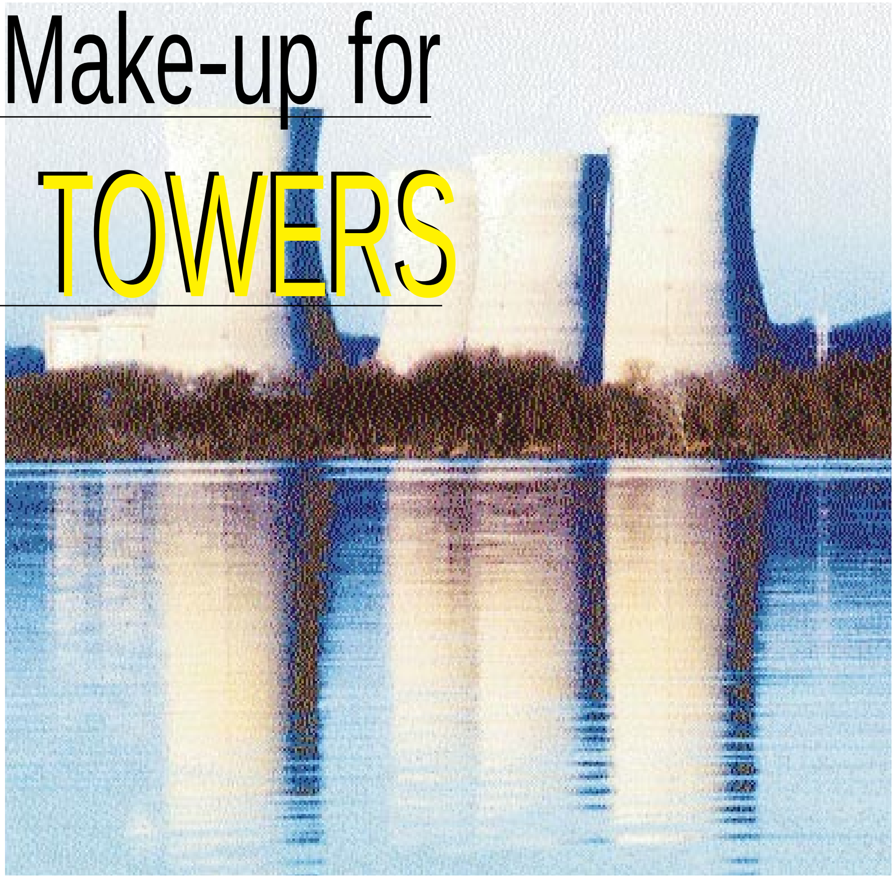
Wastewater Make-up for COOLING TOWERS



Water economy is achieved by balancing cycles of concentration with the help of chemicals, and bleed-off.

By Dr. G. H. Thanki

Cooling tower systems are designed to remove large amounts of heat from processes and air-conditioning systems in buildings. The common element in the system is the water used to produce the evaporative cooling. As water evaporates, dissolved minerals concentrate. To limit excessive mineral build-up, some of the re-circulating cooling tower water must be discharged to bleed-off. By controlling the bleed-off rate, it is possible to control mineral concentration and obtain nearly fixed cycles of concentration.

Water economy is based on how many cycles of concentration can be maintained, considering the character and concentration of minerals present in the make-up. Where hard well water is being used, normally, only two or three cycles of concentration can be allowed without risk of hardness, scale or sludge formation. Where soft, surface water is available, six to ten cycles may be permissible. Operating the system on a higher number of cycles can increase the corrosion and scaling tendencies of the water. Therefore, heat exchangers that receive second- or third-pass water incur problems when operating at higher number of cycles. Additionally, heat exchangers whose flow is regulated to control process-side temperature can also experience problems.

Typically, water treatment professionals maximise water economy and prescribe an environmentally acceptable chemical treatment strategy to control bio-fouling, scaling, corrosion and microbiologically influenced corrosion (MIC). Technologies to control such problems have changed substantially in the past decade.

Initially, the driving force for change was replacement of heavy metal biocides and corrosion inhibitors for environment reasons. Currently, however, changes in water treatment technology are motivated by the need to deal with the operation of re-circulating and closed-loop cooling systems using wastewater as make-up, and by increased water reuse.

The conservation mode of cooling water increases the corrosive species concentration, seriously impairs the life of the waterways and proves costly in running the plant equipment efficiently. Nevertheless, modern corrosion monitoring techniques are being taken up by an increasingly broad spectrum of the major process industries, to determine the corrosion rate, trend and severity of cooling water.

Incentives

The rise in wastewater make-up has various reasons, like reduction in water supply, high cost of fresh water, and the need to modify methods of wastewater discharge. The increased reuse of water is also associated with certain techno-economic reasons including blow-down water volume reduction, increase in concentration ratios, treatment cost reduction and the goal of zero blow-down.

Bottlenecks

Significant increase, in potential for cooling system problems, has taken place in the use of wastewater make-up and water reuse. These problems are related to microbiological growth, sludge, silt deposition, scale and corrosion.

Wastewater-related problems fall into the following categories:

1. Microbiological growth
   - Slime formation (biofilm)
   - Bio-fouling (biomass)
   - Biodegradation (wood rot)
   - Microbiologically induced corrosion (MIC)
2. Sludge and silt deposition
   - Deposition of suspended solids at low-flow sites
   - Plugging/fouling of filters, screens, monitoring equipment
   - Deposition of organic materials (oils and grease)
3. Scale deposition
   - Calcium carbonate formation on heat transfer surfaces
   - Fouling caused by calcium phosphate scale and sludge
   - Calcium/barium sulphate deposition in pumps, valves and pipelines
   - Reduced flow through pipelines, valves and process equipment
4. Corrosion
   - Weld failures on carbon steel and stainless steel components
   - Localised (pitting) corrosion related to chloride and sulphide concentrations
   - Uniform corrosion on ferrous and copper alloys
   - Under deposit corrosion
   - Galvanic corrosion

Cooling water treatment with a special look:

Cooling water treatment may be viewed under two basic concepts in today's operating conditions.

1. Components of the treatment programme must be coordinated. The biocide must complement the corrosion inhibitor, which must complement the scale inhibitor, and so on throughout the chemical treatment programme.
2. Every cooling water treatment programme has the following segments.

> Specific enzymes are tested to assess their ability to prevent defined biological problems and eliminate organic deposits.

- Optimised maintenance & chemical treatment: includes the use of biocides, bio dispersants and scale inhibitors in preventive mode.
- Contingency treatment: is a programme that can be immediately implemented in response to an unforeseen emergency.
- Proactive maintenance: includes a carefully defined programme of regularly scheduled maintenance and cleaning.

Specific chemical treatment:

Treatment programmes aiming for increased use of wastewater make-up and reuse, are based on application of specific treatment chemicals, and physical and mechanical processes.

State-of-the-art chemical treatment includes biocides, bio-dispersants, sludge dispersants, conventional scale inhibitors and corrosion inhibitors. Chemical agents suited for use in plants, with wastewater make-up and water reuse programmes, are as follows:

1. Biocides/biostats.
   - Oxidising biocides, including chlorine (hypochlorite), activated sodium bromide, bromochloro hydantoin, chloroisocynurate, chlorine dioxide, peroxide and ozone.
   - Non-oxidising biocides/biostats, including polyquats, methylene bis-thiocyanate, (thiocyanomethylthio) benzothiazole, glutardehyde, quaternary ammonium salts, isothiazolines, dodecyl guanidine and others.
2. Bio-dispersants
   - Non-water-soluble compounds, including dimethylamides and dodecylmorpholine derivatives. The need for these compounds has risen dramatically as a result of increased wastewater and water reuse make-up requirements.
   - Water-soluble compounds, including ethylene oxide adducts, xylene sulphonates, lignosulphonates and other surfactants.

   These bio-dispersants represent established treatments but in the past they have been used to control chemical intrusions into cooling water, rather than as bio-dispersants.
3. Sludge dispersants
   - Anionic polyelectrolyte polymers, such as polyacrylates, copolymers, terpolymers and others. The list of sludge dispersants is long, but polyacrylates and acrylate copolymers are the

most important for these applications.

4. Scale inhibitors
   - Non-stoichiometric chelating agents, including phosphonates, phosphinocarboxylic acid derivatives and others. Phosphinocarboxylic acid materials are quite new for these types of applications. They represent an area of great progress over the past few years.

     There are many specific phosphonates and phosphinocarboxylic derivatives that have been introduced in the past five years to deal with scale inhibitor requirements brought about by wastewater and water reuse make-up requirements.

     In addition to the organophosphates, there are the non-phosphate scale inhibitors. These include anionic polyelectrolyte polymers, sulphonated styrene derivatives and maleic acid/anhydride derivatives

5. Corrosion inhibitors
   - Non-heavy metal anodic passivating compounds, such as orthophosphates, polyphosphates, molybdates, azole derivatives, nitrite salts and others.
   - Cathodic passivating compounds, such as zinc salts and phosphonates.

     The use of heavy metal anodic passivating materials is now well established. In the past, however, corrosion inhibitors were not often used.

     With increased water reuse, corrosion becomes a cumulative process. Its growth can become exponential, mandating continuous corrosion protection programmes, which should invite on-line corrosion monitoring system installation.

6. Supplementary chemical treatment
   - High molecular-weight anionic/cationic flocculants for liquid-solid separations
   - De-foamers
   - pH adjustment chemicals including both acid and alkali-based materials

Physical processes

Cooling water chemical treatment programmes are used in conjunction with other water treatment or pre-treatment procedures. These operational and water conditioning procedures are usually site specific, determined by the use of the water and by the quality of the make-up or recycled water. These procedures include full-stream and side- stream filtration, ion exchange (zeolite) softening, lime soda softening, anionic/cationic resin on removal, coagulation/flocculation, aeration/bio-oxidation, oil-water separation/emulsion, and nitrate/phosphate removal.

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Emerging technologies

In addition to the technologies listed above, some new technologies designed to meet existing and future needs are in the R&D stage.

One of the two areas of development making significant progress, and close to becoming standard operating procedure, is non-toxic micro-organism control based on bio-dispersants.

Though bio-dispersant technology is in limited use now, it is expected to soon become the sole means controlling microbiological growth, without biocides or biostats. Lately, dodecylmorpholine compounds have moved from research stage to significant commercial usage. A great deal more of development in the field can be expected in the coming years.

The second area of progress is enzyme technology for non-toxic control of micro-organisms. This area of research involves new technology in which materials produced by micro-organisms are synthesized and tested under field conditions. Specific enzymes are tested to assess their ability to prevent defined biological problems and, in some cases, to eliminate organic deposits.

It may be safely assumed that in the coming years dispersants and enzyme technologies, and other new developments, will eliminate the need to use toxic and environmentally unviable materials for micro-organism control.

It is also expected that in the future there will be changes in design, operations, system engineering and design, and construction materials. Operations will probably require zero discharge, and increase the need for effective control.

One area in which on-line corrosion monitoring can contribute significantly is the optimisation of the corrosion inhibitors dose in cooling tower water. It is important to have knowledge of quality and quantity of the corrosion inhibitors. At the same time, qualification of the chemical vendor and real time information on the corrosion rate are also vital in restricting corrosion.

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