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INSTRUMENTS AND EQUIPMENT USED IN THE MODERN COOLING WATER SYSTEM

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Abstract: Cooling water systems in the industries have remained a neglected area for long period of time. Supply of fresh water to chemical process industries (CPI) is restricted. Environmental regulations regarding effluent discharge have become stricter and the market competition has resulted in continuous need for additional cooling capacity for new projects. As a consequence of these changes, cooling water systems have become an important part of CPI.

Simultaneously many technological developments have taken place in this area especially in chemical feeding and dosing systems, monitoring tools, equipment and automation. The state-of-the-art treatment programs demand use of costlier specialty additive for optimal performance. These programs demand new monitoring methods and use of diagnostic equipment like chlorinator, computerized dosing system bio-fouling monitors, non-invasive flowmeter and halogen analyses. Justification of higher operating cost and higher capital expenditure necessitate a careful study of the alternate methods of measurement and monitoring techniques.

INTRODUCTION

Cooling Water system- Open and recirculating

Most commonly and widely used cooling water systems are of open and recirculating type. Here, water is repeatedly circulated for removing heat. The degree of recirculation is measured in terms of cycles of concentrations. It is defined as the ratio of concentration of components (chemical) in the reticulating water to make up water. Heat removed from the process and equipment is rejected to the atmosphere by evaporating part of the water in the cooling tower. For cooling every 540 kg of water by one degree centigrade about 1 kg of water is evaporated. The quantity of water discharged to waste is greatly reduced in the open and recirculating type of system and chemical treatment is more economical compared to once through type of system this is mainly due to operating at higher cycles of concentration.

Open recirculating type of systems are inherently subjected to more treatment related problems than once through type of systems mainly because of operation at higher cycle which increasescorrosion and deposition potential. The larger retention time and raised temperature increases the tendency for bio-fouling in the circulating water with presence of oxygen and contaminants.

Cooling Water System-Change of Perspective

Minimum attention was paid to cooling water systems in chemical process industries this was mainly because old generation systems were operating at much lower cycles of concentration the chemical treatment programs were relatively much robust, cheaper and based on liberal use of environmental unfriendly chemicals. These older systems were often over designed and hence could cover up for their inefficiencies. There is a continuous need for additional cooling capacity for revamp/debottleneck projects. These changes have made it necessary to look at cooling water systems from a different perspective. These changes have resulted in technological development seen in this area in terms of treatment programs, feeding /Dosing system monitoring tools equipment and automation for optimisation.

Benefits from the above mentioned technological developments in cooling water system can result in

1. Reduction in operating costs due to improvement in heat transfer efficiencies and does increased margins due to higher production rate.
2. Lower maintenance costs due to lower cleaning frequency for heat exchangers and decrease in corrosion rates.
3. Increase of COC to reduce raw water and chemical consumption

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4. Improvements in performance and efficiency of key turbine condensers to overcome throughput limitations and reduce steam consumption.
5. Carry out cooling water flow network optimisation to run lesser number of cooling water pump for the same production level.

These new Stare-Of-The-Art programmes have introduced many items of new equipment. These are required for the success of treatment programme, some of them are discussed below.

EQUIPMENT FOR MONITORING, TROUBLE SHOOTING AND OPTIMISING COOLING WATER TREATMENT PROGRAMME

Electronic Dosing Pumps

The earlier program relied on dosing of the treatment chemicals manually in the solid form or by making suitable solution and then dosing them to cooling Towers. The new generation programmes are based on use of patented polymeric dispersants which keep the inhibitors and dissolved solids in the solution/suspension form above their solubility limits. These are also to be dosed in extremely small and accurate quantities on a continuous basis. The use of new generation patented chemical makes the new programs much more expensive and hence excess dosing can increase the cost of the program significantly. As a result of this small electronically controlled diaphragm pumps are required to be used for this type of program. Dosing rates can be effectively adjusted by adjusting the stroke and frequency of these pumps. These pumps are virtually maintenance free, very small in size and are easy to install. It is possible to dose chemical directly from drums using flexible tubing. This has drastically reduced handling of chemicals by operating crew and has also considerably improved accuracy.

Chlorinators

Chlorine is one of the most important components of any cooling water treatment program and need to be maintained at levels of 0.2 - 0.5 PPM. This is an oxidizing biocide. Any microbe coming in contact with it gets killed and hence microbes cannot develop immunity for it like they develop for non-oxidizing biocides. The new generation treatment needs operation on the alkaline side (7.5-8.5 pH) compared to many of the older programs which use to operate towards acidic side. In the alkaline pH the effect of chlorine is reduced and hence it needs to be augmented with bromine. This is required especially for systems where contamination due to hydrocarbons and ammonia is possible. Bromine is very difficult to handle and hence it is generated in solution form by using chlorine solution in water and a bromine salt. This process needs regulation of chlorine dosing rate. This is very effectively done by using chlorinators compared to traditional way of relying on operator’s judgment. The regular monitoring of the dosing rate and the free residual chlorine helps in quick identification of the increased biological activity.

Halogen Analysers

Nowadays analyzers based on the principle of oxidation and reduction potential are available. These analyses give residual halogens in the circulating water. This analysis can be used to automate the chlorine dosing rate.

CORROSION MONITORS

Corrosion rates over extended period can be monitored using different metallurgy coupons at multiple locations in the system. Furthermore, the instantaneous rate monitoring is carried out using portable meter. Both the methods are extremely useful to monitor the health of the system and to carry out necessary adjustments.

Bio-fouling monitors

These are the equipment which measures the magnitude of the bio film formation occurring in the system. It is important to measure the bio film formation because it offers four times resistance to heat transfer compared to a hard deposit inorganic film of the same thickness. Furthermore, bio film formation rate with the contamination in the system is very high (few hours) compared to formation of an inorganic film (few days). The bio fouling monitor consists of highly polished stainless tube of a standard length. It is generally installed on the cooling water return line and constant cooling water flow is maintained through it. Pressure drop across the tube serves as a quantitative measure of the bio fouling. It is very sensitive to formation of the bio film which is reflected by sharp increase in pressure drop over time.

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Deposit Monitors.

Most of the new generation programmes rely on polymeric dispersants that keep fouling agents and inhibitor in the solution form. Any upset in the system and temperatures of cooling water (more than 70 degree C) can result in the loss of the polymeric dispersant's activity. This can result in uncontrolled deposition of the inhibitors and fouling agents on the heat transfer surface. This equipment is extremely useful to monitor deposition. It consists of a visual heat exchange assembly fitted with a removable mild steel tube inside a glass tube. Tube can be of the desired metallurgy. The tube contains an electrical heating element. Heating rate can be adjusted using a heat flux controller. It is also fitted with the tube skin temperature and cooling water outlet temperature indicator. The conditions are adjusted to match the critical heat exchanger in the system. Regular monitoring of this equipment can indicate sudden upset in the system it is also used to quantify the deposition rate in the system over extended period. This is done by finding out the weight of the deposit on a tube exposed for longer periods.

ONLINE "TOTAL ORGANIC CARBON (TOC) ANALYSERS

Process Leaks in any hydrocarbon processing plant can lead to release of organics into cooling water system. It is well known that this type of leak (more than 50-60 PPM level of TOC) if undetected and thus unattended will lead to heavy bio fouling in the cooling water system within a few hours. The problem is more acute with water soluble hydrocarbons. Relying on spot analysis is insufficient. In the new generation programmes online analysis of TOC is of Paramount importance.

Automation of Feeding Systems

A computerized feed system[1] reduces variation caused by pump inaccuracies and process variation. It receives operating data like pH, conductivity, makeup flow rate TOC, inhibitor levels, free chlorine etc. from an online monitoring sensor/DCS system. The computerized feeding system is of self-calibrating type whereas the microprocessor determines the set point for the feeding system by using set algorithms. This system can also be integrated with the DCS system.

Another system is based on microprocessor based control system[2]. This works on the principle of direct continuous measurement of the concentration of main dispersant polymer in the system. The main polymer molecule is packed with the fluorescent dye. This helps in measuring its concentration using fluorimeter. Any slight variation in its concentration from the target value changes the set point of the polymer dispersion dosing pump. Other chemical dosing rates are cascaded with polymer dispersant. This technique can also be used as a diagnostic tool by using fluorescent dye for determining flow rates, accurate system volume etc.

Instruments/equipment for optimizing the cooling tower operating costs

A typical breakup of operating cost for cooling water system with SOA treatment program in this region would be as follows:-

1	Water make up	10-12%
2	Treatment Programme chemicals	8-10%
3	Power cost	80-85%

Table 1

From Table 1, it is obvious that the major operating cost is incurred in pumping of water and air and any additional treatment cost should seek justification from reduction in the pumping cost.

Reduction in power consumption can be achieved by reducing excess capacities and improving the performance of the tower. Major amount of power is consumed in circulation of the cooling water. In a classical design 1 m/s was the lower limit of cooling water velocity. However, new treatment methods can permit reduction in the minimum velocity of water up to 0.75 m/s compared to earlier limit of more than 1 m/s. Similarly maximum tolerance limit for cooling water outlet temperature also has gone up to 75 degrees compared to earlier 45 degrees Celsius. These changes now allow us to reduce the circulation in the system at throttling heat exchanger cooling water outlet valve and thus reduce power consumption. Power consumption can be further reduced by changing the cooling

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tower fan blades from Aluminium to the aerodynamically designed FRP blades. This FRP blade can alternately give higher air flow to improve performance of the tower. In order to achieve the above objectives the following measurements are necessary.

Non-invasive flow meter for measuring cooling water flow

Classical design practice is to install few Annubar / Pitot tubes in the cooling water circuit to measure flow at each battery limit. However, cooling water flow reduction needs a flow network optimization that, in turn, demands measurement of flow at multiple locations. This is best accomplished by using a portable non-invasive flow meter based on sonic principle. With the help of this instrument and the use of flow network computer program, it is possible to reduce 25-30% power consumption in main cooling tower during non- summer months.

ANEMOMETER FOR MEASURING AIR FLOWS

Performance of the cooling tower generally depends on the air to water ratio in each cell. This can be monitored at regular intervals by measuring air flow. This instrument was found to be useful as a good troubleshooting tool for pin pointing reasons for the poor performance of individual cells.

CONCLUSION

The technological developments in the area of cooling water technologies in terms of treatment programs, modern equipment for sensing, dosing etc. and automation have resulted in environment friendly as well as efficient operation of cooling towers.

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