Ovens, Furnaces & Heating Equipment

The use of furnaces in recycling precious metals

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By the end of 2019 it was estimated that as many as 350,000 mobile phones were disposed of every weekday - with a gold content worth $200 million according to Carol Jegou, the CEO of All green Metal Recycling, when she spoke at the E-Waste World Expo in Frankfurt. Carol went on to say that for every million phones that are recycled 16 tonnes of copper and significant quantities of silver, gold and palladium can be retrieved.

However, it isn't simply mobile phones that are being recycled today. Global demand for precious metals continues to soar, whether for jewellery or for use in industrial applications. While gold and silver have been used for thousands of years in jewellery, more recently precious metals are performing useful and specialist functions in chemical processes, electronics manufacturing, aerospace and automotive systems, (eg catalytic converters).

More than a decade ago, in excess of 1,650 tonnes of fine gold was fed back into the global gold supply chain according to figures released by the Birmingham Assay Office. This is hardly surprising as at the time it was estimated that the cost to extract the precious metals was $0.18 while the value of those same metals once extracted was over $0.75. Today, an even greater quantity of precious metals are recycled thanks to cost-effective techniques and the fact that precious metals can be recycled time and again without their properties degrading. At the time of writing in June 2020, the cost of palladium stands at over £50 per gram (a rise of over 370% in the last decade) and gold currently trades at over £45 per gram (up 70% over the last decade) so it comes as little surprise that recycling volumes are at an all-time high and continue to rise with the growing demand from high-tech manufacturers.

Specialist furnace equipment is used throughout the world both for recycling these relatively rare commodities and for assessing their purity. There are two key processes in the precious metals recycling market - smelting and cupellation.

Smelting is the separation of precious metal from non-metallic impurities. When bulk ores are involved, very large installations are required, using heat and chemical reducing agents to decompose the ore, drive off other elements such as gases or slag and leave only the metal behind. When the process involves pre-used materials – for example, catalytic converters or jewellery - the equipment is smaller in scale but involves the same principles in order to ensure a high- quality end material.

Precious metals recovery is a typical use of smelting. Scrap material is heated to above its melting temperature (1100ºC for gold, 900 to 1000ºC for silver, 1500ºC for palladium and 1550 to 1800ºC for platinum). A great example of smelting to recycle can be seen by those recycling automotive catalytic converters which are designed for exhaust gases to pass through a ceramic honeycomb coated with a fine layer of palladium group metals (PGMs). This fine coating contains platinum ore, typically two to three orders of magnitude richer than the mined ore. During the recycling process which might recover as much as 98% of PGMs, the honeycomb ceramic is crushed into a powder and placed in crucibles where it is melted, perhaps even a number of times, in the smelting furnace with a low value material such as lead and a suitable flux to recover as much as 98% of PGMs. In its molten state the low value material combines with the precious metal and the impurities form a slag, which can be easily removed when the sample cools. The cooled can then be placed in a cupellation furnace to remove the low value material and to recover the precious metal.

High quality smelting furnaces with a single or twin chamber configuration used by laboratories and assaying companies are specifically designed to provide the temperatures required for smelting, while withstanding the gases given off by the process. Those considering investing in such a smelting furnace will be looking for models with high-performance silicon carbide elements to allow continuous operation up to 1400oC. In addition, quality solutions will feature furnace chambers that are lined with silicon carbide

tiles to protect the elements and the thermal insulation, with hard-wearing refractory brick providing a solid hearth base.

The ground/powdered precious metal for recycling and the low value material is typically processed in ceramic crucibles of various sizes, and hinged chamber lids keep the heat of the insulation away from the operator when opened and these lids also typically incorporate chimneys to vent fumes. Furnace temperature is regulated by a microprocessor-based controller with a timer function allowing the equipment to be switched on automatically without an operator being present.

Accurate analysis is routinely carried out to determine the precious metal content in a wide variety of different materials. This is particularly important for fineness determination for the hallmarking of precious metals for jewellery use. The precious metal concentration in different materials can vary widely from amounts measured in parts per million (ppm) for

car catalysts or powdered ore samples to almost 100% in jewellery alloys or bullion bars.

Determining the precious metal content (assaying) of gold, silver (via silver titration) and platinum/palladium (using Inductively Coupled Plasma Optical Emission Spectroscopy [ICP-OES]) is fundamental to those valuing, buying or selling second-hand precious metals.

While X-ray fluorescence (XRF) spectrometry is far more accurate today than in the past providing reliable results, there remains several drawbacks including the initial purchasing expense. As a result, we still find gold cupellation, which dates back over 2000 years, is a much-used process. It ensures all other elements are eradicated, leaving only pure gold. Small samples are accurately weighed and wrapped in lead with a pre-determined quantity of silver to assist with the collection of gold and the removal of base metals. The wrapped samples are placed on cupels (porous blocks) and heated to 1100oC in a furnace. The lead and any base metals as oxides are driven off. A pure gold and silver bead remains, which is then boiled in nitric acid, dissolving the silver and leaving a residue of fine gold. When the weight of the residue is compared with the original sample the gold content by weight can be calculated. The assay of gold alloys by cupellation is a standard method used by the UK Assay Offices and a reference method laid down by the International Hallmarking Convention in accordance with ISO 11426:1997 and ASTM E1335-08.

Whatever the means of recovery the fact remains that we will continue to see an increasing requirement for the recycling of precious metals as our culture becomes ever more dependent on high-tech electronics. In addition, by 2040 Bloomberg New Energy Finance predicts that more than half of all vehicles sold will be electric powered (and governments around the globe are rapidly trying to increase that proportion and bring forward that timeframe). To meet these requirements, we must now recycle rather than mine extremely limited and unsustainable supplies. The cost of recycling and the reduced environmental impact will inevitably foster the creation of new recycling providers as the world's love for precious metals shows no sign of abating any time soon.

Pouring molten gold

SCF1 - smelting furnace

Article provided by Carbolite Gero who manufacture smelting & cupellation furnaces used by Assay offices and precious metal recycling organisations around the globe.