EVOLUTION OF THE BIOCENTRE® PROCESS – WHY A HIGH QUALITY FUEL IS IMPORTANT

Biocentre solid fuels – pellet form

The History

Background

Thermal treatment of raw wastes entered the waste management hierarchy in the UK one hundred and forty years ago with the construction of the first municipal incinerator in Nottingham. These early incinerators were extremely primitive, consisting of a series of combustion cells that were loaded manually with mixed municipal wastes. Upon completion of combustion resulting fused and toxic slag in the cells had to be removed by manual raking before a new charge could be loaded. There was no treatment of the exhaust emissions – they were simply exhausted to atmosphere via chimneys.

The early plant became superseded by mass burn units where the exhausts were cooled in spray towers in an attempt to remove as much of the fly ash as possible. However, the plants were still inefficient and wasteful, in that none of the heat from combustion was recovered. This issue was later addressed by delivering the hot gases from combustion to specially designed boilers, where the steam could be used for district heating and electrical power generation. Plants of this type replaced the early mass burn units and became common, but increasing environmental regulation required an almost continual process of modifications to reduce or eliminate pollutant emissions to atmosphere (Dioxins, Furans, toxic fly ash) and to ground (bottom ash and furnace slag).

Although the heat recovery incinerators enjoyed popularity for many years, the steady increase of recycling initiatives began to have an adverse effect upon them. As more and more of the higher calorific fractions were recovered, the calorific value of the residual fractions going to incinerators reduced, generally to a level of around 9.5 MJ/kg. At that level the residual wastes are hardly combustible, and they frequently required the assistance of supplementary fuels to improve combustion. This dramatically reduced the efficiency and economic viability of plants generating power or supplying district heating. In some plants an attempt was made to screen out the materials that were detrimental to combustion (mainly organics and inerts such as glass and soils), and to thereby increase the calorific value of the remainder. That, however, left the problem of how to dispose of the screened out fractions, and while aerobic digestion was possible and was implemented, the resulting product was too contaminated for use as a compost. It could only be landfilled, thereby limiting the value of incinerators as a disposal route.

Development of the UK MBHT Process For Fuel Production

In the late nineteen-seventies, in an attempt to find an alternative to incineration, the concept of using the wastes as a raw material for a solid fuel that could be consumed in industrial boilers was conceived, under the generic title of Waste Derived Fuel (WDF). Five plants were built – four sponsored by the Department of the Environment and one commissioned independently by East Sussex County Council (ESCC). The DoE plants were of a common design, but they suffered from their being unable to effectively separate contaminants from the fuel products, and they were not a commercial success. The ESCC design was fundamentally different, and the fuels it produced were of a much higher quality and calorific value. The ESCC design incorporated Mechanical Biological and Heat Treatment (MBHT) stages. The fuel products produced found ready markets at attractive prices in power stations and industrial consumers, to the extent that the plant did not have the production capacity to satisfy the demand.

The ESCC MBHT plant was successful largely because it was designed according to a different philosophy. The early DoE plants were simply seen as a means of disposing of wastes, with the products being almost an afterthought. However, the engineers who designed the ESCC plant (Tony Manser and team) took the approach that if the plant was going to be of value to waste management, then it should be seen to be a commercial producer of a value-added product for which the raw material happened to be wastes. The design philosophy targeted product quality and not waste disposal. The process was designed to eliminate contaminants to the greatest extent possible. As a result the calorific value was much higher because the process removed the non-combustibles and contaminants at several stages, reducing the ash contents to similar to those of coal, and also reducing the moisture content to less than eight percent. This created a fuel that was made almost entirely out of paper and card, with some wood, plastics, and traces of textiles.

Evolution

This MBHT technology then evolved through a series of five plants, further improving the separation and treatment processes without major changes to the original design, and employing increasing levels of automation culminating in the two large fully automated plants built for Slough Heat & Power and Castle Cement in 2003 and designed by Advanced Recycling Technologies (ART) Ltd founded by Tony Manser and others in 1991. The intellectual property of ART was acquired by Biocentre Technologies Ltd in 2012 with the intention of developing a series of MBHT process plants throughout the UK.

A fuel production plant built by ART in 2003 – processing 230,000 tonnes a year of wastes with no atmospheric emissions.

While the calorific value of the products is important, the removal of inert contaminants is equally so. The only boilers in which one can burn raw wastes or low-grade waste derived fuels (WDF) are those specifically designed for incinerators, and they are very different from conventional boilers. If one tried to burn those materials in an industrial boiler it would destroy it in weeks. Superheaters clog up with fused ash and suffer from massive high temperature tube erosion that can reduce a tube thickness by several thousandths of an inch a week — which means the tubes burst in about three months of service. Gas pass tubes also suffer badly from grit erosion, and those in the furnace are attacked by flame erosion since the flame length from crude wastes is much longer than from conventional fuels. Since the chloride and Sulphur contents in raw wastes and low grade WDF are high, boiler air heaters in the exhaust gas passes suffer from condensation of hydrochloric acid, and the Sulphur combines with moisture at temperatures below 250°C to form Sulphurous acid which, being unstable, breaks down into Sulphuric acid.

Crude wastes and low grade WDFs also contain high levels of silicates, and these fuse on boiler tubes in the high temperature zones. Because they fuse at lower temperatures than the rest of the fly ash they migrate to the tube surfaces. Silicates (sand) were once used by blacksmiths when welding iron together by forging, because silicates have a fluxing property. Meanwhile, boiler tubes always have a rust coating, but once that is established it protects the tube from further corrosion. The silicates flux that away, allowing the acidic flue gases to once more attack the tubes every time the soot blowers are operated, and again leading to tube failures in months.

Dioxins and furans

There is also the issue of dioxins and furans (Polychlorinated Dibenzodioxins and Poly chlorinated Dibenzofurans) with which conventional boilers cannot deal. These are not manufactured products, but they do arise from a number of sources, including municipal incinerators, forest fires, coal-fired power stations, and many other natural and man-made combustion processes.

The EU Waste Incineration Directive (WID) require boilers burning wastes or low grade fuel to maintain an exhaust gas temperature of 250°C in order to prevent dioxins and furans from reforming. Industrial boilers are trying to get the maximum amount of heat energy possible from fuels, rather than heating the local atmosphere. In many incinerators this issue is addressed by using oil-fired after burners in the exhaust gas passes, but that rather defeats the object of burning waste derived fuel in the first place. Fuels made in the Biocentre MBHT process are sufficiently free from contaminants, and in the next generation of plants no longer include plastics, so that they do not create dioxins or furans in measurable quantities. This was demonstrated as long ago as 1985 by the then Associated Heat Services Ltd in the first of their combustion plants to use the fuel, where tests for dioxins and furans did not discover detectable quantities of either.

The sophistication of the Biocentre process, and its ability to remove contaminants including heavy metals, is such as to offer the treatment of a wide range of wastes including household wastes without any need for any separation at source. This is a potentially important contributor to the reduction of waste management costs that have been growing exponentially for a number of years. It has been achieved by many years of research and development by ART Ltd and later Biocentre Technology Ltd, leading to the creation of mathematical modelling computer programs and data bases that permit processes to be designed with confidence.

In recent years the desire to reduce the reliance upon fossil fuels and to substitute renewable low carbon footprint biofuels in their place has led to a growing interest in how waste materials could be exploited. This has resulted in the WRAP (Waste and Resources Action Programme) classification scheme for biofuels derived from wastes. In this scheme there are five classes established according to the pollution potential, metals, ash, moisture and heavy metals contents, ranging from Class 1 (best) to Class 5 (worst). The position of Biocentre fuel products in this classification scheme are shown in the table below:

Biocentre fuel "BC17" *

Component	*WRAP Limit*	*WRAP Class*
Biomass content	>90%	Class 1
Net CV	>15 MJ/kg	Class 1-3
Moisture content	<10%	Class 1
Chlorine content	<0.2 %	Class 1
Ash content	<10%	Class 1
Bulk density	>650 kg/m3	Class 1 (optional)
Mercury content	<0.02 mg/MJ	Class 1
Cadmium content	<0.1 mg/MJ	Class 1
Sum of heavy metals	<15 mg/MJ	Class 1

Biocentre fuel "BC12" **

Component	*WRAP Limit*	*WRAP Class*
Biomass content	>90%	Class 1
Net CV	>10 MJ/kg	Class 3-4
Moisture content	<20%	Class 3
Chlorine content	<0.6 %	Class 2
Ash content	<20%	Class 2
Bulk density	>650 kg/m3	Class 1 (optional)
Mercury content	<0.02 mg/MJ	Class 1
Cadmium content	<0.1 mg/MJ	Class 1
Sum of heavy metals	<15 mg/MJ	Class 1

NB.

* Biocentre BCV is the most highly refined biofuel developed from the historical and evolved processes.

** Biocentre BFB is created by an additional process developed in 1986 to convert the organic fractions of wastes into washed peat-like fuels.

MBHT – Mechanical, Biological and Heat Treatment

MBHT is the generic term for the processing technology developed by Tony Manser and associated engineers. It is a sophisticated form of Mechanical and Biological Treatment (MBT) of wastes which includes fuel refining stages, including a flash dryer. The specification and quality of the output fuel is closely controlled – and achieves the high levels of performance quoted above which allow the fuel to be used as a direct replacement for washed singles coal or wood pellets / chips. Biocentre uses its proprietary version of MBHT.

Questions and Answers

Q1: Why is doing all of this any different from simply burning wastes?

A1: Because it involves highly sophisticated and computer controlled mechanical processing to produce fuels that have far better emissions controls when used and far lower life cycle impacts. The Biocentre process also focuses on extracting and refining the recyclates at the earliest stages so avoiding the incineration or destruction of waste materials that could otherwise be used as raw materials once they have been separated and refined.

Q2: So what about dioxins and furans that dwell for hundreds of years in the environment and poison people (e.g. through bioaccumulation)?

A2: The Biocentre products are highly refined, and they are no more likely to create dioxins and furans than are wood fuels and much less than forest fires, incinerators, and coal burning.

Q3: Why has this technology not been used more widely?

A3: The UK was in the lead for this technology in the 1980s, and it achieved an offer of derogation from the EU Waste Incineration Directive (WID) in 1990. Unfortunately, the British government at the time rejected the derogation. This set the fledgling industry back by at least twenty years.

Q4: What about global warming and the burning of fuels that releases carbon dioxide into the atmosphere?

A4: Biocentre fuels are manufactured from renewable materials (mainly residual paper and card – not suitable for recycling) which, during their growth phase, absorbed carbon from the atmosphere. When they are burned they release no more than that which they first absorbed so they are at least carbon neutral, particularly since they contain no materials of fossil origin. The carbon content of Biocentre fuels is 60% less than that of coal, but the volatile matter is nearly three times that of coal, so there is <u>less carbon to burn</u>. In addition, the paper industry claims that it plants two trees for every one that it uses for pulp. Therefore, the use of fuels made from recovered paper, card, and pulp might actually have an environmentally beneficial effect in reducing the atmospheric carbon balance. An independent assessment of the Biocentre process using the standard

Environment Agency's WRATE tool concluded that for every tonne of waste processed by a Biocentre plant there is a net saving of 550kg of CO_2 equivalent, far better than any comparable process. See here

Q5: So why don't we simply recycle paper and card into new paper and card?

A5: All recycling leads to "down cycling." This means that a sheet of clean white paper eventually ends up in low grade fibre products such as an egg box, by which time the fibre length has become such that it cannot be used any more. It ends up as a sludge that the paper mill has to get rid of, to incineration or landfill. The Biocentre process escapes this route by capturing the energy remaining in the material before it is consigned to egg boxes, for example.

Q6: So why aren't many more companies offering this technology?

A6: They are (or something they think is similar), but they don't have the proven track record of the ART technology that Biocentre Technologies acquired. They don't have the background of research and development. They don't have the computer data bases that took years to develop. They don't have the computer programmes that were developed from those data bases.

Q7: So we make this stuff and we offer it into the combustion market. What happens if a user experiences major problems with his combustion plant?

A7: The Biocentre fuels have been used in industrial boilers and processes for many years (power stations, cement works, market gardens, prisons, and even for a while in the 1980s, in the domestic market where the fuel pellets were much sought after. The combustion technology and adaptations to this fuel is well understood and has been scientifically tested and verified in operation.

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