Pilot Plant Trial: 6th July 2015 – 21st August

Location: WWTW

The Bio Thermic Digester (BTD) Pilot Plant was delivered to site on 6th July to perform tests with the dewatered sewage and water treatment sludge's, the sewage sludge which had been centrifuged to approximately 22% dry solids content and the water treatment sludge was 23% dry solids content. The tests were performed utilising temperatures of between 50 to 80$^{o}$C within the core of the biomass, which is the normal processing temperature for sewage and water treatment sludges

## CONDUCTING OF THE TESTS

Tests were performed from 6th July 2015 to 26 July utilising dewatered sewage sludge cake and 26th July to 21st August utilising water treatment sludge.

The sewage sludge cake was sourced from site, taken directly from the centrifuge at around 23% dry solids, while the water treatment sludge was imported from another Customer site at 22% dry solids. The water treatment sludge was an Alum sludge i.e. aluminum sulphate was used as the coagulating agent in the water treatment process.

The pilot plant is capable of treating up to 0.1m3 / day, and since this plant does not have a continuous feed system, the sludges were added manually, in doses of about 20 kg at a time.

The on-site operators are responsible for the collection and recording of data – date/time/weight of material in/weight of material out – to assess material reduction through the process. When the sludge is introduced into chamber 1 of the machine it is normal for the temperature to drop, by as much as 35 degrees centigrade. This is due to the temperature difference between the internal temperatures, temperature and moisture content of the material added, and ambient external temperature. The temperature will recover, normally over a four-hour period and when the machine is fully loaded and at its operating capacity, the temperature drop will decrease to around 20 degrees centigrade. The control panel of the machine will automatically record the temperatures throughout a full 24-hour period and produce an Excel spreadsheet, showing the temperatures of the mats and the core (biomass temp) at one minute intervals.

Normal practice would be for a continuous feed to the BTD over 24 hours, however during the trial period the BTD was loaded twice per day on average, but could range from one to four loads over the morning and afternoon. This is not the ideal feed condition for the process, but it did demonstrate to The Customer that the unit is resilient to shock loads. During the trial period a total of 1035 kg of sewage sludge was fed into the unit and the outfeed material was 115.6 kgs: equating to a reduction of 89%.

The total of water treatment sludge treated by the unit was 1454.3kgs and the outgoing material was 182.5kgs; equating to a reduction of 87.5%.

The process usually takes about 72 hours, once the machine is at its normal working mode and the temperatures are stable within the core of the biomass.

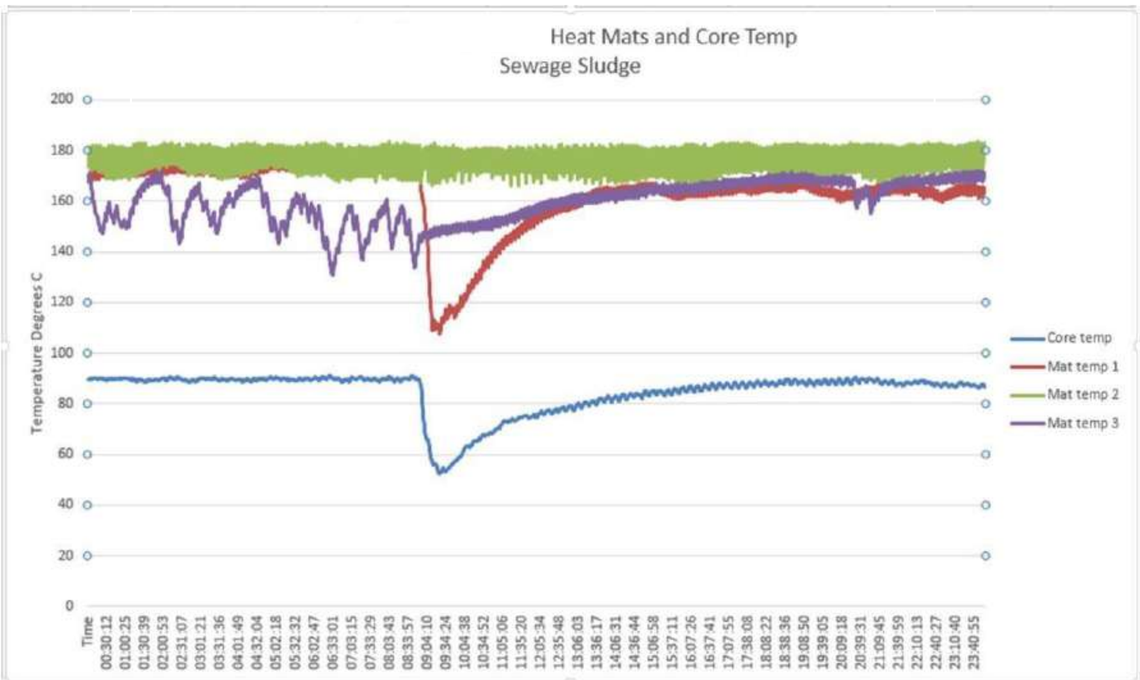
The machine axis moves the sludge in one direction and then the other as per the times contained within the operating recipe that has been used. When the shaft operates, the electric heat mats do not work, and vice versa, this reduces the chance of the machine tripping out on overload. As the shaft rotates it helps homogenizing of the biomass and spreads the heat evenly throughout the biomass.

The sludge within chamber one is heated and the bacteria is added, at set time points and as the shaft rotates the sludge is passed from chamber 1 to chamber 2.

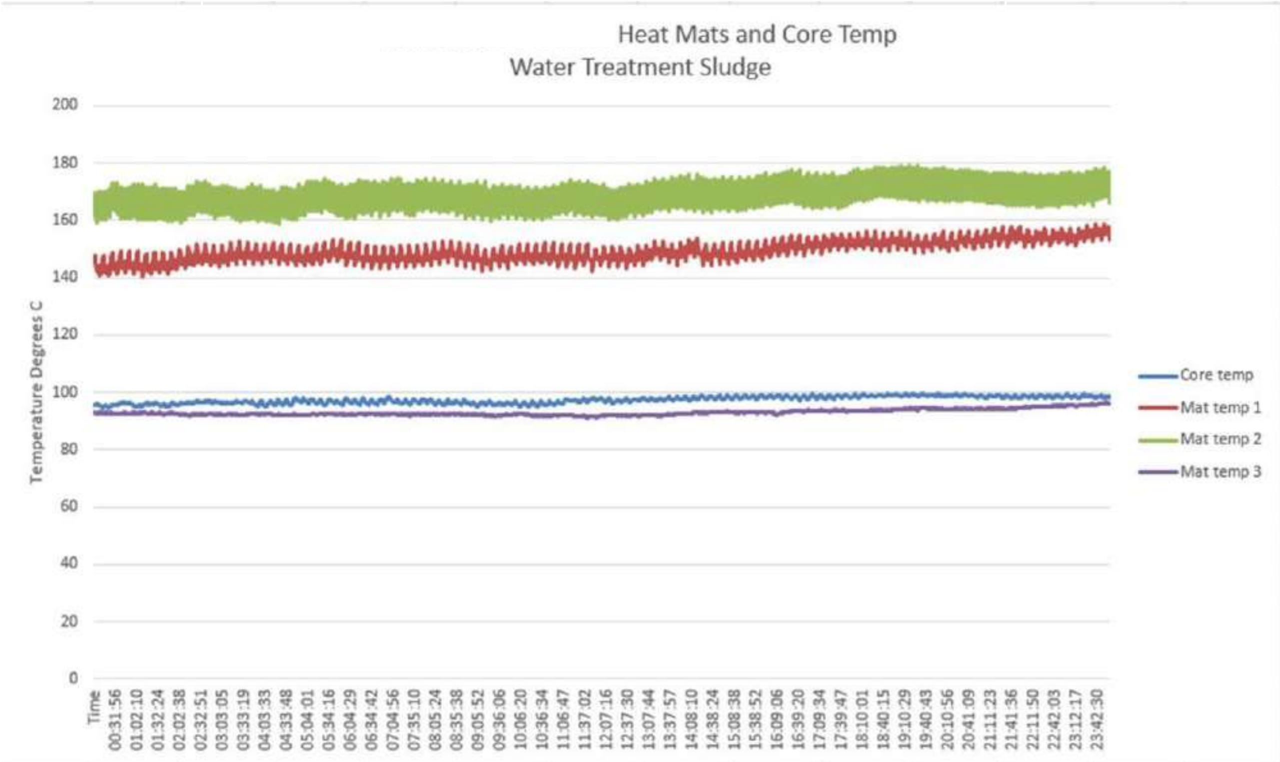
During the trial period the machine is recording various parameters at one minute intervals. The recorded parameters, stored in a USB memory stick located within the PLC. An email containing a CSV file is sent every evening to an account holder within Advetec, which shows all the previous days processing data. This data is analysed by Advetec engineers and changes where necessary, can be made, remote to the unit location.

When the data is collected some graphs that help their interpretation are made, to track process and detect any abnormality in the operation of the machine (stop, power outage, alarms, etc.).

As an example, the following graph shows a day of operation, where the infeed into the machine resulted in falling temperatures, these are clearly observed in the core measured within chamber 1. This drop-in temperature is because of adding fresh sewage sludge from the centrifuge, the volume of sludge added was 50kgs (half the daily amount)



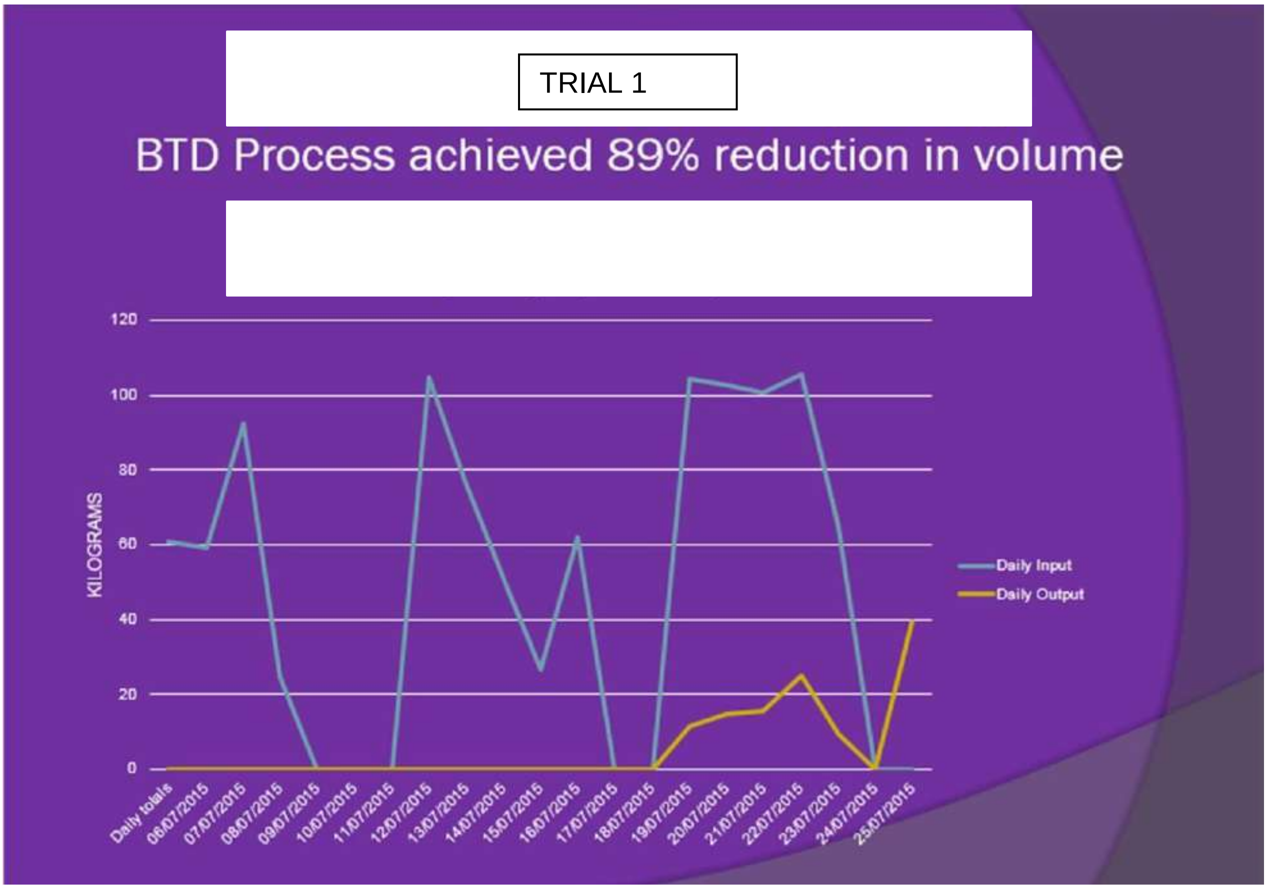

On the graph above it is clear to see that the temperatures recover quickly and the machine goes back to its 80 ° C operating regime. In a situation where the machine is installed with a continuous infeed system, these declines are not so pronounced (less than 10 degree drop) and the graph would show a much more stable trend, as shown below.



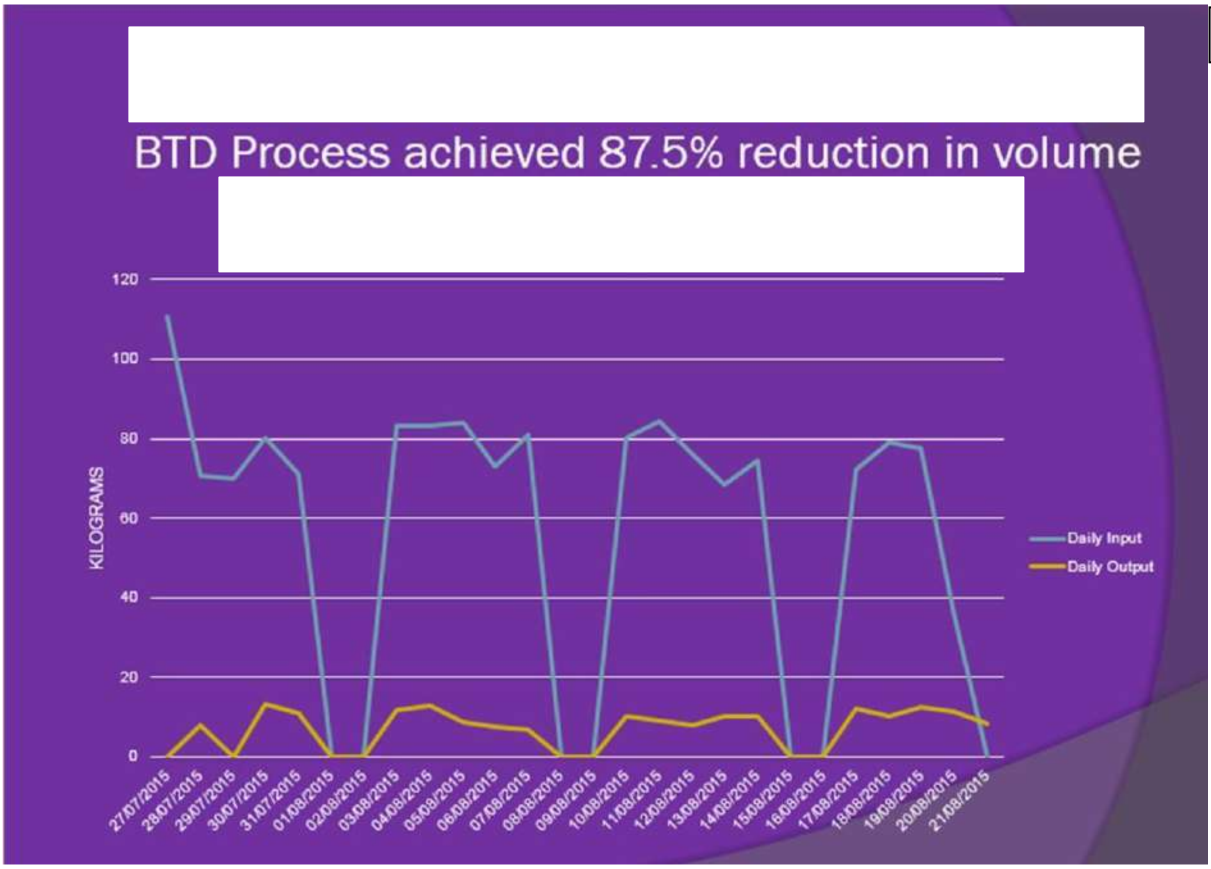

The residual material from the unit has an earthy, dusty appearance and is fully dry, as shown in these images.

The pilot machine is not as energy efficient as the larger scale units, nor is it intended to be, it is purely a way of demonstrating the process to the client base. The small-scale machine runs 20 minutes on average every hour and has a maximum three kilowatt energy consumption. The actual running cost of a three chamber BTD unit (0.5 mtrs/cubed per day, running 24/7 works out at £10.00 per day.

It is important to understand that the pilot plant serves mainly to determine how responsive the sludge is to this type of treatment, viability and to draw conclusions on the reductions that can be achieved of the sludge.



TRIAL 2




The results below were analysed by The Customer's Laboratory to compare various types of sludge products versus the Bio Thermic Digestion process.

## Trail Results

| PTE`s | Biothermic Digestor Output (raw sewage sludge cake) | Site 1 | Site 2 | Site 3 |
|---|---|---|---|---|
| As | 0.80 | 6.20 | 5.53 | 3.933333333 |
| Cu | 160.33 | 78.09 | 181.43 | 523.225 |
| Ni | 35.40 | 15.74 | 41.16 | 13.925 |
| Cd | 0.80 | 0.85 | 1.70 | 1 |
| Pb | 77.90 | 42.27 | 120.86 | 69.2 |
| Hg | 0.69 | 0.77 | 0.80 | 0.5725 |
| Cr | 40.53 | 22.17 | 55.60 | 18.225 |
| Mo | 6.73 | 3.66 | 6.54 | 4.65 |
| Se | 2.98 | 2.79 | 3.50 | 1.7325 |
| Zn | 554.00 | 302.43 | 793.14 | 433.25 |
| F | | 61.84 | 61.27 | |

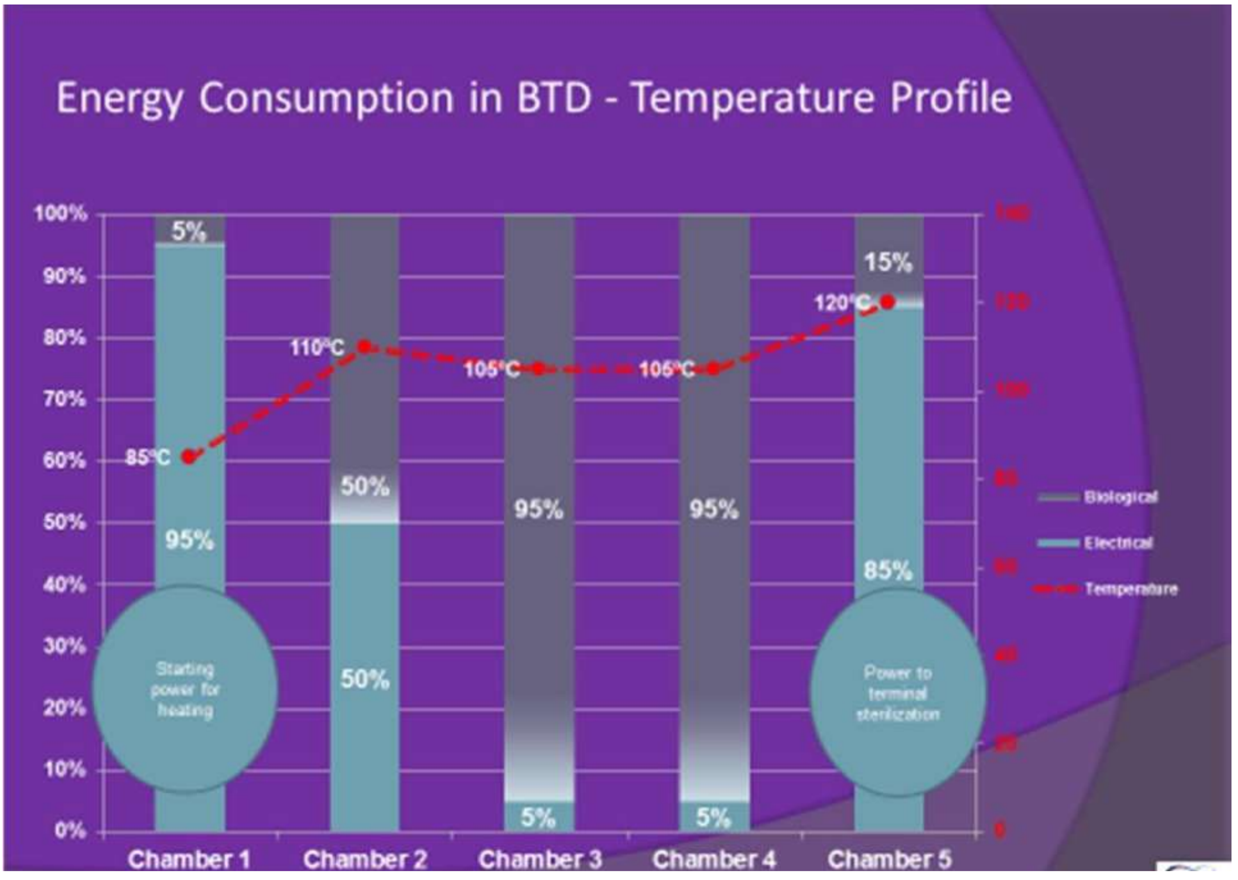
The machines marketed on an industrial scale, work much more efficiently by the way they use the thermal energy level, for the following reasons:

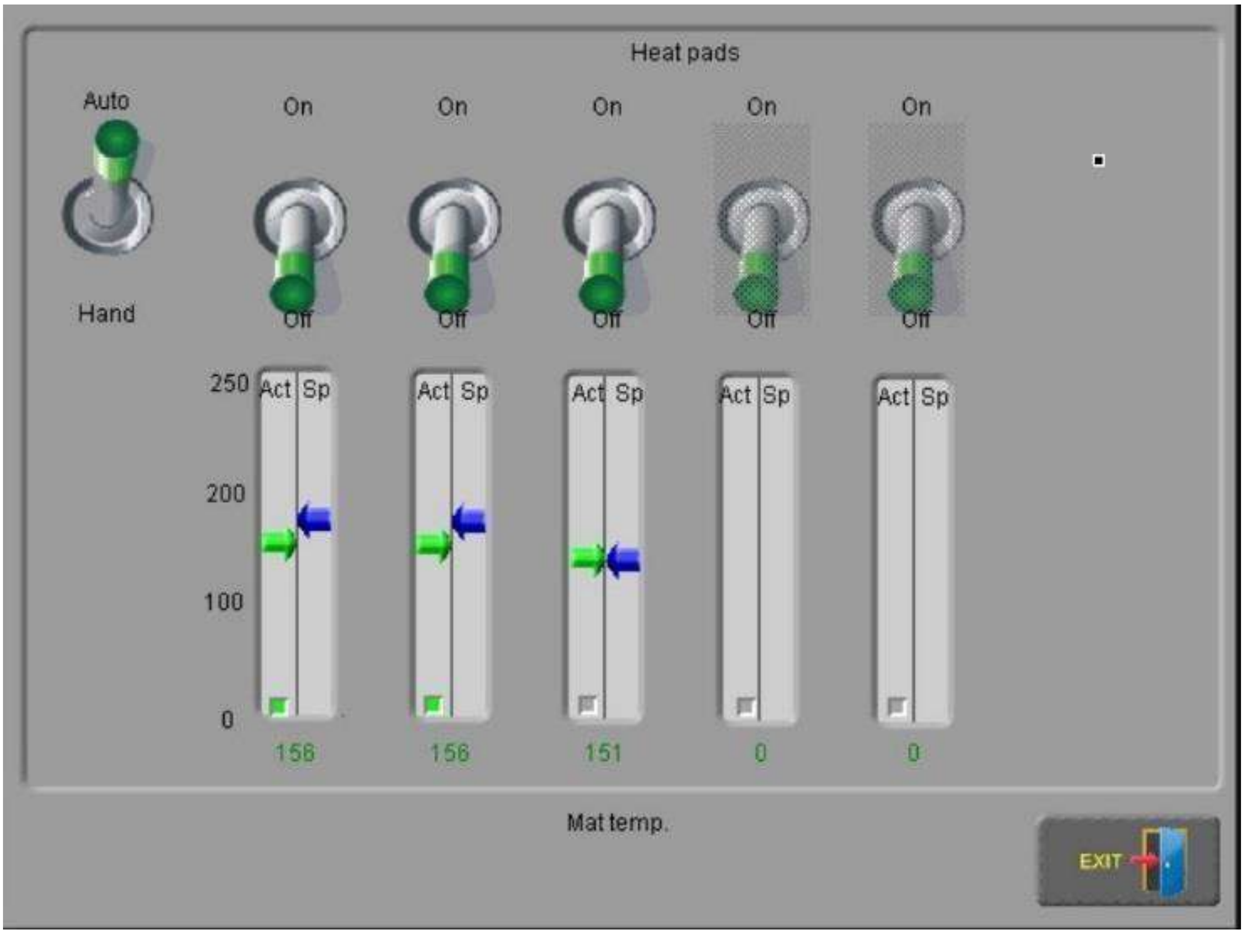
• First, they have at least three chambers instead of two. Therefore, the temperature drop is contained within chamber 1, the main processing would develop from chamber 2, where temperatures would be much more stable.

• Secondly, power is available to all heat mats and motors all the time, which prevents sudden temperature drops at the time of feeding the infeed material into the machine and therefore there is no need to provide a large heat input after chamber 1.

• Third, the hot moist air of the exhaust air system is recovered by forced circulation, recirculating from the final to first chambers, helping to warm the chamber without much external input from the heat mats.

This makes the industrial-scale machine energy efficient and is far superior to that seen with the model plant, as it would not need as much external heat input through electrical power. This balance between power and biological activity is clearly shown in the chart below.






CONCLUSIONS

The difference between the sludge being fed into the machine and the outlet material was a reduction of up to 89%. It is not only the weight and volume reduction, but that the output material is dry, inert and much easier to handle for transport, storage or landfill management.

In addition, the output material can be used as a fuel or as a fertilizer for agricultural use due to the content of nitrogen, phosphorus and potassium. The temperatures reached inside the process ensure a final material which is neutralised and free of bacteria E.coli and Salmonella, meeting the enhanced product criteria for sludge's recycled to agricultural land.

To its credit, the final product has high content of nitrogen and in general this has value as a fertilizer that is free of pathogens. This makes it among the safest type of final digestate and its ease of handling compared with other technologies.

Apart from a cleaner, drier waste, less odour and its ease of handling due to its dryness, it is obvious that this waste volume reduction could realise a significant savings in operating costs of the plant. Probably the main operating cost is transportation and management of sludge from the plant to the point of disposal or recovery, but also the commercial gain of the final digestate, if it could be sold as fertilizer, which is pathogen-free and rich in nitrogen.

Water sludges were treated and a reduction of 87.5% was achieved on volume, which was higher than Advetec had anticipated, as these types of sludge's typically contain less organic content than sewage sludge. The main driver behind the trial on the Water Treatment Sludge, was for The Customer to ascertain whether the BTD process was a viable process for reducing water sludge volume. With the 87.5% result achieved the BTD process has demonstrated that it is indeed, a very viable process for the treatment of Water Treatment sludge's.

The BTD process has the potential to reduce costs on the volume of sludge being transported between water treatment sites and sewage treatment plants, which typically treat the water treatment sludge's. This also helps the sewage treatment process, as it has a lower load to treat on a daily basis. On top of these savings, if the final product is used as a fuel source or fertiliser, there is a value that can be recovered via the sale of the final digestate.