"Extreme makeover ": UPMR's Hoboken plant

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Abstract

For technology-based companies, continuous improvement has become as natural as evolution itself. On top of this, innovative breakthroughs are necessary to keep a high performance in an ever more rapidly changing world. This paper describes the complete turn-around of Umicore's Hoboken plant, from a complex Pb-Cu-Ni concentrate smelter and refiner, to the world's largest recycling facility for precious metals. This turn-around was realised through a series of drastic improvements, which will be remembered at Umicore Precious Metals Refining as Hoboken's "extreme makeover".

The makeover allowed for treatment of complex recycled materials from the world's largest open-pit mine: the consumer world. The European environmental legislation is based on a life-cycle approach, assessing the sustainability of products through the cycle of production, use and recycling. The WEEE Directive, the Battery Directive are examples of the new legislation, setting out collection and recycling targets for valuable scattered waste streams.

Based on a long tradition in complex non-ferrous smelting, UPMR masters the complexity of many precious metals containing waste streams. The new flow sheet has great flexibility in terms of physical aspect of the recycled streams; it is able to treat dry, fine, coarse, wet or lumpy materials, making it perfectly suited for recycling. Apart from these technical realisations, UPMR's strategy is to sustain its business by being a reliable partner for its customers, socially responsible towards the community and caring for the environment, making "Materials for a better life" sound more true every day.

1. The open-pit mine of recycled consumer goods

European environmental legislation

For a long time, environmental policies have been focused on large point sources of pollution, such as industrial emissions and household waste. These policies have contributed to reduce pollution and encouraged the use of 'clean' technologies. However, smaller and more scattered waste streams are not treated in a specific way. As an example, in the EU in 2003, 90% of the waste of electrical and electronic equipment (WEEE) was landfilled or incinerated. To address the challenge of the scattered waste streams, an Integrated Product Policy (IPP) has been developed as a guideline for future environmental legislation.

This IPP is based on the concept of Life-Cycle thinking. The environmental impact of a product is a sum of the impacts during production, use and recycling. Each part of the life-cycle has an impact on the environment, but also determines the impact in subsequent phases of the life-cycle. For example, the design of a product will strongly determine the dismantling after use. The IPP ensures that environmental impacts are addressed in that part of the life-cycle where they must be solved, and not just shifted from one part of the life-cycle to another.

This new approach implies that recycling is not just the responsibility of recyclers. The producer's responsibility for his product reaches until the end of the life-cycle. This has led to the concept of Extended Producer Responsibility (EPR). The producer is responsible for the recycling, by organizing take-back of his discarded products. By this policy instrument, product groups such as packaging waste or WEEE are diverted from the household waste streams, and treated in an environmentally sound way, such as re-use or recycling. The extra cost for the take-back and recycling will initially be transferred to the consumer, but can be minimized by design improvements and material choice, thus making the recyclability a competitive advantage. Policy makers can influence the market by granting a label to excellent environmental performers, again creating competitive advantage.

European Directives, such as the WEEE Directive or the Battery Directive are based on the above-mentioned principles. In the Directives, objectives are defined in the form of collection rates and recycling rates of the targeted waste streams. For example, PC's should have a recovery rate (including heat recovery) of 75% by weight, and re-use and recycling of components or materials of 65% by weight.

The open-pit mine for precious metals

Precious metals are being used for their beauty and nobility (jewellery), but more and more for their technical properties. Examples are excellent electric conductivity (electronics) and interesting catalytic properties (car catalysts, petrochemical catalysts). A catalyst promotes chemical reactions, so that a same result is realised with less energy usage. The development of catalytic processes, often with precious metals, helps creating more sustainable technologies.

Thanks to their limited reactivity, they are endlessly recyclable, without loss of mass or quality. Precious metals recovered from recycled waste streams have exactly the same properties as those originating from primary production (mining). There is one big difference though: recycling of precious metals uses 10 times less energy than the primary production ! In the context of sustainability, recycling of precious metals should be maximised. A reason for this favourable energy balance, is the relative richness of "ores" such as waste electronic scrap en spent catalyst compared with natural resources.

2. Hoboken's Makeover: 10 Years Of Innovation

Flow Sheet before 1997

Historically, the Hoboken plant has been specializing in the treatment of complex Pb-Cu concentrates. The old flow sheet is shown in figure 1. In the roasting step, a primary desulphurisation of the sulphidic concentrates is carried out. In the sinter plant, the concentrate is agglomerated to a mechanically strong porous sinter, ready to be fed in the Pb blast furnace. The sinter is then reduced to Pb bullion, speiss, matte and slag, all of which need further processing. The Lead Refinery produces pure Pb, Sb, Sn and Bi. The speiss containing Ni and As is purified in the Cu electro-winning plant. The slag is suited for disposal after treatment in the electric furnace. Finally, the matte is fed to a second blast furnace (the Cu blast furnace), producing a rich Cu matte. The blister from the Hoboken convertors is taken to the Cu-refinery (electrolysis), and the Cu-containing converter slag is recycled internally.

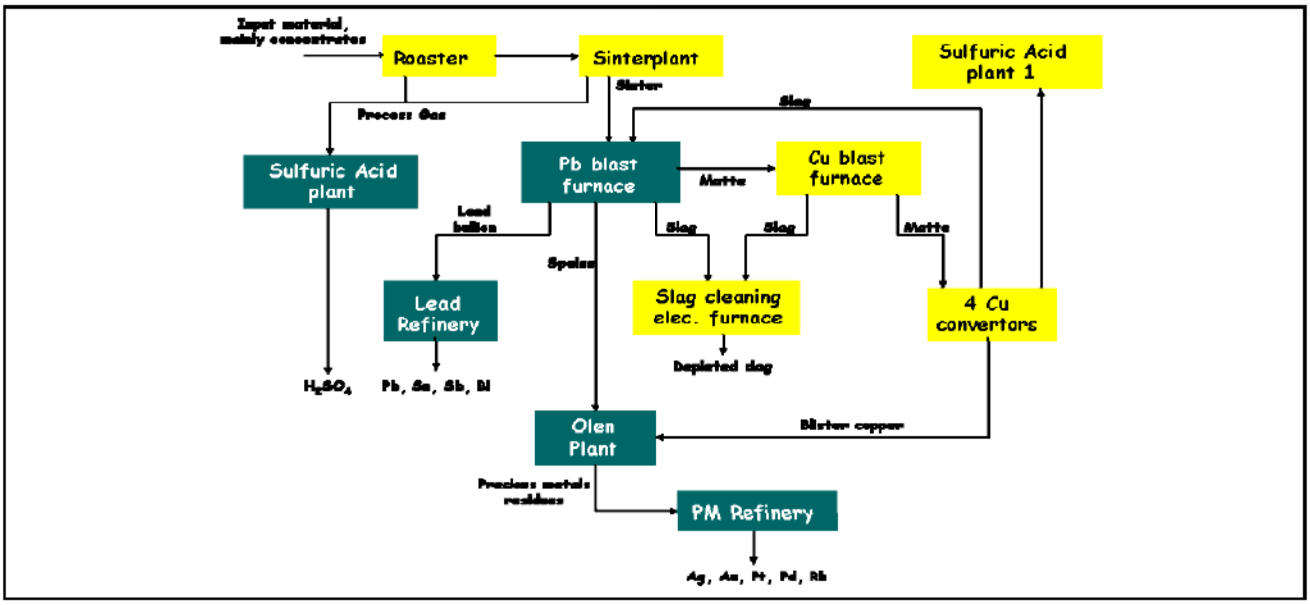


Figure 1: The Hoboken flow sheet until 1997 focused on complex PbCu concentrates

The Makeover

In 1995, the strategic decision was taken to innovate the processes in order to treat a more diversified feedstock. The core of this technological quantum leap was the new PbCu smelting process. This process uses submerged lance technology; fuel and enriched air are injected into the bath. A novel two-step batch process was developed in-house to separate the feed and form a Pb-rich slag and a Cu bullion. The Smelter is able to cope with all forms of feed material, be it wet or dry, fine or lumpy, making it perfectly suited for the processing of recycled materials from various sources, without extensive pre-processing of the feed. The closed vessel allows for good gas cleaning and optimal work floor hygiene. The Smelter replaced following installations: Roasting plant, Sinter plant, 1 of 2 Sulphuric Acid plants, Cu blast furnace and 4 Hoboken Converters. The result on the plant lay-out (and cleanliness) is spectacular:

Figure 2: Aerial view of the Hoboken plant (2003) after clean-up of old installations

In the same period 1995 - 1998, the precious metals (PM) refinery was revamped using in-house developed technologies and processes for flexible refining of all kinds of precious metals mixes. A completely new Leaching and Electro-winning (LEW) installation was commissioned in 2003, bringing this technology in-house and reducing throughput significantly. In the LEW, the Cu bullion is leached to produce Cu sulphate. The precious metals do not leach and are collected in the tank house slimes, which are subsequently treated in the PM refinery. The Cu sulphate is electrolytically deposited, resulting in 99.5% pure Cu cathodes.

The last breakthrough (until now) was realized in 2003-2004, through the integration of Precious Metals Group (PMG), the former Degussa Dmc², which specialized in precious-metals added value products. Integration of both operations offers a high added value output for UPMR, and a powerful recycling service to the former PMG and its customers.

Today's Flow Sheet

Today's flow sheet illustrates UPMR's integrated approach towards the recycling of precious metals: mastering complexity without giving up on flexibility.

The Smelter acts as an entrance gate to the flow sheet for most of the feed. Recycled materials, such as industrial by-products and consumer products, are processed and concentrated in 2 liquid phases: a Pb silicate slag and a Cu bullion. The aim is to collect precious metals (Ag, Au, PGM's) in a Cu bullion and impurities (As, Sb, Sn, Ni, Bi) in a Pb silicate slag. The feed is thus separated upfront in the flow sheet into a precious metals stream (Cu as collector) and a base metal stream (Pb and Ni as collectors).

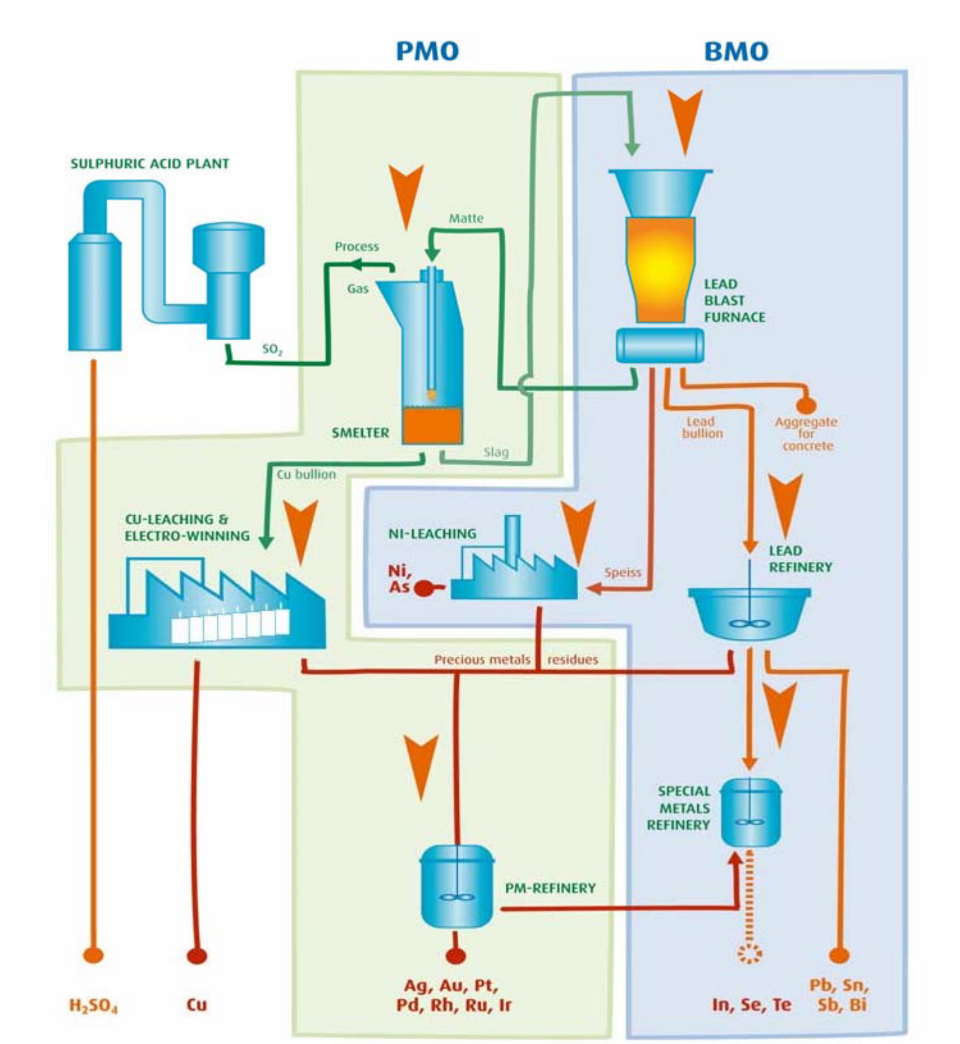


Figure 3: UPMR's flowsheet, highlighting the two major operational lines: Precious Metals Operations and Base Metals Operations

Consequently, the plant has been divided in two major operational lines: Precious Metals Operations (PMO) focuses on the rapid processing of precious-metals bearing product streams, from the feed to the pure metal. Base Metals Operations (BMO) flexibly processes the by-products of the PMO, taking care of the major impurities, while recovering the last part of the precious metals to realize an excellent overall precious metals yield.

The PMO stream is composed of Smelter, Leaching and Electro-winning (LEW) and PM refining. The Smelter uses a unique in-house developed two-step batch process to treat the complex feed-stock. In the first step, a Cu matte and Pb silicate slag are produced. The slag is fed to the blast furnace, while the matte remains in the Smelter and undergoes a converting step, producing a Cu bullion and a Cu oxide slag. The gas cleaning of the Smelter is state of the art. Halogens and Mercury are collected in the wet gas cleaning while SO2 is transformed to H2SO4 in the acid plant. The gas cleaning includes post combustion, heat recovery, fast adiabatic quenching, dust removal in a five field hot electrostatic precipitator, quenching, venturi washing, water condensation, wet electrostatic precipitation, star cooling, wet electrostatic precipitation and acid production in the acid plant. The acid plant has been adapted with extra heat exchangers to cope with changing off gas compositions encountered when operating in batch mode.

The Cu bullion from the Smelter is granulated and refined in the LEW. Pure Cu cathodes are produced, while the precious metals and impurities are collected in the tank house residues (slimes). These are subsequently processed in the PM refining, realizing the separation of Ag, Au, Pt, Pd, Rh, Ru and Ir.

The BMO stream is composed of Blast Furnace, Lead Refinery and Special Metals Refinery. The Pb silicate slag from the Smelter is reduced in the blast furnace to form a Pb bullion. The Blast Furnace slag is environmentally clean and sold as an aggregate for construction, for example in concrete applications. The Blast Furnace matte is returned to the Smelter, while the Blast Furnace speiss (an arsenic matte, the name “matte” being reserved for sulphur mattes) is leached. The precious metals containing leaching residue is treated in the PM refinery. The Pb bullion also contains precious metals. In the Lead Refinery, pure Pb is produced as well as sodium antimonate. A precious metals concentrate is sent to the PM refinery, whereas the special metals (In, Se, Te) are further refined in the special metals refinery.

3. Mastering Complexity

Complexity

Precious metals containing materials are an interesting recyclable, because they have a high value per tonne of recycled material . Unfortunately for the gold rushers looking for easy money, the first law of the Universe remains applicable: “No pain, no gain”. In industrial by-products as well as in consumer products, the precious metals tend to be associated with less attractive elements: As, Sb, Sn, Se, Te, In, Cd, Hg, Bi. Apart from causing health hazards if not dealt with properly, the separation of these impurities from the precious metals requires an appropriate flow sheet. Traditional non ferrous smelters and refiners consider these impurities as pollutants for their flow sheet, because they tend to build up and contaminate the valuable productions. UPMR being an integrated smelter, the abovementioned impurities are dealt with as part of the overall process. They are either converted into useful products (sodium antimonate, indium, selenium and tellurium) or disposed of in a safe and controlled way (arsenic, cadmium and mercury).

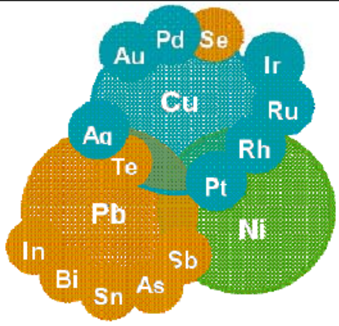
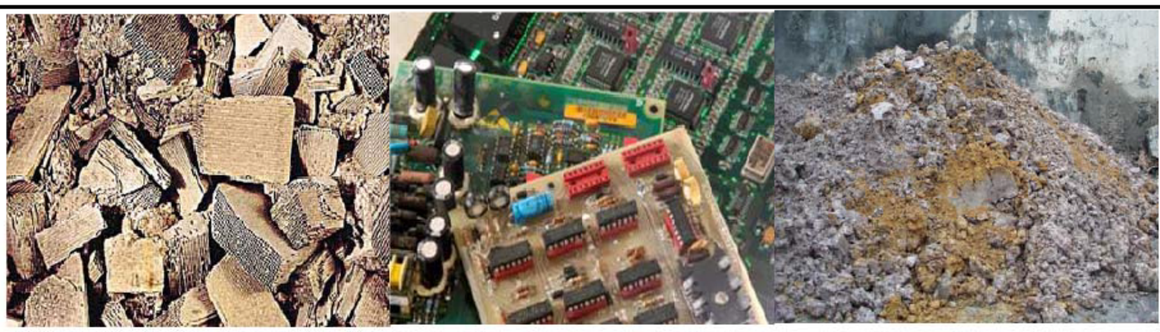


Figure 4: The complex mix of precious metals and impurities in a Pb-Cu-Ni flow sheet

The feed consists mainly of recycled materials, such as industrial by-products and consumer products. They show a great variability in analysis: per year, more than 5000 different lots enter the plant. The industrial by-products are (or should be) somewhat predictable, but the consumer products are more likely to be "catch of the day".

Apart from the analysis, the physical aspect can be just anything, dry lumps, slurries, plastic boards or dry powders. Some examples are shown in figure 5. Recycling processes, requiring an extensive pre-processing of the feedstock are vulnerable compared to flexible processes. The Smelter has the great advantage to enable treatment of all types of feed, ranging from 0 to 95% humidity. Plastics are used as a reducing agent and replace valuable reductants such as coke and fuel. The gas cleaning is designed to take care of the volatile impurities associated with the burning of plastics (VOC's, dioxins).



(a) (b) (c)

Figure 5: Some of the precious metals containing recyclables: (a) car catalysts, (b) electronic scrap and (c) zinc leaching residue

Conclusion: the mix of challenging chemical elements (Ni, Pb, As, Te, Sn, Cd), together with a large variance in analysis and physical aspect, make up the "complexity" a precious metals recycler has to deal with.

4. Ensuring reliability

UPMR is recognized as a world player, not only for the quality of its technologies and products, but also for the outstanding service level and business ethics. Sampling and commercial services are key success factors for sustainable precious metals recycling.

Sampling and Assaying

Sampling and assaying is of crucial importance for the recycling job. An accurate determination of the composition of the incoming materials is the basis for the refining agreement with the customer. Especially in our business, a reliable recycling partner is 'precious' ! Also, knowledge of the exact composition of the feed allows to tune the process and define the optimal processing route for every feed material.

The sampling facilities in Hoboken are state-of-the-art and able to treat all raw materials. Dedicated installations exist for e-scrap, automotive catalysts, fine free flowing, metallic, wet or lumpy materials. Customer-specific demands are satisfied by an "A la carte" approach, in which a sampling procedure is developed in close collaboration with the material supplier. Today, more than 150 different sampling procedures exist and are continuously improved, with regards to minimization of human intervention and shortening of lead times.

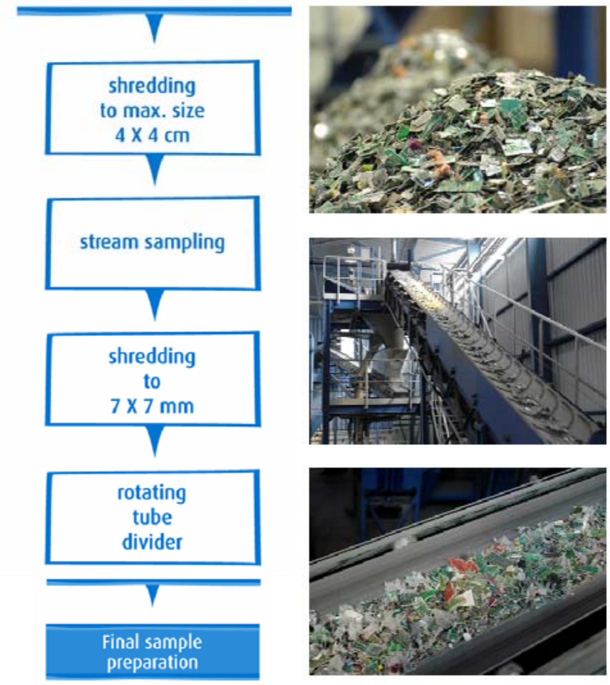


Figure 6: UPMR's dedicated sampling procedure for e-scrap

UPMR's analytical laboratory is internationally recognized in the field of precious metals and controls the assaying process. Many analytical techniques are available for precious metals and trace metals analysis as well as environmental analysis techniques (e.g. for dioxins).

Metals Management

UPMR offers a complete range of commercial and financing services for an optimal match with the customer. The logistic service provides for transport of raw materials and refined products, and assists the customer in taking care of the environmental and administrative regulations, as set out by the Basel Convention or the OECD (for Europe). On the commercial level, risk management solutions are offered. Other services such as leasing, swaps, VAT regulation or optimal metal valorisation can be tailored for every customer individually.

5. Business Sustainability

Being "able to sustain" the endless business of precious metals recycling requires a long-term vision, based on following core competencies: Master Complexity, Foster Flexibility and Ensure Reliability.

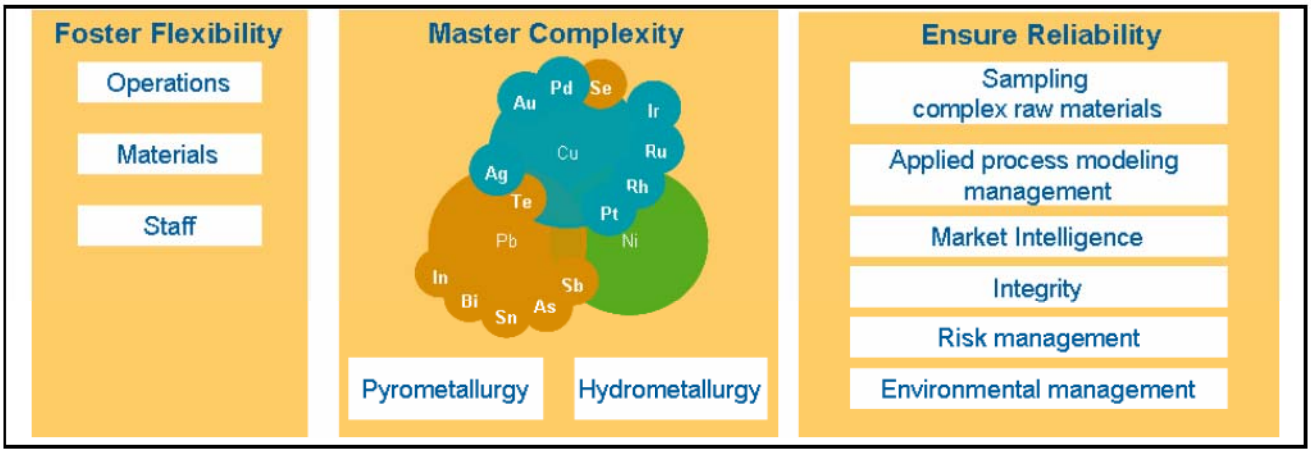


Figure 7: UPMR's core competencies