by **Dirk Schmidt and Jan Fletcher Hansen**

A plant with brains

Advanced combustion control in waste-to-energy plants

An advanced combustion control technology has enabled a waste-to-energy plant to operate in automatic mode, expand waste throughput, and increase efficiency. How can this technology help operators improve plant performance and increase cost-effectiveness?

Achieving a range of competing goals at the same time is a challenge in any industry. This is particularly true in waste-to-energy (WTE), where the variable nature of the waste being treated can cause headaches for operators keen to optimize efficiency. An emerging solution to these headaches can be found in software designed to offer operators a more holistic view. Using this approach, crucial parameters are controlled with the aid of advanced pattern recognition technology and a modelling tool, enabling targets to be set and followed automatically. How does this work? What does it mean in practice? Let's take a closer look ...

> **The variable nature of the waste can cause headaches for operators**

Using cameras to monitor flame behaviour

Conventionally, camera systems have been used in waste combustion only for basic monitoring purposes. Although video technology provides WTE plant operators with on-line information about the flame's behaviour, the usefulness of this information is limited to their ability to interpret what they see and to react in an appropriate way.

Infra-red (IR) cameras have also been developed that are capable of providing thermal mapping across the fuel bed. The thermal image is used to calculate mean temperatures for a number of locations across the grate and give an indirect indication of the intensity of combustion on the grate.

These camera measurement systems can only offer detailed information in two dimensions about the surface temperature of the fuel bed. However, implementation in the usual linear controller loops (such as for grid speed) in the control systems of waste incineration plants is difficult and dust often affects the IR temperature measurement. The main weakness of this technique is that it is difficult to ensure reliable interpretation. High radiation recorded in one area could be a result of a high concentration of burning particles and soot instead of a hot spot on the fuel bed. Furthermore, the thermal image cannot give information about the type of process going on in the fuel bed; for example, it is well known that gasification is more pronounced than combustion in some parts of the fuel bed.

Flame analysis and control system

According to Powitec Intelligent Technologies, it is possible and desirable to extract combustion data in a more advanced way. With this in mind, this German company has developed a patented flame analysis and control system.

Entitled PiT Navigator, Powitec's software offers adaptive combustion control based on self-learning neural networks working in combination with optical imaging technology. The software constantly reproduces new models on which the control is based. This 'self-calibration' enables plant operators to identify and account for both the wear of parts and changes in the characteristics of the waste.

The PiT Navigator computes and follows optimal set-points, taking into consideration factors such as:

- waste density
- the ignition behaviour of the waste
- boiler contamination
- the calorific value of the waste
- the waste's steam-generating capacity.

Via a bi-directional communication interface (bus system or other bi-directional interface to the control system of the furnace), a set-point matrix with a status signal is sent to the control system.

TABLE 1. Technical data for the L90 plant

Number of staff	20
Capacity	24 tonne/hour
Thermal efficiency	89%
Electrical production	18 MW
District heating production	54 MW
Flue gas temperature	165°C
Residual oxygen in the flue gas	4.5% vol% (wet)
Residual water content in flue gas	17.9 vol% (wet)
Carbon monoxide emissions in the flue gas	6 mg/Nm^3
Total organic carbon (TOC) in the flue gas	2 mg/Nm^3
Loss on ignition (LOI) ash	2.1%
Average heating value	10.6 MJ/kg

The PiT Navigator runs on the Linux operating system, thereby providing a stable platform to minimize down time and enabling extensive remote control functions and service activities. Data gathered by the system's cameras are fed back in as process control variables, enabling greater speed and accuracy in process control.

Intelligent control in action

The first, fully integrated example of Powitec's advanced combustion control (ACC) technology can be found at the L90 waste-to-energy plant at Esbjerg in Denmark.

The L90 plant burns 24 tonnes of waste per hour, providing a third of the heat and 100% of the electricity consumed by Esbjerg's 82,000 inhabitants. The input is a

The variable quality of waste poses a challenge for optimizing efficiency of the combustion process

mixture of household (35%) and industrial (65%) waste. Table 1 provides a summary of technical data of the plant.

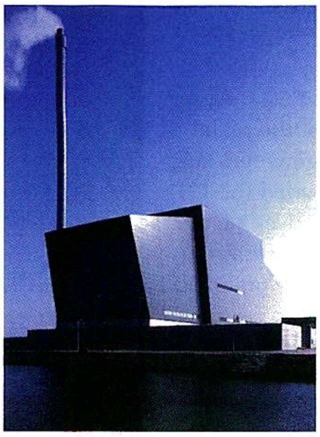
Babcock & Wilcox Vølund ApS, which engineered and commissioned the boiler of the L90 plant, included the PiT Navigator in its specification. The main objectives of this installation were to enable a high throughput of waste and to optimize steam generation for electricity production and district heating.

Powitec installed three on-line sensors – the number used depends on the geometry of the combustion chamber – accompanied by red-green-blue (RGB) thermography

The Esbjerg installation aims to enable a high throughput of waste and to optimize steam generation

technology to detect the heat distribution on the furnace grate. As a result, key process parameters such as the ignition point, flame centroid and burnout point are calculated continuously.

When the waste enters the furnace, drying and gasification takes place on the grid. The ignition point (when the waste ignites on the grid) depends on various waste characteristics, which are not measurable in advance. The ignition point needs to be measured and kept stable in the first zone of the grid and the first sensor of the PiT



Navigator accomplishes this function. The flame centroid is the balance point for the combustion process located in the main combustion zone of the grid. This is detected continuously by the second sensor device. Finally, the burnout point provides an indication of ash quality and is detected by the third sensor. As a result, the whole combustion process is monitored without any gaps in coverage.

The sensors contain CCD cameras (CCD stands for charge coupled device – a digital light-sensitive matrix) with on-board personal computers and air-cooled endoscopes. The system's digital-image-processing facility generates the parameters used to create the process model inside the PiT Navigator software.

Two months after commissioning, the main operational results from the L90 plant are:

- **More consistent steam flow.** When employing the PiT Navigator, the standard deviation was reduced from 7.2 to 3.2 at 95 tonnes per hour. More steady steam flow encourages increased waste throughput and maximized electricity production.
- **A reduction of operating time below the temperature limit of 850°C in the post combustion zone.** When employing the PiT Navigator, only 2.4% of the time was spent under this limit compared with 7.9% without it. Industrial furnaces need to maintain a minimum of 850°C in the flue gases for at least 2 seconds to eliminate pollutants such as dioxins. This approach also eliminates the use of supplementary fuels, thus reducing operational costs and fossil fuel consumption.
- **An increase in operational capacity, with a reduction in manual intervention.** Typically manual intervention occurs when the combustion process is not finished on the final grid zone (burn-out point). This results in a significant amount of unburnt carbon in the ash, meaning that the ash must then be handled as hazardous waste and the efficiency of the plant decreases. Use of ACC enables the plant to operate in automatic mode for 98% of the time compared with a standard operational capacity of around 90%.

ABOVE The L90 waste-to-energy plant at Esbjerg, Denmark, has used advanced combustion control to increase plant throughput **BELOW** Advanced combustion control analyses and monitors flame behaviour

It is not easy to comment on the financial return on investment for the L90 plant. However, other retrofit installations from Powitec have shown that an expanded waste throughput of 3% is typical with the PiT Navigator. This means that a plant processing 7.5 tonnes of waste per hour can expect to generate an additional income of €150,000 per year (with a waste price of €80/tonne) when a PiT Navigator unit is fitted. This would equate to a return on the investment in less than two years.

A plant processing 7.5 tonnes of waste per hour can generate an additional income of €150,000/year

Jan Fletcher Hansen, L90's Technical Director, commented: 'Without this ACC system, it would not be possible to operate the plant with such a continuously high output and a staff of only 20 people'.

The results from the L90 plant have been the basis for further projects in Germany, Denmark and the Netherlands.

Conclusions

As new legislation encourages more material to be diverted from landfills, there is likely to be greater variation in the heating value of waste being thermally treated. At the same time, if waste-to-energy is to become an accepted mainstream source of energy, it must provide a constant supply and be a cost-effective investment. These factors suggest that an increasing number of operators will start to consider enhancing their control strategies to optimize plant performance in this increasingly demanding environment.

Jan Fletcher Hansen is Technical Director at the L90 waste-fired power plant at Esbjerg in Denmark, and **Dirk Schmidt** is Director of Sales at Powitec Intelligent Technologies at Essen, Germany.
e-mail: d.schmidt@powitec.de
web: www.powitec.de
www.L90.dk

To comment on this article or to see related features from our archive, go to www.waste-management-world.com and click the 'Forum' tab.