Small Scale Digester Case Study: Peters/USEMCO Anaerobic Digester

Prepared by: Rebecca A. Larson, Assistant Professor and Extension Specialist, University of Wisconsin-Madison and University of Wisconsin-Extension

The Farm

The Peters Family Farm is a diverse organic farm which includes a milking operation with just over 200 head near Chaseburg, Wisconsin (WI). The family farm is owned/operated by father Wayne and sons Rory and Roger. Universal Sanitary Equipment Manufacturing Company (USEMCO) installed an anaerobic digester at the Peters' dairy facility in 2011.

Figure 1: Anaerobic Digestion System

The Digester

The digestion system is comprised of a collection tank, a mix tank, the digester itself, an effluent tank, a separation system and a generator. The entire system is housed within two separate buildings. The first building holds the three underground storage tanks and the separator. The second building houses the digester tank, generator, and control systems. The collection tank and the mix tank are both 12,000 gallon underground concrete tanks used to hold the feedstocks which are pumped into the digester

Figure 2: Digestion Tank

September 2013

using piston pumps. The digester is a 30,000 gallon vertical completely mixed steel tank standing 40 feet tall with a diameter of 12 feet. The vertical type digester is advantageous when space is limited as it has a small footprint relative to other digester designs.

System Operation

The system is operated with manure as the primary feedstock. Manure is collected from the 200 cow barn twice per day. The mix tank is equipped with a mixer and a pump to agitate the influent and feed the digester. The digester is operated at a temperature of 125 °F putting it at the higher end of the mesophilic range. With a hydraulic retention time of approximately 5 days the digester requires an influent feeding rate of 6,000 to 7,000 gallons of substrate each day. Initially the system was operated at 98 °F. However, due to the short retention time the temperature was increased to 125 °F to increase substrate breakdown and biogas production. The operators found that increased temperatures beyond 125 °F did not increase biogas yield. Mixing within the digester's lower half is achieved with a mechanical agitator which cycles an hour on and an hour off. A sweep arm at the top of the digester circles the tank to remove solids after each loading period. This digester is unique in that it allows for settled sand and grit removal at the base of the vertical tank using a valve system. This reduces the maintenance needs to clean-out the system.

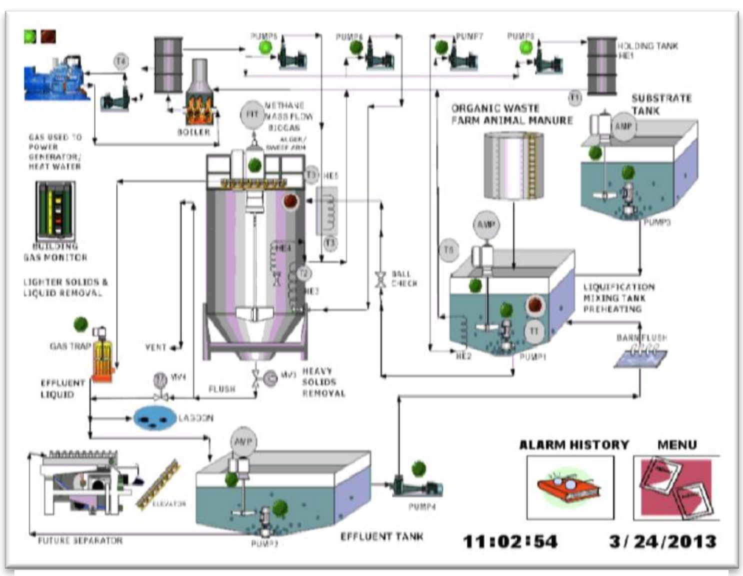

Figure 3: Electronic Control System

The system is controlled electronically. There is constant reading of the biogas production rate and the methane content within the biogas. Temperature is also measured within the digester. Flow into the digester is also recorded to get an accurate volume of the feedstocks added.

On average, the digester requires approximately 1 to 1.5 hours per day to maintain the system.

Feedstocks

Dairy manure is the primary feedstock for the digester. The manure is collected twice daily and stored in one of the feed tanks. The wash water from the milking parlor is diverted directly to manure storage as it was determined to have a negative impact on biogas production. The total solid within the manure slurry is around 10-12%, relatively high as compared to other dairy manure digestion systems in WI. In an attempt to increase biogas production, locally accessible alternative substrates were added to the digester. These additional feedstocks are held in above ground tanks and are metered into the manure slurry in the mix tank near the piston pump which feeds the digester. The biogas yield from additional substrates, such as creamery waste, chicken manure, rice hulls, glycerine, brewery waste and others, was evaluated in the digester and/or using laboratory biomethane potential assays. Some feedstocks may have had a positive impact on biogas production but were excluded due to handling and operational issues. For example, the addition of 3% by volume of glycerine, a by-product of biodiesel production, doubled biogas production to over 30,000 cubic feet per day. Unfortunately the glycerin was removed because it also increased the moisture content of the separated solids used for bedding and negatively impacted herd health.

Biogas Production and Use

Typical biogas production ranges from 16,000 to 23,000 cubic feet per day depending on feedstock blends. Biogas production has reached as high as 39,000 cubic feet per day. Data has shown the volatile solids destruction within the system reaches up to 45%. The biogas produced is stored in the top of the digester. Before being sent to the generator the biogas is treated by passing through a treatment system with a media aimed at reducing hydrogen sulfide content. This media can reduce hydrogen sulfide to concentrations below 1 ppm. The media was estimated to need replacement after one year, but after two years of operation is still effective. The estimated cost to recharge the media is between $3,000 and $4,000. Initially, the system produced enough biogas to run a 45kW generator. Recent increases in biogas production required a 110 kW generator that currently operates in the 70 kW range. The electricity produced by the generator is sold to Dairyland Power Cooperative. The current contract with Dairyland Power Cooperative does not limit the amount of electricity that can be produced and sold.

Digestate Processing and Use

The digestate exits the digester and is routed to a 12,000 gallon underground storage tank. From the storage tank it is pumped into a Fan screw press separator. The liquid from the separator is stored in a manure storage pit and is then land applied as a fertilizer. Prior to the installation of the digester the farm primarily used sawdust as a bedding material. After implementing the separator, the farm switched to separated digested solids as bedding. The solids are moved from the separator up to the barn using a blower system which also results in a drier bedding product. The bedding provides additional financial benefits as it reduces the cost of purchasing alternative bedding. However, using the solids as bedding also has challenges in terms of milk quality and takes increased management to maintain milk quality.

Figure 4: Screw Press Separator

Financial

The entire digestion system was approximately $1 million dollars. A $200,000 grant was provided to USEMCO to facilitate the implementation of small scale digestion systems in WI. USEMCO provided the funds to build and operate the digester with the intent that the Peters farm will eventually purchase and operate the digester. It is the hopes of the Peters family to pay the system back in around 7 years.

Lessons Learned

Difficulties with digestion system are common particularly in the first year or two of operation, and this system is no different. Initially the biogas production within the system was lower than predicted due to the short retention time. The temperature of the system was raised 25+ degrees significantly increasing the biogas production. Some of the substrates that have been added caused some issues within the digester or digestate. Foaming has been an issue with various substrates. In particular, cultured buttermilk caused significant foaming. When foaming becomes particularly problematic a de-foaming product used for maple syrup is effective when added to the top of the digester.

After operating the digester for a few years USEMCO designers and operators do not plan to make any functional changes to the system design in the future. However there are some basic changes that they would make to improve the system:

- Changes to the piping of the bottom sediment flush system
- Design changes to the heat exchanger before the digester
- Changes to gas piping materials, particularly the stainless steel threaded line that was used initially proved hard to work with in a system where the piping needs to be removed/reworked at certain times; at the Peters facility they have switched to milk pipeline which has been easier to work with
- USEMCO would like to evaluate buying two small generators instead of one large generator in the future, two small generators would allow the system to remain at half production during maintenance of each generator, in addition the parts to the smaller generator are much cheaper and are available locally

Acknowledgements

The author would like to thank The North Central Regional Center for Rural Development (NCRCRD) for funding in support of this work. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author

UW Extension
University of Wisconsin–Extension

Biological Systems Engineering
UNIVERSITY OF WISCONSIN–MADISON

September 2013

and do not necessarily reflect the views of NCRCRD, and reflect the best professional judgment of the author based on information available as of the publication date.

The author would also like to thank Patrick Rezin and Dale Olson (USEMCO) for providing the information on the digester design, system components, and operation.

September 2013