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Ultrasound System– A Powerful Tool for Industrial Water Quality Management

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Among numerous applications of ultrasound systems in diverse fields, the use of such systems in destruction and prevention of algal growth in water is relatively new. The use of ultrasound and cavitation for controlling algae growth has been known for a long time but the high energy required was a deterrent in this non-chemical route to algae and biofilm control.

The average energy density required for cavitation effects in water is of the order of 47 KW/Cm^2. Therefore, the cost of transducer and power generator for creation of cavitation effect in water, becomes prohibitive. The basic principle for cavitation is to physically smash the algae body through generation of high pressure and temperature in a small section through which the algae containing water is forced to pass. Thus, even though this method is feasible it is not cost effective as compared to the other established options using chemicals, Barley straw, aeration etc.

The breakthrough came with the discovery that most varieties of algae and fungi have a fragile protection system, with a natural frequency of the order of 35 KHz. Therefore, continuous application of resonant vibration at this frequency could easily destroy the cell protection mechanism, and the organism ceases to survive. This power of resonance is the key concept for application of low energy moderate frequency ultrasound waves for controlling algae growth in water.

The wave front from the ultrasound transducers, spread out at an angle of about 150 degree, although the distance covered by wave fronts away from the direct line gradually decreases. *Fig. 1* shows a typical radiation chart in a pond and in *Fig. 2* a typical ultrasonic transducer is shown. A single unit is able to protect a pond of around 200 meter length and 100 meter width and consume about 40 to 45 watt. hr. energy. Ultrasound systems can thus easily compete with conventional algae and microorganisms control methods such as UV, Ozone or, chemical, particularly when a medium to large water body is involved.

Other Useful Features of Ultrasound Systems

Apart from low energy requirement for handling large water bodies, ultrasonic systems are essentially breakdown-free. Since both the power box and the transducer do not have any moving part, they do not require any servicing or periodic maintenance. From the operating experience of such systems in the last 15 years, the life of a device (Mean Time to Failure, MTTF) is estimated at 10 years or greater.

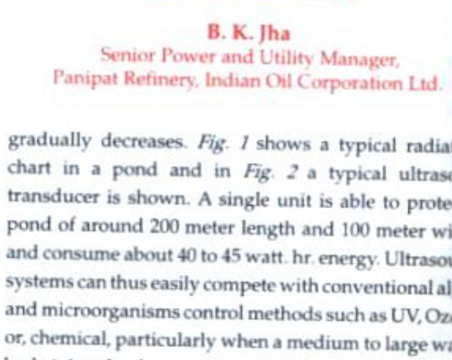


Fig. 1: Typical ultrasonic wave distribution pattern

Fig. 2: Ultrasonic Transducer

Application Areas

Due to the attractive features of the ultrasound systems for controlling algae and other microorganisms, there is widespread use of such systems in natural water ponds, swimming pools and garden fountains. The use of these ultrasounds systems are steadily increasing in industrial water quality management. With the characteristic features of ultrasonic devices and the understanding of the principles of the design and operation such systems, there is tremendous potential of using ultrasonic systems in industrial water quality management. Installation of ultrasonic systems in appropriate locations in the water circuit results in significant savings on chemicals and supervising manpower for water treatment.

In the following section we examine the potential benefits that could be realized through installation of ultrasonic systems in industrial water circuit.

Industrial Water Circuits

A very simplistic picture of the water circuit in a typical medium size industry is as follows:

The fresh water is first held in an open reservoir, with up to a day's hold up. From this intake pond, water is then sent to cooling towers after treatment and then to heat exchangers, air conditioners, refrigeration plants, steam jet ejectors etc. A part of the water is treated before discharge in the ETP plant and held till discharged or, reused.

We can easily appreciate that in this circuit, there are several locations where conditions are favorable for growth of algae and microorganisms. We shall now examine the algae growth in these specific sections.

Intake Pond

Let us assume an intake pond of 50 * 25 meter with a depth of 4 meter, holding about 5000 cubic meter of water.

We can estimate the production of algae in this pond in a day from different reported literature. It could be safely assumed that about 50 Kg. of algae is formed in a day in this pond in question.

Assuming a figure of about 50 Kg./Day for this size of pond , we could expect a saving of about 16 Tonne of chlorine consumption per year considering about equal weight of chlorine gas is needed to destroy the organic matter. Additional savings will come from reduced consumption of other chemicals, decrease in cleaning frequency of the pond surface and pumps, etc.

Cooling Tower Sump

The next important section in a typical industrial water circuit is the cooling tower. During the water evaporation and cooling stage, where the water is exposed, conditions are most favorable for the algae and fungi to thrive, so these microorganisms easily form colonies and settle on the surfaces of the cooling tower sump and on the surface of the pipes and heat exchangers and wherever a static surface is in contact with water.

We have recently examined a large cooling tower sump with a holding capacity of about 2200 M^3 The water is added and drawn from this sump at 20,000 M^3 per Hour, i.e. the residence time of water in this sump is only about 6 Min. To maintain the quality of the circulating water, about 15 Kg of chlorine is used per hour, in addition to a host of other chemicals. The other chemicals added are biocides, algaecides and corrosion inhibitors totaling about 10 Tonne per month!

Treated Effluent holding Pond

This is another important location where we could realise excellent benefits by installation of ultrasonic systems. During the holding period in the open pond for several days, algae start growing along with other bacteria and fungi. With the onset of summer, very often one experiences uncontrolled growth of algae associated with increased turbidity of the water and foul smell. To maintain the water clarity or to prevent the development of deposits in the pond surface and to control the unwanted smell etc., aeration facilities are provided in such ponds.

With installation of a single unit of ultrasonic transducer, a pond of 600 * 300 Sq. Ft. could be kept free from algae formation, without any aeration. The clean and odor free water as well as prevention of algal boom will justify the investment on the ultrasonic system.

There are numerous reports for successful application of ultrasonic systems in garden fountains, natural lakes and swimming pools. In swimming pools, storage ponds, filters, pumps and inner surface of the pipes in contact with water, the deposits are not formed and the cleaning frequency is reduced to a great extent. In case of swimming pools about 70% reduction in chlorine consumption is reported by many users. This lower chlorine concentration reduces the chlorine itch and thus increases the comfort level of the swimmers. The use of the ultrasonic systems in these areas is growing due to the comfort level it provides through reduced maintenance and overall improvement in water quality.

Recent Field Trials in India

In Industrial Intake Pond

We have recently concluded a study in a large industrial intake pond in one of our Indian refineries The pond is of about 25*50 Sq. M. size holding approximately 5000 M^3 water and receiving and delivering the water at an average rate between 250 to 300 Cu. Meter/Hour. The operation is similar to the pond referred in the section on Intake Pond.

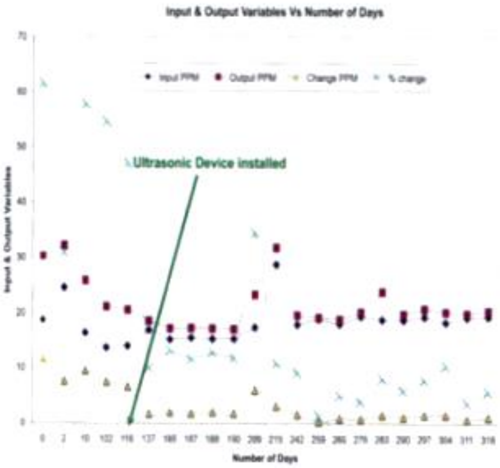


Fig. 3: ***Plot of Bio Mass concentrations Vs. operating days.***

In Fig 3, we have plotted the Organic Matter (OM) concentrations of the inlet and outlet water at certain intervals, during the trial period. It is seen that normally there is a build up of Organic Matter (OM) to the extent of about 60 %, before installation of the ultrasonic device on 116th day. Only one ultrasound device was installed in the pond. The increase in OM was sharply reduced to about 10% within one month of the installation. This is a clear measure of how much algae and other microorganisms are growing during the short residence time (about a day) of water in this pond and how the Ultrasonic device could arrest the growth. Therefore, we can safely conclude that the ultrasonic device has restricted the growth of algae to the extent of 10 PPM in the pond per day.

This means prevention of about 50 Kg. of OM from formation per day in this pond (taking the reduction in biomass growth by about 10 ppm, the total algae prevented from formation is: 50*25*4*10 Kgs.). The corresponding reduction in chlorine consumption is also about the similar amount. In addition to the direct saving of the treatment cost, the wall surface of the pond was cleaner and the clarity of the water was much better than before, which resulted in deferment of periodic cleaning of the pond surface.

The performance conclusively proves the ability of the ultrasonic wave to control growth of algae in open ponds. The benefits include clarity of the water, reduction of unwanted smell, low bacteria level in the water and absence of bio film formation.

In Cooling Tower

In another trial at a huge cooling tower of one of the Indian refineries, considering the high level of turbulence in the sump, we installed two units in two corners as shown in Fig. 4 to avoid chance of interference between the units. As a general practice, most of the chemicals are added without measuring any of the water quality parameters of the circulating water but the chlorine and chlorine dioxide is added to maintain a specific residual chlorine level in the circulating water. Obviously, when the pickup of algae or, biomass is high in the circulating water, it will directly reflect in the increased chlorine consumption and not in the usage of other chemicals.

The chemical and chlorine (and chlorine dioxide) consumption data is available only on monthly basis at this location. The cooling tower was cleaned and the entire water was replaced after shutdown. The ultrasonic devices were installed during the middle of November, 2009 and were withdrawn on 17th.February, 2010. The consumption of chlorine (and chlorine dioxide) before the shutdown was taken as basis. Before shutdown the reported monthly consumption was about 15 KG. Per hour (10800 Kg. per month) and even with this level of chlorine dosing, it was difficult to maintain the residual chlorine level in the circulating water. In Fig. 5, we have summarised the monthly consumption of chlorine for several months during the trial period as well as when the ultrasound devices were withdrawn. One can clearly observe the significantly lower chlorine consumption during the period the ultrasonic devices were in operation. It is also expected that when the ultrasound systems are used continuously for long period, the usage of other chemicals could be reduced substantially.

Conclusion

Ultrasound systems have come a long way to establish themselves in controlling water quality. The savings come not only from the reduced cost of chemicals but also from the reduced manpower cost for cleaning and supervision.

Although ultrasonic systems do not promise to eliminate chemical consumption, a significant reduction is projected. Each application area is unique and the industry has to explore the benefits by conducting systematic trials in their water circuit, before any large scale switchover to ultrasonic systems, in water quality management.

With the growth of electronic industry, extremely sturdy systems are available, which have demonstrated MTTF of more than 10 years. In earlier efforts, failures were primarily due to the improper installation and poor quality of ultrasonic transducer systems.

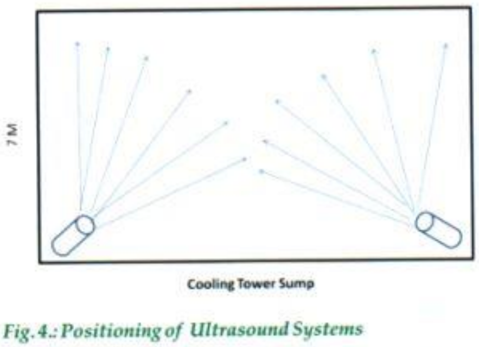
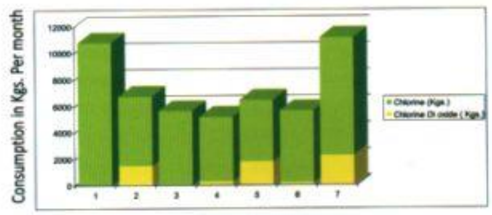


Fig.4.: Positioning of Ultrasound Systems

Consumption of Chlorine and Chlorine Dioxide in cooling Tower sump, during the trial period

The Ultrasonic devicesdevices were installed during the period From 17th. Nov. 2001 to 16th. February, 2010 (3 to 5 in the X axis)



1. Before Sept. 2009 (av. Consumption), 2. During September 2009 (before shutdown) 3. During 17th. Nov. to 16th. Dec. 2009, 4. During 17th. Dec. 2009 to 16th. Jan. 2010, 5. During 17th. Jan. 2010 to 16th. Feb. 2010, 6. During 17th. Feb. 2010 to 16th. March. 2010,(after Removal of the devices) 7. During 17th. March, 2010 to 16th. April 2010.

Fig.: 5: Chlorine consumption in Cooling Tower Sump.

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