Streamlining Treatment of Challenging Wastewaters in Food Processing

Jim McMahon, Author, Zebra Communications
Web: www.zebracom.net

Graham Brown, President, ADI Systems Inc
1133 Regent Street, Suite 300, Fredericton, Canada. NB E3B 3Z2
Tel: 506-452-7307 Fax: 506-452-7308
Email: gjb@adi.ca Web: www.adisystemsinc.com

Mike Kolakowski, Engineering Manager, Ken's Foods Inc
1 D'angelo Drive, Marlborough, MA, USA. 01752
Tel: 508-597-4215
Email: mkolakowski@kensfoods.com Web: www.kensfoods.com

Ken's Foods' newly upgraded wastewater treatment facility, the world's largest anaerobic membrane bioreactor (AnMBR) system, is not only a showpiece for the efficient reduction of chemical oxygen demand (COD) and total suspended solids (TSS) in challenging food processing wastewaters with high levels of organic content, but it is also supplying 200,000-plus cubic feet of biogas a day, providing 100% of the heat required for the treatment plant's operation.

Although all food processors have to deal with wastewater generated in their operations, the characteristics of the effluent exiting their facilities can vary greatly, requiring different processing technologies for the most efficient handling of the wastewater. Ken's Foods of Marlborough, Massachusetts, is a large-volume food manufacturer of salad dressings and marinades that recently upgraded one of its wastewater treatment facilities to more efficiently process its high-strength organic content wastewater. Effluents which contain a high content of fat, oil and grease (FOG) present serious challenges for waste treatment.

The solution incorporated a unique treatment process called the ADI-AnMBR, or Anaerobic Membrane Bioreactor, a relatively new form of anaerobic treatment technology based on submerged membrane technology developed by ADI Systems Inc. (ADI) in cooperation with Kubota Corporation of Japan. The ADI-AnMBR utilises sub-merged membranes for biomass retention and solids-liquid separation. The system maximises biogas prod-uction, increases solids digestion and provides a means to easily handle wastewaters with high concentrations of organic matter. The treatment plant is the largest of its kind in the world.

It is producing effluent that is virtually free of suspended solids and with a level of chemical oxygen demand removal of 99.4%, allowing its 100,000 gallons per day of wastewater to easily discharge into the municipal system. Considering the high strength levels of organic content (COD, BOD, FOG) in the wastewater, this performance is exceptional by any industry standards.

As part of the system upgrade, the company's previously installed low-rate anaerobic reactor, also developed by ADI, was retained to operate as the reactor portion of the new AnMBR. As a byproduct, the combined system is producing 200,000–300,000 cubic feet of biogas per day, which is being captured to provide not only 100% of the wastewater treatment plant's heating requirements, but enough residual biogas to power more than 50% of the manufacturing facility.

Overloading of Original Wastewater System

Limited space was available to construct the plant, and it was expected that at some point the original wastewater plant would need to be expanded to deal with increased wastewater from manufacturing.

The company's wastewater originates from manufacturing, wash-down from cleaning mixers, filling machines and other process equipment. It is then pumped into an equalization tank to begin the treatment process. There is no sanitary sewage being processed in this system.

After equalisation, the wastewater was sent to a low-rate anaerobic reactor designed and constructed by ADI (an ADI-BVF® system), which was capable of treating waste streams of moderate to very high organic strength. This was followed by a second stage of treatment, the sequencing batch aerobic reactor (SBR), also designed by ADI, that was needed to polish the anaerobic effluent. These two stages of treatment consistently achieved overall COD, FOG and total suspended solids (TSS) removals in the 98 to 99% range.

The treatment plant was designed for a maximum weekly flow of 550,000 gallons with a maximum daily flow of 100,000 gpd. Due to production increases, daily and weekly flows exceeded these design values. One of the issues caused by higher-than-design flows was excessive solids loading from the BVF reactor to the SBR.

> "We had too many solids coming from our anaerobic digester," explains Dale Mills, Treatment Plant Chief Operator for Ken's Marlborough plant. "We were spending a lot of time watching the SBR decant to the city and stopping it when the water quality was not good enough. Normally, this would be on a timed cycle, but we had to physically intervene because we had too much solids."

The City of Marlborough allows the release of 100,000 gallons of effluent per day, and limits the concentration of suspended solids (TSS) effluent to 600 mg/l. The manufacturing plant's production became inhibited by the overloaded treatment plant.

Ken's brought in ADI Systems to engineer a solution to the problem. "We had recently completed a very successful site research project on a large-scale anaerobic membrane bioreactor (AnMBR)," explains Dwain Wilson, Director of Process Operations for ADI Systems. "We believed the Ken's Foods applic-ation would be perfect for an anaerobic MBR, so we proceeded with the project.""The SBR aerobic system was never the bottleneck, it was the anaerobic reactor," continues Wilson. "The solution was to increase the capacity of the anaerobic reactor."

Keeping the BVF Low-Rate Anaerobic Reactor

From a design perspective, Ken's BVF low-rate anaerobic system, already in place as the primary process, is the workhorse of the system removing in excess of 90% of the organic material from the wastewater, as engineered. This system was designed specifically to handle wastewaters that are high in FOG, as well as variations in wastewater flow and characteristics, or wastewaters that are best treated anaerobically, but under less-than-ideal conditions, such as low temperatures.

The BVF reactor's organic loadings are low (typically 0.3 to 3.0 kg COD) and hydraulic retention times are relatively long (typically greater than 7 days), providing an inherent stability and robustness often not found in higher-rate anaerobic processes and allowing for significant digestion of influent solids and waste activated sludge. Additionally, a floating, insulated geomembrane cover was installed over the BVF. Built by Geomembrane Technologies Inc.

(GTI), the cover collects biogas and minimises heat loss. It also provides odor control and better corrosion resistance compared to concrete or steel. GTI has had success with similar covers at other food processing facilities.

The large volume and inventory of biomass within the BVF reactor provides several advantages, including the elimination of the need for extensive primary treatment of the waste stream (such as a primary clarifier). After screening and equalisation, raw wastewater, with its high concentrations of organic solids, is added directly to the BVF reactor where it is digested and produces biogas.

New ADI Anaerobic Membrane Bioreactor (ADI-AnMBR)

The existing ADI-BVF system was converted to an ADI Anaerobic Membrane Bioreactor (ADI-AnMBR) to expand the treatment capabilities of the anaerobic portion of the treatment process. One of the key components to any anaerobic treatment system is effective separation of treated water from the biogas generated by the anaerobic digestion process, while ensuring the biomass is retained within the reactor. The ADI AnMBR process, based on membrane technology developed by Kubota Corporation, is a form of high-rate anaerobic contact process that uses a submerged membrane barrier to perform the gas/liquid/solids separation and reactor biomass retention functions. This near-absolute barrier to solids ensures efficient system operation, even under high organic loading and intense mixing scenarios. Membrane treatment technologies are often employed when higher quality effluents are required, or when wastewater characteristics make conventional gravity settling technologies difficult or ineffective.

Since gravity settling is not required, higher organic loadings and mixing intensities can be employed than with other anaerobic technologies, increasing organic removals, improving biogas production, and allowing for treatment of wastewaters with very high suspended solids and FOG. The system can be utilised to treat essentially any wastewater amenable to anaerobic treatment, but is most applicable to very strong, concentrated wastes, solid and semi-solid wastes and slurries, and wastewaters with poor settling characteristics.

The biogas generated in anaerobic digestion is utilised to continually clean the membranes during operation via a gas scour system, which has proven to be highly effective in reducing membrane cleaning frequency. In fact, no membrane cleaning has been required after the first six months of operation.

The AnMBR system can operate at both thermophilic and mesophilic temperatures, facilitating better removals, more biogas and reduced sludge production. Yet it avoids common operating problems at thermophilic temperatures, such as biomass loss and unstable operation.

> "With the anaerobic MBR, a physical barrier allows it to maintain a larger quantity of biomass within the anaerobic reactor," says Wilson. "This provides a more stable system to weather shock loading and spikes that come out of the manufacturing process."

"The MBR also increases the solids retention time within the system," explains Wilson. "The longer the solids retention time, the lower the biomass yield. This helps reduce the amount of biomass that will require disposal. It also allows the development of specialised bacteria that can acclimate to unusual organics. Some of these organics are more difficult to degrade, but if you have a sufficiently long solids retention time, the bacteria can acclimate and start breaking them down. You can actually digest organics that you might not have been able to otherwise."

Ken's AnMBR system consists of four anaerobic basins, each equipped with seven submerged membrane units (SMUs).

A removable GTI geomembrane cover system on each AnMBR basin provides a gastight seal with biogas collection capabilities. Each AnMBR basin is covered with a retractable, structurally-supported cover system. Each cover system consists of a retractable fabric cover tensioned over a series of custom designed stainless steel arches. These patented covers provide a gastight seal which allows the biogas to be captured in the headspace above the cartridges. The biogas is returned to the gas scour system for reuse. The retractable feature allows plant staff to easily disconnect and retract the cover to access the cartridges for inspection or maintenance.

Ken's tests daily to determine the strength of its wastewater, the health of the biological process and compliance with discharge limits. The TSS concentration coming out of the MBR averages less than 1 mg per liter, biochemical oxygen demand (BOD) is typically less than 25 mg per liter. The COD removal in the AnMBR is greater than 99.4%.

The food processor's ADI-AnMBR is the first installation of this technology in North America, and the largest in the world. A number of much smaller AnMBR projects have been built in Japan, but the technology is new to the US marketplace.

Re-Purposing the Aerobic Sequencing Batch Reactor (SBR)

Before the system upgrade, the purpose of the sequencing batch reactor was to polish the anaerobic reactor effluent to meet discharge standards, a function it would not be able to do satisfactorily under higher-than-design loading conditions.

The very clean effluent from the AnMBR now goes into the old SBR, which has been repurposed for use as a sulfide oxidation and nitrification tank. Ken's purposely adds and maintains biological solids in the tank as a suitable biomass population for the treatment process. Now that solids loading to the SBR from the anaerobic process has been eliminated, the SBR can be easily used to oxidise sulfide and ammonia.

Captured Biogas Powers Treatment Plant

The biogas (methane) generated as a by-product of the anaerobic digestion process has proven to be a valuable product for the replacement of conventional energy sources like natural gas and electricity.

"We capture the biogas produced in the anaerobic digesters (reactor) and we heat both the processing building and the reactor with it," says Mills. "So we do not have any fuel costs relating to heating the treatment building in the winter, or heating the reactor. The reactor needs to be kept at 95 degrees F, which requires a fair amount of energy to maintain. But, all of that heat requirement is coming from the digester, it is self-sustaining. We also have a considerable amount of extra biogas that we flare right now. We produce between 200,000–300,000 cubic feet per day of biogas from our system."

Wastewater-derived biogas must be properly handled and often requires treatment prior to use to prevent corrosion and air emissions. ADI provided a complete design-build recovery and utilisation system which included gas collection, storage, compression and delivery systems, and gas treatment for the removal of sediment and moisture/water vapor.

"The amount of biogas that is produced from our anaerobic reactor is certainly enough to completely support the wastewater plant," says Mike Kolakowski, Engineering Manager for Ken's Foods Marlborough plant. "We are also in the process of commissioning an engineering study on using that biogas for a waste-to-energy project of co-generation of electricity using the biogas. It is a CHP (combined heat and power) project, where the amount of biogas that is generated from the reactor would not completely fulfill our needs at the manufacturing plant, but we would substantially reduce our draw from the utility grid by well over 50%. The concept inherent in the ADI design model is allowing us to broach this very large possibility for a big energy savings sustainability type of project."

As the cost of conventional energy sources continues to rise, biogas produced from wastes and wastewaters can provide a cost-effective and more environmentally sound alternative.

Improved Efficiencies

Ken's Foods upgraded wastewater system, incorporating its new ADI-AnMBR reactor, began construction in April 2008 and was fully commissioned by July. In addition to significantly lowered TSS, COD and BOD levels, and even captured biogas as an energy resource, other benefits have been realised from this new system, such as the removal and rendering of 36,000 gallons of fats, oils and grease per year, which was becoming increasingly more difficult to dispose.

Additionally, personnel no longer have to physically monitor the discharge to the city, as the quality of the water in the SBR is consistently clean enough for automated, timed release. This has allowed the maximum 100,000 gallons per day to be decanted, and eliminated the problem of manufacturing interruption previously caused by the challenges at the wastewater treatment plant.

"The entire processing plant is automated," explains Mills. "I can completely control the whole plant from my computer at the plant or from my home. The system is equipped with alarms, so if anything goes wrong it will call me, then I can get right on the computer and usually fix the problem, even if I am at home. Every pump, every motor, I can control everything from the computer screen."

The water produced through the new system is clean enough to reuse for utility services for such things as cooling water, chiller towers, site irrigation, and other non-product related uses.

> "The system is extremely cost effective," explains Kolakowski. "The overall costs of operating the AnMBR processing facility are lower than traditional treatment options. It represents at least a 50% reduction in costs going this route than with other more traditional means of water treatment."