Streamlining Wastewater Treatment in Food Processing

by Jim McMahon

Posted: October 1, 2009

The world's largest anaerobic membrane bioreactor system supplies 200,000-plus cubic feet of biogas a day, providing 100 percent of the heat required for the treatment plant's operation.

Although all food processors have to deal with wastewater generated in their operations, the effluent characteristics exiting their facilities can vary, requiring different processing technologies to achieve maximum efficiency. Ken's Foods of Marlborough, Mass., a large-volume food manufacturer of salad dressings and marinades, recently upgraded one of its three wastewater treatment facilities to improve processing its high-organic content effluents, which contained high fat, oil and grease (FOG) and presented serious challenges.

The company incorporated an anaerobic style of membrane bioreactor (MBR) treatment process, a relatively new form of treatment technology developed by ADI Systems Inc., part of an international company with headquarters in the Canadian province of New Brunswick, in cooperation with Kubota Corp. of Japan.

The anaerobic, or "An-" MBR utilizes submerged membranes for biomass retention and solids-liquid separation. It can produce an effluent that is almost completely devoid of suspended solids, with a chemical oxygen demand (COD) removal of 99.4 percent, discharging 100,000 gallons of wastewater per day into the municipal system. Considering the high-strength levels of organic content – COD, biochemical oxygen demand (BOD), and 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 was retained to operate as the reactor portion of the new AnMBR. As a byproduct, the combined system has produced 200,000 to 300,000 cubic feet of biogas per day. The biogas has been captured to provide 100 percent of the wastewater treatment plant's heating requirements, with enough residual biogas to power more then 50 percent of the company's manufacturing facility.

Overloading of original wastewater system

When the Marlborough facility originally was built, limited space was available to construct the wastewater plant, and the food company expected that at some point it would need to be expanded to deal with increased volume from manufacturing. The company's wastewater originated from wash-down of cleaning mixers, filling machines and other process equipment (no sanitary sewage was processed in this system). It was then pumped into an equalization tank to begin the treatment process.

Gas tight geomembranes cover the AnMBR system, which generates methane gas. The gas is captured and used to provide the heat needed in the treatment system, and sufficient to power more than half of the manufacturing plant.

After equalization, the wastewater was sent to the low-rate anaerobic reactor which was capable of treating waste streams of moderate to very high organic content. This was followed by a second stage of treatment, a sequencing batch aerobic reactor (SBR) that was needed to polish the anaerobic effluent. These two treatment stages consistently achieved overall COD, FOG and total suspended solids (TSS) removals in the 98 to 99 percent 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 low-rate anaerobic reactor to the SBR. "We had too many solids coming from our anaerobic digester," said Dale Mills, the treatment plant's chief operator. "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 allowed the release of 100,000 gallons of effluent per day and limited the concentration of suspended solids in the effluent to 600 mg/l. The manufacturing plant's production became inhibited by the overall treatment plant.

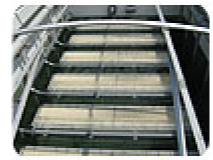
The food company brought in the New Brunswick service company to engineer a solution. "The SBR aerobic system was never the bottleneck, it was the anaerobic reactor," said Dwain Wilson, director of process operations for ADI. "The solution was to increase its capacity of the anaerobic reactor."

Keeping the low-rate anaerobic reactor

From a design perspective, the food company's low-rate anaerobic system, already in place as the primary process, was the workhorse of the system, removing over 90 percent of the organic material from the wastewater. This system was specifically designed to handle wastewaters that were high in FOG, as well as variations in wastewater flow and characteristics, or wastewaters that were best treated anaerobically but under less-than-ideal conditions, such as low temperatures. The low-rate anaerobic reactor's organic loadings were low, typically 0.3 to 3.0 kg COD. Also, hydraulic retention times were relatively long, typically greater than seven 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. The large volume and inventory of biomass within the low-rate anaerobic reactor provided several advantages, including eliminating the need for extensive primary waste stream treatment, such as a primary clarifier.

After screening and equalization, raw wastewater, with its high concentration of organic solids, could be added directly to the reactor, to be digested for the production of biogas. The low-rate anaerobic reactor was equipped with a floating, insulated cover. Built by Geomembrane Technologies Inc., Fredericton, New Brunswick, the purpose of the cover was to collect the biogas, and minimize heat loss. It also has provided odor control.

A new anaerobic MBR



A membrane reactor tank opened for inspection.

The food processor's AnMBR was 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.

The existing low-rate anaerobic reactor system was converted to an AnMBR to expand the treatment capabilities of the anaerobic portion of the treatment process. The high-rate anaerobic contact process uses a submerged-membrane barrier to perform the gas/liquid/solids separation and reactor biomass retention functions. This near-absolute barrier to solids, the company's engineers said, would ensure efficient system operation, even under high organic loading and intense mixing scenarios.

Since gravity settling was not required, higher organic loadings and mixing intensities could be employed. The system could be utilized to treat essentially any wastewater amenable to anaerobic treatment, but was most applicable to very strong, concentrated wastes, solid and semi-solid wastes and slurries, and wastewaters with poor settling characteristics, such as those found at the food company's plant.

The biogas generated in anaerobic digestion continually scour the membranes during operation, reducing membrane cleaning frequency. After six months of operation, no membrane cleaning had been required.

The AnMBR system was designed to operate at thermophilic or mesophilic temperatures. Operating problems at thermophilic temperatures, such as biomass loss and unstable operation have not occurred. "With the anaerobic MBR, a physical barrier allows it to maintain a larger quantity of biomass within the anaerobic reactor," said Wilson. "This provides a more stable system to weather the shock loading and spikes that come out of the manufacturing process."

"The MBR also increases the solids retention time within the system," said 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 specialized 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."

The food company's AnMBR system consists of four anaerobic basins, each equipped with seven submerged membrane units. A removable cover system on each basin provided a gastight seal to collect biogas.

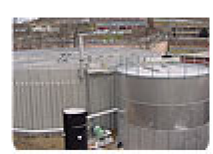
The plant has been testing daily to determine the health of the biological process and compliance with discharge limits. The TSS concentration coming out of the MBR has averaged less than 1 mg per liter, BOD has typically been less than 25 mg per liter, and the COD removal in the AnMBR has been greater than 99.4 percent.

Re-purposing the aerobic SBR

Before the system upgrade, the purpose of the SBR was to polish the anaerobic reactor effluent to meet discharge limits, which it failed to do under higher-than-design loading conditions.

Now, the clean effluent from the AnMBR is directed into the old SBR, which was re-purposed for use as a sulfide oxidation and nitrification tank. The food company purposely added and has maintained biological solids in the tank as a suitable biomass population for the treatment process. Since solids loading from the anaerobic process were eliminated, the SBR has taken on the job of oxidizing sulfide and ammonia.

New gas supply



The real coup of the new reactor, however, was in generating a new energy source, specifically, the biogas (methane) generated as a byproduct of the anaerobic digestion process.

Shown here is the low-rate anaerobic reactor with the floating geomembrane cover.

"We capture the biogas produced in the anaerobic digester (reactor) and we heat both the processing building and the reactor with it," said 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 95ºF, which requires quite a fair amount of energy to maintain. But, all of that heat as well 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 and 300,000 cubic feet per day of biogas from our system."

"The amount of biogas that is produced from our anaerobic reactor is certainly enough to completely support the wastewater plant," said Mike Kolakowski, engineering manager for the 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 percent."

Improved efficiency

The plant's upgraded wastewater system, incorporating its new 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 realized such as the removal and rendering of 36,000 gallons of FOG per year, as well as 500 tons of dewatered wastewater residual solids per year, which, according to the plant, was becoming increasingly more difficult to dispose.

"The entire processing plant is automated," said 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 overall costs of operating the AnMBR processing facility are lower than traditional treatment options," said Kolakowski. "It represents at least a 50 percent reduction in costs going this route than with other more traditional means of water treatment." ***PE***

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