BioCycle energy

SERVICING DAIRY, DISTILLERY INDUSTRIES

ANAEROBIC TREATMENT OF HIGH-STRENGTH WASTEWATER

A yogurt and cottage cheese plant in northern New York and a bourbon whiskey distillery in Kentucky install anaerobic wastewater treatment systems that reduce COD to regulatory discharge limits and significantly offset fuel costs.

Robert Spencer

THE DAIRY industry in the United States produced almost 500 million pounds per day of milk products in 2006, primarily cheese, yogurt, cream cheese, cottage cheese and sour cream. The production process for such foods generates high-strength waste by-products like whey, rinse water and cleaning chemicals. As with other food manufacturing industries, the hierarchy of waste management is determined by the highest return on value, with some materials going to products for human consumption, followed by animal feed, fuel and then land application as fertilizers.

Production of fuel as renewable energy from waste by-products has become increasingly attractive to the dairy manufacturing industry, as evidenced by Breyers Yogurt Company's North Lawrence Dairy, in North Lawrence, New York, which manufactures yogurt and cottage cheese. The plant's original waste treatment system included production of animal feed, land application and large aerated lagoons to treat the wastewater. Facing a major expansion in production capacity, the company searched for a system that would allow them to increase production capacity and meet wastewater treatment regulatory standards. In 2005, Breyers entered into a design-build-finance agreement with Ecovation to install a new, larger wastewater treatment system that also generates renewable energy. Under a separate 10-year agreement, Ecovation operates the entire wastewater treatment system.

Jay Straight, Engineering Manager of the Breyers plant, is pleased with the cost savings and performance of the Ecovation system. He reports that with only one of the plant's three oil-fired boilers converted to burn both biogas and oil, the new system is saving between 200,000 and 250,000 gallons of #6 fuel oil per year, providing about 25 percent of total energy use. "If a company has the capital to invest, and a high-strength liquid waste like our plant, it's a good system," says Straight. "Eventually it will be hard for industries with this type of waste to live without a waste treatment system that also generates so much energy."

COD REDUCTION

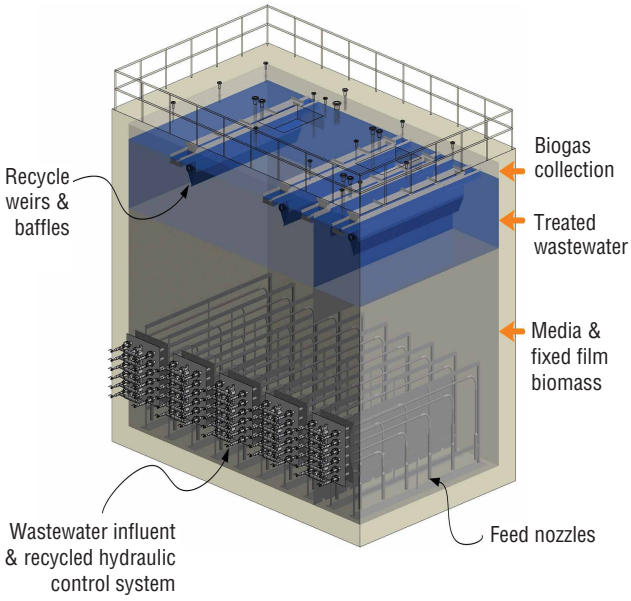
The primary targeted pollutants in wastewater from the dairy manufacturing industry are dissolved sugars, as indicated by high chemical oxygen demand, or COD. The acid whey from cheese processing can have COD concentrations as high as 350,000 mg/l. To meet the regulatory discharge limits of 30 mg/l BOD and 45 mg/l TSS, the Breyers plant utilizes Ecovation's patented Mobilized Film Technology (MFT^{SM}) to process 65,000 gallons/day. According to Ecovation, the plant can handle 38,000 pounds of COD per day, generating over 180 million BTUs per day from the resulting biogas. For every pound of COD converted by the anaerobic organisms, 5.6 ft^3 of methane gas is generated.

Breyers Yogurt Company installed an anaerobic treatment system at its North Lawrence Dairy to process 65,000 gallons/day of wastewater. The patented Mobilized Film Technology (reactor on left) can handle 38,000 pounds of COD/day.

The MFT can also handle relatively high concentrations of total suspended solids — up to 10,000 mg/l of TSS.

"Although our State discharge permit standards are written in BOD, Ecovation tests for COD since it is a two hour test compared to the 5 day test for BOD," explains Straight. "That monitoring demonstrates that the MFT system is removing more than 90 percent of the COD prior to discharge to the aerated finishing lagoons." The discharge from the MFT system then joins other wastewater from the facility for further treatment in aerated lagoons, prior to discharge to the Deer River.

The treatment system has excess capacity, which allows for acceptance of off-site high-strength materials from other cheese plants in the area and a local dairy. Breyers has a permit from the New York State Department of Environmental Conservation to accept and process off-site waste. "Since our system currently has excess capacity, we are looking for other sources of high sugar and lactose waste since we will benefit from increased biogas production," Straight says.



Ecovation's MFT℠ is shown in the above diagram. The Maker's Mark distillery is constructing a wastewater treatment system using the technology (above).

ANAEROBIC REACTORS

The Breyers plant has two MFT reactors (each concrete reactor is approximately 21 feet wide, by 35 feet long, by 25 feet high), and each is approximately two-thirds full of a proprietary, engineered media that provides very high surface-to-volume ratios. "Our media bed gives us the benefit of attaching the organisms to an extremely heavy particle compared to other anaerobic systems that do not employ media, but where the bugs attach to each other, forming a granule that does not provide nearly as much surface area," explains Robert Cummings, Chief Technology Officer and cofounder of Ecovation. "This allows for us to treat a very high organic load in a small area."

Much like an aerobic biofilter that depends on development of a biofilm on the surface of the soil particles, the MFT media uses a small diameter inert sand particle upon which bacteria can attach in a thin film. The high density of biofilm-coated media, compared to wastewater suspended solids, promotes the migration of undegraded and inert suspended solids from the reactor without displacing the active biomass. This is due to the greater density of the microorganisms on the sand particles compared to the lighter density of the suspended solids. It enables the MFT to tolerate shock loadings, since the microbial films have sufficient biomass to treat the higher loads and are of such a density that the associated biogas flux rates will not carry them out to the system.

"The hydraulic retention time is measured in hours, compared to the days required by lower rate systems," adds Cummings. The result is conversion of organic compounds into biogas, which is comprised of methane, CO_2, H_2O, and trace amounts of H_2S. Depending on the ultimate end use, some additional cleaning of the biogas may be required.

To provide dosing to the MFT treatment vessel, a series of feed nozzles alternate so that wastewater is pulsed into the bed to provide optimal loading rates. In addition, to optimize the microorganisms' efficiency, macro and micronutrients and alkalinity are blended into the wastewater before introduction to the MFT. An optimal nutrient feed results in higher efficiency of BOD removal and increased biogas production.

According to Ecovation, the drivers for adding an anaerobic treatment to a wastewater system include industrial pretreatment regulations that limit the amounts of BOD, COD and TSS that can be discharged into municipal sewer systems. Also, higher sewer use charges based on concentrations and quantities of those pollutants discharged provide an economic incentive for industries to remove them prior to discharge. The MFT treatment system has a relatively small footprint due to the lower residence time and higher populations of microorganisms per unit volume. One full-time operator manages the wastewater treatment plant.

Additional benefits include air pollution reduction. Engineering Manager Straight points out that stack tests have confirmed about a one-third reduction in sulfur dioxide emissions from the plant as biogas has replaced fuel oil.

The facility has greatly reduced the land application of its by-products, and once some additional piping has been installed within the next few months, the plant will no longer be land applying any material. "The cost of contracting for land application is greater than the cost of treating the waste in the MFT system," adds Straight. "The regulations for land application have also become more stringent, and we had to find land further away from the plant."

As for the regulatory approval, Straight says Breyers was able to get an increase in the BOD discharge limit thanks to the high treatment capacity of the MFT system. Another benefit is a reduction of odors from the aerobic lagoons since the first rinse material from cottage cheese production is treated in the anaerobic process prior to the

aerobic lagoons. Straight notes that prior to the Ecovation installation, an older lagoon system did not provide as much oxygen as the new aerated lagoons, and as a result odor has been reduced.

DISTILLERY INSTALLATION

In Loretto, Kentucky, the Maker's Mark bourbon whiskey distillery is replacing its existing wastewater treatment plant with an innovative solids separation process, Ecovation's high-rate MFT anaerobic treatment reactor, and a modified activated sludge system with integrated clarifier and denitrifying capability for final polishing. The MFT reactors are under construction and Maker's Mark expects the system will be ready for feeding by February 2008.

According to Dave Pickerell, Master Distiller at Maker's Mark, the new wastewater treatment system enables the company to carry out a long-awaited and necessary expansion. "The by-product of our distillation process is a spent grain and water mixture known as 'thick slop' or whole stillage," he explains. "We have self-service tanks filled with the stillage, and area dairy and cattle farmers pick up the material for animal feed. It takes about 4,000 head of cattle/day to consume the amount of this by-product the plant generates. Farmers have difficulty getting to us when it snows or there is flooding, and don't come at all if the grazing grass is good. This practice of giving whole stillage to farmers has created a bottleneck in our ability to expand production by 50 percent."

The traditional alternative for distilleries is a dry house process. Stillage is dewatered through a centrifuge to separate the fiber from the dissolved solids. The solids are thickened in an evaporator, then mixed back with the centrifuge cake and put through a dryer. "This is a very energy-intensive process," says Pickerell, "requiring about 40 percent of all the plant's energy consumption to operate. So in addition to the expansion, the second driver to installing the anaerobic system was to be good environmental stewards, and select a technology that generates energy. The distillery and MFT system combined will be running at about 42 percent of the total energy demand of a distillery and dry house combination."

Maker's Mark evaluated three different anaerobic digestion technologies. One couldn't handle the high strength of the whole stillage, and required diluting it by half, or about 220,000 gallons/day of water. The second technology had a residence time in the reactor of 20 days. "If there was a process upset, we would have had to shut down the feed stream until the microbial balance could be reestablished," notes Pickerell. "That would have required us to stop production. Ecovation's MFT reactors have less than a two-day residence time, with a much higher rate of reaction. It can correct itself so quickly that we don't need to worry about stopping the feed stream."

Bench-scale trials were done with the MFT process to ensure the waste stream could be treated in the reactor. Ecovation led the design and engineering team putting the new system together. "We started conceptually with the design for a centrifuge, which is expensive, maintenance-intensive and uses a lot of electricity," he says. "We challenged the design team to come up with an alternative strategy. They ultimately selected a screw press, which runs on 7.5 hp motors and generates solids as high as 41 percent." Two screw presses are being installed. The MFT reactor is being integrated into the existing sequencing batch reactor. There will be three discharges — the high fiber solids that can be sold as animal feed, biogas and treated wastewater that can be discharged into the nearby creek.

Biogas will be burned in the plant's boiler, currently fueled by natural gas. A scrubber is being installed to treat the biogas, which will be compressed prior to delivery to the boiler. Reduction in natural gas usage is anticipated to be 15 to 30 percent. The MFT reactor will treat 98,000 gallons/day and 23,000 lbs/day of COD. Deliverable energy is 85 MMBTUs/day; final discharge requirements for the system are 30 mg/L BOD; <60 mg/L TSS; <8 mg/L NH_3-N; <5 mg/L P. Pickerell says they are working with the Kentucky Division of Water to obtain its discharge permits. "The officials may not fully understand the technology entirely, but that was the case as well when we put in the sequential batch reactor," he notes. Maker's Mark is hiring a Class 3 wastewater treatment plant operator and a dedicated mechanic to operate the wastewater treatment plant.

In terms of payback for the $8 million wastewater treatment upgrade, Pickerell says that with the substantial reduction in natural gas consumption and the ability to increase production of Maker's Mark bourbon, the plant will pay for itself in full the first year the product is ready to sell. "It takes about six years to age the product, so when that batch of whiskey comes out of the warehouse, the system is paid for. In addition, the MFT operates in the mesophilic range (around 100°F), but the spent grain coming out of the distillery is 200°F. The water used to make the bourbon needs to be preheated to 140°F. So we are installing a heat exchanger to take the heat out of the spent grain and put it into the mash water via the heat exchanger, saving even more energy." ■

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