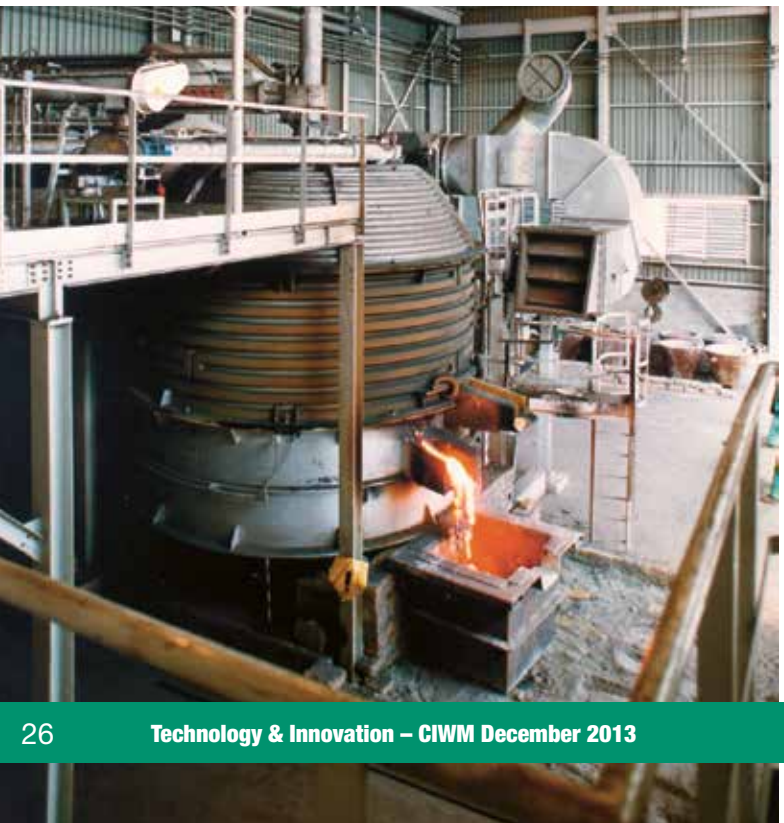
Plasma **Power**

Dr David Deegan, technical director at Tetronics International, gives a flavour of what plasma technology can offer…

Sustainability… what does this mean? It is often a term that means many different things to different people and organisations based on their perspective. When examined in detail, the definition is quite complex, something that Chartered Environmentalists will be more than familiar with. It is also something that is linked into addressing concerns around the subjects of strategic materials, critical materials and the development of cradle-to-cradle circular economy models. Therefore, you may be surprised to find out that the fulfilment of these requirements has been successfully supported by Tetronics' patented plasma technology for a considerable period of time on a commercial scale. Plasma technology sits as a recovery solution within the waste management hierarchy and is seen as a solution for the recovery of material values from wastes. This classification is very much predicated on the product status of Plasmarok®, a position endorsed by the Environment Agency. This recovery is achieved whilst destroying, transforming and/or packaging the hazardous materials that exist within the wastes. Specific examples would include:

- destruction – thermal eradication of species referred to collectively as persistent organic pollutants (POPs), which build up in the environment or are bioaccumulated and/or biomagnified in the food chain, eg furans or dioxins
- transformation – conversion of hazardous metal compounds to recover metal credits, eg hexavalent chrome to chromium metal
- packaging – the incorporation of hazardous species into the glass structure of the inert, inorganic rock-like product Plasmarok®, eg nickel monoxide, which is carcinogenic in its isolated crystalline form but innocuous once incorporated into the glassy structure of Plasmarok®.



So what is plasma? To Tetronics, plasma is a robust, industrially proven, controllable and scalable heat source with unique attributes that extend far beyond physio-chemical treatments or competing combustion-based thermal technologies. Plasma is often referred to as the fourth state of matter due to its position in the phase transformation series that typically occurs to materials with increasing temperature, ie solid, liquid, gas and plasma. In summary, plasma is the state of an ionised gas.

Spatially Stable

IN AN engineering context plasma is a spatially stable, directional, electrical heat source with some unique functionality. Plasma heat sources do not rely on combustion or the specification of the input waste, so input energy can vary independently of process chemistry, giving rise to a robust and controllable heat source; this is a key factor in controlling the partitioning of important species. In addition to its high temperature, plasma is directional and therefore the application of heat and energy can be efficiently targeted. The light that is associated with the plasma, due to electrical excitation of the gases that make it up, supports the photo-catalytic destruction of organics. Additionally, the wider material system produces transition metastable species that often give rise to accelerated process reaction stages, saving energy and time, which are collectively referred to as the "plasma effect". This excitation also gives rise to charged species that mutually repel and it is this repulsion that gives plasma a physical presence important in mass transfer processes.

In the context of waste management or environmental services, there has been a shift in mindset to seeing waste as a resource as opposed to a disposal problem. Combined with the growth in some valuable and/or challenging wastes, finite natural resources, resource security and environmental impact, plasma is a key component in sustainable waste management infrastructure and in supporting the development of circular economies. Using the terminology of this subject area, plasma has been proven to support pure material flow recovery cycles, as the materials can re-enter the supply chain with comparable quality to the virgin equivalents. Traditional waste management solutions are also coming under increasing pressure from operational, compliance, social and corporate responsibility standpoints.

Regulator's recent hazardous waste strategies call for an essential change in approach. Across the world regulations are tightening, which is leading to:

- more materials being classified as hazardous
- an increase in the number of hazardous waste producers
- a reduction in the number of available land-based disposal and storage facilities
- reduced freedom to transport and "export" hazardous waste
- increasing economic burdens associated with waste/by-product management
- pressure for recycling and recovery as opposed to disposal
- policy calling for the development of sustainable circular economies and revolutionary business models.

It is clear that treating or valorising various waste stream residues to liberate value and improve economic performance is key to competitiveness and an opportunity for businesses globally.

Unfortunately, as is often the case, Tetronics has been faced with having to dispel many urban myths and mis-selling. These myths include the belief that the technology is over-complicated, too expensive and too futuristic. You will be pleased to find out that these are far removed from the truth, which will be demonstrated by example. Tetronics has often chosen to use large and small scale examples to validate the claims about its technology and also demonstrate flexibility and control.

Large & Small-Scale Solutions

AS A large scale plant example, Tetronics has seen extensive success in the fields of ash vitrification and base metal recovery. In a European context Tetronics commissioned a 20 000 tonne per annum Electric Arc Furnace (EAF) Dust plant in 1991 for Harsco (formerly MultiServe) in Terni, Italy. A similar, but smaller, facility is also located in Sheffield, England, as operated by Outokumpu. The Italian facility has been in continuous operation since being commissioned and is reported by Harsco, the operator, to have recovered in excess of US$200m in material values. The plasma process is trademarked Plasminox® and works to carbothermically reduce the hazardous oxides in the by-product stream to produce a ferro-alloy containing the Cr, Ni and Mo values as recovered metal credits that are recycled back to the main steel plant.

EAF dust is equivalent to the Air Pollution Control Residue (APCr) of the steel industry. Using this analogy as a subject bridge, we find that there is a trend in the UK of moving residual waste management away from landfill towards EfW plants. These plants are clearly a step forward but also produce a hazardous by-product of lime-based APCr. This concentrated by-product is very much a hazardous waste and must be managed accordingly. The APCr market is set to double in size in the next three-to-four years, to in excess of circa 500 000 tonnes per annum, as more energy from waste capacity comes on line. The mass generation rate is equivalent to a volume of 833 000m^3 per year APCr.

This all occurs as the UK Environment Agency proactively consults with the intention of increasing the compliance standard and in the process, diverting this type of material away from land-based disposal mechanisms.

We believe Tetronics' technology offers a competitive recovery solution to this challenge and, on the basis of a historic track record, we anticipate seeing commercial facilities develop within the UK. Once established, and in support of the UK environmental sector, we are confident that these systems will be considered as a Best Available Technique (BAT), with these initial plants acting as the catalyst for future European-wide projects.

As a relatively small-scale plant example, but extremely high value throughput, plasma is employed in the field of precious metal (PM) recovery, and Tetronics has been quoted as the technology provider of choice for this application by independent consultants. Tetronics' plasma technology has achieved this status due its technical performance, low environmental impact, regulatory compliance and low capital and operational costs. This is all achieved from a plant occupying a small physical footprint. Overall, this gives rise to the lowest cost base per troy ounce of precious metal recovered. You may be surprised to learn that there is a commercial facility operating in the UK – the UK's first independently licensed plasma-based waste recovery facility. This facility, working at capacity, would process/produce about 150 000 troy ounces of PM per year, equivalent to the output of a primary mine shaft in South Africa. The world autocat market is currently estimated to be 45-50 000 tonnes per year, and each tonne of autocat is typically worth £50 000, based on intrinsic precious metal value.

Tetronics' PM current and near-term future reference list, in terms of installed capacity, represents about 10-15 percent of the world's market for the supply of Platinum Group Metals, if they were to all operate with typical autocat. This supply of recovered precious metals meets about 40 percent of primary demand, so these facilities are very important in achieving the sustainable supply of PMs. In the vast majority of these projects Tetronics has acted as a technology integrator, taking overall supply and performance responsibility for the plasma installation. Tetronics' scope of supply extends from material pre-treatment, blending and feeding, through to the integrated plasma system and furnaces, off-gas systems, hot material handling and continuous emissions monitoring. Tetronics has also continued to build on this impressive foundation by improving the technical recovery efficiency of the technology, through recent innovations associated with the internal recycling of selectively captured by-product streams and elemental specificity.

This technology is also used for the recovery of precious metals from industrial catalysts, eg reforming catalyst as used in the production of petroleum products and waste electrical and electronic equipment (WEEE). WEEE is subject to an extensive amount of regulation, supplier responsibility and compliance schemes, therefore Tetronics' technology is set to play an instrumental role in realising value from this growing "urban mine" market, whilst supporting the achievement of recycling targets, as consumer trends and novel "take back-based" business models develop.

I hope that this has provided you with a flavour for plasma technology, its proven track record at small and large scales of operation, and an insight into its increasing use in the development of new, sustainable waste management infrastructure in light of changing market conditions. CIWM