performance of the filter system. For each individual plant, it is, therefore, necessary to make a specific evaluation of the waste water stream and the government standards which must be met. Then, we must institute plant operating changes and controls which will ensure consistency, within recommended limits, of the waste water feed to the GBK filter system.

The unit currently is being operated manually. Start-up data are incomplete at this time, but the following trends are clear: (A) surcharges for discharging the BOD to the city sewer have been reduced to a fraction of the former amount (from ca. $14,000 to $3,000 or less/month); (B) threat of fines for FOG discharge has been eliminated, as output from the filters falls within government standards; (C) oil recovered for resale has increased by 5000 lb/day over the old system (this oil has a current market price of 14.5 cents/lb); (D) the GBK unit performs as guaranteed when required operating conditions are fully met by the customer.

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Operating experience with biological cooling towers[1]

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One of our major water pollution problems concerns the purification of, and disposal of or the bottling up of, waste water from our edible oil processing plant in Edgewater, N.J., and our fatty acids distillation plant in Hammond, Ind. It was decided to investigate the use of a cooling tower as a means of developing an environment for biota growth so that aerobic bacteria would feed on the organic matter present. This preliminary work was done in 1966 on a 30 gpm prototype tower in Hammond and a 720 gpm tower (modified) in Edgewater. As a result of this test work, Lilie Hoffman cooling towers, with high fill to volume ratio and abnormally large water basins, were purchased for our Edgewater plant and Hammond plant. The towers were commissioned in September 1972. The tower systems are fitted with the necessary controls to maintain proper basin water temperature along with automatic feed systems for the nitrogen and phosphorous required for satisfactory biota growth. The Edgewater tower, with a capacity of 3700 gpm, has performed satisfactorily with regard to chemical oxygen demand values and odor problems. There have been a few minor mechanical problems. The Hammond tower, with a capacity of 380 gpm, has had mechanical problems which have precluded sufficient continuous operation to assess its performance completely.

INTRODUCTION

In the refining of fats and oils for use in edible and soap products, high vacuums are employed. These vacuums generally are obtained by the condensation of steam in barometric condensers. Part of the process also may require steaming of the product simultaneously, and steam and organic vapors may be generated by the presence of a vacuum and heat. Therefore, the condensing water not only is heated; it picks up organic matter carried out as vapor or steam distilled from the reaction vessel.

One of our major pollution problems concerned either the purification and disposal, or bottling up, of this waste water, and studies were begun several years ago to solve the problem.

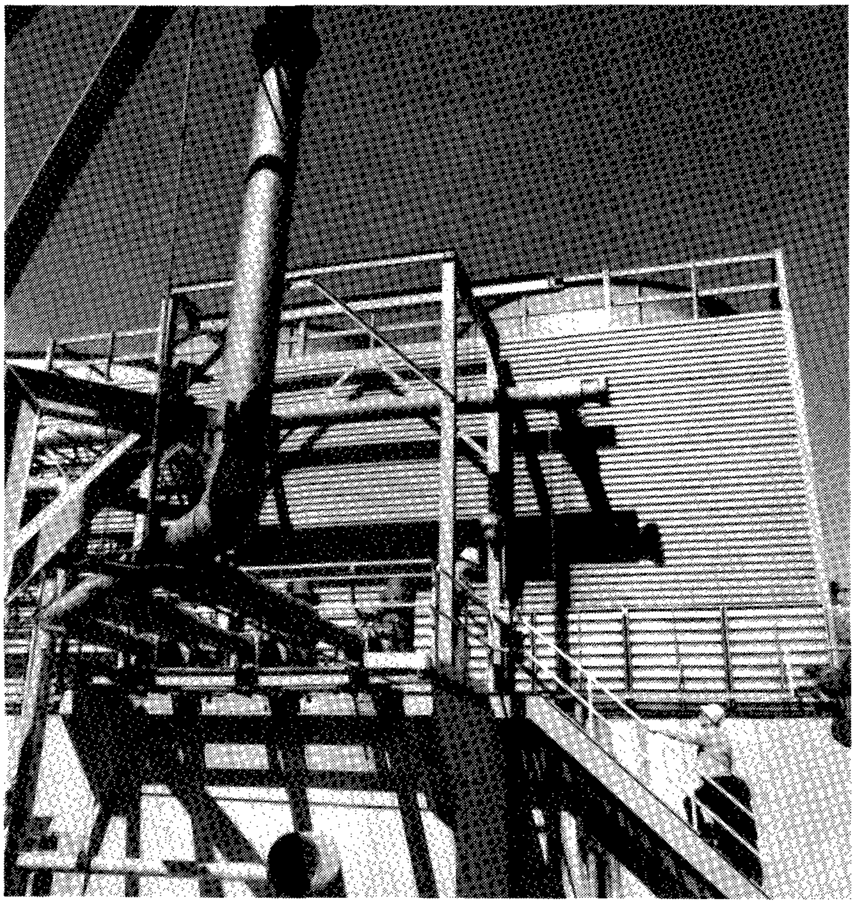

FIG. 1. Biological cooling tower shown under construction at Lever's Edgewater, N.J., plant. Piping in left foreground supplies water from cooling tower to edible process department.

[1]One of seven papers presented in the symposium, "Ecology–Practical Solutions to Environmental Problems as Practiced in the Fats and Oils Industry" at the AOCS Spring Meeting, Mexico City, Mexico, April 1974.

A study (1) was conducted on the successful pilot plant operations involving the deliberate biodegradation in closed system cooling towers. This study was based upon the marriage of the cooling tower which has long been used for heat dissipation with the trickling filter which has long been used as a device for the reduction and stabilization of organic matter in water. The pilot work was necessary to establish the criteria for developing the environment required for biota growth so that aerobic bacteria would feed on the organic matter present. This, of course, was contrary to normal cooling tower operation in which inhibitors are used to maintain minimum corrosion rates and where excessive growth of algae and slimes are controlled by chemical addition. Likewise, cooling towers operate with minimum concentration of suspended solids to protect against scale, whereas trickling filters generate suspended solids.

Work was started in 1966 on a 30 gpm prototype tower and continued on a modified existing 730 gpm tower. The results led to the installation of two full-sized installations.

EDGEWATER, N.J. PLANT

The first tower (Fig. 1) was installed in the edible processing department of our Edgewater, N.J., plant. The unit handles the barometric tail pipe water from the condensers of all the deodorizers, vacuum bleachers, vacuum driers, and emulsifier stills used to process soybean oil with lesser amounts of cottonseed, corn, safflower, palm, and coconut oils.

The tower, purchased from Lilie Hoffman, was designed to cool 3700 gpm water from 100-85 F at a wet bulb temperature of 78 F. The 3700 gpm is based upon concurrent operation of all units. However, this condition is not commonplace so that the average flow is in the range of 2500 gpm.

The tower has a high fill to volume ratio of 12:1 to permit maximum aeration of the water for the promotion of aerobic biota activity. The fill consists of rough redwood slats arranged on edge. We would have preferred polypropylene fill because of smoothness, but it was not available in the high fill to volume ratio required. A cross section through the tower and basin is shown in Figure 2.

The tower is set on a basin with a capacity of 75,000 gal. This is abnormally large to provide 30 min retention time, at the average flow rate, to assist in bacterial growth and provide settling space for the dead biota slime.

The tower has two 2-speed fans mounted on top which pull the air through multiple louvers running the full length of the tower. Except for the louvered openings and the two fan openings which are equipped with spray eliminators, the tower is enclosed completely. A Foxboro controller modulates the opening of the louvers and sequentially controls the operation of the fans to maintain the tower basin water temperature at 83 F, regardless of the outside weather conditions.

This system had one problem which was modified after startup. When only one fan was running, the downdraft through the second fan caused it to run in reverse. This caused undue strain on the fan motor windings when the controller called for it to start. A mechanical nonreversing stop installed on the fans corrected this problem.

Due to the nature of the processes, neutral oil refining, the organic matter picked up by the water is fairly high in insoluble suspended solids. To lower the load on the tower, the return water enters a skim basin which has a capacity of 20,000 gal or 8 min retention time at average flow conditions. Originally, the basin was skimmed manually on a periodic basis but an automatic skimmer has just been installed. This skim basin reduces the chemical oxygen demand (COD) in the return water to the tower and helps to keep down a sludge formation in the tower.

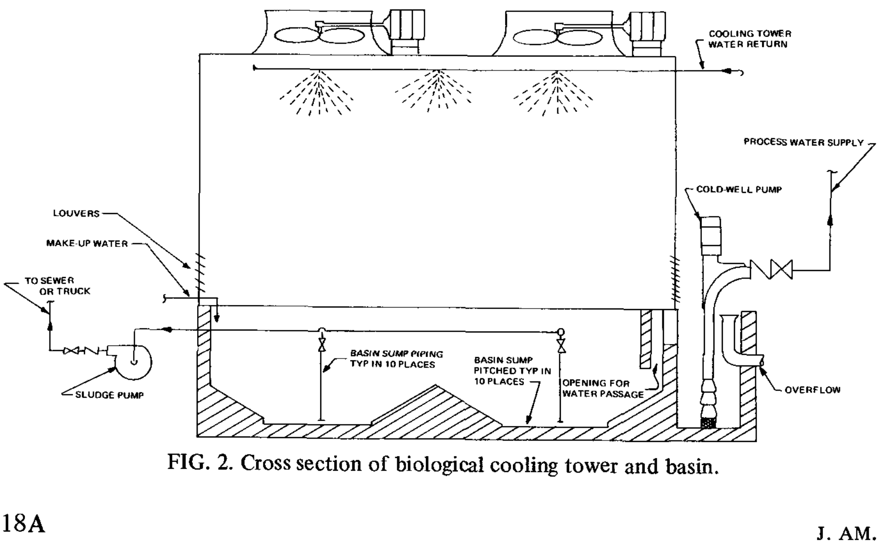

FIG. 2. Cross section of biological cooling tower and basin.

The installation of the cooling tower coincided with the installation of a large capacity semicontinuous deodorizer which is the largest single user of condensing water (ca. 1000 gpm). To reduce the organic load from this unit, an Elliot jet vactor was installed in the vacuum system of this unit. In addition to reducing the organic loading, the material collected in the jet vactor is rich in sterols and tocopherols which can be sold profitably.

The cooling tower system is complete with pH monitoring equipment, a caustic soda addition system for pH control, and feed systems for the phosphoric acid and ammonium hydroxide. The latter items supply the phosphorous and nitrogen necessary for maximum biota growth.

The cooling tower was started in September 1972 using a mixture of softened city water and steam condensate to minimize dissolved solids. All makeup is steam condensate for this reason. For the first few months, mechanical problems were the cause of several shutdowns. The single largest problem was several failures in fiberglass reinforced polyester (FRP) piping joints. Several joints came apart due to lack of fabricating experience on the part of local pipe fitters. FRP piping was used in the larger sized pipe lines because of its resistance to corrosion, lower cost, and better flow properties.

In spite of these problems, the tower had "gone biological" during this period, meaning that the airborne aerobic bacteria were feeding properly on the organic matter present.

Small swimming pool type chemical feed pumps were installed to dose the 75% phosphoric acid and 28% aqua ammonia. It was anticipated that these pumps would run continuously to maintain the required levels of phosphorous and nitrogen.

During actual operation, it was found that less labor was required if the chemicals were slug fed biweekly based upon laboratory analysis. This has resulted in average levels of 45 ppm for nitrogen and 79 ppm for phosphorous. These values are believed to be higher than necessary, and efforts are being made to reduce them.

The 50% caustic soda system likewise has been eliminated in favor of a slug feed system. Caustic soda consumption has averaged ca. 7 lb/day which is lower than had been expected. The target pH is 6.7-7.3, while the actual pH is running slightly below that, with an average value of 6.6. Steps are being taken to increase caustic usage so that pH falls within desired limits. Corrosion has not been a problem in any pilot or full-sized plant operation. The pH meter probes need careful attention because of the tendency to become coated.

It was anticipated that this tower would operate with little or no overflow and, in fact, would require some makeup. Originally, we had large quantities of overflow, but we found several previously unknown water sources. These we removed. We still have a small overflow to the sanitary sewer of an average of 5-10 gpm which we believe is due to a still undetected water source. Over the past year, the average COD has been 6000 ppm with a maximum of 14,960 and a minimum of 1681. The high readings usually occur in spikes leading us to suspect undetected spills coming from some yet unknown source.

The pilot plant work indicated the COD would be 3000-4000 ppm; so, the 6000 ppm does not seem excessive. The average biological oxygen demand is estimated to be ca. 1200 ppm.

It had been anticipated that a problem would develop with sludge buildup on this high 12:1 fill to ratio tower. This has not been a problem.

During the first several weeks of operation the sludge builds up in the form of "icicles" 4-6 in. long at which point the buildup stabilizes. Present plans call for the sludge buildup to be removed once a year. This was done during a scheduled two week shutdown in the summer of 1973, using only a hose and cold water with excellent results. At that time it was necessary to reinforce some of the fill support structure which was evidently inadequate to support the wt of sludge buildup. Sludge buildup was only detected in the lower portion of the fill.

The temperature control equipment is operating satisfactorily holding the basin temperature between 80-85 F. The only problem is that in subfreezing weather the tower spray freezes on the modulating dampers, causing them to become inoperative.

The tower normally operates Monday-Friday; the tower is shut down for 2 weeks during the summer. There have not been any problems on weekend shutdowns. Even during the coldest weather, the basin temperature only dropped ca. 5 F. Odor or carryover have not been problems.

We have had strong odors after the two week shutdown and after shutdowns of several days caused by breaks in the FRP piping. In each instance, a strong odor resembling hydrogen sulfide emanated from the exhaust fan during the first 1/2 hr of operation. This odor was evidently due to the sludge in the basin becoming anaerobic during shutdown. We were considering aeration of the basin to keep the sludge aerobic during these shutdowns but do not feel it is necessary.

The water in the system generally has a dense grey-white appearance without odor during normal operation. If the COD reaches a level of 10,000 ppm, the water begins to get a sour odor, but there is still no odor from the tower.

At present, the plant pumps a quantity of sludge out of the cooling tower basin to the sanitary sewer every 3 months. This is not required for any reason other than to reduce the sludge in the bottom of the basis sections. Original plans called for pump out once a year.

HAMMOND PLANT

The second tower was installed in the fatty acid distillation department of our Hammond, Ind., plant. This unit handles only the barometric condensing water from a coconut fatty acid vacuum distillation and fractionation plant.

This tower also purchased from Lilie Hoffman, was designed to cool 380 gpm from 102-85 F at a wet bulb temperature of 75 F. As in the case of the Edgewater tower, it has a basin large enough to provide 30 min retention time.

The control system for basin water temperature is the same as Edgewater, except that this tower has only one 2 speed fan.

The system is complete with pH monitoring equipment and chemical feed addition system for caustic soda, phosphoric acid, and ammonia.

The vacuum system from the fractionating column includes a Croll-Reynolds scrub-vactor to reduce the organic carryover to the condensing water. Previous work indicated that this was absolutely essential to reduce the organic load low enough to be handled successfully.

This tower was commissioned in late 1972. Since that time, a series of mechanical and other problems have precluded continuous operation. Only within the last 3 months have we achieved anything close to design expectations.

During one period of problems, there was some odor discernible within a radius of ca. 20 ft from the tower. This was identified as water droplets containing soluble short chain caproic and caprylic acid which were being entrained in the air exhausted from the tower. This odor coincided with a time when COD levels were ca. 20,000 ppm, which, in turn, were attributed to a faulty pH amplifer. Subsequent to this, additional mist eliminators were added to the tower, while the faulty pH amplifiers were replaced. The result has been a reduction of COD and elimination of odor. Since the improvement resulted from two simultaneous changes, it is difficult to "finger" which one solved the odor problem.

The organic contaminant in this tower water is essentially low mol wt fatty acid which is relatively soluble; consequently, we do not require or have a skim basin. The fatty acid, however, makes pH control more critical, since an overfeed of caustic can, and has, caused saponification, resulting in solids and foaming.

As might be expected with fatty acids, relatively more caustic is required to maintain pH than in the Edgewater tower. Typical chemical usages are: 28% aqua ammonia, 20-30 lb/day; 75% phosphoric acid, 3-5 lb/day; and 50% caustic soda, 150 lb/day.

Experience so far indicates that this tower will operate without any blowdown and with very little makeup, as was our experience with the pilot plant.

There is insufficient operational time to establish a COD or to comment on sludge buildup on fill or in the basin, although neither appear to be a problem.

This tower normally operates 7 days a week, thus weekend odor is not a concern. However, on one breakdown, the basin was left for 4-5 weeks. At the end of that period, there was no odor.

The application of a biological cooling tower is a viable solution to removal of certain organic contaminants in water used in a recirculation system. While there still may be some operational problems, the basic idea has been proven to be satisfactory.

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