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(54) **BIOMASS TREATMENT OF ORGANIC WASTE MATERIALS IN FUEL PRODUCTION PROCESSES TO INCREASE ENERGY EFFICIENCY**

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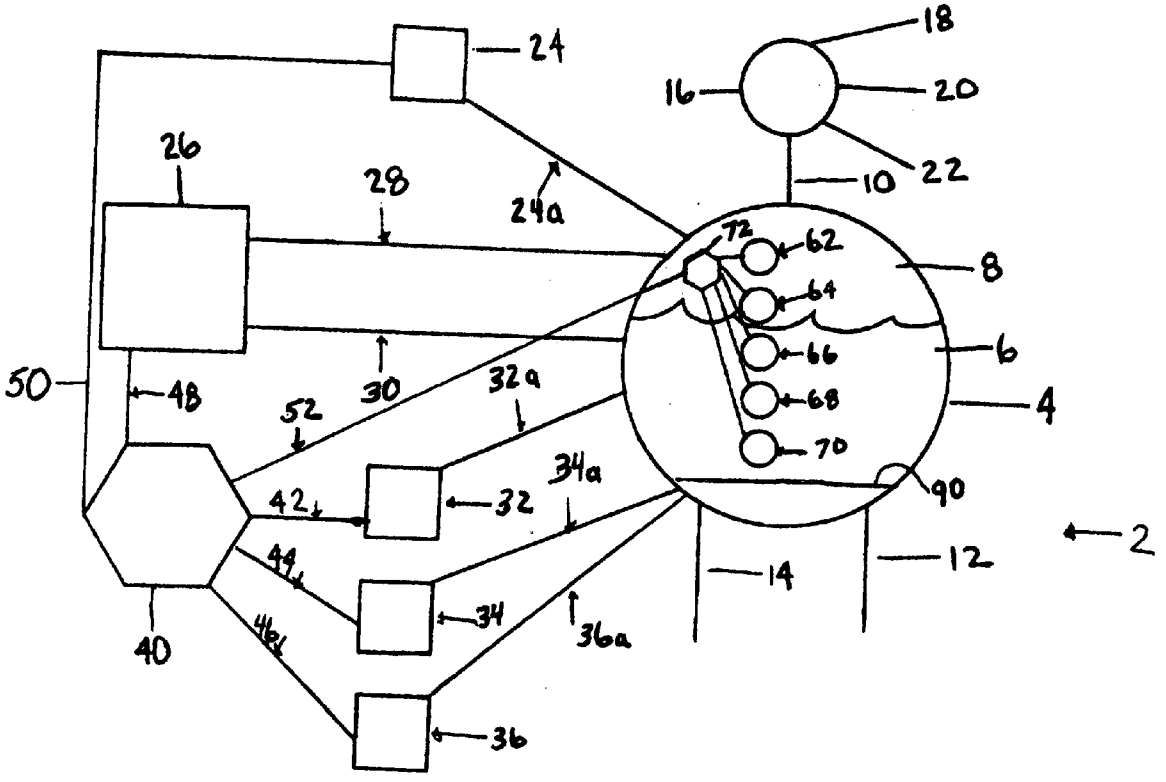
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(57) **ABSTRACT**

A method, system, apparatus and program extracts energy from organic residual materials produced by the manufacturing of biofuels. Energy is extracted from the biofuels residuals using anaerobic bioconversion to produce a fuel for use in the manufacturing process for producing synthetic biofuel or as an additional energy product for sale comprises: providing at least one bioconversion tank for conversion of organic waste material, the bioconversion tank containing an active biomass comprising at least one bacteria that decomposes organic material; providing at least one inlet to the bioconversion for organic material; a processor that receives and stores information on: the status of chemical oxygen demand of the active biomass; and the oxygen provision capability of any organic material that can be fed into the bioconversion tank through an inlet; a mass flow control system controlled by the processor which feeds at least one organic material through an inlet at a rate based at least in part upon the status of chemical oxygen demand in the bioconversion tank as recognized by the processor.



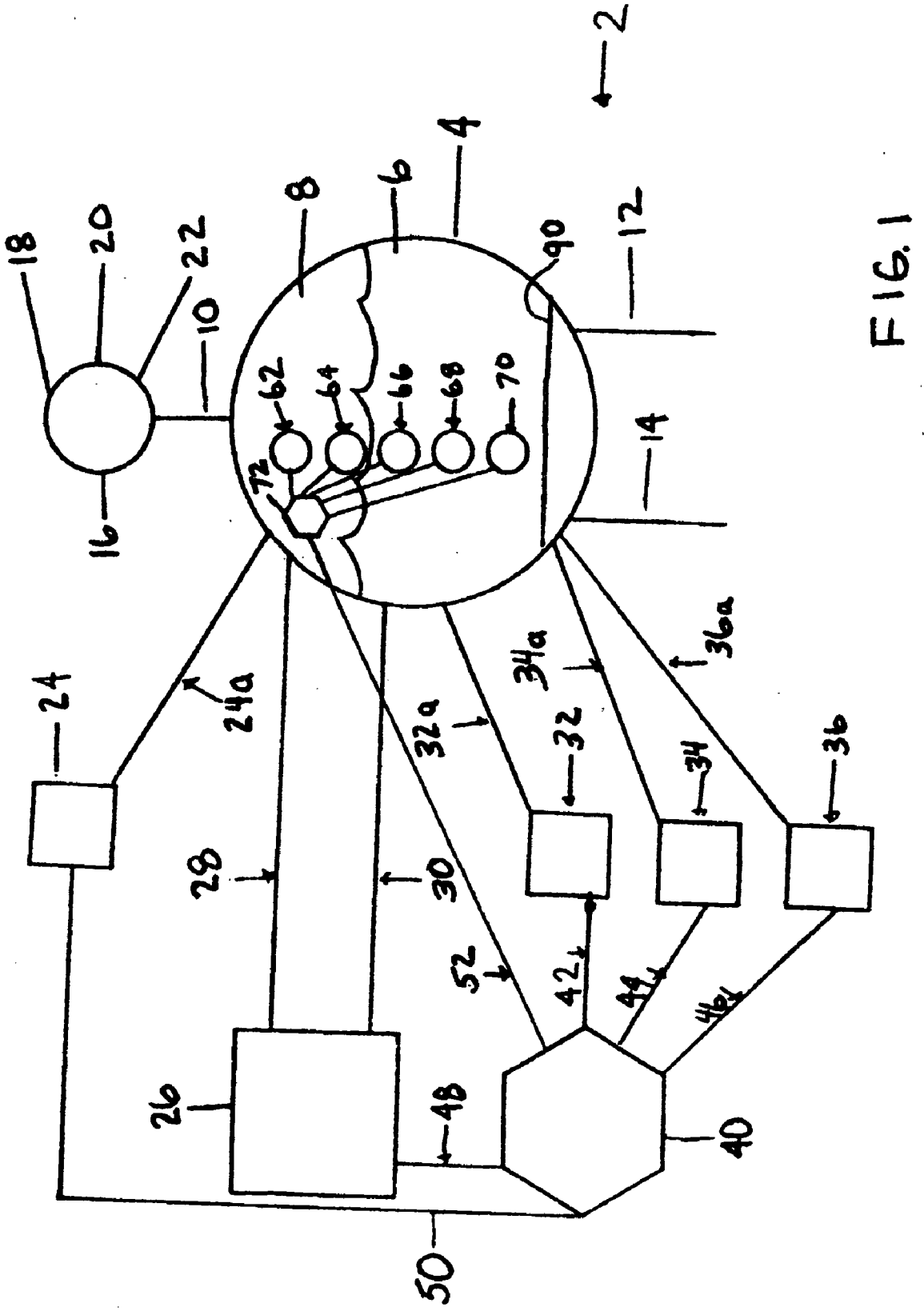

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FIG. 1

BIOMASS TREATMENT OF ORGANIC WASTE MATERIALS IN FUEL PRODUCTION PROCESSES TO INCREASE ENERGY EFFICIENCY

RELATED APPLICATIONS DATA

[0001] This application is a continuation-in-part of U.S. Provisional Patent Application Ser. No. 60/833,526, filed, Jul. 16, 2006, which is in turn a continuation-in-part of U.S. patent application Ser. No. 11/126,433, filed Aug. 18, 2006, which claims priority from U.S. Provisional Application No. 60/709,313, filed Aug. 18, 2005.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to the field of material conversion, whether original materials or wastes, particularly organic waste streams from organic fuel synthetic procedures, such as ethanol production or biodiesel production, and the conversion of such waste and contaminants into an energy source (e.g., methane) by using processes (such as fermentation or other bacterially induced or controlled chemical modification) involving living organisms (Bioconversion), such as active or bacterial biomass to convert organic biofuel processing residuals into at least some or primarily gaseous products, and use of the gaseous products as a fuel in the organic fuel synthetic process, or sale of the gaseous products as fuel, or conversion of the gaseous products to another form of energy such as electricity.

[0004] 2. Background of the Art

[0005] Many different synthetic procedures exist for the synthesis of biofuels. Each of the various procedures for synthesis of biofuels results in residual organic material(s) remaining after the primary biofuel is created. Examples of primary biofuels include ethanol and biodiesel. Examples of residuals produced by the synthesis of biofuels include whole stillage, thin stillage and glycerin.

[0006] Currently residuals from the synthetic procedures undergo further processing and refinement in an attempt to create a commercial viable product. This further processing and refinement of residuals is energy intensive. The objective of any commercialized biofuels process is to create a biofuel with more energy potential than the energy required to create the biofuel. An example would be ethanol whose published energy balance states that it requires one unit of input energy to create ethanol which has potential value of 1.2-1.8 energy units (depending on the reference used). However, the energy balance figures include all of the costs associated with the further processing and refinement of the residuals of the biofuels synthetic procedures, such processing and refining being energy intensive reducing the net positive gain in energy (input versus output) substantially.

[0007] Biodiesel is an example of a renewable diesel fuel that is used across the world today. Biodiesel can be manufactured from vegetable oils, animal fats, waste vegetable oils (such as recycled restaurant greases, called yellow grease), microalgae oils, or any combination thereof, which are all renewable. These feedstocks can be transformed into biodiesel using a variety of esterification or transesterification technologies.

[0008] Biodiesel use is growing rapidly, increasing from about 7 million gallons in 2000 to more than 20 million gallons in 2001, with additional production capacity available to quickly accommodate further growth. Current U.S. biodiesel production is based largely on soybean oil and used cooking grease, both of which are abundant feedstocks. The most frequently used biodiesel feedstock in Europe is rapeseed (canola) oil. No matter what the process or the feedstock used, the produced biodiesel must meet rigorous specifications to be used as a fuel. Fuel-grade biodiesel must be produced to strict industry specifications, as is described in the American Society for Testing and Materials method, ASTM D-6751, in order to insure proper performance in diesel engines. Technically, biodiesel is defined as a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, designated B100, and meeting the requirements of ASTM method D-6751. Fatty-acid alkyl esters are actually long chains of carbon molecules (8 to 22 carbons long) with an alcohol molecule attached to one end of the chain. Biodiesel refers to the pure fuel without blending with a diesel fuel derived from fossil fuels. The biomass-derived ethyl or methyl esters can be blended with conventional diesel fuel or used as a neat fuel (100% biodiesel). Biodiesel blends are denoted as "BXX" with "XX" representing the percentage of biodiesel contained in the blend (i.e.: B20 is 20% biodiesel, 80% petroleum diesel; B100 is pure biodiesel). Pure biodiesel typically requires special treatment in cold weather, due to a high pour point. Biodiesel, as defined in ASTM D-6751, is registered with the U.S. Environmental Protection Agency (EPA) as a fuel and a fuel additive under Section 211(b) of the Clean Air Act. Biodiesel is used mostly as a 20% blend (B20) with petroleum diesel, in federal, state, and transit fleets, private truck companies, ferries, tourist boats and launches, locomotives, power generators, home heating furnaces, and other equipment.

[0009] Biodiesel is non-toxic and biodegradable. It is safe to handle, transport, and store, and has a higher flash point than petroleum diesel. Biodiesel can be stored in diesel tanks and pumped with regular equipment except in colder weather, where tank heaters or agitators may be required. Biodiesel mixes readily with petroleum diesel at any blend level, making it a very flexible fuel additive.

[0010] One of the unique benefits of biodiesel is that it significantly reduces air pollutants that are associated with petroleum diesel exhaust. It can help reduce greenhouse gas emissions, as well as sulfur emissions since biodiesel contains only trace amounts of sulfur, typically less than the new U.S. EPA rule finalized in 2001 that required that sulfur levels in diesel fuel be reduced from 500 ppm to 15 ppm, a 97% reduction, by 2006.

[0011] Many different synthetic procedures exist for the synthesis of biodiesel fuels, such as the non-limiting list of Published US Patent Applications and US Patents 20050210739 (Esen); 20050108927 (Velappan); 20040159042 (Murcia); and 20040074760 (Portnoff).

[0012] Published US Patent document 20030111410 (Branson) teaches the use of a process and apparatus for processing agricultural waste to make alcohol and/or biodiesel. The agricultural wastes are subjected to anaerobic digestion which produces a biogas stream containing methane, which is subsequently reformed to a syngas containing carbon monoxide and hydrogen. The syngas is converted to an alcohol which may be stored, sold, used, or fed directly

to a reactor for production of biodiesel. The solids effluent from the anaerobic digester can be further utilized as slow release, organic certified fertilizer. Additionally, the wastewater from the process is acceptable for immediate reuse in agricultural operations.

[0013] Methods of treating wastewater rich in nutrients are disclosed, for example, in U.S. Pat. No. 5,626,644 to Northrop, U.S. Pat. No. 4,721,569 to Northrop, U.S. Pat. No. 4,183,807 to Yoshizawa, et al., and U.S. Pat. No. 5,185,079 to Dague. Methods of utilizing agricultural waste or biomass as fuel for electrical generation are disclosed, for example, in U.S. Pat. No. 5,121,600 to Sanders, et al. Methods of converting methanol and fats or oils to methyl esters and biodiesel are disclosed in, for example, U.S. Pat. Nos. 5,713,965 to Foglia, et al., 6,015,440 to Noureddini, and 6,440,057 to Nurhan, et al. The disclosures of these patents are incorporated by reference herein in their entirety.

[0014] Similarly, there are many synthetic procedures for the production of ethanol from agricultural materials such as corn and high sugar content crops. 20060019360 (Verser) teaches a process for producing ethanol including a combination of biochemical and synthetic conversions that result in high yield ethanol production with concurrent production of high value coproducts. An acetic acid intermediate is produced from carbohydrates, such as corn, using enzymatic milling and fermentation steps, followed by conversion of the acetic acid into ethanol using esterification and hydrogenation reactions. Coproducts can include corn oil, and high protein animal feed containing the biomass produced in the fermentation. Other disclosures of synthetic ethanol production from waste or agricultural products are shown in Published US Application Nos. 20050266540 (Offermann); 20040180971 (Inoue); 20010023034 (Verykios); and the like teach synthetic production and use of alcohols, such as methanol and ethanol from waste products. All of these patents are incorporated herein by reference for their disclosures of methods of production of biofuels from waste materials.

SUMMARY OF THE INVENTION

[0015] The disclosed technology relates to the field of renewable energy and particularly utilization of organic residuals resulting from the production of synthetic organic fuels. Additionally, the present technology relates to the improvement of the overall energy efficiency of the fuel making process so that the overall process becomes more energy efficient. Gaseous fuels created could additionally be sold as a product or converted to other useful forms of energy such as electricity.

[0016] In one sense, the technology relates to any primary or secondary synthetic, organic fuel manufacturing process that requires energy input in the manufacturing process and produces both a fuel stream and a residual waste stream. The residual waste stream is subjected to a bioconversion or chemical conversion (reaction), producing combustible gases (especially organic compound gases) such as methane (or other C1-C10 alkanes or combustible hydrocarbons or carbohydrates such as alcohols), hydrogen, ammonium and the like. The combustible gases are then used as a source of energy in the primary synthetic, organic fuel manufacturing process. The source of energy may be used to generate heat for any segment of the primary process, to generate electricity for any segment of the primary or a secondary process or for any other energy supplying purpose.

[0017] The present disclosure also includes at least software, apparatus, processes and business methods for the implementation of this technology. A method of conversion of biofuel residual organic material to a source of energy to be used in the primary synthetic, organic fuel manufacturing process or as an additional energy product is practiced on the apparatus and using the software described herein may, by way of non-limiting examples, comprise:

[0018] providing one or more tanks or other containers or contained reaction volumes (hereinafter generally referred to as "tank(s)") for bioconversion of biofuel manufacturing organic residuals, said tank(s) containing an active biomass comprising at least one bacteria that bioconverts organic material in a residual waste stream from synthetic fuel manufacturing processes (as in biodiesel production, alcohol production, and the like);

[0019] providing one or more inlets to the bioconversion tank(s), individual inlets may be for organic material or an aqueous stream containing organic material;

[0020] a processor or user that receives and stores information (either directly from sensors or from manual input or other data entry on:

[0021] the status of chemical oxygen demand of the active biomass; and

[0022] the chemical oxygen demand of a first organic material that can be fed into the bioconversion system through the first inlet;

[0023] a mass flow control system controlled by the processor and/or by manual control which feeds at least one organic material through an inlet at a rate based at least in part upon the status of chemical oxygen demand in the bioconversion tank(s) as recognized by the processor; and/or

[0024] any other data or information that would influence intelligent control of the input and/or output of materials, reactants, and/or energy during the performance of the process and/or operation of the apparatus.

BRIEF DESCRIPTION OF THE FIGURES

[0025] FIG. 1 shows a schematic of a basic bioconversion system according to teachings herein.

DETAILED DESCRIPTION OF THE INVENTION

[0026] The present technology covers a wide range of potential commercial practices, and even where a specific field-of-use is described as an example, or specific equipment, or specific chemistry, or specific bacteria, or specific conditions are described, these specific teachings are to be interpreted as species examples within the scope of the generic concepts disclosed herein. For example, one specific field of use method that is contemplated within the generic scope of the technologies originally disclosed herein is a method of bioconversion of organic waste material from a synthetic fuel manufacturing process. The synthetic fuel manufacturing process requires energy input in the performance of the synthetic fuel manufacturing process. The

method itself comprises: providing a tank for bioconversion of organic waste material, at least some of which organic waste material is derived from a synthetic fuel manufacturing process and the tank containing an active biomass comprising at least one bacteria that decomposes organic material. One or more inlets is provided to the bioconversion tank, at least one inlet comprising an inlet for organic material from the synthetic fuel manufacturing process. A processor receives and stores information automatically (e.g., from sensors or gauges) or manually input (by human operators reading gauges or observing readouts) to the processor. Among the types of matters that could be preferred subjects for input would be data or status of:

[0027] chemical oxygen demand and/or biological oxygen demand of the active biomass; and

[0028] the oxygen provision capability of an organic material that can be fed into the bioconversion tank through any inlet.

[0029] The last matter (i.e., oxygen provision capability) relates to the ability of the organic material itself or an additive or component thereof or added therewith to provide oxygen within ot into the reaction system. That is, as the system has an oxygen utilization rate or requirement, desirable information would include how much reaction useable oxygen is available in the input organic material to determine levels of additional oxygen providing materials may be needed. The term itself, "oxygen provision capability," merely reflects knowledge of self-provision of oxygen that may be used in the biodecomposition or bioconversion process without additional introduction of additional useable oxygen-providing materials or reagents.

[0030] The method also uses a mass flow control system controlled by the processor which feeds at least one organic material through an inlet at a rate based at least in part upon the status of chemical oxygen demand in the bioconversion tank as recognized by the processor. There is a stream for carrying combustible gases from the biomass; and the stream providing at least some of the energy input in the performance of the synthetic fuel manufacturing process.

[0031] One method uses at least two storage tanks for organic material, a first storage tank for the first organic material and a second storage tank for a second organic material, the first and second organic materials having different chemical oxygen provision capabilities from each other. The processor receives and stores information on the respective chemical oxygen provision capabilities of the first organic material and the second organic material; and the processor feeds the first organic material and the second organic material into the bioconversion tank at a rate based at least in part upon the status of chemical oxygen demand in the bioconversion tank, the chemical oxygen provision capability of the first organic material, and the chemical oxygen provision capability of the second organic material as recognized by the processor.

[0032] The method removes an energy depleted aqueous stream from the bioconversion tank through an aqueous stream outlet and a gas (biogas) stream is removed from the bioconversion tank through a gas venting outlet, the gas (biogas) stream comprising primarily methane and carbon dioxide is removed from the bioconversion tank. The term "energy depleted" means that a significant amount of bioconvertible material has been converted out of the original material and that a stream subsequently removed from the system has significantly (e.g., more than 25%) of its biofuel energy capability removed from the stream as compared to a stream if no bioconversion process had been performed.

[0033] It is to be noted that the bioconversion processes of the technology described herein should be directed primarily at organic residuals, or sources of combinations of organic and non-organic residuals which may come from a wide variety of individual or combined sources for the ultimate purpose of this technology in the synthesis or organic fuels. For example, the residual may result from the earliest stages of separation of components that are to be introduced to the fuel synthesis stream (e.g., separating the leaves and beans in soy plants, separating the ears and stalk from corn, separating the beets and leaves/stems from sugar beets, separating the pith of a sugar cane from the cane, formation of textile fibers from agricultural products, etc.). The residual(s) may also result from the processed mass, such as where the pulp remains from sugar beets or soy beans, and fiber residue remains from leaves, stems and stalks from which the primary synthetic fuel containing ingredient has been removed.

[0034] Synthetic organic fuel manufacturing processes have their own energy input requirements, which has been one of the main arguments against the transition away from petroleum based fuels to renewable sources of fuels, such as ethanol or diesel from agricultural products. For example, many processes require drying of the raw material and significant mass movement of materials in the synthesis. An additional drawback has been the problem that the residual waste stream from the synthesis, even though producing recoverable chemical products, has produced such significant volumes of those products that the market has become saturated and disposal cost ineffective. One potential benefit of the present bioconversion process and system is that these residual products are converted to fuels that can support the primary synthetic process, reduce or eliminate the overall external input of energy into the system, and therefore produce a system with a much better efficiency and potentially produce an additional energy product for sale. As an example, if a traditional biodiesel manufacturing system were given scholastic values of input and output of energy, it might be considered to require an energy input (e.g., electricity) of 1.0 units to produce a useful energy output (e.g., calorie or octane output of a biodiesel or ethanol) of 1.2 equivalent energy units. It is clear on its face that by using an extremely low energy consumption waste residuals bioconversion step with biomass systems to convert residual waste streams to a fuel that would then produce useful energy for the primary synthetic process, the overall input/output efficiency would be increased, prophetically by at least 10-30% through performance of the present process, such that for an energy input of 1.0 units, the process of the present technology could produce an output of 1.2 to 1.5 units, without modifying the underlying primary synthetic process.

[0035] Because the underlying synthetic biomass-type process described in the background of this technology is already somewhat readily understood as to its chemical input and chemical output, the system may operate in a manner that assists in assuring that materials are present that are not treated by the biomass or should not be introduced

into the biomass, such as metals (even in high concentrations in dissolved or organically tied or chelated form), toxins (especially antibiotics, agricultural herbicides materials that would be toxic to bacteria, such as pesticides), and non-bioconvertible materials that would tend to collect in the biomass without bioconversion. It is possible to provide a venting/discharge system for such non-bioconvertible materials, but as noted, it is preferred to avoid introduction of significant amounts (e.g., municipal wastewater treatment plant sludges or agricultural manures, which may be 0.05%, 1.0%. 5%, 10%, 20% or more solids) into the system.

[0036] The technology disclosed herein has implications beyond biofuel generation, such as in a method of reducing total external energy requirements input into the operation of a system requiring energy input. The steps of the process may comprise: providing organic materials to a bioconversion process; performing a bioconversion process on the organic materials; producing combustible volatile organic material from the bioconversion process; and providing input energy to the operation of the system by oxidizing the combustible volatile organic material from the bioconversion process. The organic material may comprise at least 10% by weight water during the bioconversion process and at least some water is added with the organic materials provided to provide a total water content during the bioconversion. In many commercial processes where organic mass residues are produced with significant water content, it has been necessary to remove water, as by mechanical pressing, evaporation and the like. This adds a significant energy component into the underlying process. Where fuels are an ultimate product of the process, as in conversion of agricultural crop(s) to biofuels, the need to eliminate water during the fuel manufacturing process reduces the overall efficiency of the process. This is why some fuel manufacturing processes may produce only 1.2 units of energy as an output while requiring 1.0 units of input. In the manufacture of synthetic biofuels, water must be regularly introduced into the front end of the system and sometimes subsequently removed, which adds energy requirements in both the purification of the water and then removal of the water. The present technology has advantages in both providing (a) fuel(s) (biogas) without the necessity of removing water before the bioconversion process and the ability to recycle the discharge of the bioconverter back to the synthetic fuel processing facility for reuse in the production of synthetic fuels. The water input rate is often a function of water content of the added biomass, and the dissipation of the water in the process. Over periods of time the average rate of water added with the organic material is decreased in the practice of the present technology by recirculation of residual water from the bioconversion process. This recirculated water is provided with low energy process requirement water from the biomass, which contributes to reduced energy input in the biofuel manufacturing process. Thus at least part of the aqueous stream is recirculated back into the biofuel manufacturing process.

[0037] The aqueous stream that is or can be removed from the reactor mass may be used to provide both moisture and nutrient for growth of agricultural products. The water effluent stream can naturally contain nutrients remaining from unconverted biomass or partially converted biomass.

[0038] It is desirable to understand the basic terminology and activity within an anaerobic bioconversion system of the general type described herein, and the immediately following discussion is intended to assist in an appreciation of that technology. Anaerobic conversion is the bioconversion of organic material without oxygen present. This results in the production of gas (biogas) or low molecular weight liquids, a valuable product containing usable energy.

[0039] The system of bioconversion may also produce as a primary or secondary or incidental product, carbon dioxide. The carbon dioxide may be collected as a relatively pure or subsequently purified product for use in refrigeration, carbonation, cleaning solvents, dry ice manufacture and the like.

[0040] Biogas produced from the bioconversion processes described herein usually comprises a mixture of several gases and vapors, primarily methane and carbon dioxide, although by selection of bacteria and particular biomass feed materials, hydrogen, ammonia, alkanes and other useful gases and low molecular weight organic liquids may be provided. Methane (and other alkanes) is the main component in natural gas and contains the bulk energy value of the biogas, with the exception of hydrogen gas, which may be useful either for fuel cell energy production or direct combustion. Biogas occurs naturally, hence its name, amongst others in swamps and lakes when conditions are right. Anaerobic bioconversion within the systems and processes described herein can be used to produce valuable energy from organic streams. The system is generally described as a biological system, indicating that the process is carried out by biological organisms such as bacteria. The bacteria in the bioconvertive or active or digestive biomass have to be kept healthy while sustaining conditions for the bacteria. The bacteria bioconvert or degrade or digest or decompose the organic matter fed into the system. This means that the organic material is broken down into component parts or converted (by bioconversion alone or in combination with supplemental catalyzed reaction) into biogas. The system is generally operated in an anaerobic environment, without oxygen. This means that air preferably is not allowed to directly interact with the organic materials as they are being bioconverted to avoid uncontrolled oxidation or other chemical reaction with the air. To promote the production of biogas as a valuable product of the degradation, oxygen should or must be kept away from the environment where the biomass is bioconverting the organic materials.

[0041] There may be a number of steps that occur in the bacterial anaerobic conversion of the organic materials. These steps may include at least some of the following:

[0042] 1. hydrolysis: high weight organic molecules (like proteins, carbohydrates, fat, and cellulose) are broken down into smaller molecules like sugars, amino acids, fatty acids and water.

[0043] 2. acidogenesis: further breakdown of these smaller molecules into organic acids, carbon dioxide, hydrogen sulfide and ammonia occurs.

[0044] 3. acetogenesis: the products of acidogenesis are used for the production of acetates, carbon dioxide and hydrogen.

[0045] 4. methanogenesis: methane, carbon dioxide and water are produced from acetates, carbon dioxide and hydrogen (products of acidogenesis and acetogenesis).

[0046] There are several groups of bacteria that may or may not participate in each step; and, in total, ten or more and even dozens of different species usually are needed to bioconvert an organic stream completely.

Process Parameters

[0047] An anaerobic bioconversion process can be carried out in quite a variety of different conditions. All of these conditions have specific influences on the biogas production. Additionally, from a technological viewpoint, the biological process can also be carried out in more than one reactor (as parallel reactions and/or serial reactions in the conversion process), which has bioconversion efficiency and economic implications.

[0048] Thermophilic Vs. Mesophilic Bioconversion

[0049] (Bioconversion) bacteria generally have a temperature range in which they are most productive in terms of production rates, growth rates and substrate bioconversion performance. The several groups of bacteria involved in anaerobic bioconversion generally each have different temperature optimums. This results in two main (and not necessarily overlapping, but possibly overlapping) temperature ranges in which bioconversion usually can be performed optimally and most economically. These ranges are: 25-38° C. called the mesophilic range, and 50-70° C. called the thermophilic range.

[0050] These ranges have different characteristics, advantages and disadvantages of which the most important ones are: compared to the mesophilic process, the thermophilic process usually results in a higher bioconversion of the substrate at a faster rate. It is less attractive from an energetic point of view since more heat is needed for the process unless the substrate is already at or above the thermophilic temperature range.

Batch Processes Vs Intermittent Processes Vs. Continuous Processes

[0051] In process technology, three main types of process (models) are used, the batch process, the intermittent process, and the continuous process. In the batch process, the substrate is put in the reactor(s) at the beginning of the bioconversion period after which the reactor(s) is(are) closed for the entire period without adding additional substrate.

[0052] As explained before, bioconversion usually consists of several consecutive steps. In a batch reactor system, all these reaction steps occur more or less consecutively. The production of biogas (endproduct) is non-continuous: at the beginning only fresh material is available and the biogas production will be low. Half-way through the degradation period the production rate will be highest and at the end, when only the less easily bioconvertible material is left, production rate will drop again. In an intermittent mode process, fresh substrate is added intermittently or episodically in relatively uniform increments of both time and chemical oxygen demand of the substrate. In this mode, reactions have characteristics of both continuous and batch modes.

[0053] In a continuous process, fresh substrate is added continuously, and therefore all reactions will occur at a fairly constant rate resulting in a fairly constant biogas production rate while maintaining a relatively constant concentration range of ingredients within the reactor(s). Several combinations or variations of these three models are developed in process technology including the so-called plug-flow reactor and the sequencing batch-reactor all of which try to combine the advantages of each model.

Residence Time

[0054] The longer a substrate is kept under proper reaction conditions, the more complete its bioconversion will become. However, the reaction rate may decrease with increasing residence time. The disadvantage of a longer retention time is the increased reactor size needed for a given amount of substrate to be bioconverted. A shorter retention time may lead to a higher production rate per reactor volume unit, but a lower overall bioconversion efficiency. These two effects have to be balanced in the design of the full scale system.

Acidity or pH-Value

[0055] The groups of bacteria needed for bioconversion not only have an optimum temperature but also an optimum acidity at which they are most productive. Unfortunately, for the different groups of bacteria the optimum pH-value (measure for acidity) is not the same. The complexity of the entire system is increased by the fact that some of the intermediate products of the bioconversion have a tendency to lower the pH, making the later steps in the process more difficult. This makes balancing the pH in the system an important design and operational issue.

Organic Loading

[0056] Bacteria have a maximum bioconversion rate depending on the type of reactor, number of reactors, substrate, temperature etc. Organic loading is one of parameters used to describe this production rate. It is the amount of organic material put into the reaction medium per time unit.

[0057] The underlying area of technology may involve a water-based input stream into the system, a biomass or organic mass input feed stream into the system, an approximately steady or growing biomass within the system, a gaseous output stream, a liquid output stream (water-based), and an incidental (or optional) active biomass control activity. Each of the streams will be discussed. The term stream is used in the Chemical Engineering sense in that it represents a mass input, but the term stream is not limited to a continuous flow input, but includes an episodic/periodic or batch input or output.

[0058] The water-based input stream (which is desirable for ultimately sustaining a water-based output stream and assisting in the removal of soluble, suspendable, dispersible or otherwise carriable waste materials from the system) may be a potable input stream (either a natural source of water, such as a stream, lake, river, etc., or a purified supply as from a water treatment plant or well) or may be a stream containing dissolved, suspended, dispersed or otherwise carried organic materials, and preferably minimal content (e.g., municipal wastewater treatment sludges or agricultural manures) of materials that cannot be bioconverted by bacteria in the active biomass, as indicated above. Industrial wastewater streams may be desirable, especially where the organic and other content of the stream can be anticipated or even controlled, and will exclude those types of materials

that are incompatible with a bioconversion system, also as indicated above. Such streams might be from food processing plants, pharmaceutical plants, and the like. Streams containing animal waste products are not preferred. By accessing such wastewater streams, a source of low cost water containing organic material that can itself be converted for ease of disposal can be used, as opposed to using potable water streams. The use of the less preferred waste streams may be more desirable in localized areas where a water stream may be provided for local agricultural uses, especially those where there are no consumable agricultural materials (such as lawn or vegetation watering). The energy output of the process may be used to move and deliver non-potable agricultural water locally, as within a community or municipality.

[0059] The organic feed stream from the residual waste stream from the synthetic fuel process may include organic materials that can be bioconverted by bacteria, such as fibrous material, pulp, organic residue compounds, glycerin, oil, alcohol, stem, leaf, and the like. Other residual waste organic materials may even be added to the stream as long as the environmental/habitat environment of the biomass is maintained within the desired and essential conditions for survival and thriving of the mass. Other such added materials might include dated food products (e.g., cheese, cheese by-products, processed cheese, low cellulosic content vegetable and fruit masses (e.g., preferably excluding wood products having significant persistent or non-bioconvertible cellulosic material) such as rice starch, potato starch, potato mass, wheat starch, sugars, syrups, animal waste products (excluding bone and certain non-bioconvertible tissue, such as cartilage), synthetic organic materials, natural organic materials, dairy products or dairy intermediates in general (e.g., yoghurt, ice cream, milk, milk fat, cream, egg content preferably excluding shells), baked goods, expired food products, and the like.

[0060] Biomass content is designed to assist in bioconversion, treatment, digestion, or decomposition of the anticipated content of the organic biomass feed stream. Sources of such bacteria, any required nutrients, and the like can be found commercially, as for example, from BZT® Waste Digester cultures, enzymes and nutrients used to improve biotreatment performance and reduce BOD/COD (biochemical oxygen demand/chemical oxygen demand) loads in municipal and industrial water treatment clarifiers, trickling filters, ponds, lagoons, activated sludge systems and aerobic and anaerobic digesters. Amnite™ L100 systems from Cleveland Biotech LTD are another source of microorganisms. Other sources of biomass and supplements include Bionetix® Canada systems, Specific types of bacteria for such processes include, but are not limited to Bacteria; Proteobacteria; Alphaproteobacteria; Rhizobiales; Bradyrhizobiaceae, including such specific species as *Rhodopseudomonas cryptolactis; Rhodopseudomonas-faecalis; Rhodopseudomonas julia; Rhodopseudomonas palustris; Rhodopseudomonas rhenobacensis*; and other *Rhodopseudomonas* sp. Even though, as indicated above, wood and high cellulosic content materials are not preferred, *R. palustris* has the potential to be very useful because it can degrade and recycle several different aromatic compounds that make up lignin, the main constituent of wood and the second most abundant polymer on earth. Thus, this bacterium and those like it may be useful in removing these types of material from the environment. In addition, *R. palustris* converts N_2 into NH_4 and H_2, which can be used as a biofuel. *Chlamydomonas reinhardtii* has been found to be effective in the production of hydrogen gas from certain organic mass sources.

[0061] The emission streams basically comprise a water-based output stream, the gaseous fuel emission stream (e.g., methane, carbon monoxide, hydrogen, etc.) and the potentially periodic biomass output stream. The gaseous emission stream comprises the gaseous bioconversion, decomposition or digestion products made by the active or bacterial biomass on the organic mass input stream. The primary gases (depending upon the particular bacteria and organic mass feed provided) are likely to comprise at least some gases selected from the group consisting of carbon dioxide, methane, hydrogen, ammonia, hydrogen sulfide, and the like.

[0062] The water based output stream may comprise water and dissolved, suspended, dispersed or otherwise carried organic matter. The water output stream can be in sufficiently acceptable form as to be sent directly to municipal waste water treatment facilities, standard (e.g., municipal) water treatment facilities for conversion to potable, reused by the primary synthetic biofuels manufacturing process (with and/or without further clean up/treatment), or at least agriculturally useful water. Alternatively, relatively improved water effluent can be used locally in non-potable water applications to vegetation that is not to be ingested.

[0063] The biomass output can be little more than removal of biomass after growth of the biomass (the microorganisms) has exceeded a volume that is useful within the bioconversion/digestion/treatment/decomposition environment or tank(s) or reactor(s). The biomass is then removed and may be treated for direct use (e.g., fertilizer) or transported to another treatment facility to become starter, replenishment, or enhancing biomass for another treatment facility. There are certain biomass system bacteria that are known as non-growth bacteria that can be useful in the present technology, which would avoid the need for any regular removal of biomass as a stream. At the present time, those tend to be more expensive, less active, and are therefore not preferred. The provision of another commercial product in the biomass solids is also a benefit to the economics of the system.

[0064] An important additional aspect of the presently described system is the automation of controls to the system. Automation control may be effected by a local or central processor. Software will be embedded in the processor that can evaluate the data and, based upon look-up tables and/or standardized responses, make adjustments in various levels of control that the processor can exercise over individual elements of the system. Multiple organic mass inputs may be provided (e.g., in batch deposits, or by more controlled batch input from holding or storage tanks). As the content of the organic materials can be determined in advance of their introduction into a reaction vessel(s), and as the content or rate of addition of various materials can and should be controlled, and as the conditions and content of the reaction vessel(s) can be monitored, automated controls can be provided in the present system to provide more frequent and more reliable control over the performance of the system. For example, even as organic input stream material is stored, its content and characteristics can change, so that merely providing a single input consideration of the material into the reaction controls and stoichiometry of the bioconversion

process can lead to wide variations in system output. As the systems are intended to produce a marketable or immediately useful energy product (methane and/or hydrogen) and commercial gas stream (e.g., carbon dioxide), it is essential that the system be provided with control sufficient to assure a reliable output of the intended gaseous products. As the energy used in the synthetic process and the output of residuals that are converted to usable fuel are stoichiometrically related or approximated, the balance can be readily automated, designed and planned.

[0065] Sensing of parameters and conditions and properties within the system (defined as any and all of including input streams, output streams, and reaction vessels) can provide information or data that can be interpreted by or responded to by artificial intelligence (e.g., processors, hardware, software, field programmable gated arrays (FPGA), ASICS, chips, and the like) to alter mass flow, temperature, reaction times, pH, pressure, nutrient addition, and the like. It is also desirable to have the various components set up in a network or even a mesh network wherein multiple receivers/transmitters are distributed throughout the system so that if any single receiver transmitter fails, signals can be captured and transmitted by other receivers in the mesh network. To best effect this type of system, individual sensing/signaling components should have specific identifying information attached to emitted signals so that upon receipt of the signals by the main or central control processor, the specific source of the signal is identified by origination information from a specific sensor as opposed to merely the path of transmission, which may have multiple sensors sending information over the same transmitter or line within the system. Among some of the types of particular analysis or sensing are estimated chemical oxygen demand (COD), estimated Biochemical Oxygen Demand (BOD), pH at various locations within the system, temperature at various locations within the system, pressure at various points within the system, specific chemical content at various points within the system, mass flow rates (including solids, liquids and gases), nutrient requirements and estimates, and the like. The following discussions relate to the software aspects of at least some of these areas of the system that can and should be regulated by processed or automated control.

[0066] The software will operate at least the active structural and material components of an anaerobic bioconversion system. The bioconversion system consists of multiple tanks, pumps and process instrumentation. The process may begin with an influent raw organic material being pumped into a storage tank for storage. From the storage tank, the organic material is pumped to the anaerobic bioconverter. Or, the organic material may be conveyed directly into the bioconverter. The effluent water flows from the bioconverter, to discharge. There is gas generated from the bioconversion process that is discharged to other process equipment and/or to a flare. The storage tank contents are mixed before it is pumped into the bioconverter. There may also be chemical (base) addition to the storage tank and/or bioconverter to adjust pH. Multiple process instruments are associated with the storage tank to monitor the raw organic material including liquid level, pH and temperature. Inside the anaerobic bioconverter, there is biomass used to convert the organic material in the stream to several gases including carbon dioxide, and methane. In at least one of the bioconversion tank(s), there may be an internal sand filter, used to filter the effluent water, maintained by two rotating blades. There are multiple process instruments associated with the bioconversion tank(s) to monitor the liquid and gas. These include liquid level, pH, temperature, arm position, pressure and gas concentration.

[0067] All of the process instrumentation and equipment may be connected to a programmable logic controller (PLC) or other logic system (which includes distributed architecture as opposed to an exclusively central control used with most PLC systems), which controls the operation of the bioconversion system.

Process Systems with Related Software Routines

[0068] For each element of the bioconversion process there may be numerous process systems. The process systems of the anaerobic bioconversion system are each operated by a software routine. The elements of the bioconversion process and the related process systems are:

Storage (EQ) System

[0069] EQ Feed Pump and Valve Control

[0070] EQ Tank Chemical Addition Pump Control

[0071] EQ Mixer Speed Control

[0072] EQ Feed Pump VFD Fault alarm

[0073] EQ Mixer VFD Fault alarm

[0074] EQ Tank Liquid Temperature alarms

[0075] EQ Tank Liquid Level alarms

[0076] EQ Tank Feed Pump Current alarms

[0077] EQ Tank Mixer Current alarms

[0078] EQ Tank pH alarms

Bioconverter Feed System

[0079] Bioconverter Feed Pump (or conveyer) and Valve Continuous Control

[0080] Bioconverter Feed Pump (or conveyer) and Valve Batch Control

[0081] Bioconverter Feed Pump (or conveyer) Flow totalization

[0082] Bioconverter Liquid Level alarms

[0083] Bioconverter Foam Level High alarm

[0084] Bioconverter Feed Pump (or conveyer) Current alarms

[0085] Bioconverter Feed Pump (or conveyer) VFD Fault alarm

[0086] Bioconverter Liquid Level Transducer Error alarm

Bioconverter Agitation System

[0087] Normal Fluidization Control

[0088] Deep Clean Fluidization Control

[0089] Sludge Rake Blade Pump Current alarms

[0090] Propulsion Blade Pump Current alarms

[0091] Sand Fluidization Blade Pump Current alarms

[0092] Sludge Rake Blade Pump Pressure alarms

[0093] Propulsion Blade Pump Pressure alarms

[0094] Sand Fluidization Blade Pump Pressure alarms

[0095] Sludge Rake Blade Pump VFD Fault alarm

[0096] Sand Fluidization Blade Pump VFD Fault alarm

Bioconverter Discharge Control System

[0097] Bioconverter Discharge Valve Control

[0098] Bioconverter Effluent Flow Totalization

[0099] Gas Separation Tank Liquid Level High alarm

Gas Handling System

[0100] Foam Lockout Control

[0101] Gas Analyzer Drain Control

[0102] Gas Pressure High alarm

[0103] Gas Temperature Low alarm

Bioconverter Temperature Control System

[0104] Bioconverter Liquid Temperature Control

[0105] Bioconverter Liquid Temperature High and Low alarms

Chemical Addition System

[0106] Chemical Recirculation Pump Control

[0107] Bioconverter Liquid pH High and Low alarms

[0108] Chemical Recirculation Pump Liquid Pressure High and Low alarms

[0109] Chemical Recirculation Pump VFD Fault alarm

[0110] Base Addition Pump Control

[0111] Metal Addition Pump Control

[0112] Nutrient Addition Pump Control

[0113] Sulfur Addition Pump Control

[0114] Anti-Foam Pump Control

Other On-Line Instruments may include:

[0115] System Air Pressure Low alarm

[0116] Titration System

Operator Adjustable Process Set Points	Operator Adjustable Alarm Set Points	System Alarms
EQ Tank Feed Pump ON Liquid Level		EQ Tank Liquid Level High-High
EQ Tank Feed Pump OFF Liquid Level		EQ Tank Liquid Level Low-Low
EQ Tank Feed Pump VFD Continuous Mode Speed	EQ Tank pH High	EQ Tank pH High
EQ Tank Feed Pump VFD Maximum Speed	EQ Tank pH Low	EQ Tank pH Low
EQ Tank Feed Pump VFD Minimum Speed	EQ Tank Temperature High	EQ Tank Temperature High
EQ Tank Feed Pump Daily Gallons	EQ Tank Temperature Low	EQ Tank Temperature Low
EQ Tank Mixer VFD Continuous Mode Speed	EQ Tank Feed Pump Current High	EQ Tank Feed Pump Current High
EQ Tank Mixer VFD Maximum Speed	EQ Tank Feed Pump Current Low	EQ Tank Feed Pump Current Low
EQ Tank Mixer VFD Minimum Speed	EQ Tank Feed Pump Pressure High	EQ Tank Feed Pump Pressure High
EQ Tank Mixer VFD Maximum Speed Liquid Level	EQ Tank Feed Pump Pressure Low	EQ Tank Feed Pump Pressure Low
EQ Tank Mixer VFD Minimum Speed Liquid Level	EQ Tank Feed Pump Flow Low	EQ Tank Feed Pump Flow Low
EQ Tank Mixer Intermittent Mode On Time		EQ Tank Feed Pump VFD Fault
EQ Tank Mixer Intermittent Mode Off Time	EQ Tank Mixer Current High	EQ Tank Mixer Current High
EQ Tank Mixer Before Feed On Time	EQ Tank Mixer Current Low	EQ Tank Mixer Current Low
EQ Tank pH		EQ Tank Mixer VFD Fault
EQ Tank pH Variation	Bioconverter Liquid Level High	Bioconverter Liquid Level High
Bioconverter Feed Pump On Liquid Level	Bioconverter Liquid Low	Bioconverter Liquid Low
Bioconverter Feed Pump Off Liquid Level		Bioconverter Liquid Level High-High
Bioconverter Feed Pump VFD Continuous Mode Speed		Bioconverter Liquid Low-Low
Bioconverter Feed Pump VFD Maximum Speed	Bioconverter pH High	Bioconverter pH High
Bioconverter Feed Pump VFD Minimum Speed	Bioconverter pH Low	Bioconverter pH Low
Bioconverter Feed Pump Daily Gallons	Bioconverter Temperature High	Bioconverter Temperature High
Bioconverter Base Addition High pH	Bioconverter Temperature Low	Bioconverter Temperature Low
Bioconverter Base Addition Low pH	Bioconverter Feed Pump Current High	Bioconverter Feed Pump Current High
Rake Blade Pump VFD Continuous Mode Speed (Rake Mode)	Bioconverter Feed Pump Current Low	Bioconverter Feed Pump Current Low
Rake Blade Pump VFD Maximum Speed (Rake Mode)	Bioconverter Feed Pump Pressure High	Bioconverter Feed Pump Pressure High
Rake Blade Pump VFD Minimum Speed (Rake Mode)	Bioconverter Feed Pump Pressure Low	Bioconverter Feed Pump Pressure Low
Rake Blade Pump VFD Initial Speed (Propulsion Mode - Normal Fluidize)	Bioconverter Feed Pump Flow Low	Bioconverter Feed Pump Flow Low
Rake Blade Pump VFD Initial Speed (Propulsion Mode - Deep Clean Fluidize)	Bioconverter Liquid Level Transducer Allowable Difference	Bioconverter Liquid Level Transducer Error
Rake Blade Pump VFD Maximum Speed (Propulsion Mode)	Bioconverter Gas Pressure High	Bioconverter Gas Pressure High
Rake Blade Pump VFD Minimum Speed (Propulsion Mode)	Rake Blade Pump Current High	Rake Blade Pump Current High
Rake Pump Intermittent Mode On Time	Rake Blade Pump Current Low	Rake Blade Pump Current Low
Rake Pump Intermittent Mode Off Time	Rake Blade Pump (Rake Mode) Pressure High	Rake Blade Pump (Rake Mode) Pressure High
Rake Blade RPM	Rake Blade Pump (Rake Mode) Pressure Low	Rake Blade Pump (Rake Mode) Pressure Low
Fluidization Blade (Normal Fluidize) RPM	Rake Blade Pump (Propulsion Mode) Pressure High	Rake Blade Pump (Propulsion Mode) Pressure
Fluidization Blade (Deep Clean Fluidize) RPM	Rake Blade Pump (Propulsion Mode) Pressure Low	Rake Blade Pump (Propulsion Mode) Pressure
Fluidization Blade Pump VFD Initial Speed	Fluidization Blade Pump Pressure High	Fluidization Blade Pump Pressure High
Fluidization Blade Pump VFD Maximum Speed	Fluidization Blade Pump Pressure Low	Fluidization Blade Pump Pressure Low

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Operator Adjustable Process Set Points	Operator Adjustable Alarm Set Points	System Alarms
Fluidization Blade Pump VFD Minimum Speed	Fluidization Blade Pump Current High	Fluidization Blade Pump Current High
Chemical Feed Pump VFD Initial Speed	Fluidization Blade Pump Current Low	Fluidization Blade Pump Current Low
Chemical Feed Pump VFD Maximum Speed	Chemical Feed Pump Pressure High	Chemical Feed Pump Pressure High
Chemical Feed Pump VFD Minimum Speed	Chemical Feed Pump Pressure Low	Chemical Feed Pump Pressure Low
Normal Fluidization - Time to Complete	Chemical Feed Pump Current High	Chemical Feed Pump Current High
Normal Fluidization - Number of Clicks to Complete	Chemical Feed Pump Current Low	Chemical Feed Pump Current Low
Deep Clean Fluidization - Time to Complete		
Deep Clean Fluidization - Number of Clicks to Complete		
Deep Clean Fluidization - Number of failed normal fluidizes to start deep clean		
Bioconverter Discharge Liquid Level		
Bioconverter Discharge Liquid Level Variance		
Bioconverter Temperature		
Bioconverter Temperature Variance		
Bioconverter Discharge Valve Opening Maximum		
Bioconverter Discharge Valve Opening Minimum		
Bioconverter Sand Filter Differential Pressure to Maintain		
Bioconverter Discharge Valve Opening % in Manual Mode		
Bioconverter Discharge Delay Time Prior to Opening Discharge Valve		
Bioconverter Feed Rate		
Bioconverter Feed Interval between Feeds in Batch Mode		
Bioconverter Gas Pressure to Open Gas Valve		
Bioconverter Gas Pressure to Close Gas Valve		
Fluidization Time Between Fluidizations		
Fluidization Sand Filter Differential Pressure to Trigger Fluidization		
Fluidization Maximum Time to Complete One Revolution of Sand Blade		
Fluidization Number of Failed Normal Fluidizes to Trigger a Deep Clean		
Fluidization Sand Filter Differential Pressure after a Fluidize to Trigger a Deep Clean		
Separator Tank Discharge Pump On Time		
Separator Tank Discharge Pump Off Time		
Chemical Nutrient Pump On Interval Time		
Chemical Sulfur Pump On Interval Time		
Chemical Anti-Foam Pump On Interval Time		
Chemical Metals Pump On Interval Time		
Chemical Nutrient Pump Cycle On Time		
Chemical Nutrient Pump Cycle Off Time		
Chemical Sulfur Pump Cycle On Time		
Chemical Sulfur Pump Cycle Off Time		
Chemical Anti-Foam Pump Cycle On Time		
Chemical Anti-Foam Pump Cycle Off Time		
Chemical Metals Pump Cycle On Time		
Chemical Metals Pump Cycle Off Time		

Storage (EQ) System

[0117] Raw organic material may be pumped from a storage vessel outside of the anaerobic bioconversion system via the EQ tank feed pump into the EQ tank.

[0118] Raw organic material may also be mixed with water or wastewater to reduce the solids concentration and pumped to the EQ tank.

EQ Tank Feed Pump and Valve Control

[0119] The EQ Tank Feed Pump and EQ Tank Feed Pump Valve turn on at the EQ Tank Feed Pump ON Liquid Level and turn off at the EQ Tank Feed Pump OFF Liquid Level based on the liquid level measured by a pressure transducer in the EQ Tank.

EQ Tank Chemical Addition Pump Controls

[0120] The chemical (base) addition to the EQ Tank is based on EQ Tank pH, EQ Tank pH Variation and the measurement from the pH sensor in the EQ Tank. The pump turns on when the measured pH in the EQ Tank is less than EQ Tank pH-EQ Tank pH Variation and turns off when the pH is greater than EQ Tank pH.

EQ Tank Mixer Speed Control

[0121] The EQ Tank Mixer speed is proportionally controlled based on the liquid level in the EQ Tank. The mixer speed varies between EQ Tank Mixer VFD Maximum Speed and EQ Tank Mixer VFD Minimum Speed proportionally as the liquid level varies between EQ Tank Mixer VFD Maximum Speed Liquid Level and EQ Tank Mixer VFD Minimum Speed Liquid Level.

EQ Tank Feed Pump VFD Fault Alarm

[0122] The EQ Tank Feed Pump VFD sends an EQ Tank Feed Pump VFD Fault alarm if a fault occurs in the VFD. The alarm will alert the operator of the fault and shut off the VFD output to the pump.

EQ Tank Mixer VFD Fault Alarm

[0123] The EQ Tank Mixer VFD sends an EQ Tank Mixer VFD Fault alarm if a fault occurs in the VFD. The alarm will shut off the VFD until the fault is manually corrected. The alarm will alert the operator of the fault and shut off the VFD output to the Mixer.

EQ Tank Liquid Temperature Alarms

[0124] The EQ Tank has a temperature transducer that measures water temperature in the EQ Tank. There are EQ Tank High Temperature and EQ Tank Low Temperature alarms if the temperature is out of range. The EQ Tank has a tank heater that may or may not be controlled by the software. Both alarms will alert the operator.

EQ Tank Liquid Level Alarms

[0125] The EQ Tank has two liquid level switches. There are EQ Tank High-High Liquid Level and EQ Tank Low-Low Liquid Level alarms if the liquid level is out of range. The EQ Tank High-High Liquid Level alarm will alert the operator and shut off the EQ Tank Feed Pump. The EQ Tank Low-Low Liquid Level alarm will alert the operator and shut off the EQ Tank Mixer and Bioconverter Feed Pump.

EQ Tank Feed Pump Current Alarms

[0126] The EQ Tank Feed Pump VFD outputs the EQ Tank Feed Pump current (amps) to the PLC. There are EQ Tank Feed Pump High Current and EQ Tank Feed Pump Low Current alarms if the current is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

EQ Tank Mixer Current Alarms

[0127] The EQ Tank Mixer VFD outputs the EQ Tank Mixer current (amps) to the PLC. There are EQ Tank Mixer High Current and EQ Tank Mixer Low Current alarms if the current is out of range. Both alarms will alert the operator and shut off the VFD output to the mixer.

EQ Tank pH Alarms

[0128] The EQ Tank has a pH sensor used to measure pH in the tank. There are EQ Tank High pH and EQ Tank Low pH alarms if the pH is out of range. The EQ Tank High pH alarm will alert the operator and shut off the EQ Tank Chemical Addition Pump and the Bioconverter Feed Pump. The EQ Tank Low pH alarm will alert the operator and shut off the Bioconverter Feed Pump.

Bioconverter Feed (DF) System

[0129] Raw organic material may be pumped from the EQ tank to the anaerobic bioconverter where organic materials are bioconverted or, the organic material may be conveyed directly into the bioconverter.

Bioconverter Feed Pump and/or Feed Conveyor and Valve Continuous Control

[0130] The bioconverter feed pump (and/or feed conveyor) can run in either of at least three modes, continuous mode or intermittent mode or batch mode, or switched between modes at different stages of operation. In continuous mode, the bioconverter Feed Pump (and/or feed conveyor) VFD operates the pump continuously, varying the speed of the pump (conveyor) to maintain a specified flow rate. The specified flow rate is determined by calculating the instantaneous GPM (or speed) of the pump (conveyor) required to achieve the bioconverter Feed Pump (conveyor) Daily Gallons (mass). The VFD speed is allowed to vary between Bioconverter Feed Pump (conveyor) VFD Maximum Speed and Bioconverter Feed Pump (conveyor) VFD Minimum Speed. If the VFD is required to operate above Bioconverter Feed Pump (conveyor) VFD Maximum Speed, the system alerts the operator that the Bioconverter Feed Pump (conveyor) Daily Gallons (mass) must be decreased or the Bioconverter Feed Pump (conveyor) VFD Minimum Speed must be increased. If the VFD is required to operate below the minimum speed, the VFD runs the pump (conveyor) at Bioconverter Feed Pump (Conveyor) VFD Minimum Speed cycling the pump (conveyor) on and off as if it were in batch mode.

Bioconverter Feed Pump (Conveyor) and Valve Intermittent Control

[0131] In intermittent mode, the VFD operates the pump (conveyor) at Bioconverter Feed Pump (conveyor) VFD Speed. The pump (conveyor) cycles on at Bioconverter Feed Interval between Feeds in intermittent Mode intervals. The pump (conveyor) cycles off if either the software calculated required number of gallons (mass) per feed interval has successfully fed or the Bioconverter Feed Interval between Feeds in intermittent Mode period has elapsed. The Bioconverter Feed Pump (conveyor) will operate if the liquid level in the bioconverter is below Bioconverter Liquid Level or on an operator selectable time schedule. There are two pressure transducers, one being redundant, on the bioconverter to measure the liquid level. The primary pressure transducer is used to determine operation of the Bioconverter Feed Pump (or conveyer).

[0132] Bioconverter Feed Pump (conveyor) Flow (mass) Totalization

[0133] Liquid (mass) flow from the Bioconverter Feed Pump (conveyor) passes through a liquid (mass) flow meter prior to entering the bioconverter. There is a pulsed output from the flow meter to the PLC. The flow meter outputs one pulse per gallon liquid (per mass unit) through flow meter. These pulses are totalized in the PLC and displayed as total gallons (mass) pumped through the flow meter by the Bioconverter Feed Pump (conveyor).

Bioconverter Liquid Level Alarms

[0134] The bioconverter has two liquid level switches. There are Bioconverter High-High Liquid Level and Bioconverter Low-Low Liquid Level alarms if the liquid level is out of range. The Bioconverter High-High Liquid Level alarm will alert the operator and stop the Bioconverter Feed Pump. The Bioconverter Low-Low Liquid Level alarm will alert the operator and shut off the Bioconverter Discharge Valve.

Bioconverter Foam Level Alarm

[0135] The bioconverter has one liquid level switch used for high-level foam detection. There is a Bioconverter High Foam Level alarm if the foam level is over range. The Bioconverter High Foam Level alarm will alert the operator and shut off the Bioconverter Feed Pump.

Bioconverter Feed Pump Current Alarms

[0136] The Bioconverter Feed Pump VFD outputs the Bioconverter Feed Pump current (amps) to the PLC. There

are EQ Tank Feed Pump High Current and EQ Tank Feed Pump Low Current alarms if the current is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

Bioconverter Feed Pump VFD Fault Alarm

[0137] The Bioconverter Feed Pump VFD sends a Bioconverter Feed Pump VFD Fault alarm if a fault occurs in the VFD. The alarm will alert the operator and shut off the VFD output to the pump.

Bioconverter Feed Conveyor Current Alarms

[0138] The Bioconverter Feed Conveyor VFD outputs the Bioconverter Feed Conveyor current (amps) to the PLC. There are Feed conveyor High Current and Feed Conveyor Low Current alarms if the current is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

Bioconverter Feed Conveyor VFD Fault Alarm

[0139] The Bioconverter Feed Conveyor VFD sends a Bioconverter Feed Conveyor VFD Fault alarm if a fault occurs in the VFD. The alarm will alert the operator and shut off the VFD output to the conveyor.

Bioconverter Liquid Level Transducer Error Alarm

[0140] The liquid level measurement from the primary pressure transducer and liquid level measurement from the redundant pressure transducer varying by more than Bioconverter Liquid Level Transducer Allowable Difference will cause a Bioconverter Liquid Level Transducer Error alarm. The alarm will alert the operator.

Bioconverter Agitator System

[0141] There may be, for example, one, two or more rotating blades in the anaerobic bioconverter used to maintain the bioconverter sand bed filter as well as aid in the mixing of the bioconverter contents. Two examples of blades are the Sand Fluidization Blade and the Propulsion Blade. Any blade may be operated mechanically (e.g., gear, planetary gear, shaft, belt, magnetic drive, piston or any other mechanically transmitted power drive) or pneumatically hydraulically, fluid pressure or air pressure) driven for purposes of this technology.

Sludge Rake Blade Control

[0142] The Sludge Rake Blade is used to "rake" the sludge/biomass layer directly on top of the sand bed filter in the anaerobic bioconverter. This raking effect aids in increasing the effluent discharge flow from the bioconverter. If operated hydraulically, the sludge rake blade pump can run in either of two modes, continuous mode or intermittent mode. In continuous mode, the VFD that controls the rake blade pump runs continuously, varying the speed of the Rake Blade Pump between Rake Blade Pump VFD Maximum Speed (Rake Mode) and Rake Blade Pump VFD Minimum Speed (Rake Mode) to control the rotational speed of the rake blade. In intermittent mode, the VFD turns on and off for Rake Blade Pump Intermittent Mode On Time and Rake Blade Pump Intermittent Mode Off Time periods while still varying the speed of the rake blade pump to control the rotational speed of the rake blade. The rake blade may be mechanically (e.g., gear, planetary gear, shaft, belt, magnetic drive, piston or any other mechanically transmitted power drive) or pneumatically (hydraulically, fluid pressure or air pressure) driven for purposes of this technology.

[0143] Magnetic switches that actuate as the blade rotates determine the rotational speed of the Rake Blade. The time between switch actuations (clicks) is measured by the PLC. The Rake Blade RPM is calculated from the time between clicks. The Rake Blade VFD output is adjusted up or down based on the current RPM compared to the Rake Blade RPM. If the time between clicks is too long (i.e. the blade is moving too slow) the VFD output is increased incrementally speeding up the Rake Blade, if the time between clicks is too short (i.e. the blade is moving too fast) the VFD output is decreased incrementally slowing down the Rake Blade.

Normal Fluidization Control

[0144] The sand fluidization blade is used to "fluidize" the sand bed filter in the anaerobic bioconverter to prevent the sand bed from getting "packed" and restricting effluent flow. A fluidization cycle is started in either of two ways. If the Fluidization Time between Fluidizes period elapses without a fluidize cycle, one will begin. A fluidize cycle will also begin based on the differential pressure measured across the sand filer bed. When the bioconverter is discharging and the differential pressure across the sand filter bed becomes greater than Fluidization Sand Filter Differential Pressure to Trigger Fluidize, the discharge will stop and a fluidize cycle will begin. It is also contemplated in the practice of the present technology to use one or more blades to effect this function, either during continuous operation of the process, or as a separate intermediate step while this section of the system is not active in the bioconversion process. A blade may be mechanically (e.g., gear, planetary gear, shaft, belt, magnetic drive, piston or any other mechanically transmitted power drive) or pneumatically (hydraulically, fluid pressure or air pressure) driven for purposes of this technology.

[0145] The Propulsion Pump is used to hydraulically propel the Fluidization Blade through the sand filter during a fluidize cycle during operation. The Sand Fluidization Pump is used to "fluidize" the sand in front of the rotating blade, allowing it to be propelled through the sand bed. The Propulsion Pump VFD initially starts at Propulsion Pump Initial VFD Speed and varies the speed between the Propulsion Pump Maximum VFD Speed and Propulsion Pump Minimum VFD based on the rotational speed of the sand blade. The Sand Fluidization Blade VFD initially starts at Sand Fluidization Pump Initial VFD Speed and is capable of varying the speed between the Sand Fluidization Pump Maximum VFD Speed and Sand Fluidization Pump Minimum VFD Speed.

[0146] Magnetic switches that are actuated as the blade rotates determine the rotational speed of the Fluidization Blade. The time between switch actuations (clicks) is measured by the PLC. The Fluidization Blade RPM is calculated from the time between clicks. The Sand Blade Pump VFD speed is adjusted up or down based on the calculated RPM compared to the Fluidization Blade (Normal Fluidize) RPM. If the time between clicks is too long (i.e. the Fluidization Blade is moving too slow) the VFD output is increased incrementally speeding up the Fluidization Blade, if the time between clicks is too short (i.e. the Fluidization Blade is moving too fast) the VFD output is decreased incrementally slowing down the Fluidization Blade.

[0147] A successful fluidize cycle is recorded when a set number of clicks are recorded during a fluidize cycle. An

unsuccessful fluidize cycle is recorded when Normal Fluidization—Time to Complete elapses before a successful fluidize. If the number of unsuccessful fluidizes exceeds Deep Clean Fluidization—Number of Failed Normal Fluidizes to Start Deep Clean a Deep Clean Fluidize cycle will start.

[0148] Deep Clean Fluidization Control by Automated or Manual Control

[0149] A Deep Clean Fluidize is a fluidize cycle where the Propulsion Pump runs at a slower speed than in the Normal Fluidize Cycle to more thoroughly fluidize the sand bed compared to a Normal Fluidize. It is also contemplated in the practice of the present technology to use one or more blades to effect this function, either during continuous operation of the process, or as a separate intermediate step while this section of the system is not active in the bioconversion process. A blade may be mechanically (e.g., gear, planetary gear, shaft, belt, magnetic drive, piston or any other mechanically transmitted power drive) or pneumatically (hydraulically, fluid pressure or air pressure) driven for purposes of this technology.

[0150] A Deep Clean Fluidize step is initiated when the time to perform a successful normal fluidize is less than Normal Fluidization—Time to Complete, a successful normal fluidize has not occurred during Deep Clean Fluidization—Number of Failed Normal Fluidizes to Start Deep Clean or after a successful Normal Fluidize, the differential pressure across the Sand Filter Bed exceeds Fluidization Sand Filter Differential Pressure after a Fluidize to Trigger a Deep Clean. The Sand Blade Pump VFD speed is controlled the same way it is in a Normal Fluidize. The Propulsion Pump VFD speed is adjusted up or down based on the calculated RPM compared to the Fluidization Blade (Deep Clean) RPM.

Sludge Rake Blade Pump Current Alarms

[0151] The Sludge Rake Blade Pump VFD outputs the Sludge Rake Blade Pump current (amps) to the PLC. There are Sludge Rake Blade Pump High Current and Sludge Rake Blade Pump Low Current alarms if the current is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

Propulsion Blade Pump Current Alarms

[0152] The Propulsion Blade Pump VFD outputs the Propulsion Blade Pump current (amps) to the PLC. There are Propulsion Blade Pump High Current and Propulsion Blade Pump Low Current alarms if the current is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

Sand Fluidization Blade Pump Current Alarms

[0153] The Sand Fluidization Blade Pump VFD outputs the Sand Fluidization Blade Pump current (amps) to the PLC. There are Sand Fluidization Blade Pump High Current and Sand Fluidization Blade Pump Low Current alarms if the current is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

Sludge Rake Blade Pump Pressure Alarms

[0154] The Sludge Rake Blade Pump has a pressure transducer on its effluent side. There are Sludge Rake Blade Pump High Pressure and Sludge Rake Blade Pump Low Pressure alarms if the pressure is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

Propulsion Blade Pump Pressure Alarms

[0155] The Propulsion Blade Pump has a pressure transducer on its effluent side. There are Propulsion Blade Pump High Pressure and Propulsion Blade Pump Low Pressure alarms if the pressure is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

Sand Fluidization Blade Pump Pressure Alarms

[0156] The Sand Fluidization Blade Pump has a pressure transducer on its effluent side. There are Sand Fluidization Blade Pump High Pressure and Sand Fluidization Blade Pump Low Pressure alarms if the pressure is out of range. Both alarms will alert the operator and shut off the VFD output to the pump.

Sludge Rake Blade Pump VFD Fault Alarm

[0157] The Sludge Rake Blade Pump VFD sends a Sludge Rake Blade Pump VFD Fault alarm if a fault occurs in the VFD. The alarm will alert the operator and shut off the VFD output to the pump.

Propulsion Blade Pump VFD Fault Alarm

[0158] The Propulsion Blade Pump VFD sends a Propulsion Blade Pump VFD Fault alarm if a fault occurs in the VFD. The alarm will alert the operator and shut off the VFD output to the pump.

Sand Fluidization Blade Pump VFD Fault Alarm

[0159] The Sand Fluidization Blade Pump VFD sends a Sand Fluidization Blade Pump VFD Fault alarm if a fault occurs in the VFD. The alarm will alert the operator and shut off the VFD output to the pump.

Bioconverter Discharge Control

[0160] The anaerobic bioconverter discharges water in order to maintain a liquid level in the tank(s).

Bioconverter Discharge Valve Control

[0161] The anaerobic bioconverter has an actuated valve on the discharge that is adjusted based on the differential pressure across the Sand Filter Bed when the bioconverter is discharging. The discharge valve's percentage open is adjusted between Bioconverter Discharge Valve Opening Maximum and Bioconverter Discharge Valve Opening Minimum to maintain Bioconverter Sand Filter Differential Pressure to Maintain. The bioconverter will begin to discharge water when the liquid level in the bioconverter is greater than Bioconverter Liquid Level. When the bioconverter is discharging and the Sand Filter Bed is becoming "packed", the differential pressure across the Sand Filter Bed will become greater than Fluidization Sand Filter Differential Pressure to Trigger Fluidize and a Normal Fluidize cycle will start. When the fluidize cycle is finished, if the liquid level in the bioconverter is still above Bioconverter Liquid Level minus Bioconverter Liquid Level Variance the bioconverter discharge valve will begin the discharge-fluidize cycle again until the liquid level is below Bioconverter Liquid Level minus Bioconverter Liquid Level Variance.

Bioconverter Effluent Flow Totalization

[0162] Discharge liquid flow from the bioconverter passes through a liquid flow meter. There is a pulsed output from the flow meter to the PLC. The flow meter outputs one pulse per gallon liquid through flow meter. These pulses are totalized in the PLC and displayed as total gallons discharged from the bioconverter. The flow may then enter a gas separation tank or may be discharged directly from the bioconverter.

Biogas Separation Tank Liquid Level Alarm

[0163] The Biogas Separation Tank has one liquid level switch used for high liquid level detection. There is a Biogas Separation Tank Liquid Level alarm if the liquid level is over range. The Biogas Separation Tank Liquid Level alarm will alert the operator and close the bioconverter valve.

Foam Lockout Control

[0164] Biogas handling is required as biogas generated inside the bioconverter, passes to the biogas separation tank. This biogas is combined with the separated biogas from the discharge water. A sample of this combined biogas is pumped through a biogas analyzer. The remaining biogas passes through a flow meter and is discharged to a flare or other biogas processing equipment.

Biogas Analyzer Drain Control

[0165] The biogas that passes to the biogas analyzer contains moisture. This moisture is collected and the biogas analyzer drain pump is activated to drain the condensate collector.

Biogas Pressure Alarm

[0166] A pressure transducer continuously monitors bioconverter headspace pressure. When the biogas pressure reaches Bioconverter Biogas Pressure to Open Biogas Valve, a solenoid valve opens and biogas is released through the flow meter and subsequently to the flare. This valve stays open until the pressure measured reaches Bioconverter Biogas Pressure to Close Valve. To prevent any liquid from entering the biogas process piping a solenoid valve is located at the beginning of the biogas piping. If a Bioconverter High Foam Level or a Biogas Separation Tank Liquid Level alarm is detected, this valve will close until the alarm is cleared.

[0167] The Bioconverter Biogas Discharge has a pressure transducer on its effluent side. There is a Bioconverter Biogas Discharge High Pressure alarm if the pressure is out of range. The alarm will alert the operator and cause a Foam Lockout Alarm.

Bioconverter Temperature Control

[0168] A bioconverter heater maintains a constant temperature in the bioconverter.

Bioconverter Liquid Temperature Control

[0169] The bioconverter heater is turned on and off based on Bioconverter Temperature and Bioconverter Temperature Variance. The bioconverter heater turns on when the temperature is less than Bioconverter Temperature—Bioconverter Temperature Variance and turns off when the temperature is above Bioconverter Temperature.

Bioconverter Liquid Temperature Alarms

[0170] There are Bioconverter Temperature High and Bioconverter Temperature Low alarms if the bioconverter temperature is out of range. Both alarms will alert the operator.

Chemical Addition System

[0171] There may be multiple metering pumps used to supply supplemental chemicals to the bioconverter. They include but are not limited to a Base Pump, Nutrients Pump, Sulfur Pump, and Metals Pump.

Bioconverter Chemical and Solids Recirculation Pump Control

[0172] The Bioconverter Chemical and Solids Recirculation Pump is used to provide recirculation of bioconverter contents within an individual bioconversion tank or between multiple bioconversion tanks within the bioconverter system and allow for chemical addition to the bioconversion tank(s). No alarms cause the Recirculation Pump to shut off.

Bioconverter Liquid pH Alarms

[0173] The bioconverter has pH sensors used to measure pH in the tank. There are Bioconverter High pH and Bioconverter Low pH alarms if the pH is out of range. The Bioconverter High pH alarm and Low pH alarm will alert the operator and may turn on or off any of the chemical addition metering pumps.

Bioconverter Chemical and Solids Recirculation Pump Liquid Pressure Alarms

[0174] The Chemical and Solids Recirculation Pump has a pressure transducer on its effluent side. There are Chemical and Solids Recirculation Pump High Pressure and Chemical and Solids Recirculation Pump Low Pressure alarms if the pressure is out of range. Both alarms will alert the operator.

Bioconverter Chemical and Solids Recirculation Pump VFD Fault Alarm

[0175] The Chemical and Solids Recirculation Pump VFD sends a Chemical and Solids Recirculation Pump VFD Fault alarm if a fault occurs in the VFD. The alarm will alert the operator and shut off the VFD output to the pump.

Base Pump

[0176] One or more chemical feed pumps are used to add base to the system. One of the pumps may add base to EQ tank and another pump may add base to the bioconverter. Base pumps operate the same way. The EQ Tank Base pump turns on when the measured pH in the EQ Tank is less than EQ Tank pH—EQ Tank pH Variation and turns off when the pH is greater than EQ Tank pH The bioconverter Base pump turns on when the measured pH in the bioconverter is less than Bioconverter pH-Bioconverter pH Variation and turns off when the pH is greater than Bioconverter pH

Nutrient Pump

[0177] The Nutrient Pump is a metering pump that adds nutrients to the bioconverter. The Nutrient Pump has adjustable settings. They may include Nutrient Pump Capacity (GPD), Nutrient Pump Flow (GPD) and Nutrient Pump Pumping Interval. Nutrient Pump Flow is divided by Nutrient Pump Capacity to calculate the amount of time during the day the pump has to run. The required daily run time of

the pump is divided into intervals based on Nutrient Pump Pumping Interval and the pump on and off times per interval are calculated.

Sulfur Pump

[0178] The Sulfur Pump is a metering pump that adds sulfur to the bioconverter. The Sulfur Pump has adjustable settings. They may include Sulfur Pump Capacity (GPD), Sulfur Pump Flow (GPD) and Sulfur Pump Pumping Interval. Sulfur Pump Flow is divided by Sulfur Pump Capacity to calculate the amount of time during the day the pump has to run. The required time is divided into equal intervals based on Sulfur Pump Pumping Interval and the pump on and off times are calculated.

Metals Pump

[0179] The Metals Pump is a metering pump that adds metals to the bioconverter. The Metals Pump has adjustable settings. They may include Metals Pump Capacity (GPD), Metals Pump Flow (GPD) and Metals Pump Pumping Interval. Metals Pump Flow is divided by Metals Pump Capacity to calculate the amount of time during the day the pump has to run. The required time is divided into equal intervals based on Metals Pump Pumping Interval and the pump on and off times are calculated.

Anti-Foam Pump

[0180] The Anti-Foam Pump is a metering pump that adds anti-foam to the bioconverter. The Anti-Foam Pump has adjustable settings. They may include Anti-Foam Pump Capacity (GPD), Anti-Foam Pump Flow (GPD) and Anti-Foam Pump Pumping Interval Anti-Foam Pump Flow is divided by Anti-Foam Pump Capacity to calculate the amount of time during the day the pump has to run. The required time is divided into equal intervals based on Anti-Foam Pump Pumping Interval and the pump on and off times are calculated.

Other On-Line Instruments

System Air Pressure Alarm

[0181] The System Air Pressure has a pressure switch associated with it. There is a System Air Pressure Low alarm if the pressure is out of range. The alarm will alert the operator.

[0182] Additional considerations and controls applied in the Bioconverter System may include one or more of the following Additional parameters involving the bioconverter:

[0183] 1. Intermediate degradation component detection and control

[0184] a. Intermediate degradation components can be monitored and information sent to the PLC. System variables such as pH, feed rate and alkalinity can be adjusted to maintain the process.

[0185] 2. Contaminant alarm

[0186] a. The process can be monitored for the presence of contaminants (such as quaternary ammonium) with information being sent to the PLC to cause alarm conditions.

[0187] 3. Solids concentration monitoring and control

[0188] a. Detection of the solids concentration in the bioconverter is sent to the PLC to allow the system to adjust system parameters such as feed rate to maintain the process.

[0189] 4. BOD and COD monitoring and control

[0190] a. Real time or near real-time monitoring of COD and/or BOD allowing the PLC to adjust system parameters such as feed rate and pH to maintain the process.

[0191] 5. Surface tension/foam detection monitoring and alarm

[0192] a. Surface tension is monitored sending information to the PLC to cause an alarm condition if the surface tension is outside of acceptable user selectable parameters.

[0193] 6. Fats, Oils, and Grease (FOG) monitoring and alarm

[0194] a. FOG is monitored sending information to the PLC allowing system parameters such as feed rate and feed type to be adjusted to maintain the process. An alarm condition is triggered when FOG levels are outside of user selectable parameters.

[0195] 7. Dissolved biogas monitoring and alarm

[0196] a. Dissolved biogas is monitored sending information to the PLC allowing system parameters such as feed rate and feed type to be adjusted to maintain the process. An alarm condition is triggered when dissolved biogas levels are outside of user selectable parameters.

[0197] 8. Volatile acids monitoring and alarm

[0198] a. Volatile acids concentration is monitored sending information to the PLC allowing system parameters such as feed rate and feed type to be adjusted to maintain the process. An alarm condition is triggered when volatile acids concentration levels are outside of user selectable parameters.

[0199] 9. Detection and control of specific bacteria concentration/activity

[0200] a. The activity of specific bacteria may be monitored and other system parameters such as feed rate may be adjusted to maintain desired activity level and/or concentration

Titration

[0201] A titrator may be incorporated in the system for checking critical data. This titrator consists of instrumentation and control valves that are controlled via the PLC. The titrator consists of independent, dedicated solenoid valves that are connected to multiple sample points within the bioconversion process including influent, effluent and various locations on the bioconverter tank:

The titrator also may have the following:

[0202] 1. DI water

[0203] 2. CDA (Clean Dry Air)

[0204] 3. Drain solenoid valve

[0205] 4. Feed pump

[0206] 5. Sample bottle

[0207] 6. Sample stirrer

[0208] 7. pH probe

[0209] 8. Metering pump

[0210] 9. Purge Solenoid valve

[0211] 10. Drain Solenoid Valve

[0212] The titrator is used to run two pre-programmed routines. The first routine only checks for initial pH. The second routine tests for the following: pH, Alkalinity, Volatile Acids. The pre-programmed routines proceed in a stepwise fashion through the following steps:

[0213] 1. Sample Preparation

[0214] 2. Initial pH

[0215] 3. Initial Volatile Acids Step

[0216] 4. Alkalinity Determination

[0217] 5. Final Volatile Acids Step

[0218] 6. Equipment Cleaning.

[0219] For each test, samples may be automatically taken from the above listed sample points at user selectable sampling intervals (intervals for each sampling point will be different).

[0220] The Acid Metering pump may operate by dispensing a known volume of Acid each time it receives a discrete signal to initiate pumping. The PLC shall operate the pump by making an 110V contact closure signal. The pump shall then dispense a known quantity of acid (typically 20 microliters) into the titration vessel. There shall be a time delay between discrete signals, settable by the HMI (typically 3 seconds), to allow time for the mixer to disperse the acid, and obtain a valid pH reading.

[0221] The mixer should be always on.

Sample Preparation

[0222] At the beginning of each cycle, clean water is in the Titration Vessel (as the last step in the Equipment cleaning process). In addition, prior to collecting the sample to be analyzed, sample material shall be purged directly to drain, to assure that a valid sample is being tested. Since the physical distance to the sample port is different for each port, the quantity of sample to be purged is different for each selected sample. This shall be controlled by the quantity of time that the purge valve is open, and shall be individually changeable via the HMI. Sample preparation shall proceed as follows:

[0223] 1. Open drain solenoid valve to empty titration vessel, for a time adjustable via the HMI.

[0224] 2. Close drain valve

[0225] 3. Open Purge valve, and selected sample port valve, for a quantity of time settable via the HMI. The specific sample port valve shall be selected via the HMI. At the same time turn on feed pump (p-10).

[0226] 4. At the end of the purge cycle, close the sample port valve, turn off the feed pump and close the purge valve.

[0227] 5. Open the CDA Valve to push the sample into the titration vessel. The quantity of time that the CDA valve will be open shall be settable via the HMI (typically 20 seconds).

[0228] 6. Close the CDA Valve

[0229] 7. Sample preparation is complete.

pH

[0230] Collecting an accurate initial pH is generally the first step in all of the pre-programmed routines. To test for pH, the titrator shall do the following:

[0231] 1. Wait a predetermined quantity of time to allow sample stabilization prior to recording the initial pH (typically 20 seconds). This time delay shall be settable via the HMI.

[0232] 2. Take pH reading. When the pH varies by less than 0.02 pH units in a 5-second period, store the data in a form usable to the HMI interface.

[0233] 3. If the pH is the only item requested by the HMI, proceed to the Equipment Cleaning procedure.

Alkalinity and Volatile Acids

[0234] 1. Collect an initial pH (per above procedure).

[0235] 2. Add in acid, using discrete pulses to the Acid metering pump (as described above), and record the number of pulses required to reduce the initial pH to pH 5.00.

[0236] 3. Continue to add acid, using discrete pulses to the Acid metering pump (as described above), and record the number of pulses required to reduce the initial pH to pH 4.30.

[0237] 4. Continue to add acid, using discrete pulses to the Acid metering pump (as described above), and record the number of pulses required to reduce the initial pH to pH 4.00.

[0238] 5. If the pH of 4.00 cannot be reached within a maximum number of acid additions settable by the operator (typically 200 cycles), end the procedure and set an alarm for the HMI.

[0239] 6. Calculation of the Alkalinity and Volatile Acids shall be performed in the HMI and shall use the recorded values.

Equipment Cleaning

[0240] 1. After the sample analysis is complete, open the Titrator vessel drain valve, the DI valve and the purge valve, for a time settable by the HMI (typically 20 seconds).

[0241] 2. Close the valves.

[0242] 3. Open the DI valve for a time settable by the HMI to put excess DI water into the titrator vessel.

[0243] 4. Close the DI valve.

[0244] 5. Open the CDA valve for a time settable by the HMI to push DI water into the vessel.

[0245] 6. Open the drain valve to drain the titrator vessel.

[0246] 7. Close the titrator drain valve.

[0247] 8. Open the purge valve and the DI water valve, for a time settable by the HMI.

[0248] 9. Close the valves.

[0249] 10. Repeat steps 3-8 for a number of repetitions settable by the HMI (typically 2).

[0250] 11. For the final rinse cycle repeat steps 3-5.

[0251] 12. Equipment cleaning step is now complete.

Software Content

[0252] The software (where used) can be provided in any operative language or code useful for operation of the system. Examples of actual software used in a typical operation of a sense and response system are provided below and in Appendices of the ladder step details of the procedures filed with this application and incorporated herein by reference for the:

Bioconverter Discharge

XIO I:7.0/11 NXB XIC T4:29/DN BND XIO B3:0/1 BST TON T4:29 1.0 5 0 NXB XIC T4:29/DN OTE N9:17/11 BND

1. XIC I:6.0/11 XIO N9:21/2 XIO N9:21/3 XIC I:7.0/10 XIC I:7.0/11 XIC I:7.0/9 XIC N9:21/11 BST XIC T4:73/DN OTE B3:1/0 NXB OTE N9:21/14 BND

2. BST CPT F8:7 N9:2-((N9:5-5000.0)*0.12042) NXB MOV F8:7 N9:112 BND

3. BST SUB N10:66 N10:13 N9:109 NXB BST GRT N9:112 N10:66 NXB XIC N9:21/11 BND GRT N9:112 N9:109 OTE N9:21/11 BND

4. BST MOV N10:100 T4:73.PRE NXB XIC N9:21/14 TON T4:73 1.0 60 0 BND

5. BST SUB N9:2 N9:64 N9:47 NXB LES N9:47 0 MOV 0N9:47 NXB GRT N9:47 N10:33 OTE B3:I/1 NXB LES N9:47 N10:33 OTE B3:1/2 NXB GRT N9:47 N10:44 TON T4:47 1.0 5 0 BND

6. XIC B3:1/0 BST XIC T4:12/DN BST XIC B3:1/1 SUB N9:81 50 N9:81 NXB XIC B3:1/2 ADD N9:81 50N9:81 BND NXB LES N9:81 N10:45 MOV N10:45 N9:81 NXB GRT N9:81 N10:46 MOV N10:46 N9:81 NXB LES N10:46 N10:45 MOV 10000 N10:46 BND

7. XIC I:6.0/10 XIO N9:21/2 XIO N9:21/3 XIC I:7.0/9 MOV N10:71 N9:81

8. BST XIO I:6.0/11 XIO I:6.0/10 NXB XIC N9:21/2 NXB XIC N9:21/3 NXB XIC I:6.0/11 XIO B3:1/0 BND MOV 0 N9:81

9. GRT N9:81 0 OTE O:1.0/13

10. BST XIC I:6.0/11 BST XIC B3: I/O OTE N9:94/1 NXB XIO B3:1/0 OTE N9:94/2 BND NXB XIO 1:6.0/11 XIO I:6.0/10 OTE N9:94/3 NXB XIC I:6.0/10 OTE N9:94/4 BND

11. XIC N9:17/11 OTE N9:94/5

12. BST BST BST XIC I:8.0/2 NXB XIC O:3.0/3 BND XIC I:7.0/14 XIC I:6.0/13 XIC I:7.0/11 NXB XIC 1:6.0/12 BND BST OTE O:3.0/3 NXB OTE O:1.0/14 BND NXB XIC O:3.0/3 MOV N10:123 N9:161 NXB XIO O:3.0/3 MOV 0 N9:161 BND

13. BST XIC I:6.0/13 BST XIC O:3.0/3 OTE N9:94/6 NXB XIO O:3.0/3 OTE N9:94/7 BND NXB XIO I:6.0/13 XIO I:6.0/12 OTE N9:94/8 NXB XIC I:6.0/12 OTEN9:94/9 BND

14. XIC B3:0/0 OTE N9:94/10

15. BST BST BST XIC I:8.0/0 NXB XIC O:2.0/13 BND XIC I:8.0/1 XIC I:6.0/15 XIC I:7.0/11 NXB XIC 1:6.0/14 BND BST OTE O:2.0/13 NXB OTE O:1.0/15 BND NXB XIC O:2.0/13 MOV N10:122 N9:160 NXB XIO O:2.0/13 MOV 0 N9:160 BND

16. BST XIC I:6.0/15 BST XIC O:2.0/13 OTE N9:95/0 NXB XIO O:2.0/13 OTE N9:95/1 BND NXB XIO I:6.0/15 XIO I:6.0/14 OTE N9:95/2 NXB XIC I:6.0/14 OTE N9:95/3 BND

17. XIC B3:0/0 OTE N9:95/4

18. BST XIC B3:2/3 OSR B3:2/4 ADD F8:6 1.0 F8:6 NXB XIO I:8.0/13 TON T4:78 1.0 0 0 NXB BST XIC I:8.0/13 NXB XIC B3:2/3 BND XIO T4:78/DN OTE B3:2/3 BND

[0253] 19. BST BST XIC I:8.0/8 NXB XIC I:8.0/9 XIO N9:21/12 LEQ N9:113 N10:117 BND BST OTE O:3.0/14 NXB OTE O:2.0/0 BND NXB BST XIO I:8.0/9 NXB XIC N9:21/12 NXB LEQ N9:113 0 BND ADD N10:117N10:118 N9:113 NXB XIC I:8.0/9 XIO N9:21/12 XIC T4:14/DN SUB N9:113 1 N9:113 NXB XIC O:3.0/14 MOV N10:124 N9:72 NXB XIO O:3.0/14 MOV 0 N9:72 BND

20. BST XIC I:8.0/9 BST XIC O:3.0/14 OTE N9:94/11 NXB XIO O:3.0/14 OTE N9:94/12 BND NXB XIO I:8.0/9 XIO I:8.0/8 OTE N9:94/13 NXB XIC I:8.0/8 OTE N9:94/14 BND 0. BST

Titration Tester/Sensor

[0254] 0. GRT N10:60 0 BST BST MOV N9:24 N9:86 NXB MOV N10:60 N9:87 NXB MOV 0 N9:34 NXB MOV 0 N9:35 NXB MOV 0 N9:36 NXB MOV 0 N9:37 NXB MOV 0 N9:88 BND NXB LES N10:60 20 EQU N9:32 0 MOV 1 N9:32 NXB EQU N10:60 20 MOV 0 N9:32 NXB EQU N10:60 21 MOV 21 N9:32 NXB MOV 0 N10:60 BND

1. BST MOV N10:84 T4:53.PRE NXB EQU N9:32 1 BST OTE N9:33/0 NXB TON T4:53 1.0 90 0 NXB XIC T4:53/DN MOV 2 N9:32 BND BND

2. BST MOV N10:93 T4:54.PRE NXB EQU N9:32 2 BST OTE N9:33/1 NXB TON T4:54 1.0 40 0 NXB XIC T4:54/DN MOV 3 N9:32 BND BND

3. BST MOV N10:85 T4:55.PRE NXB EQU N9:32 3 BST OTE N9:33/2 NXB TON T4:55 1.0 7 0 NXB XIC T4:55/DN MOV 4 N9:32 BND BND

[0255] 4. BST MOV N10:86 T4:56.PRE NXB EQU N9:32 4 BST OTE N9:33/3 NXB TON T4:56 1.0 10 0 NXB CPT F8:3 ((((N9:100+N9:101)+N9:102)+N9:103)+N9:104)|5.0 NXB MOV F8:3 N9:105 NXB SUB N9:105 N9:53 N9:106 NXB ABS N9:106 N9:106 NXB XIC T4:56/DN LEQ N9:106 N10:94 OTE B3:1/12 NXB XIC T4:12/

DN BST MOV N9:103 N9:104 NXB MOV N9:102 N9:103 NXB MOV N9:101 N9:102 NXB MOV N9:100 N9:101 NXB MOV N9:53 N9:100 BND NXB XIC T4:56/DN XIC B3:1/12 BST TON T4:68 1.0 5 0 NXB XIC T4:68/DN BST MOV N9:53 N9:34 NXB GRT N9:87 10 MOV 10 N9:32 NXB LES N9:87 10 MOV 21 N9:32 BND BND BND BND

5. EQU N9:32 10 BST OTE N9:33/4 NXB LEQ N9:53 N10:99 BST MOV N9:88 N9:108 NXB MOV 11 N9:32 BND BND

6. EQU N9:32 11 BST OTE N9:33/4 NXB LEQ N9:53 N10:95 BST MOV N9:88 N9:35 NXB MOV 12 N9:32 BND BND

7. EQU N9:32 12 BST OTE N9:33/5 NXB LEQ N9:53 N10:96 BST MOV N9:88 N9:36 NXB MOV 13 N9:32 BND BND

8. EQU N9:32 13 BST OTE N9:33/6 NXB LEQ N9:53 N10:97 BST MOV N9:88 N9:37 NXB MOV 21 N9:32 BND BND

9. BST MOV N10:88 T4:57.PRE NXB EQU N9:32 21 BST OTE N9:33/7 NXB MOV N10:92 N9:89 NXB TON T4:57 1.0 90 0 NXB XIC T4:57/DN MOV 22 N9:32 BND BND

10. EQU N9:32 22 BST OTE N9:33/8 NXB TON T4:63 0.01 50 0 NXB XIC T4:63/DN MOV 23N9:32 BND

11. BST MOV N10:89 T4:58.PRE NXB EQU N9:32 23 BST OTE N9:33/9 NXB TON T4:58 1.0 7 0 NXB XIC T4:58/DN MOV 24 N9:32 BND BND

[**0256**] 12. EQU N9:32 24 BST OTE N9:33/10 NXB TON T4:67 0.01 10 0 NXB XIC T4:67/DN MOV 25 N9:32 BND 13. BST MOV N10:90 T4:59.PRE NXB EQU N9:32 25 BST OTE N9:33/11 NXB TON T4:59 1.0 5 0 NXB XIC T4:59/DN BST GRT N9:89 0 MOV 26 N9:32 NXB EQU N9:89 0 MOV 0 N9:32 BND BND BND

14. BST MOV N10:98 T4:64.PRE NXB EQU N9:32 26 BST OTE N9:33/12 NXB TON T4:64 1.0 90 0 NXB XIC T4:64/DN MOV 27 N9:32 BND BND

15. EQU N9:32 27 BST OTE N9:33/13 NXB TON T4:65 0.01 50 0 NXB XIC T4:65/DN MOV 28 N9:32 BND

16. BST MOV N10:91 T4:60.PRE NXB EQU N9:32 28 BST OTE N9:33/14 NXB TON T4:60 1.0 7 0 NXB XIC T4:60/DN MOV 29 N9:32 BND BND

17. EQU N9:32 29 BST OTE N9:33/15 NXB TON T4:66 0.01 50 0 NXB XIC T4:66/DN BST GRT N9:89 0 SUB N9:89 1 N9:89 NXB MOV 23 N9:32 BND BND

18. BST XIC N9:33/1 NXB XIC N9:33/9 NXB XIC N9:33/14 BND OTE O:4.0/0

19. XIC N9:33/1 OTE O:4.0/1

20. BST XIC N9:33/2 NXB XIC N9:33/11 NXB XIC N9:33/14 BND OTE O:4.0/2

21. XIC N9:33/9 OTE O:4.0/3

22. XIC N9:33/1 BST EQU N9:87 7 NXB EQU N9:87 17 BND OTE O:4.0/4

23. XIC N9:33/1 BST EQU N9:87 6 NXB EQU N9:87 16 BND OTE O:4.0/5

24. XIC N9:33/1 BST EQU N9:87 5 NXB EQU N9:87 15 BND OTE O:4.0/6

25. XIC N9:33/1 BST EQU N9:87 4 NXB EQU N9:87 14 BND OTE O:4.0/7

26. XIC N9:33/1 BST EQU N9:87 3 NXB EQU N9:87 13 BND OTE O:4.0/8

27. XIC N9:33/1 BST EQU N9:87 2 NXB EQU N9:87 12 BND OTE O:4.0/9

28. XIC N9:33/1 BST EQU N9:87 I NXB EQU N9:87 11 BND OTE O:4.0/10

29. BST XIC N9:33/0 NXB XIC N9:33/7 NXB XIC N9:33/12 BND OTE O:4.0/11

30. BST XIC O:4.0/2 NXB XIC O:4.0/3 BND OTE O:4.0/13

31. BST BST XIC N9:33/4 NXB XIC N9:33/5 NXB XIC N9:33/6 BND BST XIO T4:62/DN BST OTE O:3.0/10 NXB OSR B3:1/13 ADD N9:88 1 N9:88 BND NXB XIO T4:61/DN TON T4:62 0.01 50 0 NXB XIC T4:62/DN TON T4:61 1.0 3 0 BND NXB MOV N10:83 T4:61.PRE BND

32. BST BST XIC N9:33/4 NXB XIC N9:33/5 NXB XIC N9:33/6 BND GRT N9:88 N10:87 NXB XIC N9:18/6 BND XIO B3:0/1 BST OTE N9:18/6 NXB OSR B3:1/14 MOV 21 N9:32 BND

Bioconverter Fluidizer

1. XIC B3:0/0 BST BST XIC N9:21/2 NXB XIC N9:21/3 BND GRT N9:65 N10:14 NXB XIC T4:16/DN BND XIO B3:0/1 BST TON T4:16 1.0 5 0 NXB XIC T4:16/DN OTE N9:16/11 BND

2. XIC B3:0/0 BST BST XIC N9:21/2 NXB XIC N9:21/3 BND XIC O:2.0/15 LES N9:65 N10:15 NXB XIC T4:17/DN BND XIO B3:0/1 BST TON T4:17 1.0 5 0 NXB XIC T4:17/DN OTE N9:16/12 BND

3. XIC B3:0/0 BST BST XIC N9:21/2 NXB XIC N9:21/3 BND GRT N9:15 N10:68 NXB XIC T4:18/DN BND XIO B3:0/1 BST TON T4:18 1.0 5 0 NXB XIC T4:18/DN OTE N9:16/13 BND

4. XIC B3:0/0 BST BST XIC N9:21/2 NXB XIC N9:21/3 BND XIC O:2.0/14 LES N9:15 N10:69 NXB XIC T4:19/DN BND XIO B3:0/1 BST TON T4:19 1.0 5 0 NXB XIC T4:19/DN OTE N9:16/14 BND

5. XIC B3:0/0 BST BST XIC N9:21/2 NXB XIC N9:21/3 BND GRT N9:52 N10:20 NXB XIC T4:20/DN BND XIO B3:0/1 BST TON T4:20 1.0 5 0 NXB XIC T4:20/DN OTE N9:17/3 BND

6. XIC B3:0/0 BST BST XIC N9:21/2 NXB XIC N9:21/3 BND LES N9:52 N10:21 NXB XIC T4:21/DN BND XIO B3:0/1 BST TON T4:21 1.0 5 0 NXB XIC T4:21/DN OTE N9:17/4 BND

7. XIC B3:0/0 BST BST XIC N9:21/2 NXB XIC N9:21/3 BND GRT N9:51 N10:22 NXB XIC T4:22/DN BND XIO B3:0/1 BST TON T4:22 1.0 5 0 NXB XIC T4:22/DN OTE N9:17/5 BND

8. XIC B3:0/0 BST BST XIC N9:21/2 NXB XIC N9:21/3 BND LES N9:51 N10:23 NXB XIC T4:23/DN BND XIO B3:0/1 BST TON T4:23 1.0 5 0 NXB XIC T4:23/DN OTE N9:17/6 BND

9. XIC N9:21/2 GRT N9:26 8 BST OTE B3:0/6 NXB MOV N9:44 N9:45 BND

10. XIC N9:21/3 GRT N9:26 N10:36 OTE B3:0/12

11. BST XIC N9:21/2 NXB XIC N9:21/3 BND MOV N10:32 N9:29

12. XIC I:5.0/11 BST XIO N9:21/2 XIO N9:21/3 XIC T4:14/DN GRT N9:29 0 SUB N9:29 1 N9:29 NXB LEQ N9:29 0 OTE N9:21/4 BND

13. BST XIC N9:21/2 NXB XIC N9:21/3 BND BST XIC T4:12/DN LES N9:44 30000 ADD N9:44 1 N9:44 NXB OSR B3:1/11 MOV 0 N9:44 BND

[0257] 14. BST XIO N9:21/3 XIC N9:21/4 NXB XIO N9:21/3 XIC T4:47/DN NXB XIO N9:21/3 XIC N10:0/0 NXB XIC N9:21/2 BND XIO B3:0/5 XIO B3:0/6 XIC I:5.0/11 XIC I:5.0/13 BST OTE N9:21/2 NXB BST OTU N10:0/0 NXB OSR B3:0 µl MOV N9:24 N9:30 BND BND BST XIO N9:21/2 XIC B3:0/0 LES N9:45 N10:28 NXB XIO N9:21/2 GEQ N9:38 N10:30 NXB XIO N9:21/2 XIC N10:0/1 NXB XIC N9:21/3 BND XIO B3:0/5 XIO B3:0/12 XIC I:5.0/11 XIC I:5.0/13 BST OTE N9:21/3 NXB OTU N10:0/1 NXB MOV N10:28N9:45 NXB MOV0N9:38 BND

15. XIO N9:17/4 XIO N9:17/3 XIO N9:17/6 XIO N9:17/5 XIO N9:16/12 XIO N9:16/14 LES N9:43 N10:29 OTE B3:0/7

16. XIO B3:0/7 BST OTE B3:0/5 NXB XIC N9:21/2 OSR B3:1/9 ADD N9:38 1 N9:38 BND

17. BST XIC N9:21/2 NXB XIC N9:21/3 BND OSR B3:0/8 BST MOV 0 N9:26 NXB MOV 0 N9:27 NXB MOV 0 N9:40 BND

18. XIC I:7.0/6 OSR B3:0/9 OTE B3:1/6

19. XIC I:7.0/13 OSR B3:0/10 OTE B3:1/7

20. XIC B3:1/6 ADD N9:26 1 N9:26

21.XIC B3:1/7 ADD N9:27 1 N9:27

22. XIC I:5.0/10 MOV N10:34 N9:73

23. BST XIC N9:21/3 LES N9:26 2 OSR B3:1/15 MOV N10:35 N9:73 NXB XIC N9:21/2 LES N9:26 2 OSR B3:2/0 MOV N10:110 N9:73 NXB XIC N9:21/2 MOV N10:109 N10:39 NXB XIC N9:21/3 M4V N10:108 N10:39 BND

24. BST XIC N9:21/3 NXB XIC N9:21/2 BND XIC T4:13/DN ADD N9:43 1 N9:43

25. XIO N9:21/3 XIO N9:21/2 MOV 0 N9:43

[0258] 26. XIC N9:21/10 GRT N9:43 N10:39 BST XIO T4:71/DN TON T4:71 1.0 5 0 NXB XIC T4:71/DN BST ADD N9:73 200 N9:73 NXB GRT N9:73 10000 MOV 10000 N9:73 BND NXB BST EQU N9:107 10000 NXB XIC N9:18/8 BND XIO B3:0/1 BST TON T4:72 1.0 300 0 NXB XIC T4:72/DN OTE N9:18/8 BND BND

27. EQU N10:39 0 MOV 25 N10:39

[0259] 28. NEQ N9:26 N9:40 BST XIC N9:21/3 GEQ N9:26 2 BST CPT F8:1 (((N9:43*N9:73)|N10:39)*0.25)+(N9:73*0.75) NXB LIM 0.0 F8:1 10000.0 MOV F8:1 N9:73 NXB GRT F8:1 10000.0 MOV 10000 N9:73 BND NXB BST MOV N9:43 N9:46 NXB MOV N9:43 N9:84 NXB MOV 0 N9:43 NXB MOV N9:26 N9:40 BND BND

29. BST LES N9:73 N10:40 MOV N10:40 N9:73 NXB GRT N9:73 N10:41 MOV N10:41 N9:73 BND

30. XIO N9:21/2 XIO N9:21/3 XIO I:5.0/10 MOV 0 N9:73

[0260] 31. BST BST XIC N9:21/2 NXB XIC N9:21/3 NXB XIC I:5.0/10 BND BST TON T4:24 1.0 5 0 NXB BST XIC N9:21/2 NXB XIC N9:21/3 XIC S:4/5 BND OTE O:1.0/5 NXB XIC T4:24/DN OTE N9:21/10 BND NXB BST XIC N9:21/10 NXB XIC N9:21/9 BND XIC I:8.0/7 OTE O:2.0/14 NXB BST XIC T4:24/EN NXB XIC O:3.0/5 BND XIO T4:52/DN BST OTE O:3.0/5 NXB OTE N9:21/5 BND NXB XIO T4:24/EN TON T4:52 1.0 5 5 BND

32. BST XIC I:5.0/11 BST XIC O:2.0/14 OTE N9:91/9 NXB XIO O:2.0/14 OTE N9:91/10 BND NXB BST XIO I:5.0/10 XIO I:5.0/11 OTE N9:91/11 NXB XIC I:5.0/10 OTE N9:91/12 BND BND

33. BST XIC N9:16/11 NXB XIC N9:16/12 NXB XIC N9:17/4 NXB XIC N9:17/5 BND OTE N9:91/13

[0261] 34. BST BST XIC N9:21/2 NXB XIC N9:21/3 NXB XIC I:5.0/12 BND BST OTE O:1.0/6 NXB TON T4:46 1.0 5 0 NXB XIC T4:46/DN XIC I:8.0/7 OTE O:2.0/15 BND NXB BST XIC O:1.0/6 NXB XIC O:3.0/6 BND XIO T4:51/DN BST OTE O:3.0/6 NXB OTE N9:21/7 BND NXB XIO O:1.0/6 TON T4:51 1.0 5 5 BND

35. BST XIC O:2.0/15 BST MOV N10:70 N9:80 NXB LES N9:80 N10:42 MOV N10:42 N9:80 NXB GRT N9:80 N10:43 MOV N10:43 N9:80 BND NXB XIO O:2.0/15 MOV 0 N9:80 BND

36. BST XIC I:5.0/13 BST XIC O:2.0/15 OTE N9:91/14 NXB XIO O:2.0/15 OTE N9:91/15 BND NXB BST XIO I:5.0/12 XIO I:5.0/13 OTE N9:92/0 NXB XIC I:5.0/12 OTE N9:92/1 BND BND

37. BST XIC N9:16/11 NXB XIC N9:16/12 NXB XIC N9:17/4 NXB XIC N9:17/5 BND OTE N9:92/2

38. BST XIC I:7.0/7 NXB XIO I:7.0/7 XIC B3:0/0 BND OSR B3:0/13 BST ADD N9:66 2 N9:66 NXB DIV N9:66 6 N9:67 BND

39. BST XIC I:5.0/8 NXB XIC I:5.0/9 LES N9:66 2 BND XIO N9:21/2 XIO N9:21/3 XIC N9:21/9 MOV N10:47 N9:107

40. GRT N9:107 0 XIC T4:13/DN ADD N9:68 1 N9:68

[0262] 41. XIC N9:21/9 GRT N9:81 0 GRT N9:68 N10:37 BST XIO T4:69/DN TON T4:69 1.0 5 0 NXB XIC T4:69/DN BST ADD N9:107 200 N9:107 NXB GRT N9:107 10000 MOV 10000 N9:107 BND NXB BST EQU N9:107 10000 NXB XIC N9:18/7 BND XIO B3:0/1 BST TON T4:70 1.0 300 0 NXB XIC T4:70/DN OTE N9:18/7 BND BND

42. EQU N10:37 0 MOV 50 N10:37

[0263] 43. XIC I:5.0/9 XIO N9:21/2 XIO N9:21/3 NEQ N9:66 N9:79 BST GEQ N9:66 2 BST CPT F8:2(((N9:68*N9:107)|N10:37)*0.05)+(N9:107*0.95) NXB LIM 0.0 F8:2 10000.0 MOV F8:2 N9107 NXB GRT F8:2 10000.0 MOV 10000 N9:107 BND NXB BST MOV N9:66 N9:79 NXB MOV N9:68 N9:85 NXB MOV 0 N9:68 BND BND

44. XIO N9:17/0 OTE B3:0/15

45. BST LES N9:107 N10:101 MOV N10:101 N9:107 NXB GRT N9:107 N10:102 MOV N10:102 N9:107 BND

46. BST XIC N9:21/2 NXB XIC N9:21/3 NXB XIO I:5.0/8 XIO I:5.0/9 NXB XIO B3:0/15 BND BST MOV 0 N9:107 NXB MOV 0 N9:66 BND

[0264] 47. BST BST XIC I:5.0/8 NXB XIC I:5.0/9 BND XIO N9:21/2 XIO N9:21/3 XIO N9:91/13 XIO N9:21/10 BST BST XIC I:5.0/9 XIO N10:0/6 NXB XIC I:5.0/8 NXB XIC I:5.0/9 XIC N10:0/6 XIO T4:79/DN BND BST OTE O:1.0/4 NXB OTE N9:21/9 BND NXB XIC I:5.0/9 XIC N10:0/6 XIO T4:80/DN TON T4:79 1.0 119 0 NXB XIC T4:79/DN TON T4:80 1.0 1680 0 BND NXB MOV N10:113 T4:79.PRE NXB MOV N10:114 T4:80.PRE BND

[0265] 48. BST BST XIC I:5.0/8 NXB XIC I:5.0/9 BND XIO N9:21/2 XIO N9:21/3 XIO N9:91/13 XIO N9:21/10 BST BST XIC I:5.0/9 XIC N9:21/14 NXB XIC I:5.0/9 XIO N9:21/14 XIC N10:0/6 XIO T4:79/DN NXB XIC I:5.0/9 XIO N9:21/14 XIO N10:0/6 NXB XIC I:5.0/8 BND BST OTE O:1.0/4 NXB OTE N9:21/9 BND NXB XIC I:5.0/9 XIC N10:0/6 XIO T4:80/DN TON T4:79 1.0 119 0 NXB XIC T4:79/DN TON T4:80 1.0 1680 0 BND NXB MOV N10:113 T4:79.PRE NXB MOV N10:1 14 T4:80.PRE BND

49. XIC N9:21/9 BST GRT N9:81 0 MOV N9:107 N9:73 NXB EQU N9:81 0 MOV N10:105 N9:73 NXB OTE O:3.0/4 BND

50. BST XIC I:5.0/9 BST XIC N9:21/9 OTE N9:91/4 NXB XIO N9:21/9 OTE N9:91/5 BND NXB BST XIO I:5.0/8 XIO I:5.0/9 OTE N9:91/6 NXB XIC I:5.0/8 OTE N9:91/7 BND BND

51. XIC N9:18/7 OTE N9:91/8

Organic Biomass Input Feed Stream

[0266] An estimated minimum scope of patent protection that could be reasonably sought for a generic treatment process might be couched as follows:

[0267] a) Liquid, solid or dry material storage equipment;

[0268] b) feed from liquid, solid or dry storage to an EQ tank and/or directly to an anaerobic bioconverter;

[0269] c) flow from the bioconverter; and

[0270] d) discharge of energy depleted water from the system

[0271] e) discharge of energy rich biogas

[0272] wherein {specific parameters} are sensed in the anaerobic bioconverter to provide signals to a processor that controls influx of i) nutrients, ii) oxidizing agents [inclusive of sulfur and oxygen], iii) antifoam agents and iv) metal additives, wherein with respect to at least two of i), ii), iii) and iv), at least one different condition is sensed to provide sensed data for controlling introduction rates for each of the at least two of i), ii), iii) and iv).

[0273] Upon further review, the process may be broadened so as not to require all four additions, with otherwise similar limitations on process control.

[0274] The system may also monitor and control all elements of material handling within the and out of the system. Material handling is another potentially important independent step in the process of converting waste food materials to energy. Prior to the EQ tank, material must be received and qualitative and quantitative information obtained to allow the system to process the material into a suitable feed substrate (feedstock) to the bioconverter.

[0275] Waste fuel production by-products and any supplemental additives such as food materials may be dry, a slurry, or aqueous in nature. Materials can be stored in segregated fashion, such as individual tanks, or multiple materials can be combined in a single container. Once the material is received and stored, the system can monitor multiple parameters from each storage vessel for each type of waste. While several parameters are common to all types of wastes, some parameters are more appropriate for specific types of wastes. For example, weight is a more appropriate quantitative measure of a dry material while gallons is a more appropriate quantitative measure of an aqueous material. COD is an example of a parameter common to all food wastes and biofuel production residual or by-products.

[0276] To maintain the bioconversion process as close to a theoretical optimal level as possible requires quantitative and qualitative characteristics of the waste materials to be sent to the PLC allowing the PLC to determine the appropriate next step(s) in the process.

[0277] Maintaining a relatively stable and consistent organic loading to the bioconversion step of the process is a critical factor. Waste biofuel residuals and/or food material must be processed in various ways depending of the characteristics of the material to form a feedstock. Multiple steps may be required. For example, dry material may be required to be ground into smaller particles size and combined with aqueous and/or slurried materials in a proportional manner that creates a feed substrate matching the parameters required by the bioconversion step of the process. Another example would be that various aqueous materials need to be combined in proportion based on their COD concentrations to result in a COD of the combined material equal or near equal to the desired COD concentration the bioconverter expects to process. A third example would be that the materials lack specific compounds or chemicals such as nitrogen and phosphorous which must be added to the waste material to properly condition the material for bioconversion. The PLC software can obtain quantitative and qualitative information regarding each type of waste food material and direct the subsequent process steps required to create the desired feed substrate to the bioconverter.

[0278] Multiple quantitative and qualitative characteristics are incorporated into the material handing process including:

[0279] 1. Weight/Volume/Density/Flow

[0280] a. There are many examples of quantitative information that may be used to determine amount of materials available to be processed or being processed. They may be measured at various points along the system, correlated with known or expected results, and the system designed (e.g., programmed or set to provide an alarm or notice) according to past measurements.

[0281] 2. Viscosity/Moisture content/FOG (Fats, Oils, and Greases)

[0282] a. These are used to determine additional processing requirements such as dilution, from which established needs of the system can be responded to.

[0283] b. These may also be used to determine what type of conveyance device is used to transport the material through additional processing steps.

[0284] 3. pH and alkalinity monitoring and control

[0285] a. Used to determine if the pH must be adjusted. The bioconversion step in the process operates around neutral pH. For example, the pH of two distinct stored organic material sources will have been measured, and the balance of the materials may be shifted to reflect the needs of pH adjustment suggested by the readings.

[0286] 4. Temperature

[0287] a. The bioconversion step requires operating temperatures between 77- and 100 degrees F. for mesophilic operation and between 122 and 158 degrees F. for thermophilic operation. The temperature may be automatically adjusted in response to the measurement of shifting or undesirable temperatures.

[0288] 5. BOD/COD/Volatile Acid concentration/Protein concentration/FOG concentration/Carbohydrate concentration/Sugar concentration/Methane potential

[0289] a. These all are examples of parameters which may be used by the PLC to determine proportional amounts of each waste food material required to create the desired feedstock for the bioconversion step

[0290] b. These are all are examples of parameters which may be used by the PLC in determining if additional compounds or chemicals such as traces metals (nickel, iron, cobalt, etc) are required to be added.

[0291] 6. Particle Size

[0292] a. Used to determine if waste material should be processed differently through grinding and crushing operations to create the desired particle size/shape in the feedstock for the bioconversion step. Upon determination of required size change, the operating parameters of material sizing equipment may be altered.

[0293] 7. Detection of contaminants and alarm

[0294] a. Detection in the raw waste food material of contaminants which would disrupt and/or destroy the biological bioconversion activity can be essential, and rapid response is desirable. Examples of contaminants include high chlorine levels and quaternary ammonium. The PLC would not use the contaminated material when creating feedstock for the bioconversion step of the process. Materials can be available that are known antagonistic vectors against such contaminants and which might leach, absorb, chelate or otherwise restrain or remove such contaminants.

[0295] 8. General water quality parameters such as conductivity and ORP may also be usefully measured and automatically adjusted in the system.

[0296] Energy control, energy output and energy conservation considerations may also be effected and maintained in the operation of the present system. For example, Connections to Energy Production equipment require monitoring and control of equipment. Monitoring and control is done both to optimize energy production and to accurately count the units being sold to the end user.

[0297] Parameters controlled by the PLC to optimize energy production may include gas input flow maintenance including control valves to supplement with pipeline natural gas as needed to supplement bioconverter gas output; maintenance of gas blowers to maintain a constant gas pressure; control of equipment for moisture reduction; control of equipment for sulfur dioxide reduction; connections to the end-user require connections to, control and measurement of the output electrical power; connections to, control and measurement of hot water piping flows, pressure and hot water heat output; connections to, control and measurement of steam piping, pressure, flow, steam quality and steam heat output.

[0298] A view of the Figures will assist in an additional appreciation of the scope of the present technology. FIG. **1** shows a schematic of a basic biomass bioconversion system **2** according to general teachings herein. The system **2** shown in FIG. **1** has a biomass bioconversion tank **4** containing the mixture **6** of biomass and liquid and a gas containing space **8** over the mixture **6**. The bioconversion tank **4** is shown with three outlet systems **10**, **12** and **14** for the gas outlet (**10**), the liquid and dissolved, dispersed, suspended solids outlet (**12**), and an optional mass outlet (**14**) which may be used for the infrequent removal of excess biomass from the bioconversion tank **4**. The gas outlet **10** is in mass transfer communication with a gas separation system **16**, which is shown with three venting outlets **18** (e.g., for CO_2), **20** (e.g., for CH_4, H_2) and residual gas outlet **22** for any other gases emitted. There may be additional vents if H_2 is a significant gaseous component of the stream initially vented through outlet **10** from the bioconversion tank **4**.

[0299] The configuration of the system **2** in FIG. **1** shows an adjacent organic waste producing commercial biofuel production facility **26** (e.g., a biodiesel or ethanol synthesizing plant, etc.) that may produce a solids waste stream **28** and/or an aqueous waste stream **30** that may each be fed into the bioconversion tank **4** as at least one source of both organic solids and aqueous material (which may also contain dissolved, suspended or dispersed solids). The system **2** is also shown with a nutrient storage tank **24** and feed stream **24***a* to the bioconversion tank **4**, and three separate organic solids material storage tanks **32**, **34** and **36** with their individual feed streams **32***a*, **34***a* and **36***a* to the bioconversion tank **4**. There may be, and preferably is, a separate aqueous supply stream that can be fed either directly into the bioconversion tank **4** or into the individual organic solids storage tanks **32**, **34** and **36** or into their individual feed streams **32***a*, **34***a* and **36***a* to the bioconversion tank **4**. A central data processing system **40** is shown with various communication links (which may be hard wire or wireless) **52**, **42**, **44**, **46**, **48** and **50** to other components (e.g., distal node, FPGA, ASIC, subprocessor, or signal router **72**; organic solid material storage tanks **32**, **34** and **36**; commercial plant **26**; and nutrient storage tank **24**, respectively). Each feed stream (including at the site of the storage tank or originating facility) would preferably have an automatically controlled rate flow system in communication link with the central processor **40**. A filter bed **90** is shown between the biomass and the liquid outlet **12** to assure retention of larger size particles and other solids. Liquid outlet **12** may flow to a liquid/gas separation tank **92** prior to discharge.

[0300] As indicated more thoroughly in the discussion above, the sensors may be (in the gas volume **8** for gas

pressure, gas temperature, gas content (e.g., methane, carbon dioxide, volatile acid and/or hydrogen content), gas acidity, gas conductivity (as an indication of gas content) and the like, and in the biomass volume **6** for pH, nutrient content, temperature, density, temperature, specific component or by-product content, water content, chemical oxygen concentration or requirements, flow rates through the filter **90** or into the liquid outlet **12**, and the like, as described above.

[**0301**] Inside and/or at flow inlets and outlets to the bioconversion tank **4** may be sensors as indicated in the discussion above. In FIG. **1** are shown two sensors **62** and **64** in the gas volume **8** in the bioconversion tank **4** and three sensors **66**, **68** and **70** in the biomass volume **6** in the bioconversion tank **4**. These sensors **62**, **64**, **66**, **68** and **70** may be in direct communication with the processor **40** or may be linked to the processor **40** through a router or other intermediary device **72**. In order to reduce computing power needed and to simplify repair and replacement of parts, the sensors may communicate as nodes in a distributed architecture format, using linking element **72** to properly format, translate or encode signals to be sent to processor **40** for reading, storage and analysis, followed by commands or state change signals from the processor or responsive or controlled elements, such as the flow control or rate of flow control in the various sources of materials (and energy) to the bioconversion tank **4**, as explained above.

[**0302**] Attached and incorporated into this application is Appendix I, which contains three distinct software ladders for use in various individual and separate component sequences in the practice of technology that is described herein. LAD 6 represents a sequence that may be used with the bioconverter discharge controls and constitutes copyrighted code and material of the assignee.

[**0303**] LAD 5 represents a sequence that may be used with the bioconverter agitator controls and constitutes copyrighted code and material of the assignee.

[**0304**] LAD 11 represents a sequence that may be used with the Titrator Sequence controls and constitutes copyrighted code and material of the assignee.

[**0305**] Other software for other individual performance steps identified in this disclosure may be similarly structured as taught by the technology. One of ordinary skill in the art, upon reading this disclosure will become readily aware of variations, alternatives and orientations that are not specifically identified in this disclosure, but which are within the scope of the technology disclosed. These variations and equivalents are intended to be included within this disclosure and the discussion of specific structures, materials, software and line code is not intended to limit the scope of protection afforded by the following claims to this technology.

[**0306**] In its simplest embodiment, the technology of the present invention may be associated with any biofuel synthesizing or manufacturing plant that produces organic waste. The organic waste residuals are then processed in a bioconverter to generate combustible gaseous or volatile fuel (such as methane, hydrogen and the like). The combustible fuel is then, sold as an energy product, oxidized or burned to generate energy (either directly as heat, or secondarily as an electrical generation system) to provide energy to the biofuels synthesizing or manufacturing plant, and/or as a saleable energy product.

[**0307**] All references to other publications made herein incorporate each and every reference in their entirety herein to provide additional information according to this disclosure.

1. A method of bioconversion of organic waste material from a synthetic fuel manufacturing process that requires energy input in the performance of the synthetic fuel manufacturing process, the method comprising:

providing a tank for bioconversion of organic waste material, at least some of which organic waste material is derived from a synthetic fuel manufacturing process, the tank containing an active biomass comprising at least one bacteria that decomposes organic material;

providing one or more inlets to the bioconversion tank, comprising an inlet for organic material from the synthetic fuel manufacturing process

a processor receiving and storing information automatically or manually input to the processor on:

the status of chemical oxygen demand and/or biological oxygen demand of the active biomass; and

the oxygen provision capability of an organic material that can be fed into the bioconversion tank through any inlet;

the processor exercising control over a mass flow control system which feeds the at least one organic material through an inlet, the processor directing mass flow at a rate based at least in part upon the status of chemical oxygen demand in the bioconversion tank as recognized by the processor from received information;

a stream carrying combustible gases from the biomass; and

the stream providing at least some of the energy input in the performance of the synthetic fuel manufacturing process.

2. The method of claim 1 wherein there are at least two storage tanks for organic material, a first storage tank for the first organic material and a second storage tank for a second organic material, the first and second organic materials having different chemical oxygen provision capabilities from each other;

the processor receiving and storing information on the respective chemical oxygen provision capabilities of the first organic material and the second organic material; and

the processor feeding feeds the first organic material and the second organic material into the bioconversion tank at a rate based at least in part upon the status of chemical oxygen demand in the bioconversion tank, the chemical oxygen provision capability of the first organic material, and the chemical oxygen provision capability of the second organic material as recognized by the processor and a filter may be present between the active biomass in the bioconversion tank and the treated aqueous outlet; or wherein an energy depleted aqueous stream is removed from the bioconversion tank through an aqueous stream outlet and a biogas stream is removed from the bioconversion tank through

a gas venting outlet, the biogas stream comprising primarily methane and carbon dioxide is removed from the bioconversion tank.

3. (canceled)

4. The method of claim 2 wherein at least one of the active biomass and energy depleted aqueous stream are automatically tested for active biomass nutrient content and testing information is provided to the processor or wherein when testing for pH indicates that the pH level in the treatment tank is not within a desired range stored in the processor, the processor directs a feed system for a pH active material selected from the class consisting of at least one of a base, an acid or a buffer to input pH active material into the bioconversion tank to bring the pH level in the tank within the desired range.

5. The method of claim 4 wherein when testing for active biomass nutrient content indicates that the nutrient level in the bioconversion tank is not within a desired range stored in the processor, the processor directs a nutrient feed system to input nutrient material into the bioconversion tank to bring nutrient level in the tank within the desired range and wherein testing may be performed for at least one of available nitrogen and available phosphorous, and the results of such testing are used by the processor to determine how much nutrient is to be added to the bioconversion tank to specifically adjust at least one of nitrogen and phosphorous content in the treatment tank.

6. (canceled)

7. (canceled)

8. (canceled)

9. (canceled)

10. (canceled)

11. (canceled)

12. An organic bioconversion system for providing energy to a synthetic biofuel manufacturing process comprising:

a) at least a first organic material storage tank for a first organic material;

b) an aqueous stream input source;

c) a bioconversion tank having a controlled input connection from a) and a controlled input connection from b), and containing an active biomass that comprises bacteria capable of decomposing the first organic material from the first organic material storage tank;

d) a processor that controls the input connections from a) and from b);

e) a sensing system that determines the chemical oxygen demand of the active biomass in the bioconversion tank and controls flow of at least the first organic material through the input connection from a) to provide oxygen from the first organic material is provided to the active biomass in the bioconversion tank at a rate sufficient to support health of the bacteria in the bioconversion tank;

f) an aqueous stream outlet from the bioconversion tank; and

g) a gaseous stream outlet from the bioconversion tank that is stored and then fed or directly fed to an oxidizing system that produces energy for the synthetic biofuel manufacturing process having a nutrient sensing system that detects levels of nutrients in at least one of the biomass in the bioconversion tank and an aqueous stream passing into or through the aqueous stream output and information from the nutrient sensing system to the processor, and the processor determines levels of nutrients that should be provided to the active biomass in the bioconversion tank, and wherein the processor may contain software that determines levels of nutrients that should be provided to the active biomass in the bioconversion tank from sensed data from the nutrient sensing system and controls flow of nutrients into the bioconversion tank to provide nutrients in a quantity determined by the software, and wherein nutrients sensed may comprise at least one nutrient selected from the class consisting of available nitrogen and available phosphorous and wherein the gaseous stream outlet may be connected to a gas stream separation system that can increase the concentration of methane in a first concentrated stream and can increase the concentration of carbon dioxide in a second concentrated stream.

13. (canceled)

14. (canceled)

15. (canceled)

16. The bioconversion system of claim 12 wherein there are at least two storage tanks for organic material, a first storage tank for the first organic material and a second storage tank for a second organic material, the first and second organic materials having different chemical oxygen provision capabilities from each other and wherein the processor may control feed rates for the first organic material and the second organic material into the bioconversion tank, and directs feed of the first organic material and the second organic material at a rate based at least in part upon the status of chemical oxygen demand in the bioconversion tank, the chemical oxygen provision capability of the first organic material and the chemical oxygen provision capability of the second organic material as recognized by the processor and wherein there are sensing systems for at least one other sensible condition may be selected from the group consisting of pH of the biomass in the bioconversion tank, pH of the aqueous stream from the bioconversion tank, concentration of a specific gas component in the gaseous stream from the bioconversion tank and gas pressure within the bioconversion tank, and the processor may contain software that controls rate flows of materials into the bioconversion tank in response to an indication from sensed data that the rate flows of specific materials into the bioconversion tank, and the software may be responsive to the sensed data in controlling mass input into the bioconversion tank.

17. (canceled)

18. (canceled)

19. The bioconversion system of claim 16 wherein the processor contains software that determines levels of nutrients that should be provided to the active biomass in the bioconversion tank from sensed data from the nutrient sensing system and controls flow of nutrients into the bioconversion tank to provide nutrient in a quantity determined by the software and at least one nutrient is selected from the class consisting of available nitrogen and available phosphorous and wherein the waste material may be selected from the group consisting of waste material comprising at least one of whole stillage, thin stillage and glycerin.

20. (canceled)

21. The method of claim 1 wherein mass flow through the system is at least in part automatically controlled by sensing

at least one of a) Weight/Volume/Density/Flow; b) Viscosity/Moisture content/FOG (Fats, Oils, and Greases); c) pH and alkalinity monitoring; d) Temperature; e) BOD/COD/Volatile Acid concentration/Protein concentration/FOG concentration/Carbohydrate concentration/Sugar concentration/Methane potential; f) Particle Size; g) Detection of contaminants and alarm; and h) General water quality parameters such as conductivity and ORP, and

automatically providing a presumed appropriate response to the sensing according to at least one of a lookup table, hardware response and software response, or wherein the bioconverter system is sensed and automatically responded to by sensing at least one of a) Contaminant alarm, b) Solids concentration monitoring and control, c) BOD and COD monitoring and control; d) surface tension/foam detection monitoring and alarm; e) Fats, Oils and Grease monitoring and alarm; f) Dissolved gas monitoring and alarm; g) Volatile acids monitoring and alarm; h) Detection and control of specific bacteria concentration/activity; and

automatically responding thereto

22. (canceled)

23. (canceled)

24. (canceled)

25. A method of reducing total external energy requirements input into the operation of a system requiring energy input comprising:

providing organic materials to a bioconversion process;

performing a bioconversion process on the organic materials;

producing combustible volatile organic material from the bioconversion process; and

providing input energy to the operation of the system by oxidizing the combustible volatile organic material from the bioconversion process, and wherein the organic material may comprise at least 10% by weight water during the bioconversion process and at least some water is added with the organic materials provided to provide a total water content during the bioconversion, and wherein water may be added with the organic material at an average rate over time and wherein over periods of time the average rate water added with the organic material may be decreased by recirculation of residual water from the bioconversion process.

26. (canceled)

27. (canceled)

28. (canceled)

29. (canceled)

30. (canceled)

31. (canceled)

32. The method of claim 25 comprising at least one process selected from the group consisting of:

A) performing a process for the manufacture of the synthetic biofuel and inputting energy to perform the process;

collecting organic waste material from the process for manufacture of the synthetic biofuel;

providing collected waste material to a bioconversion process;

providing combustible volatile organic material from the bioconversion process; and

providing input energy to the process for the manufacture of the synthetic biofuel by oxidizing the combustible volatile organic material from the bioconversion process; and

B) i) at least a first organic material storage tank for a first organic material;

ii) an aqueous stream input source;

iii) a bioconversion tank having a controlled input connection from a) and a controlled input connection from b), and containing an active biomass that comprises bacteria capable of decomposing the first organic material from the first organic material storage tank;

iv) a processor that controls the input connections from a) and from b);

v) a sensing system that determines the chemical oxygen demand of the active biomass in the bioconversion tank and controls flow of at least the first organic material through the input connection from a) to provide oxygen from the first organic material is provided to the active biomass in the bioconversion tank at a rate sufficient to support health of the bacteria in the bioconversion tank;

vi) an aqueous stream outlet from the bioconversion tank; and

vii) a gaseous stream outlet from the bioconversion tank that is stored and then fed or directly fed to an oxidizing system that produces energy for the synthetic biofuel manufacturing process

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