Fixed Film Digester at Farber Dairy Farm: Case Study

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Who Should Consider a System Like This?

- Farms in need of odor control that may not want to generate electricity
- Farms where manure can be collected easily
- Farms with technical interest and skills for the system operation and maintenance
- Farms with capital available for the building and maintenance of the system
- Farms that want a digester and have limited space

Farm Information

JJ Farber Dairy is located in the town of East Jewett in Greene County. The farm milks 100 cows and has been a closed herd for many years. The farm is located in the New York City watershed and has used a liquid manure storage system for the past 10 years. Complaints about odor from neighbors are the primary reason for the installation of the fixed film digester.

Why the Digester?

The JJ Farber farm has turned to the fixed film digester to solve problems with odor control. The farm operates in a tourist area of the Catskill Mountains including winter skiers and summer golfers and hikers. The farm is also a vacation house for the owner. The fixed film digester is an anaerobic digester that will reduce the odor from stored manure. Another of the potential benefits of the system is the possibility of using dried solids as bedding. The digester system requires a manure separator and the separated solids after composting may be used for bedding.

Digester System

System and Process Description

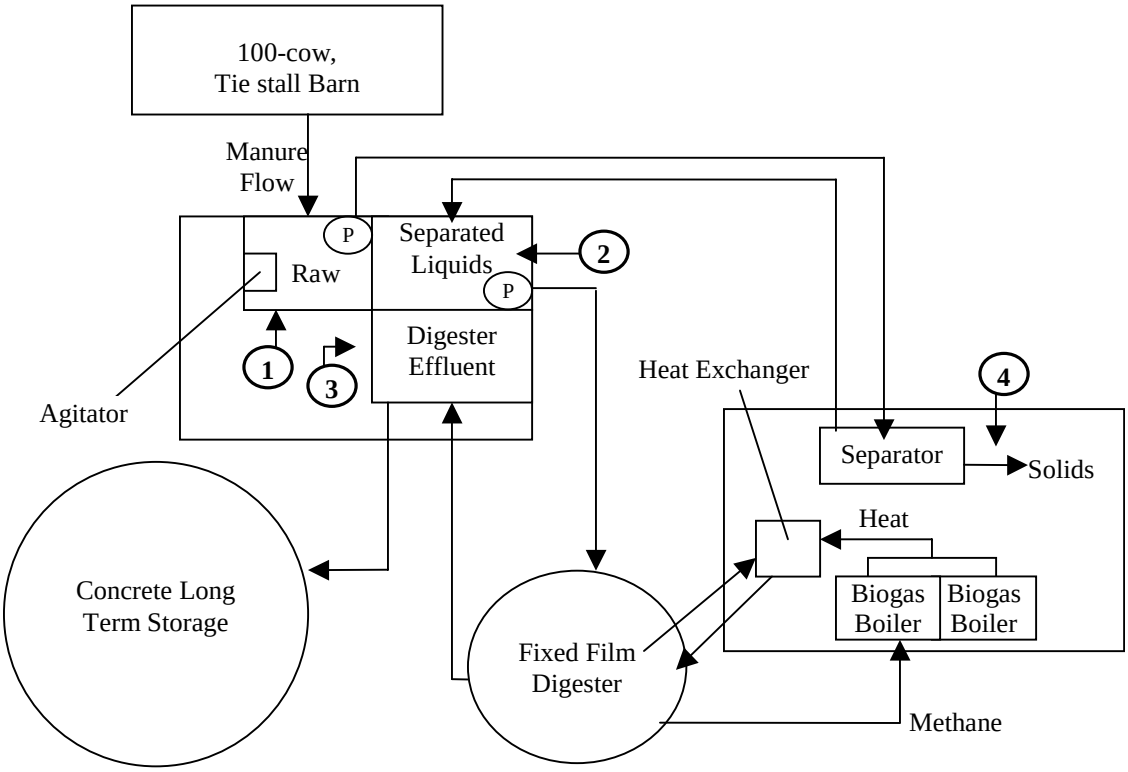
The digester system is composed of sub-systems. (See figure 1)

- Manure collection
- Fixed Film Digester and Biogas production
- Boiler system and heat exchange
- Manure separator system
- Liquid storage
- Composting

The digester at the JJ Farber farm is a fixed film anaerobic digester consisting of an insulated 10.5’ diameter x 16’ overall height concrete tank. The fixed-film media is corrugated plastic

drainage tile set upright inside in bundles giving the microbes 12,000 square feet of surface area for attachment. This allows the system to have a 4-day retention time by retaining a large amount of organisms in the digester. The insulated digester is liquid and gas tight to collect the 2400ft^3/day (24ft^3/cow-day) of biogas (40% carbon dioxide, 60% methane).

A gutter collects 1,872 gallons of manure daily from the tie stall barn. This cleaner delivers the manure into a 2-day reception pit where milk house waste is added and clean water can be added as needed to create a pumpable slurry. Daily, 2,000 gallons of this slurry is pumped to a screw-press type manure separator that produces 1,620 gallons of liquids and 140 cubic feet of solids. This slurry is pumped to a manure separator whose separated liquids are fed to the digester; the solids are composted and sold off farm or used as bedding.



FA	Mass Flow (lbs)	Moisture Content (%)
1 - Raw manure	16,919	89.73
2 - Separated Liquids	13,494	94.87
3 - Digester Effluent	11,334	95.50
4 - Separated Solids	3,425	75.24

Figure 1. Schematic of Fixed Film Anaerobic Digester System on Farber Dairy Farm.

Heat Generation

Heat for the digester is obtained from two natural gas boilers. The boilers are set-up in series. Water is first heated with the methane boiler then, if needed, the secondary propane boiler raises the water to the desired temperature. The propane boiler runs very little in the winter and less in the summer. The digester generally produces enough methane to heat the digester with some extra heat for the drying of composted solids. Hot water from the two boilers flows through a

stainless steel shell-in-tube heat exchanger. Manure from the digester tank is also continuously circulated through the shell in tube heat exchanger with a 1 HP pump. This heat exchange system maintains the digester at 98^{o}F without contaminating the clean hot water.

Liquids and Solids Process Description

Prior to digestion, the manure from the barn is separated using a screw press manure separator. This produces a liquid with solids content of about 5% and a stackable solid with a solids content of about 27%. The separated liquids are pumped to the digester with a grinder pump ensuring every particle is ¼ inch in diameter or smaller. The grinder pump runs every 30 minutes for 20 seconds. The digested liquids (4.2% solids) gravity flow to a temporary underground storage, then are pumped to the long-term storage (for up to 8 months) before being spread on fields in the spring, summer and fall months.

The solids have multiple uses. These include daily spreading, composting for off farm sales and as an alternative bedding. Finished compost has been sold for $10/ yard.

Economic Information

	Items	Costs/Benefits
Capital Costs	Digester	
	– Digester Tank and materials	$46,000
	– Partial building cost	$5,000
	– Boilers and heat exchange	$8,000
	Subtotal	$59,000
	Solids and Liquids Separation	
	– Separator	$12,000
	– Composter Drier	$11,000
	– Building and equipment	$25,000
	Subtotal	$48,000
	Liquid Storage (existing)	$160,000
	Others	$27,000
	Total Capital Cost	$294,000
	Annual Capital Cost	$21,925
Annual Operating Costs	Maintenance, Repairs, Labor, Fuel, Insurance, Reporting, Spreading Costs, etc,	$24,000
Annual Benefits Including	Bedding material replacement, fertilizer savings, bedding savings, field usage	$13,000
Annual Cost per Cow ($/cow/year)		$329

Environmental Benefits

The indicator organism fecial coliform has a 1.5 log reduction as it goes through the separation and five day digestion process in the system. Nutrients from the manure can be managed better and used on the farm due to the reduction of odor of the liquid storage manure. Fields that were previously inaccessible to manure spreading due to odor complaints can be fertilized with the low odor digester effluent. Nutrients can be exported off the farm and possibly out of the New York City watershed from the sale of compost.

Advantages and Disadvantages

Advantages	Disadvantages

- Odor control - Pathogen reduction - Bedding savings - Nutrient reduction	- High capital cost - High operating cost - Dedication to digester system management

Lessons Learned

Pumping tiestall manure with long hay is still problematic. Farms that need to pump manure for further processing may need to chop bedding and not use the manure as a disposal for refused hay. One point two gallons of water added near the impellor increases the pumping rate of undiluted manure from a tiestall barn.

Separation ahead of digestion removes 30% of the Biodegradable Volatile Solids. The solids removed are about 1 cubic foot per cow per day, and consist of about 27% solids and are 20% of the mass. The liquids, about 17 gallons and 80% of the mass, consist of about 6% solids. The liquids are pumpable after the separator.

A grinder pump will convert any remaining longer particles of manure into pieces less than 1/4th of an inch. Smaller particles will cause less plugging of heat pipes and provide better digestion.

A conical bottom to facilitate solid removal may prevent solids from remaining in the digester bottom even after a drainpipe is opened. Sediment will accumulate even with flow promoted from outside to the center with a flat bottom.

An external shell and tube heat exchanger made with ¾ inch pipe can work in digesters on separated liquid. An automatic back flush device operating for 26 seconds every 2 hours will keep plugging from occurring. The external heat exchanger allows maintenance to occur with out opening up the digester.

Calcite added to the manure system as bedding conditioner and barn floor traction will precipitate out of digesters and cover fixed film components in a digester. Don't add lime to a manure processing system without a method for calcium removal.

A 5-day retention time in a fixed film digester will provide odor control as well as 30 cubic foot of biogas per cow per day. The gas production is sufficient to maintain operating temperatures in the digester with a biogas boiler even during the winter.

Corrugated Plastic Drainage Tubing can be used as a fixed film media. Four inch diameter CPDT placed 8 feet on end in a ten foot diameter tank provided 11,965 square feet of surface area on the corrugated pipes, 433 square feet on the walls, and 86 square feet on the floor surface area. Other proprietary media may also work. Increasing the surface area to increase the biological activity is the goal of the fixed film.

Foaming issues occurred as changes to the digester feed rate occurred and when the diet of the cows changed. Foam can be controlled with a foam cutter sprayed on the surface at a concentration of 100ppm. Other adoptions to reduce the impact of foaming were raising the gas inlet and increasing the water trap in the gas line.

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