Enabling the Performance of the MBBR Installed to Treat Meat Processing Wastewater

***Miroslav Colic[1], Wade Morse[1], Ariel Lechter[1], Jason Hicks[1], Steve Holley[1], Carl Mattia[2]**

[1]Clean Water Technology, Inc. (CWT); 151 W 135th Street, Los Angeles, CA 90061
[2]EEC USA
[*]To whom correspondence should be addressed: Email: mcolic@cleanwatertech.com

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ABSTRACT

West Liberty Foods (WLF) meat processing plant in Mount Pleasant, Iowa was discharging wastewater into a local creek. New regulations required that suspended solids (TSS), BOD's and FOG's (fats oil and grease) are removed almost completely before a discharge. The MBBR system was installed to achieve these goals. However, increase in plant capacity and amount of contaminants in wastewater resulted in complete failure of the installed system. To enable the performance of the MBBR, the GEM flotation – pretreatment System was installed ahead of the bioreactor. The System reduced TSS, FOG and BOD to the levels that MBBR could handle. The System also introduced capabilities to robustly neutralize the pH, eliminate antimicrobial agents and reduce amount of foam forming substances. Large equalizations tanks were built to average out fluctuations in wastewater contaminants. The installed System performs well, saving WLF large amounts in discharge fees and fines.

KEYWORDS

Meat processing wastewater, MBBR, primary treatment, hybrid centrifugal – dissolved air flotation system

INTRODUCTION

Food manufacturing inevitably results in the generation of large volumes of mostly biodegradable, nontoxic liquid and solid waste. Industrial wastewater streams have to be pretreated prior to discharge to municipal treatment plant or fully treated ahead of discharge to streams, rivers, lakes and oceans. Meat processing and packaging facilities produce wastewater from different sources. Cleaning in place (CIP) produces particularly challenging to treat waste streams. Such streams are loaded with detergents, stable oil in water emulsions and biocides. This presents several technical – economic problems related to wastewater treatment. Large seasonal and hourly variations in concentration and type of contaminants, hourly and daily total flow, pH and amount of chemicals needed to treat waste streams further complicate the situation. The available space for the wastewater treatment plant is also often very limited. Food processing wastewater produces large volume of sludge, often with low solids loading. The cost of coagulants and flocculants needed for primary treatment is also very high due to ever increasing prices of oil. Finally, installed treatment systems have to be sustainable since most plants are increasing (or decreasing) the production capacity due to market pressures.

WLF, an Iowa based farmer owned cooperative opened in 2003 a new meat processing and packing facility in Mount Pleasant, Iowa. WLF facility started at 55,000 square feet with 12 meat slicing rooms. Even then, the increase in production capacity was planned (another 25,000 square feet) and addition of 8 new slicing rooms. The facility specializes in pre-sliced, deli trays and specialty products (whole turkey, bone in breasts, deli breasts, boneless turkey, cooked/smoked turkeys). Among other customers, WLF produces over a million pounds of turkey products per week for SUBWAY's stores. Various sandwich set-ups for Wal-Mart, including meat and cheese, sliced turkey and Turkey and Ham for Denny's chains are also among company products.

Before the WLF plant expansion, our company (CWT) performed laboratory and pilot experiment with the produced wastewater. The long term waste stream analysis identified dissolved BOD's as main contaminant in the WLF wastewater. Only small amount of TSS (less than 400 mg/l, and FOG's (less than 60 mg/l average) were identified. Based on our experience and available literature, it was decided that the best solution to treat such waste stream would be biodegradation. Since water is to be discharged into a stream (BOD and TSS as low as possible required) aerobic treatment was selected. Finally, recent experiences (Joslin and Farrar, 2005, Mattia 2001) showed that moving bed biofilm reactors (MBBR) are particularly efficient in treatment of slaughterhouse and meat processing wastewater. As a first step, the EEC USA MBBR System was installed at the WLF Mount Pleasant plant. The System will be described in more details in following paragraph.

The Installation and Performance of the EEC USA MBBR System

Prior to plant expansion, the total daily wastewater flow at WLF rarely exceeded 70,000 gallons per day (GPD). Average BOD's of 1,600 mg/l and TSS of 162 mg/l were measured. TSS and FOG rarely exceeded 950 and 250 mg/, respectively. Plant did not have any treatment facilities.

As already described above, the analysis of waste streams and treatment effluent requirements identified aerobic bioreactors as the best solution for the job. Activated sludge and sequence batch reactors were developed for the treatment of municipal wastewater treatment, where concentration of contaminants is low and almost constant. Biofilm bioreactor processes are increasingly being favored for food processing wastewater treatment. There are several reasons for that: smaller footprint, less sludge produced, no return activated sludge needed, biosolids that are easier to separate are produced, and attached biomass is more specialized (higher concentration of relevant organisms) at a given point of the process train.

Moving bed biofilm reactors (MBBR) are a hybrid of activated sludge and biofilter processes (Odegaard, 2004). Contrary to most fixed film bioreactors, MBBR utilize whole tank volume for biomass. However, contrary to activated sludge reactor, MBBR does not need return activated sludge (RAS). This is achieved by having a biomass grow on plastic high surface area carriers that move freely in the water volume of the reactor kept within the reactor volume by a sieve arrangement at the reactor outlet. At the bottom of the tank, large bubble aeration system assures mixing and floating of plastic carriers with attached biomass.

The biofilm carrier is made of high density polyethylene (0.95 g/cm3) and shaped as small cylinders with a cross on the inside of the cylinder and “fins” on the outside. The original cylinders have a length of 7 mm and diameter of 10 mm. Later, various shapes and sizes were introduced by numerous manufacturers. One of the important advantages of the moving bed biofilm reactor is that the filling fraction of carrier in the reactor may be subject to needs. That means that by increasing the filling fraction one can increase surface area and capacity of the reactor to reduce BOD’s without additional tanks. Microorganisms growing on such media are also much more resistant to pH and toxic shock as well as fluctuations in BOD’s. Produced biosolids are also easy to separate and dewater.

Specific MBBR design criteria of the WLF treatment facility are shown in Table 1. Influent from a 20,000 gallon equalization tank is fed to MBBR reactor 1 (see Figure 1) and then to MBBR reactor 2. The container of the EEC MBBR system includes a clarifier to separate produced biosolids. Settled solids are periodically pumped to a sludge tank for further thickening. EEC MBBR Systems are compact, container based treatment plants for easy transportation and installation. A mild steel tank is coated with epoxy to prevent corrosion. The MBBR is filled with the proprietary “AMB Bio Media”. The AMB bio medium provides an effective surface area of 500 m^2 per m^3 bulk media.

Table 1. MBBR Design Specifications

Design Average Flow (gal/day)	75,000
Design influent BOD (average, mg/l)	1,200
Design influent TSS (average, mg/l)	400
Design average FOG (mg/l)	60
Design maximum temperature (^oF)	95
Number of tanks	2
Tank length (feet)	39
Tank width (feet)	7.5
Tank height (feet)	8.2
Water depth (feet)	6
Reactor Empty Bed Volume(ft^3)	2,400
Bulk volumetric filling of carriers%	50
Hydraulic Retention Time at Design Flows (Hours)	8

Specific biofilm surface area (ft^2/ft^3)	75
Design Soluble BOD Load (lb/day)	750
Design Surface Area (ft^2)	187,500
Loading Rate (lb/1,000ft^2/d)	4.1

During first four weeks of operation biofilm growth occurred and BOD reductions improved every week. After six weeks it was possible to reduce BOD to 200 mg/l. However, after the second month of operation several severe problems occurred. This resulted in loss of biofilm and MBBR performance.

The analysis of wastewater and changes in operation parameters and load/volume increase identified following problems that had to be dealt with to enable the performance of MBBR system installed:

1) The installed system to neutralize pH was not adequate. This resulted in very high values of pH during CIP hours (pH >12). It is well known that microorganisms cannot survive at such high pH.
2) WLF based on USDA regulations introduced very potent antimicrobial cleaning reagents such as chlorine, peracetic acid and primary and quaternary cationic surfactants.
3) Wastewater fluctuations in concentrations of BOD were very high.
4) Increase in production volume resulted in 400% increase in TSS and FOG in wastewater.
5) Total daily flow increased 50%.
6) Surfactants in wastewater along with MBBR aeration system caused significant foaming problem.
7) Large particles and objects occasionally interfered with the MBBR sieves used to retain media in the tank.

To address these issues an advanced pretreatment system was designed and tested in pilot studies. Upon successful pilot tests the full scale system was installed. In short period of time the above described problems were dealt with. Since then, system performed better than predicted by initial design, with residual TSS and BOD usually below 20 mg/l respectively.

The following paragraphs will describe the installed system in more details.

THE ADVANCED MBBR PRETREATMENT SYSTEM AT WLF FACILITIES

To address the above mentioned problems observed during operation of the MBBR installed at the WLF facilities, following pretreatment system was designed. First, to remove large objects and particles that interfere with the performance of the MBBR System self cleaning rotary drum screen was installed (20 mesh grid).

To address fluctuations in wastewater contaminants concentration, additional equalization tanks (EQ) are installed. Existing 20,000 gallons EQ tank was supplemented with two 25,000 gallons EQ tanks. Pumps were installed to mix water inside the tanks and circulate water between different tanks to assure uniform contaminant distribution.

More robust pH adjustment, removal of FOG and TSS and removal of antimicrobial agents were achieved in the GEM System. The GEM System is a novel hybrid centrifugal hydrocylone – dissolved air flotation. As a part of the System, *in situ* mixing of various chemicals can be achieved inside the same hydrocylone columns and top heads that are used for solid – liquid separation and bubble formation. Adjusting the pH around 7, removing chlorine and peracetic acid with sodium thiosulfate reduction (redox sensor controlled) and removing TSS and FOG below 30 and 10 mg/l respectively also resulted in BOD reductions between 40 and 65%. In short, these changes enabled the total System to perform better than originally designed with BOD and TSS of final effluent being below 20 mg/l, respectively. Occasional foaming had also to be dealt with (see Figure 2). Antifoaming agents were added and mixed into water with the GEM System.

Figure 1. The picture of EEC MBBR System.

Figure 2. Top of the MBBR tank indicating foaming problem.
The Description of the GEM based Pretreatment System

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GEM

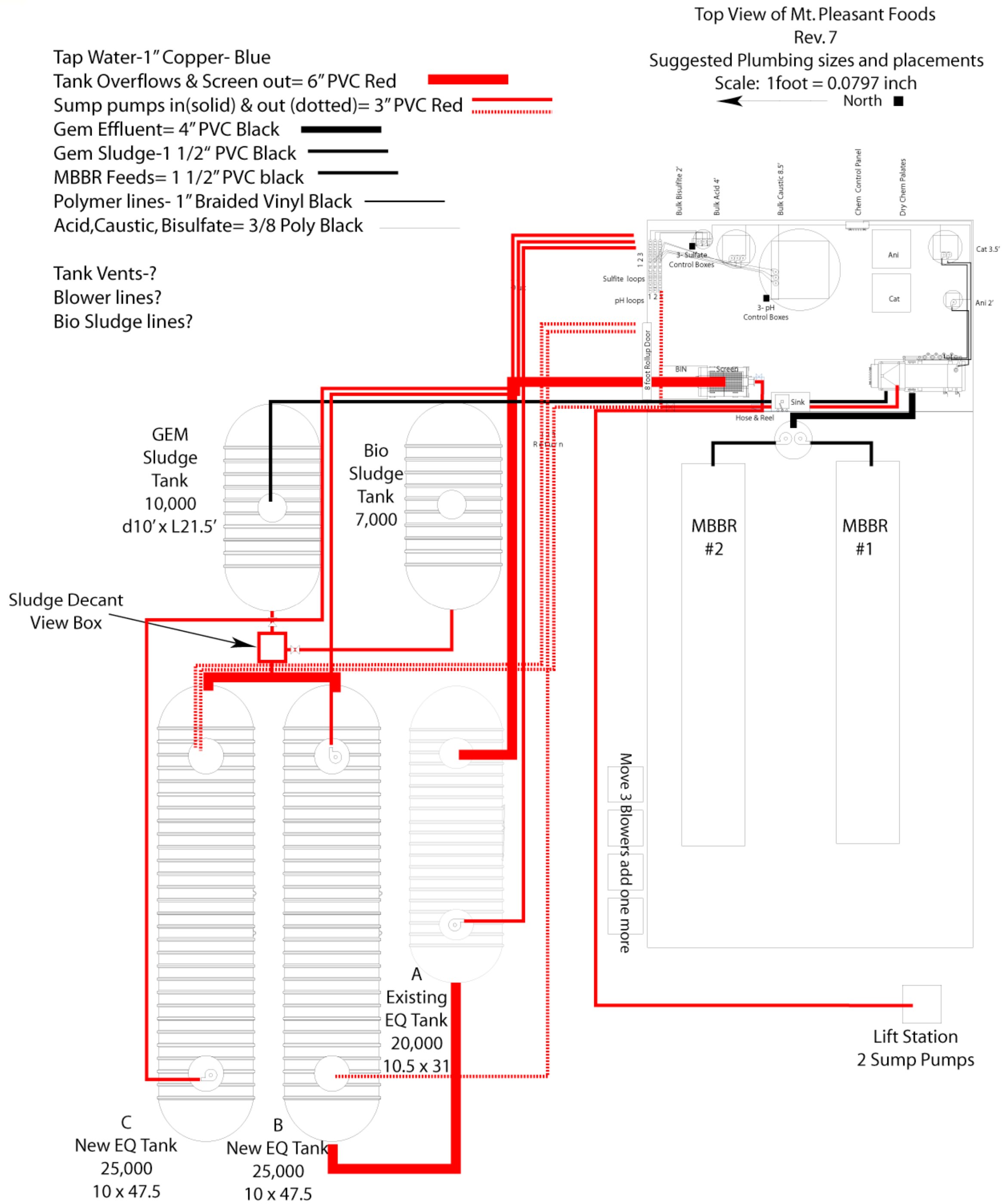

Figure 3. Schematic Presentation of the System Installed to Treat WLF wastewater.

Introduction to Flotation Systems

The GEM System is basically a hybrid centrifugal hydrocylone – dissolved air flotation. Flotation is a gravimetrically based solid-liquid separation technology. Most fats, oil and grease and light particles present in food manufacturing wastewater have low density and cannot be separated by sedimentation.

One of the key steps in the flotation method is the introduction of air bubbles into water. In early flotation machines coarse bubbles (2 to 5 mm) were introduced into the contaminated wastewater by blowing air through canvas or other porous material. Air can also be introduced with impeller mixers as in Induced Air Flotation Systems. Another flotation method called dissolved air flotation (DAF) is common in the treatment of oily wastewater (Kiuri, 2001). In DAF, a stream of wastewater is saturated with air at elevated pressures up to 5 atm (40-70 psi). Bubbles are formed by a reduction in pressure as the pre-saturated water is forced to flow through needle valves or specific orifices. Small bubbles are formed and continuously flowing particles are brought into contact with bubbles (Ross et al., 2003). Such bubbles rise very slowly to the surface of the tank. This is the main driver of the large dimensions of the DAF tanks.

To avoid clogging of such orifices only a fraction of already pretreated water is aerated and then recycled into the tank where bubbles nucleate under already preformed flocs. Therefore, the number of bubbles is limited and treatment of high strength food manufacturing wastewater with high TSS and FOG loads is often inefficient.

To answer these problems, centrifugal (Miller, 1981), jet and cavitation flotation (Clayton et al., 1991) systems have been developed. In these systems centrifugal forces have been used to produce smaller bubbles and enhance mixing of particles with treatment chemicals such as coagulants and flocculants. Centrifugal flotation systems are based on liquid/liquid hydrocylone technology. Contact of air, contaminants and treatment chemicals occurs inside the hydrocylone column under the influence of centrifugal forces. Solid-liquid separation occurs inside the column. This results in much faster response flotation units with smaller footprint. Flotation tanks are used only for sludge skimming. However, larger bubbles cannot remove small particles and dissolved air flotation still produces better contaminant removal efficiencies. To answer that problem, we developed the hybrid centrifugal – dissolved air flotation system, which we termed the GEM (gas – energy mixing) System. This system will be described below.

The Description of the GEM System

We proposed that a more efficient flotation system could be developed by combining high-energy centrifugal mixing of a liquid cyclone system (we termed it the liquid cyclone particle positioner, LCPP) with dissolved air as a source of flotation bubbles (Morse et al., 2001; Morse et al, 2004). Coagulants and flocculants can be delivered *in situ* directly into the flotation hydrocyclone unit. Pressurized air can be delivered to

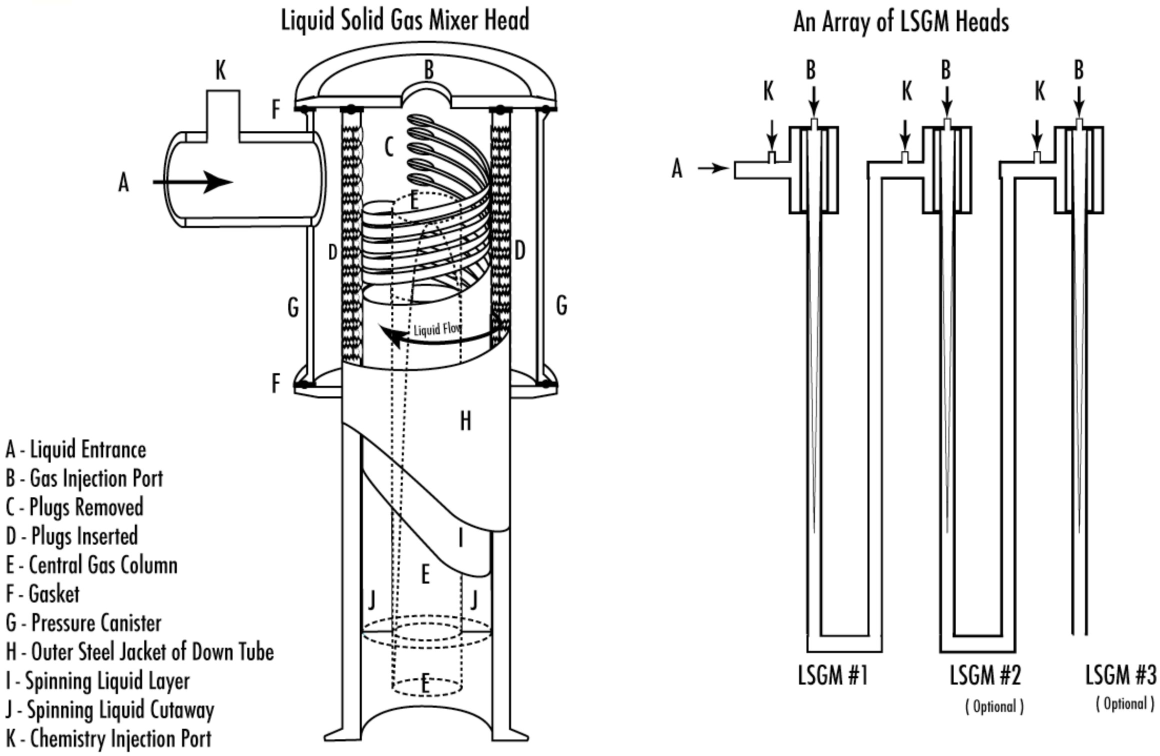

Figure 4. Schematic Presentation of the LCPP/LSGM.

LCPP heads at the same time as flocculants. Such a procedure results in flocs, which are very porous and loaded with entrained and entrapped air.

As shown in Figure 4 the LCPP also acts as a liquid-solid-gas mixer (LSGM). Replacing the classical hydrocyclone head with the LCPP provides extremely energetic mixing by sequentially transporting liquid and entrained particles and gas bubbles throughout a centrifugally rotating liquid layer. Microturbulence in such vortices results in all particles and bubbles down to colloidal and molecular size acting as little mixers. Axial and radial forces inside the LCPP help mix coagulants and flocculants with the particles. Uncoiling of polymer and better mixing of ultrahigh-molecular-weight polymers (and more concentrated emulsions) is achieved in the LCPP. Such efficient mixing is important for proper flocculation of suspended particles. Centrifugal mixing also results in less floc breakage than with commonly used impeller or floc tube mixers.

Further modification of LCPP heads, as opposed to hydrocyclone heads, introduced multiple holes with plugs inside the LSGM heads, as shown in Figure 5. By changing the number of plugs, we can modify the mixing energy and head pressure from very low to very high. In this way, we can mix low-molecular-weight coagulant at relatively high energy and high-molecular-weight flocculants at relatively medium and low mixing energy to promote final large floc formation.

Hybrid centrifugal – dissolved air flotation technology (The GEM System developed at CWT [see Figure 6]) provides the best of both centrifugal and dissolved air systems: efficient continuous flow mixing and in line flocculation with the nucleation and entrainment of fine dissolved air bubbles. This development has resulted in systems with very efficient removal of particulate contaminants, a small footprint, drier sludge, durable long lasting flocs, fast response

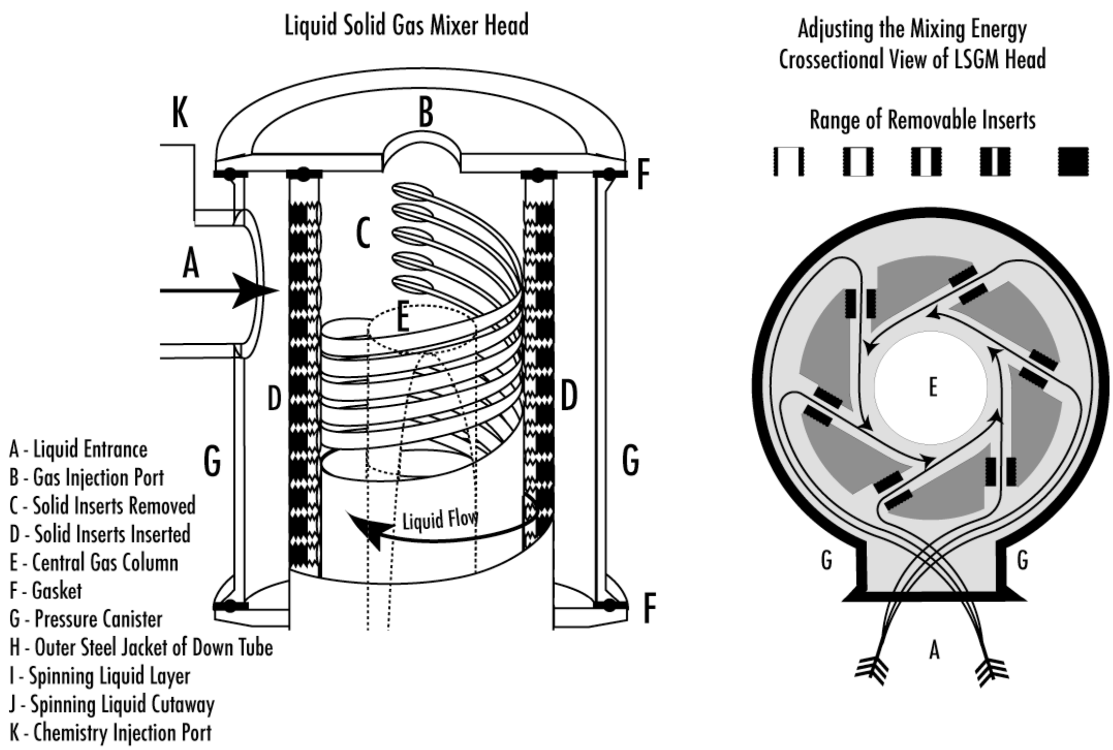

Figure 5. Schematic Presentation of the LSGM Heads.

and treatment of the total wastewater stream (no recycling characteristic for DAFs). The design of on-line turbidity or fluorescence driven sensors for automatic control of coagulant and flocculant dosage is also underway. Computational fluid dynamics (CFD) has been used to design better flotation tanks with a vortical flow pattern that results in the formation of a dense air bed inside the tank (Ta et al, 2001; Desam et al., 2001). Such fine bubble layers prevent sedimentation of already floated heavier particulates, which results in significantly higher flotation rates.

SYNERGISM OF CHEMICAL AND MECHANICAL ASPECTS OF THE SOLID/LIQUID SEPARATION SYSTEMS

Solid/liquid separation processes are only as efficient as the weakest “link in a chain”. New generation of high performance flotation units can only deliver if appropriate chemicals are used to coagulate and flocculate particles and emulsions in wastewater.

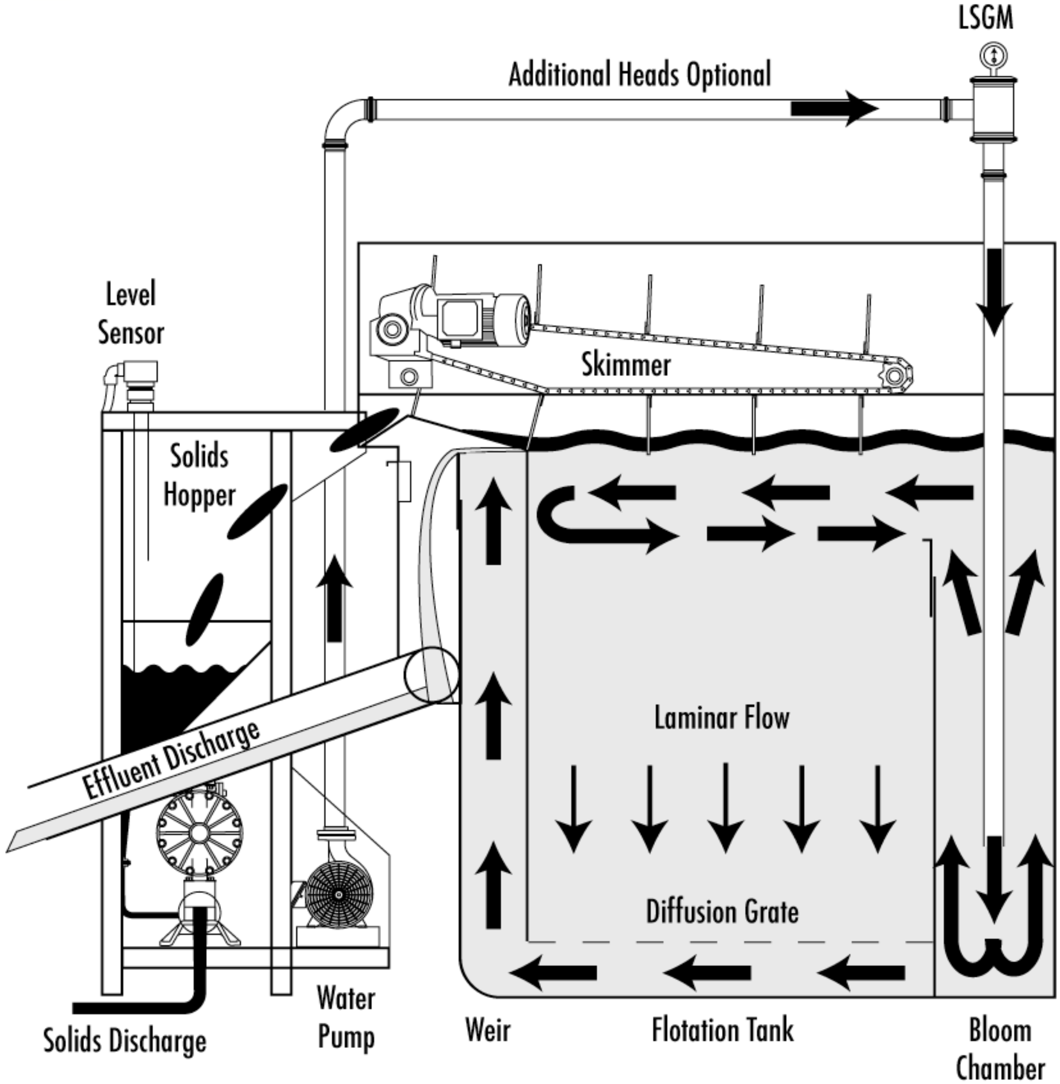

Figure 6. Schematic Presentation of the Hybrid Centrifugal – Dissolved Air Flotation System.

Coagulation, flocculation and flotation are among the most effective approaches to remove fats oils and grease, suspended solids and colloidal materials (even some proteins and macromolecules) from any industrial wastewater, such as for instance food processing. Solids, colloids and macromolecules present in food processing wastewater are generally charged. Charge stabilization often produces very stable colloidal suspensions. Solids and colloids that are charge stabilized repel each other and produce systems that have a tendency to “swim” within the wastewater bulk, rather than sediment or float. Surface charge has to be neutralized in order to get particles close together so that other attractive forces such as hydrophobic or van der Waals forces result in formation of larger aggregates that either sediment or attach to bubbles and float. Most colloids, macromolecules and solids in food processing wastewater are of organic nature. Ionization of carboxyl and amino groups from fatty acids or proteins produces some charge. Oil and grease particles are often emulsified and charge is present in the surfactants used as emulsifying agents. Many neutral colloids will preferentially adsorb hydroxyl ions and become negatively charged.

Most colloids present in any food processing wastewater are negatively charged, probably due to preferential adsorption of hydroxyl ions and widespread surface availability of carboxyl groups. The surface charge/dissociation of such groups is pH dependent. It is possible to find a pH at which total surface charge is zero (point of zero charge). At such pH colloids are quite unstable. However, coagulants and flocculants are designed so as to promote even faster, more efficient destabilization of colloids with growth of large, stable aggregates. The pH, therefore, should be adjusted close to the point of zero charge, in order to save on dosage of coagulants and flocculants needed to neutralize the surface charge. If surface charge is fully neutralized, the performance of flocculants is low.

Once the pH is adjusted, coagulation and flocculation process follow. Coagulation is addition of oppositely charged ions or molecules in order to neutralize surface charge and destabilize colloidal suspensions. Inorganic coagulants such as sulfate or chloride salts of trivalent iron (Fe[III]) or aluminum (Al[III]) have been quite popular in food processing wastewater treatment. However, such salts hydrolyze as part of coagulation process and produce oxohydroxyde sludge that is bulky and difficult to dewater. Prehydrolyzed –inorganic polymeric aluminum reagents such as polyaluminum chloride (PAC) or aluminum chlorohydrate (ACH) are more efficient in charge neutralization. Such salts also produce less bulky sludge. Cationic polyelectrolytes (organic low molecular weight polymers) such as quaternary polyamines produce less sludge that is easier to dewater. Such reagents are also much more efficient in charge neutralization. Therefore, the dosages needed to neutralize surface charge with polyelectrolytes are often more than order of magnitude lower compared to dosages of aluminum or iron salts. However, ferric salts have to be used if blood clarification is to be achieved. Precipitation of phosphate or sulfide ions also can be achieved only with inorganic ions. Finally some proteins can be removed with proper pH adjustment and use of inorganic coagulants.

Flocculation is a process of formation of large stable flocs that either sediment or float. Flocculants are reagents that achieve flocculation. Flocculants are large polymeric molecules that bind together smaller flocs produced by coagulation. Synthetic high molecular weight polyacrylamides are the most commonly used flocculants. Cationic polyacrylamides can neutralize residual negative surface charge and also bind smaller flocs together. Flocs may also be overcharged with coagulants and cationic flocculants, with subsequent use of anionic polyacrylamide. Such approach, termed dual flocculants approach, will be described in detail later in this manuscript (also see Figure 7).

Several steps are involved in the coagulation and flocculation processes. First, coagulants are added to the wastewater with the precise dosing pumps. Then coagulants are mixed with the particles in the high energy mixing process in order to uniformly distribute adsorbed coagulant molecules or ions. Upon initial charge neutralization, flocculants are added. Even more precise dosing is needed in order to avoid under or overcharging of particles. Flocculants are mixed with less energy in order to avoid breakup of formed flocs or even polymer molecules, which are large delicate chains. On the other hand, enough mixing intensity is needed to achieve uniform distribution of polymer and adsorption on all particles, rather than over - absorption on nearby particles only (Carissimi and Rubio, 2005). Mixing is also needed to activate polymeric flocculants. Such giant molecules are coiled into the tight coils. Linearization is needed to achieve polymer configuration that can bind numerous smaller flocs together (see Figure 8).

Wastewater samples tested while developing the system described in the manuscript were coagulated and flocculated at numerous pHs ranging from 3 to 11. For most samples, best flocculation can be achieved at pH between 5 and 6. Removal of fine emulsions and proteins is also most efficient in this pH range. Some wastewater samples had a very small amount of TSS and colloidal materials. For such samples, the pH was adjusted between 7 and 9. Similar approach was used for samples with colloidal materials that are almost neutral. Increasing pH above 8 results in higher surface charge and stronger adsorption of flocculants. At pHs below 5, performance of flocculants was found to be sub optimal with smaller, weaker flocs and more carryover in laboratory flotation tests. At pHs above 9, consumption of coagulants and flocculants was very high.

Numerous inorganic, organic and blend coagulants were tested with food processing wastewater. Ferric (FeIII) and aluminum(III) sulfate require the highest dosages and produce sludge with the lowest % solids that is most difficult to dewater and dry. As wastewater becomes loaded with TSS and FOGs, the necessary dosages to achieve coagulation can be as high as 6,000 mg/l. These two coagulants also interfere with the performance of flocculants, producing “pinpoint” floc with very small particles and high amount of carryover (often over 200 mg/l) in laboratory flotation tests. However, if water is rich in blood proteins, small amount of ferric coagulant (10-60 ppm) is needed to clarify wastewater and reduce foaming problems.

Prepolymerized inorganic coagulants suffer from similar deficiency, namely large dosages needed, carryover after flotation produced, and sludge with low % solids produced. Needless to say, dosages are lower than that of monomeric ferric or aluminum ions based coagulants. The most popular reagents from this group are polyaluminum chlorides, (PAC) with various basicity
and aluminum chlorohydrate (ACH). Also, inorganic coagulants produce sludge with tendency to sediment, rather than to float.

Organic polyelectrolyte coagulants are the most advanced new generation of coagulant reagents. Usually, those are small cationic polymers with 100% backbone charge. Polyethyeleneimines were the first reagents used for such purpose. Modern quaternary polyamines, epiamine, and polydyallyldymethyl chlorides (polyDADMAC’s) are most often used in wastewater treatment applications. Such reagents do not interfere significantly with the performance of flocculants. They also produce sludge with high solid % and dosages needed to coagulate the wastewater can be an order of magnitude lower than that of inorganic reagents. Total cost of wastewater treatment is actually lower when using such reagents rather than inorganic coagulants. Low molecular weight epiamines and quaternary polyamines (10,000 – 25,000 D) coagulated food processing wastewater with the lowest dosages and least interference with the performance of flocculants downstream. Higher molecular weight and crosslinked polyamines (weight over 50,000 D) interfered with the performance of flocculants, and surprisingly were less efficient in coagulating wastewater colloidal contaminants. If combination of ferric and polyamine coagulants are needed, it is often better to add them separately then as a blend. Blend coagulants contain fixed ratio of ferric to polyamine coagulants. However, when treating changing wastewater influents, the ratio of amount of ferric and polyamine ions can vary quite significantly. From economic standpoint, blend coagulants are also very expensive.

Flocculants are the key component of any successful flotation wastewater treatment. We tested granular, emulsion, direct dispersion and brine flocculants. Flocculants with molecular weight between 1,000,000 D and 70,000,000 D were tested. Flocculants with charge (mole%) between 2 and 100% were tested and the effects of ionic strength (salinity, temperature, pH and surfactant present were studied). In all cases studied, granular high molecular weight, high charge polyacrylamides performed best. Such reagents yielded best flocs, sludge with the highest % solids, and least amount of TSS in the effluent. Dual flocculant approach in which addition of cationic flocculant is followed by addition of anionic flocculant always yielded the best performance (Fan et al., 2000). Emulsion flocculants produced smaller flocs, sludge with less solids and more TSS in the effluent. The higher the % active polymer in the emulsion, the better the performance. The same applies for brine and direct dispersion flocculants. Granular high charge (50% or more), high molecular weight (5,000,000 D or higher), cationic polyacrylamides were always the cheapest solution, with the best performance, and lowest dosage needed for efficient flocculation. At high temperature (over 40^o Celsius) or high salinity (over 10, 000 micromhos/cm) cationic flocculants could not flocculate colloidal components anymore. Cationic polayamine coagulants were then used to overcharge colloids with the subsequent addition of granular or emulsion ultrahigh molecular weight polyacrylamides. Medium charge mole % (20-30%) or very high charge % flocculants (100%) were needed to achieve flocculation at high salinity.

DUAL POLYMER FLOCCULATION

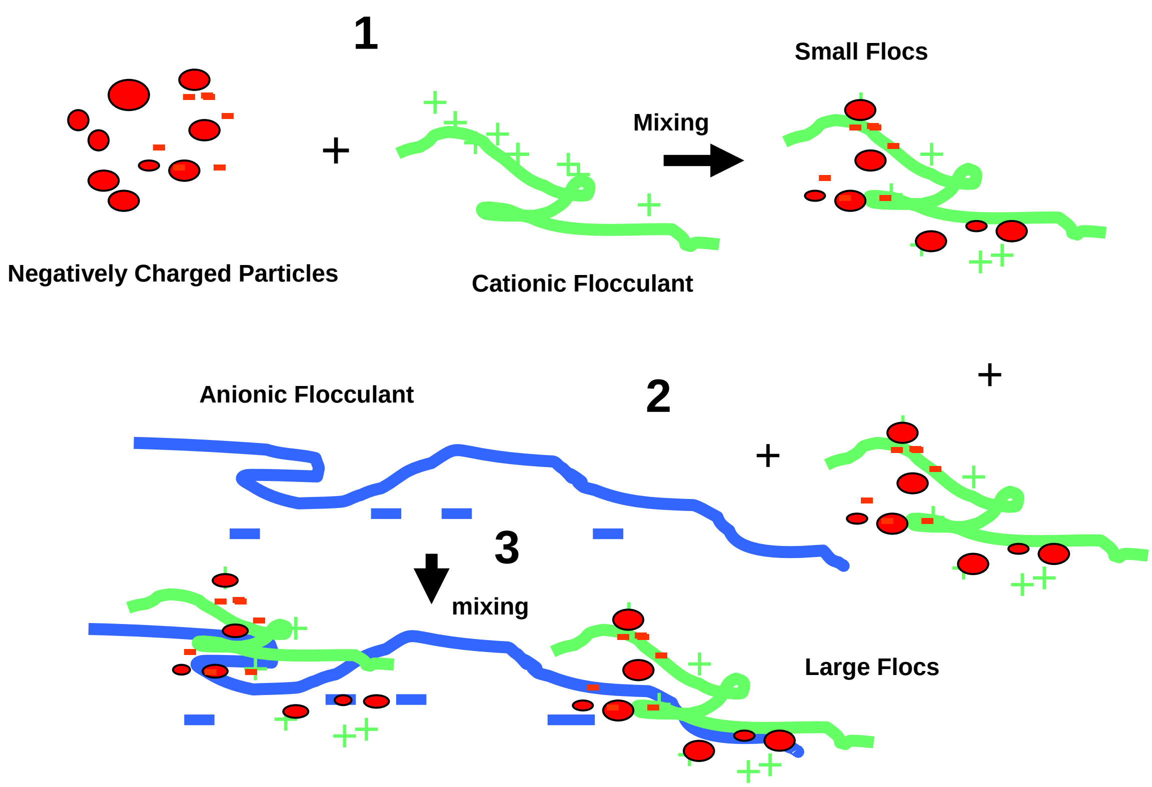

Figure 7. Dual polymeric flocculant approach.

UNCOILING (ACTIVATION) OF POLYMERIC FLOCCULANTS

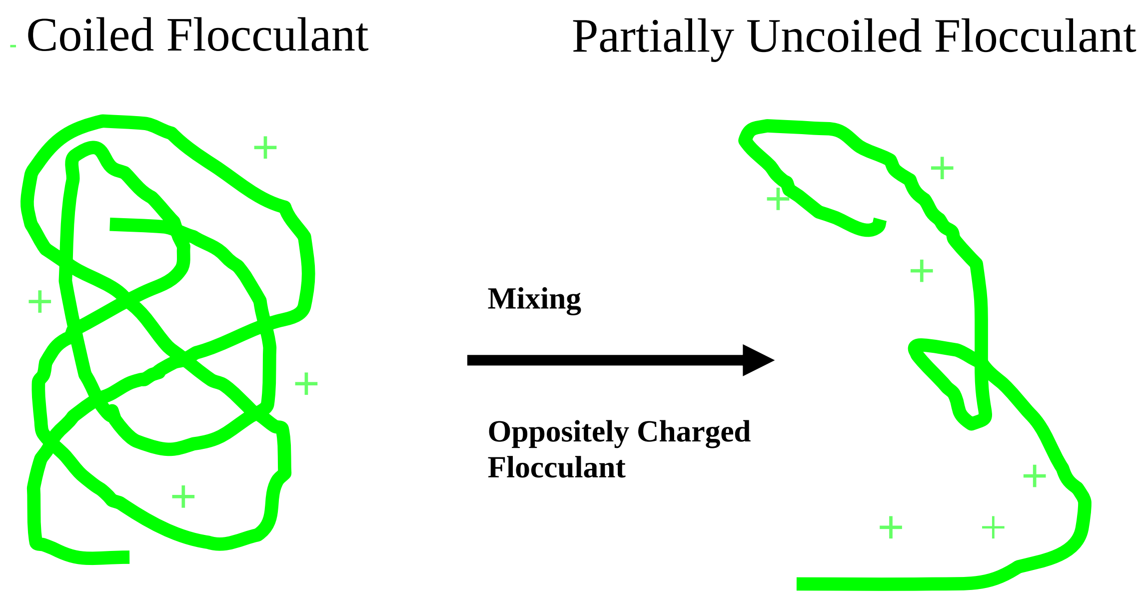

Figure 8. Uncoiling of high molecular weight polymeric flocculant molecules.

THE PERFORMANCE OF THE GEM-MBBR SYSTEM

Table 2. The wastewater treatment plant parameters before the installations (what the MBBR system was designed for) and after actual MBBR and subsequent GEM. installations

	Before MBBR installation	After MBBR and GEM installation
Flow:	50 GPM	75 GPM
Average TSS/mg/l	200	900
Average FOG/mg/l	150	650
Average BOD/mg/l	1,500	6,200

Table 3. The performance of the GEM and MBBR system (average numbers for 30 days period- August 2007).

	Before GEM	After GEM	After MBBR and clarifier
TSS/mg/l	950	45	20
FOG/mg/l	650	12	1
BOD/mg/l	6,000	1,100	18

Table 2 summarizes the operational parameters of the system installed to treat WLF wastewater stream before and after the upgrade with the GEM based pretreatment. Table 3 shows system performance for an average of 30 consecutive days. Occasionally, foaming that cannot be addressed with antifoaming reagents occurs. On such days less oxygen is delivered to the system with the blowers. Also, when wastewater with large amount of dissolved organic contaminants (BOD) appears, residual BOD's can be as high as 1,500 mg/l. Fortunately, this rarely happens. In Winter season, the GEM system performance is sometimes lower. This happens due to reluctance of plant operators to adjust flocculant dosage at night. In the future, TSS sensor based automatic flocculant dosage control system will be installed. Finally, while it is not a topic of this presentation, a proprietary culture of microorganisms that are much less sensitive to primary and quaternary amine cationic surfactants that are used in sanitation was developed and used.

CONCLUSIONS

The primary goal of this project was to enable the installed moving bed biofilm reactor (MBBR) at WLF meat processing plant to perform as specified. Following reasons were identified as problems that interfered with the specified wastewater treatment plant performance: 1) the total daily wastewater flow increased 50%. 2) amount of TSS and FOG in wastewater increased 400%. 3) cleaning in place agents contained chlorine, peracetic acid and primary and quaternary amine surfactants that are all toxic to microorganisms. 4) the cleaning in place chemicals often increased the pH to 13, which overwhelmed neutralization system installed. 5) Equalization tanks for influent flow equalization were too small. The objective of this project was to install primary pretreatment system that will solve the above mentioned problems and enable the performance of the MBBR.

The GEM flotation System was installed as an advanced pretreatment option. The capacity of equalization tanks was increased to produce influent with stable contaminants concentrations. Rotary drum screen (20 mesh) was installed to remove larger particles. The GEM System removed TSS and FOG almost completely. The System also reduced BOD's for at least 50% (and up to 80%). More robust pH adjustment system was installed. Also redox controlled chlorine and peracetic acid destruction was achieved. The microorganisms that are more resilient to toxic shock (primary and quaternary surfactants) were developed. These changes resulted in enabling the MBBR to perform even better than what it was designed to achieve. Currently, most of the time the treated wastewater contains less than 20 ppm of TSS and BOD, respectively.

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