 3 where ozonisation is done was observed for two months. The result obtained were as follows;

For Unit No 2 (chlorine treated):

Mild Steel : Heavy corrosion observed

Copper : Mild corrosion observed

For Unit No 3 (ozone treated):

Mild Steel : No corrosion observed

Copper : No corrosion observed

7. From the various parameters, it can be stated that the cycle of concentration (COC) of cooling water can be increased, which can save water.

8. Ozonization is environmentally friendly, safe to operate compared to conventional chlorination practice having corrosion safety and hazardous problem.

Cost Benefit Analysis

- Improvement in Heat Rate due to gain in vacuum: 1 mm Hg gain in vacuum, heat rate improves by 2.2 Kcal / Kwh .
- for 15 mm of Hg heat rate gain 33 kcal / kwh
- Annual saving in Rupees, with PLF 90 % assumed
- A) 33* 210mw *1000*8760*.90=54636120000 kcal
- Equivalent coal in MT with CV 3300 kcal/Kg
- A/3300*1000= 16556.4 MT of coal saved
- With cost of raw coal Rs. 1250/MT= Total annual saving in Rs. 2.07 Cr.
- Predicted soft water savings by increase in C.O.C= 0.35 Cr.

Predicted Soft water savings for Unit 3, Khaperkheda TPS

- Present make-up of soft water : 10,000 m3/day
- Cost of soft water : Rs. 3 per m3
- Present cost incurred per day: 10,000 x 3 = Rs. 30,000/-
- Present cost incurred per year: 30,000 x 335 days = Rs.1,00,50,000/-
- Present cycles of concentration (COC): 3 nos.
- Soft water required per COC (excluding evaporation losses) = 712 m3/day
- Predicted COC increase: 8 nos.
- Total COC increased 8 – 3 = 5 nos. i.e. 5 x 712 = 3560 m3/day water can be saved
- Total cost savings 3560 m3 x Rs.3 = Rs. 10,680/- per day.
- Total cost savings per year = Rs. 10,680 x 335 days = Rs. 35,77,800/-

References

1. "Ozone Treatment of Cooling Waters" by Alan E. Pryor
2. "Ozonization Manual for Water and Wastewater treatment" by W. J. Masschelein.
3. Certificate issued by Khaperkheda Thermal Power Station (MSPGCL)