FACTFILE:

GCE ENVIRONMENTAL TECHNOLOGY

ANAEROBIC DIGESTION

Rewarding Learning

Anaerobic Digestion

Learning outcomes

Students should be able to:

- outline key terms associated with anaerobic digestion:
  - low and high solids;
  - residence time;
  - single; and
  - multistage;
- explain the stages associated with anaerobic digestion:
  - mechanical pretreatment;
  - hydrolysis;
  - Acidogenesis;
  - Acetogenesis; and
  - methanogenesis (chemical equations not required);
- outline how anaerobic digestion can deliver both heat and power (CHP).

Course Content

Anaerobic digestion is the name given to a process which breaks down organic wastes such as food and other biodegradable wastes using naturally occurring bacteria which can grow and take part in the process in the absence of oxygen. It has traditionally been used as a waste treatment process but is increasingly seen as a source of renewable energy. The process generates a gas called biogas which is a mixture of 60% methane and 40% carbon dioxide which can then be used to;

- generate heat;
- generate electricity;
- act as a fuel for transport applications; and
- provide a source of energy in a combined heat and power application.

The process also produces a nutrient rich solid and liquid fertiliser called digestate which can be utilised in soil conditioning of land. A wide range of organic materials can be processed in this way such as;

- leftover food;
- sewage, slurry and manure;
- animal waste;
- industrial effluents;
- grass clippings; and
- waste paper and cardboard which because of food contamination is unsuitable for recycling.

Wood type materials are not suitable for the process as bacteria cannot break down lignin, the material which provides wood with its strength.

Treatment of material waste in this way reduces the need for landfill and provides a useful alternative source of energy.

Anaerobic digestion takes place in large sealed and insulated vessels in the absence of air with control exerted over heating and mixing processes. The material to be treated is subjected to initial screening known as mechanical pre-treatment. This is to enable filtering, separation according to size of material contained within the feedstock, and where it is processed into a thick liquefied form. It is then pumped into temperature controlled sealed vessels called digesters. This is where bacteria feed on the waste and produce biogas.

Anaerobic digestion is a series of bacterial processes which can be summarised in four stages.

1. Hydrolysis – insoluble polymers are broken down into soluble organic compounds.

2. Acidogenesis – soluble organic compounds are fermented into volatile fatty acids and alcohols.

3. Acetogenesis – the alcohols and fatty acids are converted into acetic acid and hydrogen.

4. Methanogenesis – the bacteria convert acetic acid and hydrogen into methane and carbon dioxide – biogas.

No methane is released into the atmosphere during the process. The digestate has to undergo a process of pasteurisation to remove any harmful elements before use a fertiliser. This reduces the need for fossil fuel derived fertiliser. It is estimated that for every tonne of food waste treated in this way there is a corresponding reduction of between half and one tonne of carbon dioxide entering the atmosphere.

Low solid and high solid digestion

The nature and composition of the feedstock for the anaerobic digestion process can present different challenges to the precise system being used. High solid digestion is a term used when the feedstock is up to 55% solid material whilst low solid digesters deal with feedstock which is around 15% solid. A basic difference between the two types of system is that in the high solid system more energy is used to pump the material than in the low solid variant. This has implications for the overall energy efficiency of the installation. On the other hand high solid systems require less land space then the low solid due to the lower volume of the degradable material.

Single stage and multistage systems

In a single stage digestion system the biological reactions occur within one holding tank and the biogas is available from this tank. Multistage systems provide a greater degree of control of the overall process with hydrolysis, acetogenesis and acidogenesis stages taking place in one vessel with the methanogenesis stage being in a separate reactor from where the biogas is extracted.

Residence time

This is the time that the full degradation of material in an anaerobic digestion system can be measured as having been complete. It depends on a number of factors namely the type of material being decomposed, the temperature of the system and whether it is single or multistage. Typically a single stage system has a residence of 14 days whilst a multistage system may have a residence time of between 15 and 40 days.

Anaerobic Digestion and Combined Heat and Power (CHP)

In a typical power plant the combustion of fuel is used to produce electricity with large amounts of the heat produced being lost to the atmosphere. In a combined heat and power system the electricity is produced in the normal manner but the excess heat is then used as heat for other purposes. Biogas lends itself to this application with the heat being used possibly for the digestion process itself or for sharing with local community needs.

Pupil Activity

Draw a labelled block diagram of the anaerobic digestion process showing the stages of the process, the products available at the end and their use as energy sources.