CONTINUOUSLY STIRRED TANK REACTOR

The Continuously Stirred Tank Reactor, or CSTR, is one of the main workhorses of the anaerobic digestion industry. By providing a fully mixed reaction volume and facilitating sludge retention with an external sludge separation filter, the CSTR optimises the use of space. Active contact between the feed and the existing biomass is maintained whilst preventing internal stratification and temperature gradients. The mixing action also minimises the formation of a scum layer and the settlement of sludge solids.

There are several methods of facilitating reactor contents mixing. The approach adopted by Organics is to use external pumps for recirculation. By facilitating withdrawal from key locations and enabling return at varying levels and with multiple options, the control of mixing may be optimised. There is also no special requirement for access in the case of mixer malfunction.

The CSTR is often compared to the Covered Lagoon Anaerobic Reactor (CLAR) (Organics Datasheet ODSR35) and the Upflow Anaerobic Sludge Blanket reactor (UASB) (Organics Datasheet ODSR34). In fact, Organics has adopted the mechanisms of another form of reactor, the Anaerobic Baffled Reactor (ABR) to work within both the CSTR and the CLAR. By hydraulically baffling flow-paths, optimum mixing can be obtained

Whilst there are exceptions, the CLAR is generally less expensive to build than the CSTR but requires a larger footprint. If space is not available for a lagoon the CSTR is the better option. The UASB works well with soluble solids but would not the choice of preference for general agricultural waste streams, unless a secondary settleable-solids reactor may be included within the scope of supply.

The CLAR tends to have a longer retention time and a lower rate of reaction. This makes it stable and easy to operate. The CSTR, by contrast, can have a similar gas productivity whilst giving tighter control to process variables. Where, for example, ambient temperature may be low a CLAR can lose reaction performance, whereas the CSTR can readily accommodate both heating and cooling.

Organics

COMPONENTS INVOLVED IN A WASTE-TO-ENERGY SYSTEM USING A CSTR

Feed preparation

Front-end processing

Anaerobic digester

Ammonia control

Biogas pumping equipment

Biogas dewatering

Biogas clean-up

Instrumentation systems

Burners and/or power generation equipment

All of the above items are available directly from Organics using project-proven proprietary technology

ISO 9001 REGISTERED FIRM

ENVIRONMENTAL MANAGEMENT SYSTEM ISO 14001

CE

PROJECT ROUTE

Organics has developed a project delivery structure for anaerobic digestion projects over many years that ensures reliable completion and quality control whilst maintaining specification requirements, and time-schedules.

WASTE STREAM CHARACTERISATION

Waste stream characterisation involves two primary subject areas: (1) rate of waste arisings; (2) analysis of waste received. The first is achieved with a sampling campaign, the second with lab analyses and BMP testing.

SITE ASSESSMENT AND SPECIFICATION

Establishing a clear statement of the practiical design parameters is the first step determining scope. This will require a detailed study of each specific situation.

DESIGN

Each project is designed as a unique entity to ensure that all details are fully addressed.

PROCUREMENT

The procurement function takes full responsibility for maintaining delivery schedules. Their remit is from drawings and component specification through to all parts ready for final fit-out and commissioning.

MANUFACTURE

Manufacture may either be completed to “good engineering practice” or, where specifically requested, under the supervision of a Third Party Inspector, such as Lloyds.

INSTALLATION

Installation can be a complex process and requires careful planning.

COMMISSION AND HANDOVER

Established procedures are followed to ensure that equipment is fully operational at the point of handover.

ANAEROBIC DIGESTION

Anaerobic digestion involves the breakdown of organic waste by bacteria in an oxygen-free environment. It is commonly used as a waste treatment process but also produces a methane-rich biogas which can be used to generate heat and/or electricity.

Anaerobic digestion equipment consists, in simple terms, of an anaerobic reactor volume, a gas holder to store the biogas, and a gas-burning engine/generator set, if electricity is to be produced. Alternatively, biogas may be used to fire a boiler or to power converted spark-ignition vehicle engines. Organic waste is broken down in an anaerobic digester with up to 95% of the biodegradable organic content being converted into biogas. The rate of breakdown depends on the nature of the waste, the reactor design and the operating temperature. Biogas has a calorific value of typically between 50% and 70% that of natural gas and can be combusted directly in modified natural gas boilers or used to run internal combustion engines.

Organics offers a number of anaerobic digestion systems suitable for varying feedstocks and specific operating conditions.

The process of anaerobic digestion (AD) consists of three steps:

The first step is the decomposition (hydrolysis) of plant or animal matter. This step breaks down the organic material to usable-sized molecules such as sugar.

The second step is the conversion of decomposed matter to organic acids.

Finally, the acids are converted to methane gas.

Process temperature afects the rate of digestion. Usually, it will be maintained in the mesophilic range (30°C to 35°C - 86°F to 95°F). At higher temperatures the process requires a greater degree of attendance and understanding.

HYDROGEN SULPHIDE REMOVAL

It is essential to remove hydrogen sulphide for all activities other than direct flaring of biogas. Hydrogen sulphide can combine with water to form sulphuric acid, which is highly corrosive to engines, burners and all steel surfaces.

Determining the correct capacity for hydrogen sulphide removal equipment is an important part of project specification. It is too easy to accept a low default level only to find out that it is too low, and the equipment installed on site needs to be upgraded. Such increases in capacity can be very costly and certainly more expensive than if the correct capacity were installed in the first place.

The amount of hydrogen sulphide produced is a function of the sulphur content of the feed. Typical concentrations in biogas of between 1,000 to 2,500 ppm (mass) may be encountered in cassava waste whereas concentrations of up to 20,000 ppm, or more, may be encountered in applications such as vinasse AD.

Organics would usually recommend a bio-scrubber for this application. The bio-scrubber is easy to operate. requires no chemical additions and no special equipment. The bacteria involved are ubiquitous and can be produced anywhere. The great advantage in tropical climates is that ambient temperatures are such that external heating is not a requirement. Where a temperate climate is concerned, heating may be used with a bioscrubber, or other forms of hydrogen sulphide removal may be employed. Such alternatives include chemical scrubbers, granular activated carbon adsorption and iron sponge.

A key requirement for a bioscrubber is to determine the source of make-up liquid. The bio-scrubbing process requires that bacteria are kept moist, whilst excess acidity is controlled.

FLARING

Successful and safe flaring may no longer be considered an activity for the enthusiast or layman. There are a great many detailed regulations which must be adhered to in their entirety in order for safety and environmental concerns to be fully addressed. For example, the whole industry has been shaken by the rigorous depth of audits into data recording and record-keeping required by Designated Operational Entities under CDM protocols. Cutting corners and saving money in the face of such high standards can only be seen as a quick route to losing revenues.

Organics has worked on many biogas projects in SE Asia, China, South Africa and South America. The company has extensive experience in discussing detailed standards and results with both Regulators, Validators and Verifiers. Against this background Organics is confidently able to provide systems which will meet the applicable standards.

Instrumentation

The heart of the recording process is contained within the instrumentation used to record the destruction of greenhouse gases. Every project must be treated as unique and understood in its entirety in order to design the instrumentation system. Certain elements, such as flow recording protocols, may be similar but the overall quality of data recording and data integrity must be high. It is only to be expected that standards will continue to increase and become more demanding.

Instrumentation is a fundamental element in a successful project.

BIOGAS UTILISATION

Biogas may be used in several ways to generate both energy and carbon credits. Where methane is destroyed and fossil fuel is offset carbon credits will also be available.

The simplest route for biogas utilisation is to pipe gas to a boiler or a kiln. As with all green-house destruction, it is essential that the actual destruction of methane is proven beyond any doubt.

Should such an option not be available at a specific location, as is often the case at tapioca mills, the next option is to generate electrical energy, either for in-house use or for sale to the national electricity grid. In either case, the electricity produced should preferably be used to offset fossil fuel electricity, such as power from diesel engines, rather than power generated by means of clean biomass.

One further option is that of converting biogas into bio-methane. This involves the removal of carbon dioxide from biogas and the compression of the balance-methane to approximately 3000 psig. This technology draws upon global experience with CNG in vehicles. Compressed Bio-Methane (CBM) may be suitable for vehicle use and creation of carbon credits but careful attention must be paid to the problem of destruction-verification. Simply put, it is difficult to prove methane destruction in a vehicle that is travelling around.

As with anaerobic digestion, each technology has its own optimum point of application. The decision as to which route to take is a function of cost, opportunity, technology and practicality. Organics can assist in such decisions from a perspective of knowledge, experience and familiarity with all relevant costs.

KEY FEATURES

TURNKEY DESIGN, MANUFACTURE AND INSTALLATION OR COMPONENT SUPPLY ONLY

FINANCE AVAILABLE THROUGH AFFILIATED COMPANIES FOR BUILD, OWN, OPERATE AND TRANSFER PROJECTS

OPERATION AND MAINTENANCE SERVICES PROVIDED

A ONE-STOP SOLUTION FOR A COMPLETE SERVICE RELATING TO THE DEVELOPMENT OF RENEWABLE ENERGY PROJECTS

The objectives of a project designed to recover energy from cassava processing waste are:

• The installation of an anaerobic digester which will generate and capture waste gases currently produced from the factory's treatment lagoons
• Reduction of odours and harnessing energy in the form of methane
• Generation of renewable electricity to offset the use of fossil-fuels
• Improvement of factory wastewater treatment
• Where applicable, reduction of greenhouse gas emissions and creation of Certified Emission Reductions (CERs) by reducing greenhouse gas emissions

Organics is equipped to supply individual components within a complete system or all of the components required to make up a complete system. Organics has been active in this sector in SE Asia since 2002 and has a wide experience with all elements of such systems, from equipment design, instrumentation set-up for CDM compliance and CDM compliant gas flaring to gas production technologies as well as energy generation using engines operating with biogas.

MULITPLE WASTE TYPES

There are many feedstocks that are suitable for anaerobic digestion. Perhaps many more than are generally recognised. The first encountered substrates are animal manures and agricultural waste stream. To these many be added fish and meat processing waste materials, chicken litter, restaurant waste, market waste, energy crops, ethanol stillage and glycerine as a by-product from biodiesel production.

A digester should be supplied with a consistent quality and type of feedstock t/o maintain a productive microbial community. This will result in consistent organic destruction and biogas production, whilst minimising operational issues. It is necessary to ensure that feedstocks are free of toxic and inorganic contaminants that will damage the intended microbial processes. Sand, gravel, and other inert materials should be removed to the extent possible to minimise sediment accumulation in the digester. Feedstocks from outside sources should be routinely characterised to monitor consistency.

The advantages of small particle size are an increased surface area being available to the microorganisms as well as ease of pumping. Other known and equivalent methods for reducing particle size are often employed, subject to the specifics of the waste to be processed.

PROCESS REQUIREMENTS

Waste arisings come in many forms and periods of regularity. If necessary a buffer tank may be required to accumulate feed wastewaters. It is also possible that some form of pre-treatment may be required, such as pH adjustment. Batch or continuous operation are also options to be evaluated in the front-end feasibility study, subject to feedstock mix, feedstock availability and the general operating environment.

Temperature controls on the tank are optional, depending upon ambient temperature expectations, the source of the substrate and the planned length of the storage period. It should be noted, however, that the norm is to manage temperature as a part of the facility. Anaerobic digestion is an exothermic process, the magnitude of which is a function of the specific materials being treated. Methanogenesis is highly sensitive to temperature, so any changes of as little as a few degrees can have an impact upon performance.

Mixing within the CSTR is also substrate specific. The options range from occasional mixing to continuous. It is important to maintain the correct degree of mixing in the anaerobic digestion tank in order to avoid the build-up of a scum on the surface or prevent the separation of elements within the substrate. The mixing action also provides increased contact between the microorganisms and fresh substrate, as well as reducing the accumulation of solids on the bottom of the tank.

A lamellar filter may be employed to retain sludge within the anaerobic digester, rather than allowing it to depart with the effluent. An option is to employ a Ultra-Filtration membrane as a filter, The choice to use a membrane for sludge retention comes down to a matter of cost, environmental preference and requirements, and operator choice.

SPECIAL CONSIDERATIONS

Each substrate has its own specific requirements. For example with fish wastes, large amounts of fish oil from high-lipid species of fish such as herring and menhaden present mixing problems in the digestion tank and require a longer digestion time than do protein and carbohydrate wastes. To ensure complete, rapid digestion of the lipid material, the ground-up fish in the storage tank can be pre-treated for a period of approximately 24 hours with a lipase or other enzyme which breaks down fats.

Organics possesses a range of proprietary pre-treatment technologies that can be brought to bear on a large number of different feedstocks, many of which may be considered unsuitable for anaerobic digestion. Similarly, in reactor operating conditions can be tailored to specific substrates, in order to optimise biogas production.

Organics

Organics Group plc

Sovereign Court II
University of Warwick Science Park
Coventry CV4 7EZ,
United Kingdom
T: +44 (0) 24 7669 2141
F: +44 (0) 24 7669 2238
E: comms@organics.co.uk
W: www.organics.co.uk