THE DRANCO TECHNOLOGY: A UNIQUE DIGESTION TECHNOLOGY FOR SOLID ORGANIC WASTE

Organic Waste Systems nv

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Accelerated Landfill Degradation

The Dranco digestion technology is a digestion technology that was developed by studying and optimizing the spontaneous ‘dry’ digestion that takes place in a landfill. Municipal solid waste is dumped in a landfill, containing a sizeable amount of biodegradable waste. During a limited period, oxygen is present so that decomposition occurs by means of aerobic bacteria. This may cause an accumulation of acids and an increase in temperature. After several weeks or months, depending on the rate of filling and depth of the waste, the oxygen has been consumed and decomposition subsequently has to take place under anaerobic conditions and at the rather ‘dry’ conditions in terms of fermentation that exist inside a landfill. Anaerobic bacteria take over the role of the aerobic bacteria at total solids concentrations of 50% or more in the waste that has been dumped in the landfill. Biogas or what is called landfill gas is being produced during this stage. Anaerobic decomposition in a landfill is uncontrolled and very slow. Biogas production in the landfill may occur for about 20 to 50 years, and even longer depending on the moisture present in the landfill.

The Dranco technology was developed by optimising the digestion parameters of the “dry” and “static” anaerobic digestion that takes place in a landfill. At first, batch experiments were carried out which allowed the digestion process to be essentially completed in 2 to 5 years. Subsequent improvements led to batch digestion times of 6 months, then 3 months until a digestion time of 2 to 3 weeks was made possible by using a continuous process. Once this was reached, a totally new design of digester needed to be conceived which could handle an incoming feedstock of more than 40% total solids, as such “dry” digesters did not exist at the time.

Basic digestion scheme

The basic scheme for a Dranco digester is as follows:

1) The organic fraction must be reduced in size to less than 40 mm. For the treatment of municipal solid waste, this means that large components such as plastics and textiles must be screened off or reduced in size by means of a shredder. Ferrous and non-ferrous metals can be recovered for recycling purposes. Stones, glass and hard plastics should be eliminated as much as possible, but efficiencies of 50 to 80% or even less are sufficient in most cases. The Dranco process can handle high concentrations of pollutants and non-degradables in the organic fraction sent to the digester, but removal of these components may reduce energy consumption and abrasion. The cleaner the feedstock, the less complicated the pretreatment.
2) The pretreated organic fraction of less than 40mm in size is subsequently mixed with a large amount of digested residue coming from the digester. The mixing ratio is usually around 1 ton of feedstock with 6 to 8 ton of digested residue. This takes place in the mixing part of the feeding pump. A small amount of steam is added to the mixture in

order to raise the temperature to 35 – 40℃ for mesophilic operation and to 50 - 55℃ for thermophilic operation.

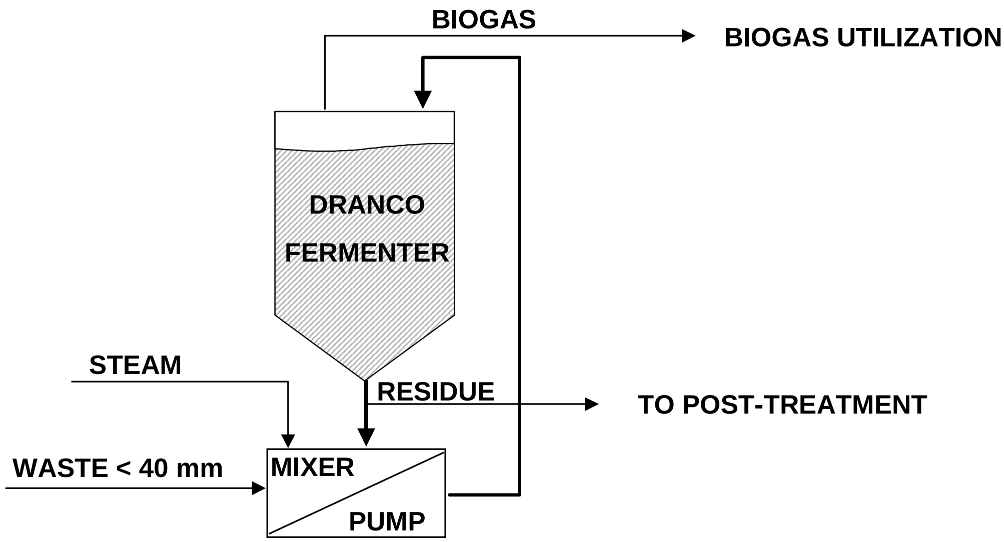

Figure 1: Basic Dranco process scheme

3) The preheated mixture of fresh organics and digested residue is then pumped to the top of the digester through feeding tubes. These feeding tubes cut through the cone in the bottom of the digester and reach to about a 1m distance from the roof inside the digester. The material is pushed out of the feeding pipes and flows into the upper part of the digesting mass in the digester.
   The internal feeding tubes have a diameter of about 1m in order to minimize friction and energy consumption during pumping. The distance and height over which the material is pumped, is also minimized through the internal feeding, while the weight on top of the roof is also greatly reduced in comparison to feeding through the top of the roof by using external feeding pipes.
4) Once the material enters into the main body of the digester, it takes about two to four days depending on the feeding rate to reach the bottom of the digester. The digesting mass descends through the digester by gravity only. No mixing equipment or gas injection is needed in the inner part of the digester. Biogas rises and exits the digester through the roof and flows towards the gas storage and treatment.
5) The digested residue is extracted from the bottom of the digester by means of screws hanging underneath the conical outlet. The largest part of the extracted material is recycled in the process and screwed to the mixing part of the pump for mixing in with the fresh incoming feedstock. The remaining part is deviated towards further treatment. The average retention time in the digester is around 20 days with a pass-through time every 2 to 4 days.

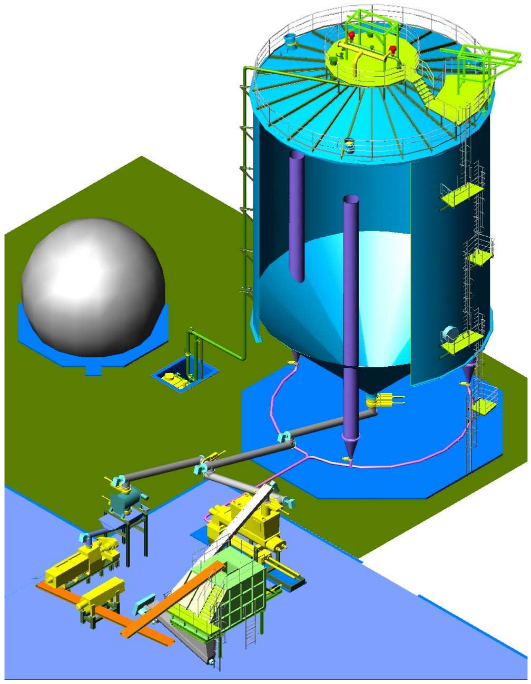

Figure 2: Inside view of a Dranco digester with internal feeding tubes

Advantages of the Dranco digestion

The patented Dranco process has a few significant advantages over conventional “wet” and other “dry” digestion systems.

1) High-rate ‘dry’ digestion
   The Dranco process can operate at total solids concentrations of up to 45 to 50% going into the digester, and with total solids concentrations up to 40% for the digested residue coming out of the digester. These very concentrated operating conditions are possible because the mass moves in a vertical direction through the digester, i.e. from top to bottom. Digestion systems, in which the digesting mass moves horizontally through the digester, require a higher level of flowability. They operate at total solids concentrations that are about 10 percentage points less than the Dranco system. They are also typically equipped with mixers or gas injection nozzles to move the material forward. This is not needed in high solids vertical digestion. Such a high concentration of solids also allows for high biogas production rates. In full-scale plants, biogas production rates of up to 10 m³ of biogas per m³ of active digester volume per day can be maintained as annual averages for organic feedstocks. This minimizes the required volume needed and as a consequence the number of digesters. A single digester of 3150 m³ of total volume can treat 50,000 ton per year of organic waste, yielding 7.4 million m³ of biogas containing 55% of methane. Conversion of all the biogas in internal combustion engines yields 9 to 10 million kWh per year.

2) <u>No scum or settling in the tank</u>
Operation at a sufficiently high dry matter content prevents scum formation or settling of heavies in the bottom of the digester. Heavy particles less than 40 mm, such as sand, as well as any remaining glass and stones passing through the screen of 40 mm can be handled. Concentrations up to 22% of glass have been found in the digested residue of mixed waste. The heavy components present in the waste cannot sink through the concentrated mass in the digester, nor can light materials, such as wood, styrofoam etc. float.

3) <u>Minimal heat requirements</u>
The temperature of the digester is maintained by injecting steam in the mixing part of the digester. The heat requirements are kept to an absolute minimum because only the incoming fresh feed needs to be heated up to the operating temperature. Heat losses are minimal in the digester because of the high solids concentration that greatly reduces convection losses. The digester therefore only needs to be insulated in order to maintain the temperature in the digester for several days without slowing down the biological process. High solids digesters operating at high loading rates can actually be observed to rise in temperature due to the exothermal energy released during anaerobic decomposition. This amount of exothermal energy will be rather limited to a couple of degrees Celsius but nonetheless measurable. No danger exists for overheating however, as is the case in aerobic decomposition of organics.

4) <u>Thermophilic operation</u>
As is the case with most dry fermentation systems, the Dranco process can easily be operated under thermophilic temperatures. Thermophilic operation typically yields a higher production per ton of waste treated and can reach significantly higher loading rates. An added benefit to operating in the 50°-tem perature level is the fact that human pathogens are killed off at these temperatures, thereby improving hygienisation and kill-off of weed seeds.

Energy from organic solids in practice

The Dranco technology has been applied to a wide range of substrates. These vary from rather wet wastes such as mainly restaurant and food waste, to dewatered sludges, source separated organics with or without the addition of non-recyclable paper/cardboard to organics produced in the pretreatment of mixed municipal or residual waste (after removal of recyclables and often also after separate collection of the clean compostable fraction).

1) <u>Source separated organics at the facility of IGEAN in Brecht, Belgium</u>
The largest Dranco facility was built in Brecht, Belgium, and has been functioning for 6 years. The plant was designed for a capacity of 42,500 ton per year, but was able to reach a capacity of more than 50,000 ton per year after the first 3 years. The incoming feedstock is composed out of source separated organics, such as garden, kitchen and food waste and to which also diapers and non-recyclable paper or cardboard can be added. This plant was built for the intermunicipality of IGEAN, an association of 26 municipalities around the city of Antwerp, who owns and operates the plant. On the same site, another older Dranco facility was revamped, which is treating an additional 15,000 ton per year, so that a total of more than 65,000 ton per year are treated on the site.
The source separated organics are first sent to slowly rotating homogenizing drums with a retention time of 4 to 6 hours in total. The material is screened and the organics which pass through the sieve of 40 mm are sent to the digester after ferrous metals are removed by means of an overband magnet. The organics are digested in a digester of 3150 m^3 of volume, and which has a height of 25 m and a diameter of 15m. During the

last year, 7.4 million m³ of biogas were produced and consumed in two gas engines with an electrical power output of 625 kW each. The electrical production amounted to 9.1 million kWh, enough to provide power to 2000 to 2500 homes. The gas engines operated during 97% of the time during the year.
The digested residue is dewatered by means of a screw press to a dry matter concentration of at least 45%, and is composted aerobically for a period of 2 to 3 weeks. During the first week of aeration, temperatures of more than 60° are reached so that any remaining pathogens are killed off. The dewatered cake is converted to a well-stabilized compost during this period, which can be used in agricultural applications. The plant produces 20,000 ton of compost, meeting the Flemish regulations for high quality soil amendment. The excess wastewater is centrifuged and sent to the wastewater treatment plant on site, designed to treat the wastewater from both digestion plants and from the adjacent landfill and green waste open-air composting plant.

Figure 3: Dranco installation Brecht, Belgium

	2002	2003	2004	2005*
FEEDSTOCK (T/Y)				
- BIOWASTE	45 394	45 691	51 229	52 190
- OTHER	966	1 776	2 525	2 110
TOTAL	46 360	47 467	53 754	54 300
PRODUCTION OF BIOGAS				
- M³ BIOGAS (IN MILLIONS)	5.8	6.0	6.9	-
- M³ BIOGAS/TON INCOMING	125	127	127	-
- M³ BIOGAS/M³/DAY	6.6	7.4	7.4	-
VOLUMETRIC CAPACITY USED	83%	70%	81%	-

*2005 BASED ON 31 WEEKS

Table 1: Digestion results of the Brecht-II plant

2) Residual waste digestion

The Dranco process is well suited for the treatment of highly contaminated organic fractions derived from the pertreatment of mixed or residual household solid waste. Residual waste is pretreated in order to recover recyclable components, such as ferrous and non-ferrous metals but also for any paper or plastics that can be removed from the residual waste for recycling or minimization of the further disposal costs.

The Dranco process is ideal for partial stream digestion due to its very high total solids concentration in the digested residue. This is the process whereby only a fraction of 50 to 65% of the total organic fraction is actually digested, while the remaining 50 to 35% is bypassed and is not subjected to anaerobic decomposition. The digested residue is then intensively mixed with the non-digested organics. The dry matter concentration of 45% in the resulting mixture of the two fractions allows for efficient aeration and rapid aerobic decomposition. The energy for reaching high temperatures and for drying during the aerobic phase is mainly provided by the fraction that was not digested. Partial stream digestion avoids the costly need for dewatering and wastewater treatment.

A plant treating 100,000 ton per year of residual solid waste is recovering recyclables and producing burnable fractions. About 28000 ton per year of organics are diverted to digestion, to which also about 7000 ton per year of non-digested dewatered sewage sludge is added. No wastewater is produced at the plant.

Figure 4: Partial stream digestion

Figure 5: Flow scheme Pohlsche Heide using partial stream digestion

In case fullstream digestion is used, as described in Figure 6, then a wet posttreatment process can be applies to the digested residue. About 50 to 60% of the volatile solids, representing the easily degradable and often wet and sticky organic components of the waste are already converted to biogas in the digester. This results in a digested residue that can be easily separated by means of screens and other wet separation equipment, as developed in the Sordisep process. Sand, fibers, inerts can be recovered and cleaned in order to produce marketable endproducts. This increases landfill diversion to 75% and recovery of materials out of mixed waste to 40%.

Figure 6: Sordisep for maximum recovery of recyclables (40%) and landfill diversion (75%)

3) Energy crops

The Dranco technology is ideally suited for the digestion of corn. Corn (maize) is harvested with a dry matter content of around 32% and is chopped during the harvesting to a size of less than 20 mm. This means that the total plant as harvested can be fed to a Dranco digester without any further pretreatment or even any addition of water. The corn can be stored as silage during the winter months and gradually fed to the digester.
The digested residue from corn digestion is extracted at a solids content of 20 % and can either be dewatered or simply returned to the fields, on which the energy crop was grown. Compared to ethanol or biodiesel, the net energy yielded per hectare is significantly higher. For biodiesel, for every ton of fossil fuel consumed in the production, about 2 ton of renewable fuel is produced, while this amounts to 2.5 to 3 for ethanol plants. Biogas from corn can yield 6 to 8 ton of renewable fuel per hectare for every ton of fossil fuel put into the crop growing, harvesting etc.

Figure 7: Flow scheme for Dranco demonstration plant for the digestion of energy crops

Conclusion

The Dranco technology is unique because of the vertical design, the high solids concentration and the absence of mixing inside the digester. This permits small digester volumes and the operation of a plant without excess wastewater production.
About 20 plants have been constructed or are under construction, treating a wide range of feedstocks: source separated organics (with and without non-recyclable paper/cardboard), mixed waste organics, residual waste organics, sewage sludge, …
Even energy crops, such as corn, can be efficiently digested at a high rate and will provide a source of renewable energy for the future.