Case Study of Trident Processes Nutrient Recovery Fair Oaks Dairy, Fair Oaks, IN Jan. 19th, 2016

Attending

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Background

Fair Oaks Dairy Farms was established in 1999. The operation is located in Northwest Indiana and consists of five, 3,500 cow dairy units located on 15,000 acres. The dairies are freestall barns with sand bedding that have approximately 3,000 milking cows and 500 dry cows at any one time.

When originally built the first four units were designed for scraped manure with direct field application, parlor water was discharged to one-million-gallon lagoons that were located on each unit and was used for irrigation on nearby fields. This work was done by a crew of 12 employees and one full time manager.

In 2003 Fair Oaks Dairy built its first anaerobic digester at Unit #2 designed to take all of the manure and parlor water from this dairy. This digester was considered a vertical plugged flow system with a specialized sand removal and solids recovery system. The performance of this system was very poor initially and was modified significantly over the next three years. The sand removal system was improved until it was removing 98% of the sand (must meet established specification) and the solids removal system was completely redesigned as a continuously operating dissolved air floatation (DAF) system. The system did a fair job separating the suspended solids but there was no effective dewatering system available for

producing a dry cake that would allow for the handling of the high phosphorus solids.

In 2006 Fair Oaks Dairy built a second digester, centrally located to the four other dairies, and processes the manure from 14,500 cows. When built, this system incorporated the design improvements from the first unit. The system includes a three phase sand removal system that includes McLanahan Sand Manure Separators, and hydro cyclones as well as a sand settling lane and uses a DVO mixed plug flow anaerobic digester. After the digester the system has coarse solids separation and included a series of DAF units for solids recovery and a centrifuge for dewatering approximately 20% of the effluent, the balance being returned to the digester for further processing. Due to the undersized dewatering centrifuge, the high cost of operation and low milk prices the DAF units were decommissioned and removed in 2008 and the system was operated with only coarse solids removal from that point on.

Technology and Process

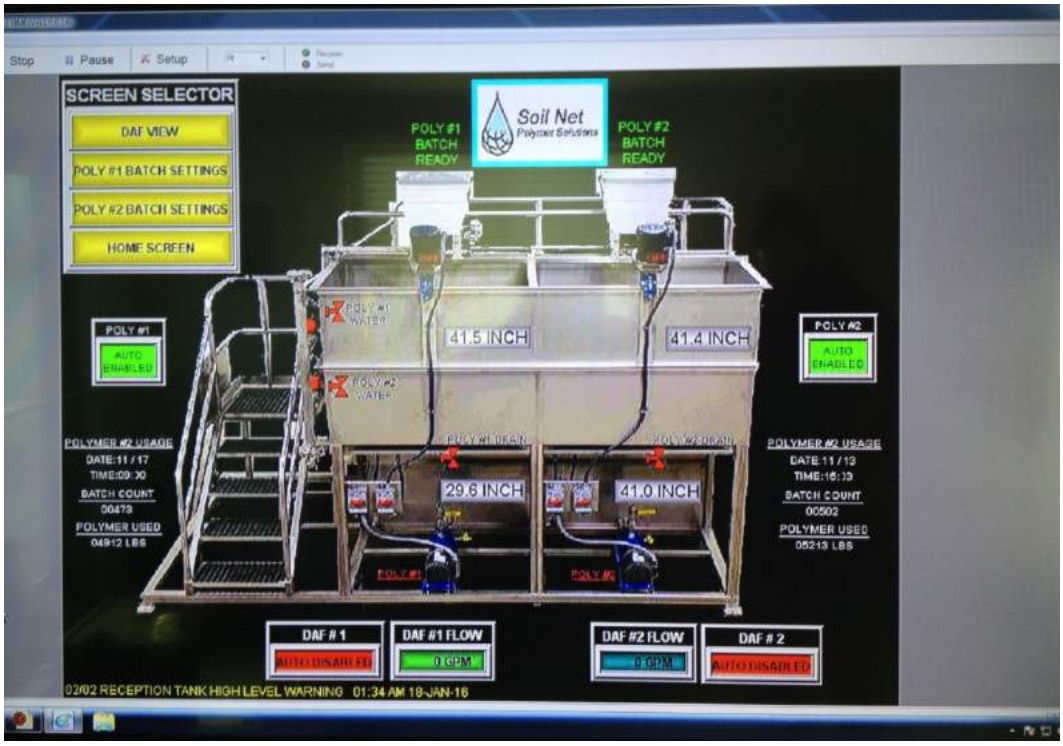
In 2015 the decision was made to incorporate a fine solids recovery system made by Trident Processes LLC known as the Trident Nutrient Recovery System. This system was designed to utilize a rotary drum coarse solids removal system supplied by Manure Systems but this installation was modified to include the existing US Farms Systems slope screen coarse solids removal. From this system the digestate flows to a concrete holding tank from which it is pumped to two 400 square foot surface area DAF units where the digestate is treated with polymers causing flocculation of the suspended solids. Dissolved air injected at the bottom of the DAF unit causes the flocculated solids to float to the surface where an overhead paddle system scrapes them into a trough located at the end of the DAF units. The trough system distributes the harvested solids to three sets of three moving disc presses where the solids are dewatered. The resulting solids cake is higher in phosphorous than raw manure products. The cake is approximately 23% dry matter and is conveyed out of the building to a concrete pad where it stacks nicely and can be loaded into trucks for transport to a nearby fertilizer facility that is being built by Proteus Environmental Technologies.

The following is a series of photographs showing the process:

1 Side by side DAF units

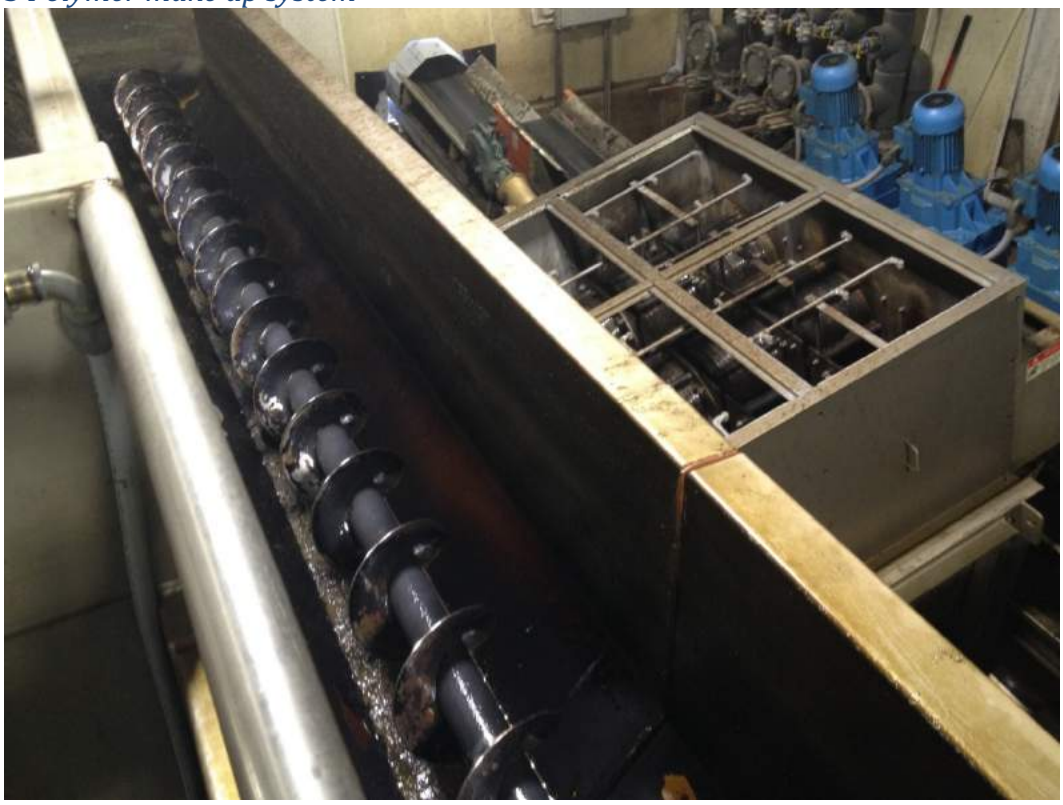
2 DAF side view

3 Air diffusion system



4 Polymer control panel

5 Polymer make up system



6 DAF "floc" collection auger

7 Moving disc press top view

8 Moving disc press side view

9 Solids discharge conveyor

10 Solids transfer conveyor

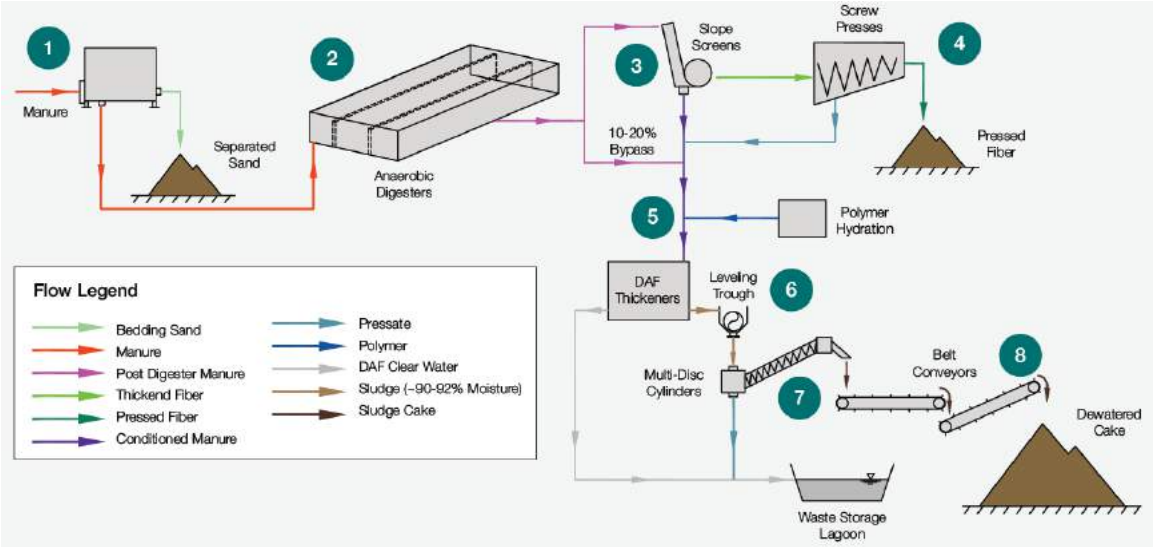
11 Solids pad

12 Solids cake at 23% DM

Upon completion of the Midwestern BioAg plant the high phosphorous solids will be incorporated into a fertilizer pellet that can be used as a natural replacement for commercial fertilizer products that utilizes phosphorous that is mined, processed and shipped over long distances. This manure derived fertilizer product will be used by Midwest Bio-Ag a fertilizer and crop consulting company.

System Performance

The following diagram was provided by Trident Processes:



This table is based on the samples gathered by Fair Oaks Dairy personnel since the start-up of the system in September of 2015 as installed at Fair Oaks Dairy (US Farms slope screens instead of rotary screens).

	TS	TKN	P	K
DIGESTER EFFLUENT AVERAGE	4.10%	0.24%	0.05%	0.14%
DAF INFLUENT AVERAGE	2.63%	0.20%	0.04%	0.13%
DAF EFFLUENT AVERAGE	1.09%	0.15%	0.01%	0.12%
DAF CAKE AVERAGE	23.39%	0.87%	0.35%	0.17%
DAF TO DIGESTER EFFLUENT REDUCTIOIN	73.30%	39.41%	81.00%	13.14%

Trident Processes LLC Business Plan

Trident Processes LLC is prepared to sell or lease this system and also can provide financing to qualified projects. They require an operating agreement that has them supplying polymer and performing upkeep of the equipment.

Our Observations

- The only weak point in the system, as pointed out by the Fair Oaks personnel, is the use of conveyors for the DAF Cake handling. The conveyors that were originally installed were not designed for products that are as heavy as the solids are and the equipment was not capable of handling the load. The conveyors were not provided by Trident Processes LLC and are currently being replaced by conveyors of heavier design. Ideally the system would discharge directly to a push wall where the solids could be removed using a front loader or similar piece of equipment.
- The low power costs and low maintenance costs of the Trident Nutrient Recovery System is one of the real advantages that this system has over typical dewatering systems such as centrifuges and belt filter presses.
- Like all coagulation or flocculation systems, the need for polymer and the ongoing cost of this product is one of the negative aspects of this technology.
- Comparison of Trident's published expected results and the actual results indicate that the rotary screens normally supplied with this system, designed to size the coarse solids to maximize the DAF performance, would be expected to increase the phosphorus recovery by approximately 5%. At Fair Oaks the existing slope screens were used.
- It should be noted that the results from the dairy did include a significant number of samples during the start-up of the system that will probably be statistically removed once the number of results is increased.

How Newtrient Can Help

- Integration of these systems with other advanced nutrient recovery systems like ammonia recovery and energy recovery systems like digesters and gasifiers will lead to more adoption. Newtrient can facilitate the inclusion of this technology in some projects over the next several years.
- Integrating this technology as part of a larger "back-end" system that includes companies like Midwest Bio-Ag and Proteus Environmental Technologies represents a way to increase the value for this manure derived fertilizer product.
- Inclusion of this technology in the recommendations of Newtrient will assist in the marketing of the process and the acceptance by dairymen who have not had personal experience with the system.

Newtrient Technology Evaluation

Trident Nutrient Recovery Technology	Newtrient Opinion
State of Development	This is a fully developed technology that is operating at a commercial scale.
Minimum size available (number of cows)	Provider estimates that the smallest standardized system will be able to process the manure from 500 cows. It can be used on smaller herds but would be underutilized.
Expected value added output	Approximately 8.5 lbs. per cow per day at 77% moisture of fine solids cake that is higher in phosphorous than raw manure.
Estimated Capital Cost	$800,000 for smallest standardized system.
Estimated Annual Operating Cost	Approximately $20,000 per year for fully utilized smallest standardized system
Estimated Gross Sales	Approximately $25,500 per year for fully utilized smallest standardized system at an average price of $400/ton for N & P contained in the cake and effluent.
Estimated IRR (Based on 15 Years @ 25% equity)	At above values there is no return on investment for fully utilized smallest standardized system.
System Strengths	The low power costs and low maintenance costs are the real advantages that this system brings over typical dewatering systems such as centrifuges and belt filter presses.
System Weakness'	The need for polymer and the ongoing cost of this product is one of the negative aspects of this technology.
Current Newtrient Recommendation	This technology is ready for commercial installation at this time. The technology shows great potential for the dairy industry and has been proven by four years of operation on a dairy in WI. We recommend it at this time for appropriate applications.