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customer application

The Finest Green Energy Digester

It's amazing how much technology is involved in delivering the humble tomato to the Great British public's salad bowl. A fact that Hitech Instruments recently discovered when asked to supply a solution for monitoring biogas on a new, anaerobic digester (AD) system designed by Biotech Services and supplied to A.Pearson and Sons, a UK tomato grower for a major UK supermarket.

A.Pearson and Sons currently have 5.2 hectares of glass houses at their Alderley Edge site which produces 33 million tomatoes p.a. along with 15 to 20 m³ of waste vegetation per day which, in years gone by, would have been disposed of by landfill with its inherent carbon footprint and commercial costs. Now however, with the help of this new, state of the art, multi-phase anaerobic digester system, the tomato plant waste will be producing biomethane of sufficient quality to power vehicles. It will also produce electrical power, heat and carbon dioxide for the cultivation of plants in glasshouses. As well as these benefits, the 14,000 litres of nutrient rich waste liquor produced every week as a by-product of the digestion process is used as a fertiliser. Thus recovering water and nutrients which would otherwise be lost out of the tomato plant growing cycle. Overall, the installation of the digester system has made the tomato supply chain from producer to consumer extremely environmentally friendly and commercially efficient, particularly if the vehicles used to transport the tomatoes are powered using biomethane produced by the site's own AD system.

The AD process as shown in Figure 1, involves the introduction of spent tomato plants into the receptor tank of the mesophilic digestion process. This comprises a total of five tanks, plumbed in series with each other. At pre-determined times, digestate is transferred from tank to tank via a controlled pumping system, taking approximately 12 to 15 days to complete the digestion process. Temperature, composition of head space gas and pH conditions are closely monitored during the process to optimise digester loading and methanogen microbial activity.

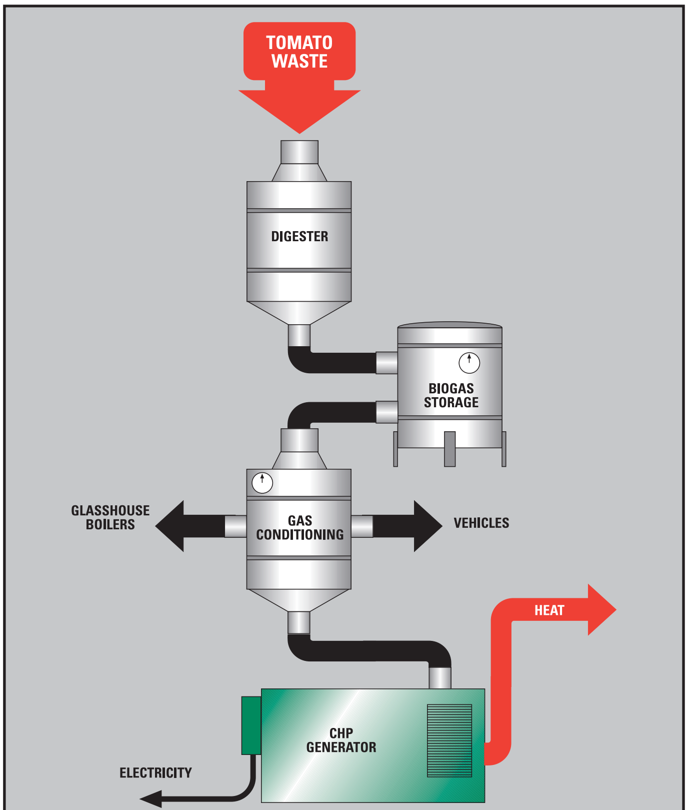

Figure 1: Anaerobic Digester

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During the process, approximately 70% of the chemical energy conserved in the tomato plants organic matter is converted into methane gas, allowing up to 99% of the total weight of plant material to be digested, leaving <1% of waste solids that is mainly comprised of lignin - a material that the microbial cultures find difficult to break down.

Optimum temperature conditions for the mesophilic process are in the region of 35 to 40ºC, although methanogen microbes will still function down to temperatures as low as 3ºC, albeit at a much slower rate. Generally, the higher the temperature the greater the activity, so during colder months, to help maintain this activity, cooling water and/or exhaust gases from the CHP engine generator can be used to warm up the digester tanks. This, in association with gentle agitation of the digestate, helps maintain the optimum conditions to maximise microbial activity and gas production.

Figure 2: Digester Tanks

The main macronutrients in the digestate are ammonium and phosphate based organo compounds which are broken down by a range of microbes to eventually produce acetic acid which, in turn, is acted upon by the methanogen microbes to produce methane (60% v/v) and carbon dioxide gas (40% v/v). Micronutrients that are also essential for methanogen microbe activity include zinc, iron, copper and manganese which are supplied through the breakdown of the tomato plants. The optimum pH for best microbe activity is in the range of 7.3 to 8.0, which is maintained by the self buffering capacity of the digestate due to the presence of ammonium based compounds.

The gas collected from the process in the final storage tank is passed through a series of gas conditioning stages to make it suitable for use in the glasshouse boilers, CHP engine generator and/or vehicles as liquefied biomethane. The degree of final gas conditioning is dependant on the intended use of the gas, ranging from a simple water “knock out” drying process for burning the gas in glasshouse boilers, to a more sophisticated chemical scrubbing process to remove hydrogen sulphide levels to less than 1000 ppm v/v for use with the CHP engine generator. For biomethane production for use in vehicles, the hydrogen sulphide (H_2S) level has to be reduced to <10ppm and the carbon dioxide gas (CO_2) to <1.0% v/v in order to meet the necessary purity standards.

The overall result of the AD process is that the majority of the chemical energy held within the waste tomato plants is converted into biogas and waste liquor, a source of nutrient which is recycled back into the tomato plant food chain.

To enable Biotech Services to maximise the efficiency of the digestion process and to recover as much chemical energy and nutrients from the waste tomato plants as possible, it was vital to characterise and control each stage of the digestion process in terms of temperature, pH and biogas make up. To help achieve this, they installed a Hitech Instruments GIR5000 gas analyser to continuously measure methane (CH_4), oxygen (O_2) and hydrogen sulphide (H_2S) gas during all stages of the process. The readings were recorded 24 hours a day via a data logging facility, providing vital trend analysis data so the process could be fine tuned to produce the highest quality of biomethane gas. To enable any process problems to be flagged up, gas concentration, temperature and pH alarms were all programmed on the data capture system, thus providing a warning system to operators of any impending process problems.

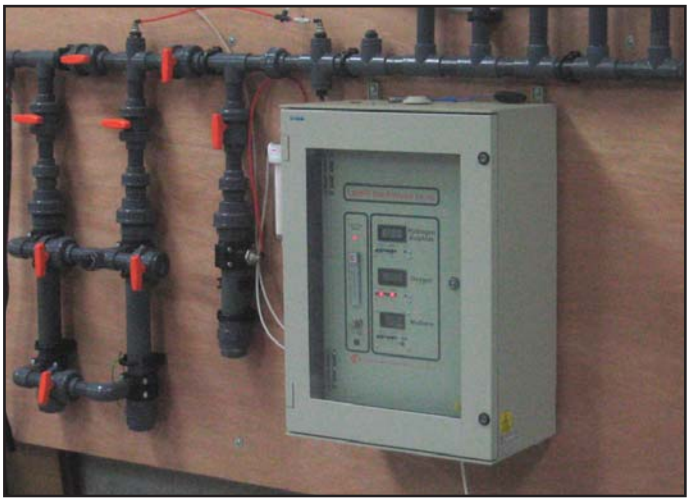

Figure 3: Hitech GIR5000 Gas Analyser

Instrumentation in this environment requires robust design and, more importantly, ATEX certification is a must due to the hazardous nature of the product. To reduce project down time and maintain full control during the six month trial, Biotech Services carried out all servicing and calibration of the monitoring equipment, so it was important the equipment was both user and service friendly. To help facilitate sampling from different stages of the digestion process, a multi-stream pumped sample system was provided with the analyser, together with suitable sample gas conditioning equipment to remove condensed water and particulates prior to analysis. This proved to be a vital feature, as it allowed operators to individually monitor each of the five digestion tanks in the process when working with research bodies such as York University and the University of North Lancashire during trials to optimise the mesophilic microbe cultures.

Figure 4: Waste Tomato Plants

Issues encountered during the project included the requirement to measure high concentrations of hydrogen sulphide gas (>2000 ppm H_2S) in the final stages of the digestion process, which resulted from the breakdown of sulphate based fertiliser chemicals being present in the tomato plant digestate. To overcome this problem the hydrogen sulphide measuring range was increased to 5000 ppm H_2S, which allowed the biogas to be monitored before and after the hydrogen sulphide scrubbing system. Typical levels of H_2S gas after the scrubber were less than 10 ppm v/v, with suitable alarm levels being programmed on the gas analyser to pick up any breakthrough of H_2S gas in the event of the scrubber failing or saturating. Concentration levels of methane (CH_4) gas taken straight off the digester were typically 70% v/v with the balance gas being made up primarily of carbon dioxide, which was subsequently removed using a CO_2 scrubber to make biomethane gas for vehicle use. Oxygen levels in the initial tank stages of the digestion process were greater than 2.0%, finally dropping to less than 0.2% in the final biogas storage tank.

The vehicle grade biomethane gas produced by the system after H_2S and CO_2 scrubbing was typically better than 98% v/v CH_4, which when compressed into 1 Kg of liquid biomethane (LBM) will have the equivalent energy value of 1.2 litres of commercial grade diesel. The generation of electrical power from the 40KW CHP engine on the site is intended to be used to power the CO_2 circulation fans which, in turn, will deliver scrubbed CO_2 to the glasshouse enhancing growing conditions for the tomato plants. This again represents a significant benefit to the producer, while at the same it reduces their carbon footprint and makes them more competitive with warmer climate tomato growers.

It doesn't stop there. As an alternative to producing either vehicle fuel or electrical power, the biogas, after drying, can also be diverted directly to gas boilers in the glasshouses. This proves to be the most efficient way of utilising the gas as energy conversion losses are minimised. Again, the waste CO_2 gas present in the products of combustion is captured when released into the glasshouses through the tomato plants photosynthetic growth cycle. A major benefit of heating glasshouses in this way is that the tomato plants growing cycle can be extended to 9 months making the grower again more competitive with warmer climate competitors.

The hard commercial facts of the project are that through investing in an on-site anaerobic digestion system, A.Pearson and Sons are saving around £30,000 per annum in terms of landfill charges as well as reducing their reliance on fossil fuels for energy to heat and power their glasshouses. Further improvements can be made if they also take in organic waste from other sources, which will increase the potential energy output from their AD process, leading to even greater savings.

Very much a working research and development plant, the information gathered here will be integral to the development of future plants in other food production facilities that can utilise their own waste to deliver similar benefits to the producer, the supply chain and customers.

The project carried out on this nursery represents a perfect example of what can be achieved in identifying keys points in the food supply chain where both environmental benefits and cost savings can be made. The government is trying to promote these initiatives through WRAP (Waste and Resource Active Programme) and it is indicative of the current drive by some retailers to work closer with their suppliers in reducing the carbon footprint and impact on the environment in their supply chain.