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Advancement & Digitalization in Cooling Water Treatment to have Informed Decision making & Avoiding Microbiological fouling to improve the asset life and Quality in Reverse Osmosis Membranes

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ABSTRACT

This paper is to give in-depth about understanding the Automation required in cooling Water Treatment (CWT) and what it should feedback us and control the system to have Scale, Corrosion & Microbio fouling free operations. The new advancement in chemical treatment in CWT is to reduce or eliminate the Sulphuric acid, helping the system to operate at Higher pH providing scale and corrosion free system.

In the preparation of water for CPP, RO membranes are widely used. These membranes generally suffer Microbio fouling causing poor water quality & frequent membrane replacement apart from energy increase due to increased feed pressure. These problems can be easily mitigated with Oxy Cleaners (dual component programme) to have sustained feed pressure and quality.

KeyWords: Cooling Water Treatment – Automation –Ionic balance Modelling technique – Cloud storage–Water Chemistry –Phosphate &Non-Phosphate Treatment – Corrosion Rates – Cycles of Concentration & pH – Recirculating water.

Reverse Osmosis Membrane- Current practices – Scaling & Fouling – Chemical cleaning – CIP –Non-Ox Biocides – DBNPA – NSF approval –Cartridge & Ultra Filters – Case studies.

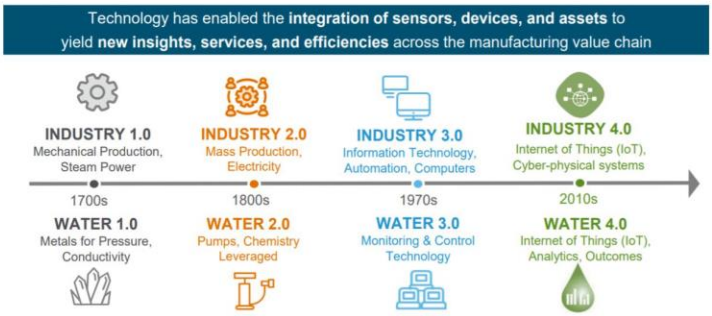
Introduction

Paper Industry using huge amount of water for the production and utility comprising Captive Power Plant, Evaporators, HVAC, Machine Cooling towers using substantial water. In most of the cases these applications are using cooling water to transfer heat energy form process Heat exchangers or Surface condensers. When water used at higher cycles of concentration can cause issues like Scaling, Corrosion and fouling along with microbiological growth.

Issues in CWT – Scaling, Corrosion& Microbio fouling:

Whenever, there is transfer of heat in the HX or surface condensers, due to evaporation in the cooling towers leading to concentration of dissolved solids in the recirculating water. Over saturation of specific ions like Calcium, Silica, Magnesium, Phosphateetc. can precipitate as scale in the heat transfer surface. Also, the suspended solids from makeup, dusty atmosphere with higher turbidity in the recirculating water can cause severe fouling on the heat exchanger. Any mineral scaling or fouling will cause poor transfer of heat causing production loss or unscheduled shutdowns.

The other important issue in cooling water system is Corrosion. Corrosion is electro-chemical process, in which the parent metal will turn to its Oxide stable state. For e.g. Fe2+ (Mild steel) turning into Fe3+ with formation of Ferric or Ferrous Hydroxides. Beyond scaling and corrosion, the conditions like the cooling tower temperature, exposed to sunlight and pH conditions are very conducive of microbiology to grow. During the metabolic activity of these organisms producing slime layer, which can absorb the Suspend solids and salts of saturation to cause crystalline growth or scaling in the heat transfer areas.



Till 1980, there were traditional approach in doing the cooling water treatment programme with Molybdate, Nitrite process. The introduction of Phosphonate chemistry was revolution in year 1985. With various new molecules as scaling and corrosion inhibitors the asset life and the problems related to scaling and corrosions were considerably reduced.

In early 90's, the pH and conductivity controllers paved way for initiation of automation in cooling water systems, from thereon, many different companies started to have different ways to automate the cooling water system for its optimum performance.

After 2010 onwards, the Internet-of-Things (IoT) is the buss word, were the data accumulation, processing of data and having informed decisions made is the State-of-Art.

From 2015 onwards, the cooling water automations is acquiring the Operational parameters and integrating with Cooling water critical parameters. This gives a scope to analyze the Cause and Impact of poor chemical treatment in cooling water programme on the critical heat exchangers.

In this process, need to acquire data like temperature, velocity, pressures, heat load, U-Value (Cleanliness factor) etc. synchronizing with the cooling water parameters like chemical residues, pH, heat load, Scale & Corrosion Index etc... With special algorithms and Artificial Intelligence, should be able to make informed decision. Also, this level of Internet-of-Things, will enable the Paper Mill to have corporate dashboard view.

Advanced Chemistry to Avoid Sulphuric Acid in Cooling Towers:

In general, to control the pH and alkalinity in the recirculating water, industries normally using Sulphuric acid – 99% concentration. The H+ ions in the acid consuming the CO3, HCO3& OH ions to keep the pH and alkalinity under control. Though its regular practice but has potential safety hazard handling the concentrated acid in huge quantities to be dosed into cooling towers.

Apart from safety hazard, we normally use Phosphonate's and Phosphate's to control the scaling and corrosion in the cooling water system. The blowdown discharged from such towers will carry > 5 – 10 ppm of PO4 to the effluent. These PO4 is good source of food material for the Algae & microbio to grow. In many European union and Greater China, discharge of PO4 < 0.5 ppm is the norm in the effluent water discharged outside the mills. Thus, the PO4 causing algae bloom in the public sewers where effluent with rich PO4 is discharged.

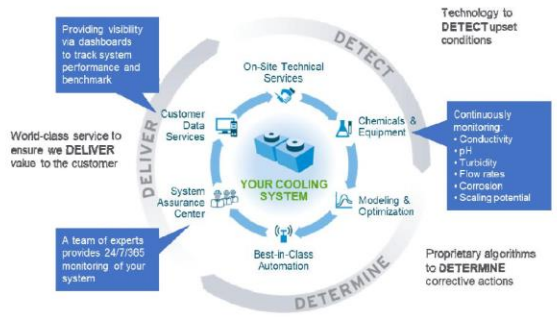
Also, Phosphate chemistry restricts the pH and alkalinity to be operated below 8.0 & < 150 ppm respectively with the help of Sulphuric acid.

Traditional Approach to Cooling Water?

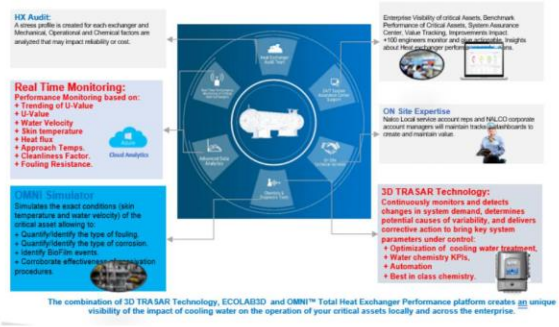
- Stress is the total of everything which can cause a loss of cooling efficiency in the system
  - MECHANICAL Heat exchanger design & operation
    - High temperatures or heat fluxes, low flow velocities
    - Long Holding Time Indexes (HTI's)
  - OPERATIONAL Cooling water chemistry & control
    - Poor or failed control/testing or dosing equipment
  - CHEMICAL Raw water chemistry
    - Variable water quality
    - Phosphate added by water utility
    - Suspended Solids

- Dependency on Water analysis,
  - Pinks & Blues
  - Grab Samples once per day, not representation of the day
  - Reactive approach
- Mechanical & Operational Parameters
  - The chemistries dosed on Ad-hoc basis
  - The dosages not linked to real time corrosion & scale in system
  - Not considering the above stress in the system
  - Operations negligence on critical parameters etc.

Essential components of Automation Platform



Fingerprinting the Operational parameters…



Right Components of Integrating the Data to take Informed decisions:

Non-Phosphate Treatment Programme:

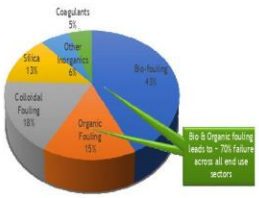
All the above issues, forced many water treatment companies to come up with Low-PO4 or Non-Phosphate programme, still effectively managing the scale and corrosion issues in the cooling water systems. NALCO being the pioneer in

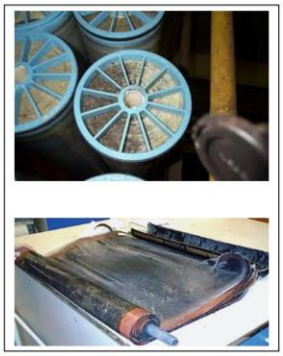
introducing molecules, had synthesized Tri-Carboxylic chemistry, which will effectively disperse Calcium Carbonate scale and naturally available carbonates will be used as corrosion inhibitor.

Reverse Osmosis Membrane

Handling Microbio Fouling more effectively than traditional way…

The following is the general trend on different types of fouling happens to Reverse Osmosis membrane.





Being Microbio fouling major cause of membrane replacement, quality variation and higher energy consumption per m3 of water generated.

In the current practices, we allow to build microbio fouling over period, then will do a CIP (Cleaning-In-Place) to get rid of the foulants. This process cannot get rid of 100% of the foulants after cleaning, so losing the recovery % of the RO system over period of time.

NALCO did research on to have Oxy cleaners which is safer to Polyamide membranes, but effective on microbio fouling on the membranes. With this two component programme, we can either have continuous or intermittent dosages depending upon the type and severity of foulant. Thus, not allowing the microbio population to increase and cause fouling issues. The following is the illustration of Traditional way of cleaning the microbio fouling and Oxy Cleaner way from NALCO…

Case study: The Oxy Cleaner from NALCO has helped a Paper mill in South India to improve the performance of RO membranes, Cartridge filters with savings in terms of reducing the caustic flushing and savings in terms of energy.

CONCLUSION

As water becoming costly commodity and scarce, it has to be managed more wisely and to be operated at the maximum stress levels, still without risking the equipment and its efficiency. Therefore, Automation based informed decision and dashboard view through IoT is very important. At the same time, we can avoid saftey hazards like Sulphuric acid with Non-Phosphate programme.

Having greater control on the Microbio fouling will help us to operate the system effeciently interms of lower Rs./m3 permeate generation, asset protection and waste generation in membrane systems. The Oxy Cleaners compatible with membranes will help in achieving this.

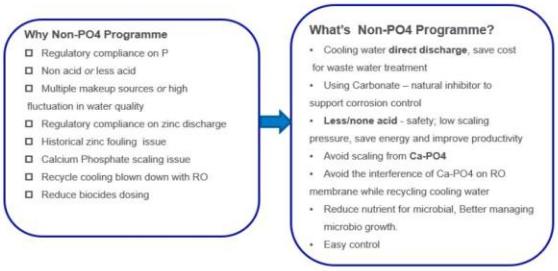
Refference:

Nalco water Handbook, Daniel J Flynn

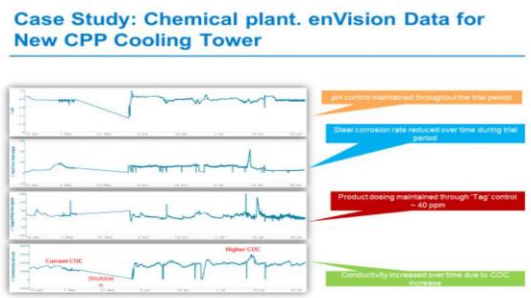
NexGurad 3D TRASAR System – System Assurance Centre

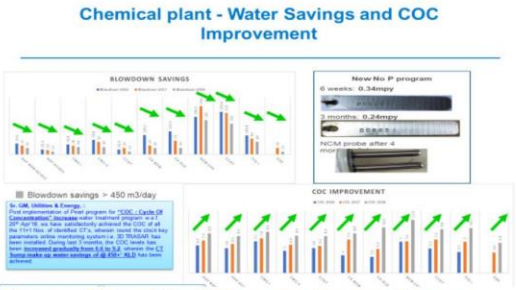
Membrane Research group. USA

Drivers for Non-PO4 Technology:



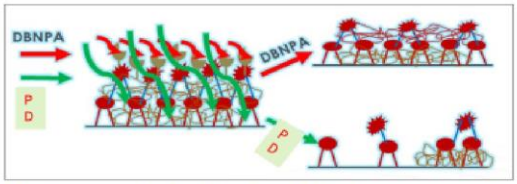
Case study: A Chemical Industry CPP from Gujarat:





Advanced Benefits of Oxy membrance cleaner

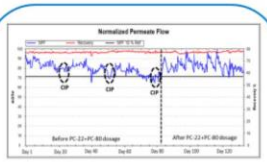
- Dual stabilized biocide - compatible with polyamide RO membranes
- Two drum approach efficient bio-management
- Acts during microbe growth phase (proactive control)
- Can act on mature bio-films better than DBNPA
- Provides deep cleaning and thereby leading to complete removal



Trial Summary - India (Surface Water)

This paper plant has a raw water RO. Due to high microbial contamination in the incoming stream, this RO plant was struggling with severe bio-fouling related concerns.

KPI	Baseline	With PC-22 & PC-80
Reduction in alkaline frequency	Every alternate day	Weekly once
Reduction in MCF replacement	Every 3 -4 days	Every 20 days
Reduction in CIP frequency	Monthly once	Every 60 days (and more)



- Raw water and treated water savings in the tune of 18,000 m3/ annum
- 5 times improvement in MCF life has led to savings of 15K USD per annum
- Handling of aggressive chemicals reduced by 50% - annual impact is ~ 16K USD