The AGF Process

The AGF process uses existing anaerobic reactors to improve the digestion process. Anaerobic bacteria are conserved by concentrating the bacteria and returning them to the digester. The digester's bacterial and solids concentration are maintained at a higher level.

Solids retention times (SRT's) can be three to four times the hydraulic retention time (HRT). The percentage of solids converted to gas is significantly improved. More methane gas is produced.

Solids are periodically wasted from the thickened return solids stream. Since the waste solids are highly concentrated, only a small volume must be wasted. The waste solids flow is approximately 1/4th to 1/5th of the influent flow to the digester.

The concentrated waste solids are also charge neutralized. The time and polymer required to further dewater the waste solids are substantially reduced. Belt press dewatering is commonly reduced to 1/4th the conventional time required.
Gas Flotation Separation

The AGF process uses "Anoxic Gas Flotation" to accomplish solids separation. Flotation is a natural non-disruptive anoxic process which does not adversely affect bacterial viability. Flotation is more effective than settling without the adverse effects of more intense separation techniques. Gas flotation can also improve gas quality by significantly reducing the H2S and CO2 concentration of the product gas.

Use of CO2 flotation creates carbonates which provide many benefits including the prevention of struvite formation and scaling.

Flotation separation can also remove hydrophobic proteins, enzymes, and organic acids resulting in a relatively clear effluent.

During flotation, both charge induced particle attachment and surface tension effects accomplish solids separation. Consequently, less polymer and energy are required for flotation separation.

Effluent Quality

Seventy five to eighty percent of the of the raw sludge flow to the digester is discharged from the AGF unit as a relatively clear effluent. Typically the effluent contains less than 1000 mg/L of total solids.

The inhibitory end-products of digestion such as ammonia and sulfide are removed with the effluent. Removal of the inhibitory end-products enhances the anaerobic digestion process. Ammonia and soluble phosphate can be recovered as a valuable product.
The AGF pasteurization process takes advantage of the enhanced digestion capabilities of the AGF process. Typically the AGF process increases the capacity of a single digester by three to four times its conventional capacity. Additional digesters are then available to redigest pasteurized solids. An AGF separator occupies less than 1/4 the space of a single digester, uses less energy than that required to mix a single digester, and will cost less than 1/3rd the cost of a single digester.

The AGF process makes additional digesters available for the re-digestion of pasteurized solids with pathogen free bacteria. The low volume of waste solids from the AGF process can be economically pasteurized in small pasteurization tanks with detention times of 0.5 to 1.0 hours. The pasteurization tanks typically have a volume of 100 gallons per 1.0 mgd of treatment plant capacity.

Pasteurization Operation

Small quantities of thickened waste solids are withdrawn from the float, or thickened return flow at one hour (±) intervals throughout the day. The float solids are generally 5.5% to 6% total solids. The thickened solids are diluted to a digester concentration of 2.75% to 3.5% with steam to reach the 70°C
pasteurization temperature. The pasteurized solids are then re-digested in a secondary digester. Re-digestion of the pasteurized solids increases the total volatile solids reduction by an additional 5% to 10%. A total process volatile solids reduction of 70% to 80% is expected. The remaining 20 to 30% are Class A biosolids. However, since they have little or no odor and do not possess vector attraction characteristics, we give these solids a mark of A+.

**Heat & Energy Requirements**

The secondary digester obtains sufficient heat from the pasteurized influent. No additional digester heating is required.

The AGF pasteurization process is more economical than other thermophilic or pasteurization processes since only a small fraction of the total flow is heated to higher temperatures. Each of the AGF digesters are operated at mesophilic temperatures. The AGF pasteurization process does not require any more additional heat than that required by two conventionally insulated mesophilic digesters, unlike thermophilic processes. The excess gas produced can be used for energy production.

**Implementation**

The existing digesters, heat, and mixing systems are used. The process can be implemented by simply adding an AGF unit, pasteurization tank, and steam injector. The AGF can be installed in an existing tank. The process can be installed in 3 to 6 months.
The ClearCycle™ Process

The ClearCycle™ process is used to treat dilute industrial waste containing both slowly degradable and rapidly degrading constituents. The factor limiting the performance of any retained biomass process is the accumulation of organic and inorganic solids within the digester. Since all retained biomass processes accumulate inorganic and slowly hydrolyzed organic materials, a certain portion of the reactor contents must be wasted daily to maintain manageable solids concentrations in the digester. Unfortunately, wasting inorganic and slowly degrading organic solids results in the unnecessary loss of beneficial biomass.

The best approach is to remove only the inorganic solids in a separate waste stream using existing technology while further reducing the slowly degrading organic solids in a separate high solids concentration holding reactor. To overcome the adverse consequences of accumulating inorganic and slowly degrading organic materials in the anaerobic reactor, we developed the ClearCycle™ process, which uses two smaller anaerobic reactors with an intermediate separator of any type. The total tank volume is minimized.

The degradation of particulate matter is accomplished in two reactors. The rapidly assimilated materials are degraded in a low retention time, low solids concentration, reactor. The slowly degraded solids are reduced in a high solids concentration reactor over a prolonged period of time. Since only dilute solids are thickened, chemical use is minimized. The ClearCycle™ process can be used with an AGF separator or any other separator to treat mixed organic waste containing constituents with different hydrolysis rates. The process is independent of the volume treated. The process design is based solely on organic loading. The process has been successfully demonstrated treating two different potato wastes over a 12 month period.
The above process is patented and trademarked.
Flotation Technology

From the discussion of the AGF and related technologies, it is clear that flotation design is one of the key technologies that enables the process to be successful. We have invested thousands of hours in the study of alternative approaches to the flotation process. We have in the course of developing the AGF developed a significant amount of insight and expertise in the design of flotation units.

Based on this experience, we design, construct, and install flotation units that meet the unique requirements of treatment processes as well as the particular spatial and footprint requirements of a site. Our separators can be installed in existing tanks, with or without covers, and with internal or external hydraulic drives.

Our ability to install flotation separators in existing tanks allows us to replace overloaded gravity thickeners with high capacity flotation thickeners. The drive mechanism for the thickener is simply replaced with our flotation unit and a cover placed over both the existing tank and the float unit.

Our flotation technology is used in our patented AGF process and associated processes. Biogas consisting of methane, hydrogen sulfide, and carbon dioxide are used for flotation. Gas cleaning and sequestering of carbon dioxide and hydrogen sulfide can be incorporated in the process.

We offer flotation units in a variety of construction materials including fibreglass, coated carbon steel, powder coated steel, 304 and 316 stainless steel. The covers can be constructed of the same or different materials.
Benefits Summary of the AGF Process

Capacity

The AGF Process expands the capacity of existing digesters by 3 to 4 times their current capacity while using 1/4th the land area, and 1/8th the volume of a single digester. The AGF process uses less energy than required to mix a conventional digester. SRT/HRT ratio's above 3.0 are commonly used.

Volatile Solids Destruction

The AGF Process substantially increases the SRT of a digester and as a result, substantially increases the volatile solids conversion to gas. (70% to 80% VS destruction using AGF alone and 80% + with AGF Pasteurization Process).

We have created a plot of VS destruction vs SRT for the different existing technologies including AGF. This plot shows that each of the technologies achieves a common VS destruction as a function of SRT. The issue becomes the cost effectiveness of achieving that SRT/VS Destruction. We believe that AGF is significantly less expensive than the other technologies.

VS Destruction vs SRT Plot as a PDF.

Operational Flexibility

The influent solids do not have to be thickened to the extent required for conventional digestion. More dilute influent solids can be fed. In addition, dewatering requirements are not based on influent sludge volume. The solids can be concentrated in the digester while the dewatering schedule is adjusted to accommodate the needs of the operator. Incorporating AGF solids removal reduces the need to clean digesters.

Solids Dewatering
Environmental Energy Benefits

The time required to dewater waste solids is reduced to 1/3rd of the time required to dewater conventionally digested solids. Dewatering polymer is also reduced while cake solids concentrations are increased.

Gas Quality

The AGF process produces a high quality gas. Ninety percent reductions in H2S levels and fifty percent reductions in CO2 levels can be achieved.

Scaling

Struvite formation and precipitation are inhibited through the AGF gas flotation process.

Effluent Quality

Both soluble and particulate constituents can be removed by gas flotation. A high quality liquid effluent is produced from which nitrogen and phosphorus can be recovered.

Storage

Biosolids are stored in existing digesters but their solids concentration is increased. This allows the digesters to in a sense work more efficiently. This enablest a plant's total processing capability to be significantly increased just through the use of the AFG process without any need for additional digesters.

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Papers on Environmental Energy Company's Technology

Overview of AGF (in PDF) and its use in pilot plants and full scale facilities.

Operational Economics Example for a 10 MGD Plant (in PDF). Shows the benefits deriving from purely operational benefits associated with energy production and decreased solids disposal costs.


**Environmental Energy Patents**


Burke, D.A., ...*Pasteurization Process*, approved, number to be assigned.

**Independent Papers on AGF and Associated Processes**

Various King County, WA Reports, one of which is excerpted below.

[King County's assessment](#) of AGF Pilot Plant at Renton Facility

National Pork Producers Council, [Technology Assessments](#)
