



Secondary Lead Smelting at the Beginning of the 21st Century

Dr. Andreas Siegmund

RSR Technologies, Inc.

2777 Stemmons Freeway, Suite 1800

Dallas, TX, USA, 75207

Abstract

Close to 85% of all products using lead metals are recyclable. One direct consequence is the continuously rising recycling rate of lead bearing scrap. In 1999, refined lead recovered from secondary materials totaled 2.9 million tonnes, equivalent to 47.2% of total production worldwide or 58.9% in the Western World. The majority of the secondary lead comes from spent lead-acid batteries with the remainder coming from other sources such as lead pipe and sheet. Most of the lead secondaries are recycled pyrometallurgically. During the last two decades, lead recycling experienced many technological innovations, mainly by the addition of physical separation and/or hydrometallurgical processing steps, resulting in a remarkable improvement in the utilization of the components contained in batteries. Additional advancements were motivated by the introduction of more stringent environmental legislation and health and safety regulations as well as economical considerations. Developments at commercial primary and secondary lead operations are described, covering these implemented modifications and innovations.



INTRODUCTION

Notwithstanding the significantly changing patterns in the market segments, the consumption of lead has steadily grown in most countries, regions and overall over the past three decades. Lead usage as gasoline additive as well as in paint, seals and solder has declined and virtually disappeared, while products like radiation shielding, sheet for roofing, compounds in the glass and plastics industries, insoluble anodes for metal electrowinning have survived and grown. The principal consumption for lead, however, with the strongest and still fastest growing share is for lead-acid batteries. They are used as starter batteries in vehicles, but also as industrial batteries in emergency systems, in computers, in fork-lift trucks and to a growing extent for telecommunication systems, uninterruptive power sources, remote access power systems (RAPS), hybrid and electric vehicles (1). The average end use pattern for lead over the last five years is illustrated in Figure 1.

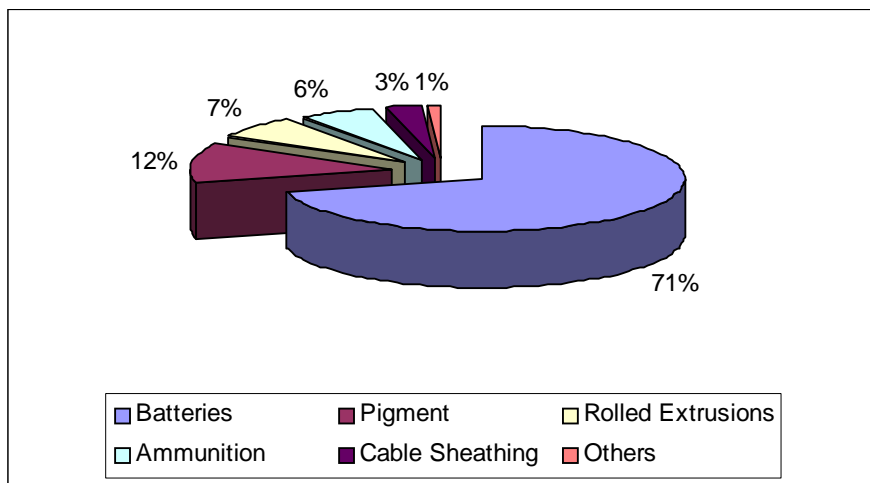


Figure 1 – End Uses for Lead over the Last Five Years (2)

Secondary lead smelting involves the recovery of metallic lead from lead bearing scrap material generated by industrial and consumer sources. Close to 85% of all products using lead metals are recyclable making lead one of the most recycled materials utilized today. In addition, there are a significant amount of lead containing secondary materials available from industrial processes and environmental clean-ups representing a potential raw material source. One direct consequence is the continuously rising recycling rate of lead bearing scrap. In 1999, refined lead recovered from secondary materials totaled 2.9 million tonnes, equivalent to 47.2% of total production worldwide or 58.9% in the Western World. The majority of the secondary lead however comes from spent lead-acid batteries with most of the remainder coming from other sources such as lead pipe and sheet.

While some secondary smelters are associated with battery manufacturers, as part of an integrated and closed production circuit, others are independently operated. These stand alone smelters are purchasing scrap and selling metal or converting metal for a customer on a toll basis. More and



more primary smelters also tend to treat secondary materials. In conjunction with environmental concerns, the decreasing net lead mine output during the last ten years, which resulted in difficulties in sourcing adequate supplies of concentrates and leading to temporarily high treatment charges, the use of secondary materials was intensively pursued (3).

SECONDARY LEAD SMELTING PROCESSES

Primary lead smelting predominantly relies upon the converting of concentrates from mining operations. During the last 10 years environmental concerns and decreased net lead mine output, which resulted in difficulties in sourcing adequate supplies of concentrates and led to temporarily high treatment charges, significantly increased the use of secondary materials in primary smelters. This is much more evident in industrialized countries where sufficient scrap material is available and efficient collecting systems for lead scrap are in place. In general, almost all new technologies like QSL, Kivcet and Ausmelt allow the treatment of a wider range of raw materials, including secondary feed. Despite this trend, the majority of the lead from recycled secondary materials is still produced pyrometallurgically in secondary smelters. Process configurations for secondary smelters vary greatly from plant to plant, region to region, country to country, and continent to continent. There are always site specific constraints, which affect the decisions of equipment, process and design configurations (4). In Europe, the configuration of a secondary lead smelter is typically a battery breaking plant in conjunction with a discontinuously operating short rotary furnace technology and a refinery. A few smelters apply blast furnace operation treating the entire, unbroken battery, while one smelter utilizes a lance type furnace. Several lance type furnaces have been placed into operation also in Australia and the Pacific Rim. The smelters in the US rather employ reverberatory furnaces coupled with either blast furnaces or electric furnaces on a continuous basis.

More than ten years ago a secondary lead smelter was producing lead and lead alloys, and controlling their emissions of flue dust, lead and SO₂. By-products were either being sold or discarded. Based on a US operation, a typical process flow sheet resembled figure 2 (4). During the last two decades, lead recycling experienced many technological innovations, mainly by the addition of physical separation and/or hydrometallurgical processing steps, resulting in a remarkable improvement in the utilization of the components contained in batteries. Additional advancements were motivated by the introduction of more stringent environmental legislation and health and safety regulations, the lead industry's recognition of its environmental responsibility as well as economical considerations. One of the current emphases is to eliminate or significantly reduce the generation of waste materials and by-products but converting them into valuable products. Today, efforts are being made to return by-products to the battery manufacture. Necessary modifications and expansions to the plant process flow sheet have been made at smelters to generate value-added products. Waste sulfur is recovered in a crystallizer as sodium sulfate crystals, or ammonia solutions are generated for sale. Polypropylene is washed and cleaned for extrusion purposes and subsequent



utilization of the granules in battery manufacturer's injection molding operations for battery cases and tops.

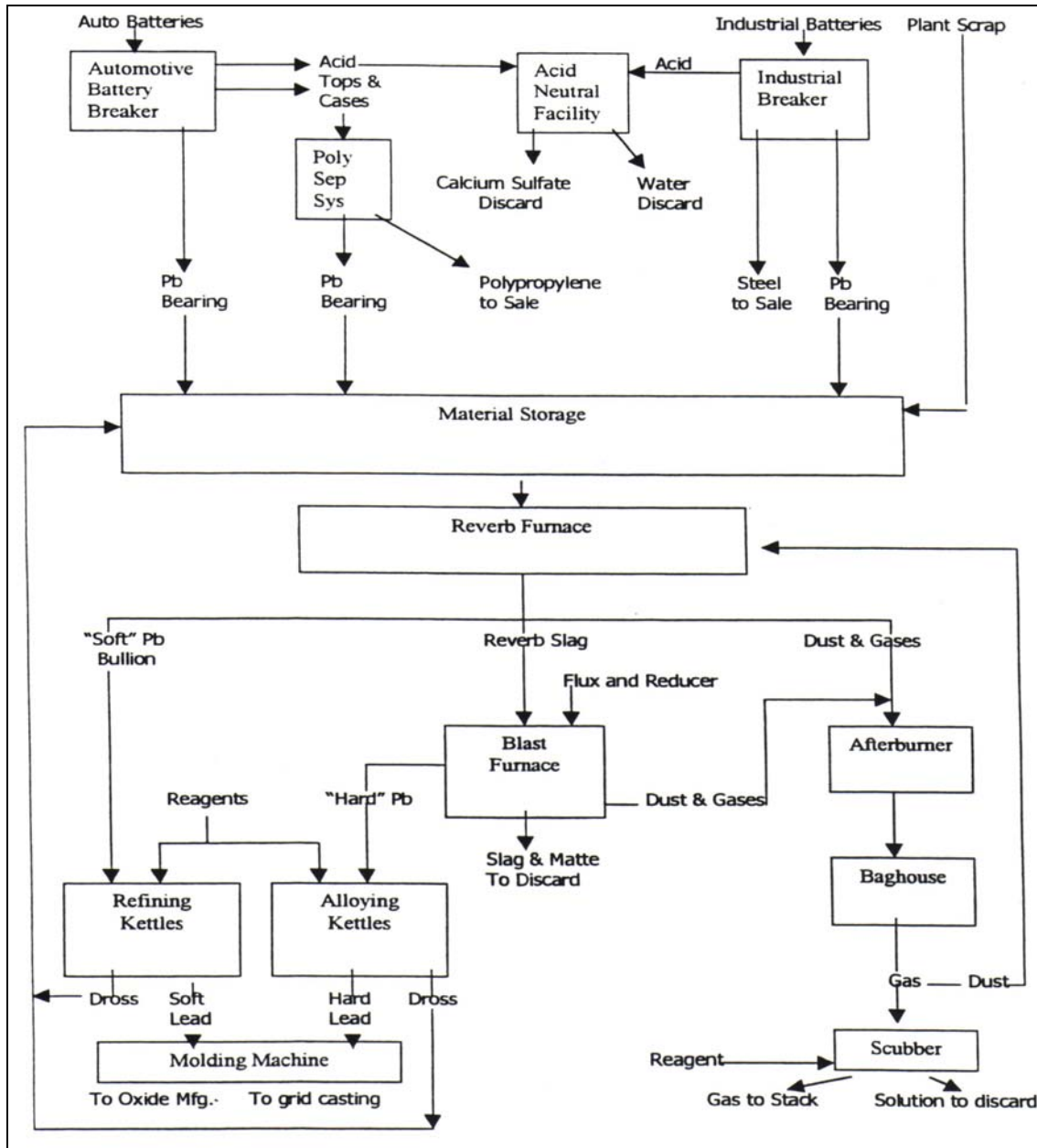


Figure 2 – Former Secondary Lead Smelter Flowsheet US-Operation

Further process additions are, for example, the affiliation of an incineration plant to a German secondary lead smelter incinerating the non-recyclable components of the scrap batteries obtained from the secondary smelter together with other combustible waste materials subject to monitoring recovering energy (5). Another German smelter produces high quality polypropylene compounds with



specific physical and mechanical properties, which is carried out by the accurate dosing of organic as well as inorganic additives (6). In the US, one smelter now purifies the sulfuric acid byproduct from battery breaking employing a solvent extraction process for reuse in new batteries (7). The only real waste product is still the slag from the final reduction furnace, which is generated in a non-hazardous form in most plants. The current process flow sheet of a modern US operation resembles more figure 3 (4).

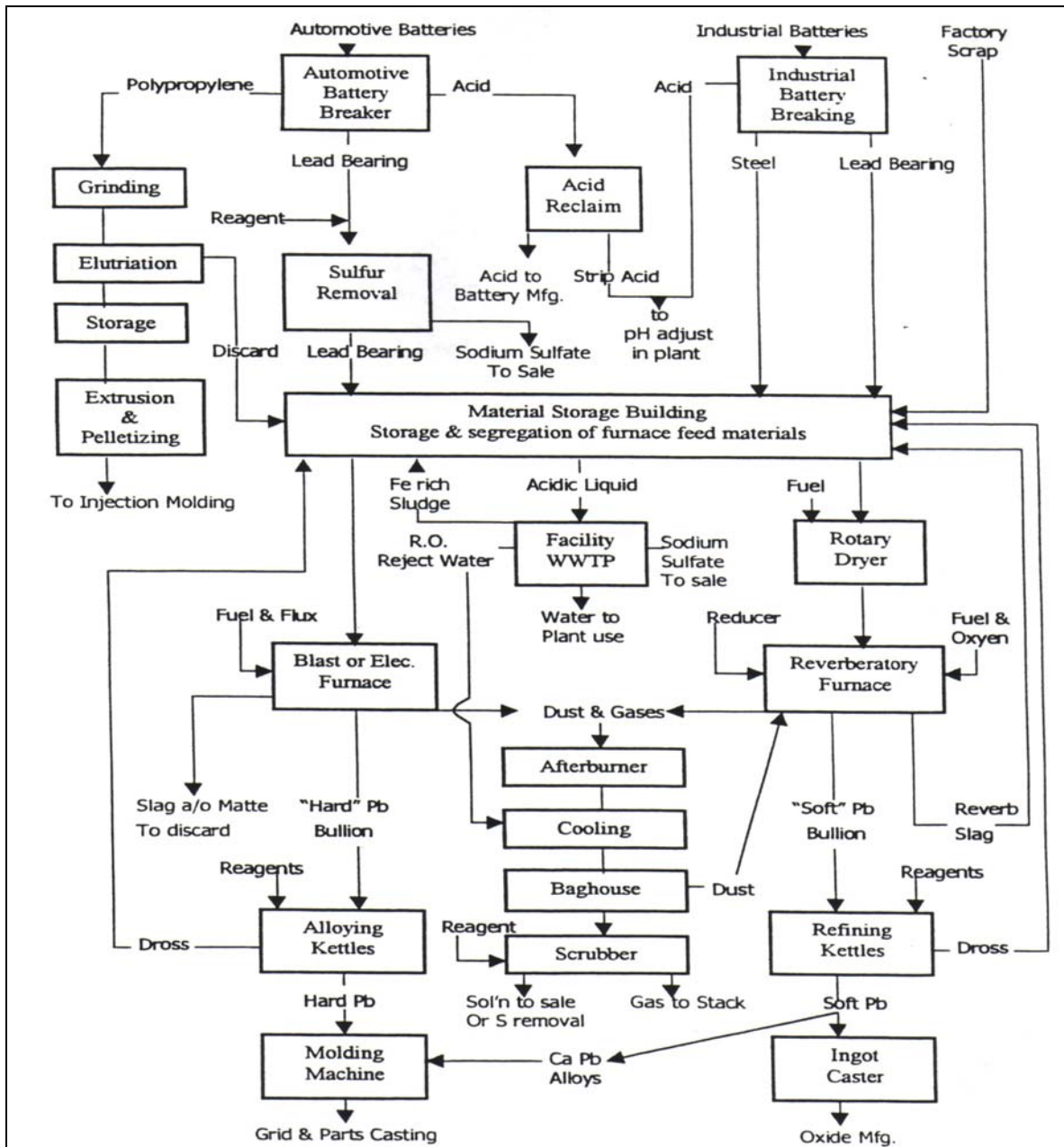


Figure 3 – Modern Secondary Lead Smelter Flowsheet US-Operation



Battery Breaking and Component Separation

Typically the primary material processed in a secondary lead smelter is the spent automotive lead-acid battery, which accounts for approximately 80-90% of the materials received from off-site. This percentage may change depending on supply. Exact specifications for components of an auto battery vary from manufacturer to manufacturer. A typical auto lead-acid battery may have the following average composition:

Metallic Pb (grids and poles)		25 %
Lead paste	PbSO ₄	50 - 60 %
	PbO ₂	15 - 35 %
	PbO	5 - 10 %
	Metallic lead	2 - 5 %
	Other	2 - 4 %
Polypropylene cases		5 %
Separators, hard rubbers, etc.		10 %
Sulphuric acid (about 15 %)		22 %

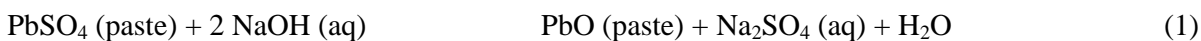
Table I – Typical contents of a lead-acid automotive battery (8)

Until the early 1970's, batteries were broken manually, which involved sawing off the battery tops and dumping the contents into the furnaces for processing purposes. Casing components were either processed in a separation system to recover lead products and polypropylene or discarded. During the eighties the industry started to replace the existing system by installing automated facilities consisting of breaking the batteries and subsequently physically separating the spent automobile battery into its component by efficient gravity units. Batteries are shipped to the plant in an environmentally safe manner in dump trucks or on pallets where they are unloaded and, if necessary, stored in an acid-proof warehouse. If acid recovery is desired, then the batteries must first be perforated or pre-crushed to allow the acid to be drained and collected. The batteries are re-claimed and loaded through a hopper system or straight from the pallets normally onto a conveyor that discharges them into a battery breaker, either a crusher with a tooth-studded drum or a swinging type hammer mill. Both types of breaker can be designed to process larger amount of battery scrap and can be automated. In the breaker the batteries are shredded into small pieces for a subsequent ergonomic separation into its components. Water is added to the breaker to flush the shredded material through the mill and to slurry the paste. Efficient separation and concentration of the sulfur-rich paste is accomplished by screening in a rotating drum or on a vibrating screen applying high-pressure water spray



nozzles. The paste suspension is then pumped into tanks for chemically removing the sulfur or straight to a filtering device (press or belt) to recover paste. The remaining battery components are separated employing gravity based hydro flotation separators. In these separators the metallic lead sinks countercurrently to a water flow into a screw conveyor for removal from the system. The casing materials is carried away with the water and passed into a sink-float tank where polypropylene is separated by gravity from polyethylene, ebonite, and other plastic materials (PVC, glass fabrics, etc.). The entire process results in four different intermediate products: 1) Lead paste for smelting, 2) Metallic lead for melting or smelting, 3) Polypropylene for recycling purposes, and 4) Lead contaminated plastic fraction which has to be disposed or, if permitted, can be charged to a furnace.

More recently several smelters have installed a leach circuit to chemically remove sulfur from the paste prior to the smelting process in order to overcome three disadvantageous objectives during smelting: 1) Reduction of SO₂ emission, 2) Reduction in matte generation, and 3) Minimizing the quantity of slag. In general, the sulfur removal can be achieved by using various reagents. The most common reagents however are either caustic or soda ash producing lead hydroxide and sodium sulfate (Equation 1) or lead carbonate and sodium sulfate (Equation 2), respectively.



Both reactions decrease the paste's sulfur content from about 6 – 7% to less than 1%. The process can be designed on a continuous or discontinuous basis. In both cases the pH is closely monitored for accurate addition of reagent because of detrimental effects of the furnace operation, if conditions are not strictly maintained. The reacted slurry is then sent to filter presses and the sodium sulfate solution to a crystallizer. Some facilities combine the liquid from their post baghouse scrubber with the liquid from the reaction. The scrubber solution however requires oxidation to assure that all the sulfites have been converted to sulfate prior to entering the crystallization process. The sodium sulfate solution is cleaned, crystallized and dehydrated for sale. Figure 4 illustrates a typical flow sheet of a battery breaking plant applying described process steps.

In an alternative procedure, the battery pieces are conveyed from the breaker to a density gradient sink-float vessel with a media specific gravity of 1.4 g/cm³. Plastic, hard rubber, and separators float and are conveyed to the plastic recovery system. Paste and grid material are moved by drag-chain conveyor and discharged onto a wedged-wire shake screen. Metallic material discharges into a screw conveyor and is transported to the raw material storage building. The paste slurry collected from the shake screen flows to a reactor tank for desulfurization as described above or straight to a filtering unit. The desulfurized paste is filtered through a dewatering press with the effluent pumped to the onsite wastewater treatment plant. Desulfurized paste is discharged into the raw material storage building. The plastic recovery system consists of a hammermill, primary and secondary



sinkfloat washers, and pneumatic transfer to trucks for shipment. Byproducts (hard rubber and separators) are conveyed to the raw material storage building.

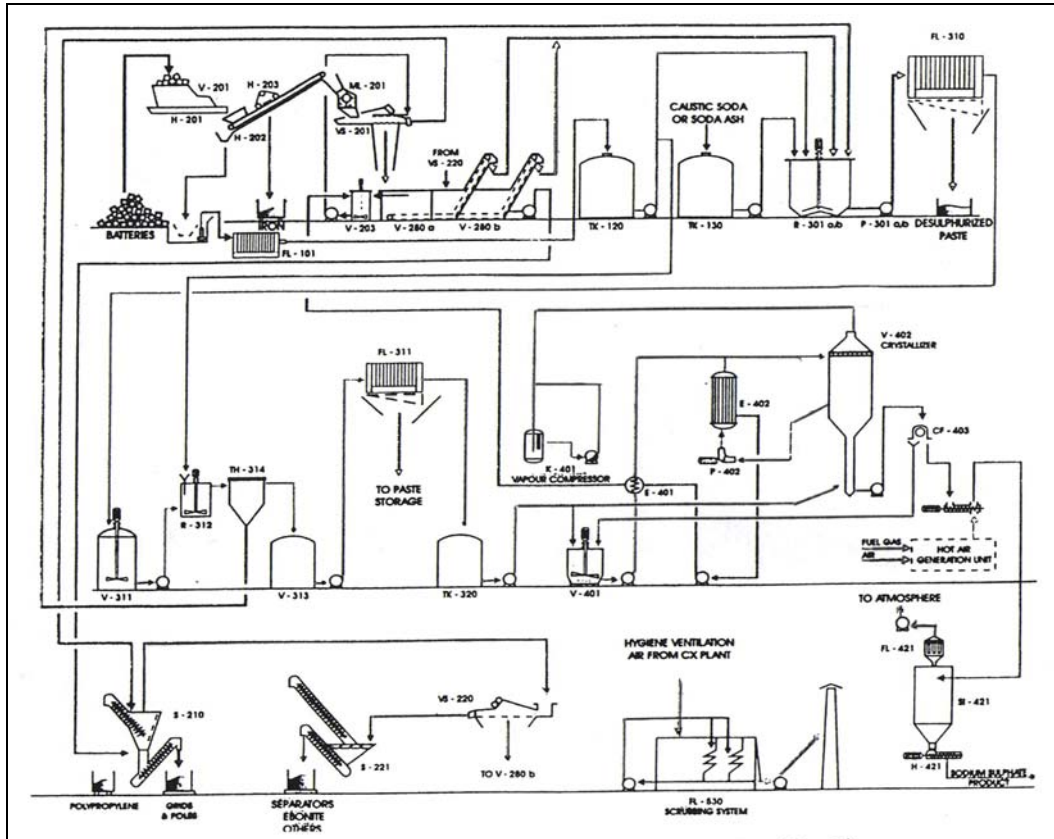


Figure 4 – Process Flow Sheet Battery Breaking Plant

Smelting of Battery Scrap Material

Ten years ago raw materials were stored uncovered, outside. Today, they are stored in an environmentally state-of-the art containment building, which serves as a ventilated concrete epoxy lined building to store waste materials related to the lead-acid battery recycling industry. These materials may include slag, paste and metallics from battery breaking, factory scrap and some raw materials that can be fed directly to the furnace together with the lead bearing material coming out of the Battery Wrecker. Many buildings are equipped with a leak-detection system and conform with all state and federal regulations. Coke products that are used as reducing agents and fluxes are also stored inside the containment building.

In the US, the predominantly applied smelting technology consists of a multi-step process consisting of a selective reduction smelting of the raw materials in a reverberatory furnace coupled with a



slag reduction in either a blast furnace or electric furnace. This combination allows producing low-antimony “soft” lead bullion from the reverb. The slag reduction unit treats the PbO-rich reverb slag as well as recycled dross from the refinery to concentrate the alloying elements (mainly Sb, Sn and As) in the “hard” lead bullion. This is used to generate various alloys required for different structural parts in the batteries. In this technology, the raw materials are typically mixed and passed through a drying system before being charged to the reverb. A typical charge consists of 85% wrecker material, 5% of mud coming from the desulfurization process and Wastewater Plant, 5% Refinery dross, and 5-10% Factory Scrap. In addition to these materials, all the plastic recovery system byproducts are fed in the mixture working as reducing agents and possessing some calorific value inside the furnace(8). The concept of utilization an electric furnace rather than a blast furnace is commercialized by one major secondary producer in the US. This allows to directly connecting both furnaces together providing an overall continuous operation. Higher slag temperature in the electric furnace permits also the production of an environmentally more stable slag and results in lower flux consumption, decreasing slag volume by about one-third. Recovery of lead, antimony, and particularly tin is therefore increased (9). Currently, two electric furnaces are in operation. The discard slag from both reduction furnaces is characterized by an iron-lime matrix and has to pass an eluation test in order to demonstrate a leachability of the RCRA metals below the permitted toxicity levels. Typically the slag is ground and combined with stabilization agents like cement or phosphates prior to landfill.

In Europe, the lead bullion is most prevalent produced in short rotary furnaces. They provide a high flexibility in handling feed materials but are batch type furnaces in contrast to the nature of other aggregates. The metallic lead grids, desulfurized or non-desulfurized lead paste, scrap metal and lead-rich residues (flue dust, slimes, dross) can be either together, separate or in each combination smelted at temperatures of about 1000⁰ C to deliver lead bullion. Depending on the selected charge composition, “soft” and “hard lead bullion can be produced or only one bullion tapped from the furnace. In the past almost exclusively a soda-based slag was generated in order to capture the remaining sulfur minimizing emission. With the tendency to produce more stable slags many secondary lead smelters have changed the slag composition to a soda containing slag with a silica matrix or completely to a fayalithic slag. Discard slag is typically disposed on a landfill. Recent investigations are focussing on stabilizing the slag to such an extent that it can be used as a construction material in combination with other materials avoiding high disposal costs.

Alternatively, long rotary furnaces can also be applied treating secondary feed material. One long rotary furnace, for example, operates in Canada. Some plants in Europe smelt the secondary lead material in a blast furnace without breaking the batteries in a breaker system. The batteries may be pre-chrushed with a front-end loader before being charged to the furnace mainly to drain the sulfuric electrolyte contained in the battery. Only one type of bullion is produced and the generated slag is primarily iron-silica-lime containing slag. Sulfur is captured as a matte

All of the furnace bullion is refined and alloyed pyrometallurgically in kettles with indirect heating by means of burners. Refining is done in selective treatments forming oxides or sulfides removing



undesired impurities accompanying the lead bullion. The resulting drosses are skimmed from the surface of the metal employing automated systems. The addition of required reagents is carried out either manually or with the assistance of automated systems. Alloying of lead is performed by controlled weight additions of alloying elements. All of the individual refining and alloying procedures are temperature controlled and typically the yields and the efficiencies are calculated and monitored. In general, finished metal is cast as 1 or 2 ton blocks or on a casting machine as 25 to 50 kg ingots depending on the assortment, batch and customer.

Since all secondary smelters are required to control their sulfur dioxide emissions, sulfur is either removed prior to smelting in a desulfurization step of the paste or by scrubbing sulfur dioxide from the off-gas or tying it up as a matte. There are smelters scrubbing with caustic and lime, combining the resulting solution with dilute acid from the raw material storage making gypsum, making gypsum and disposing it. Others are scrubbing with caustic and oxidizing the solution prior to making sodium sulfate crystals or handling it in the wastewater treatment facility. At one smelter sulfur dioxide is scrubbed with ammonia. After several purification steps the resulting anhydrous ammonia is sold as a raw material to the fertilizer industry. All smelters are well equipped with efficient fabric filter systems to minimize and control the dust and heavy metal emissions. In addition, many smelters have meanwhile implemented a complete hooding of the plant, which further minimizes emissions. Efficient filter systems, integrated dust cleaning and flue gas cleaning systems continuously remove both dust and lead emission levels in order to comply with the local environmental regulations on a permanent basis.

Recovery of Polypropylene

As battery manufacturers became more vertically integrated polypropylene became a valuable by-product for the smelters. They implemented compounding plants producing recycled polypropylene granules for their battery customers. The raw material for the production of polypropylene compounds is the shredded polypropylene fraction from the separation of the casings of lead-acid battery scrap in the battery breaking area. Before being transferred to the compounding plant the collected polypropylene chips actually undergo intensive preparation steps. In a milling unit they are washed to remove any remaining paste and dust, shredded to a smaller and more homogenous fraction in a knife mill, and dried to evaporate all remaining moisture. Based on the prevailing quality of the polypropylene fraction from the milling unit it can be either processed in a single or twin extruder to a product suitable for injection molding of new battery cases or upgraded to a highly valuable product by the application of specific refining procedures. One smelter in Germany concluded after a detailed economic and ecological analysis that the high valuable product route was the more suitable application of the two technically viable choices for their purposes (6). The overall process concept of the compounding plant is illustrated in figure 5. Main equipment of the plant is a twin screw extruder, a filter system, a granulator and a dryer. The clean polypropylene pieces and the additives are fed separately continuously to the twin screw extruder. The extruder is de-



signed in particular for the requirements of the polypropylene material and consists of several individual heated chambers to maintain desired extruding conditions. The charge mixture is melted under carefully controlled operating parameters and subsequently mixed with additional components according to predetermined specifications in order to obtain a homogenous melt.

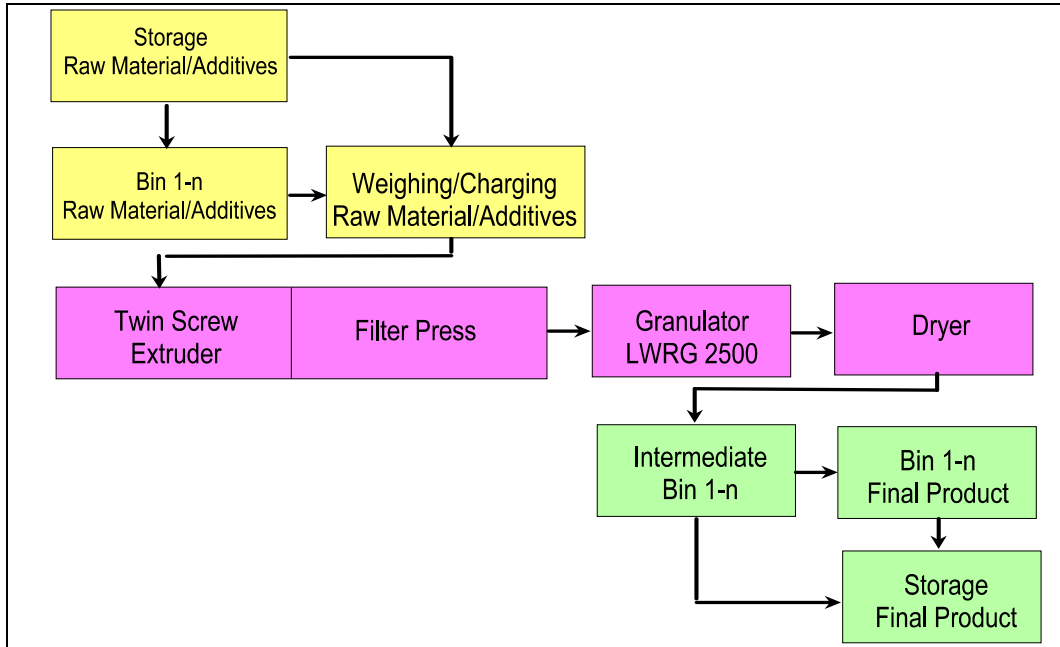


Figure 5 – Block Diagram Compounding Plant (6)

Today, the continued and permanent improvement of the refining process of recycled polymers results in an economic and environmentally complying solution producing high quality polypropylene compounds, which can be applied in many diversified industrial areas. The most dominant product group, however, consists of components for the car industry (85%). Popular applications in that area are fender liner, headlight and air suction filter casings, V-belt covers, cable covers, etc. But SECULENE PP materials are also used in the electronic industry as components for washing machines, dryers, vacuum cleaners and dishwashers.

Arising Problems with Elements in Lead Recycling

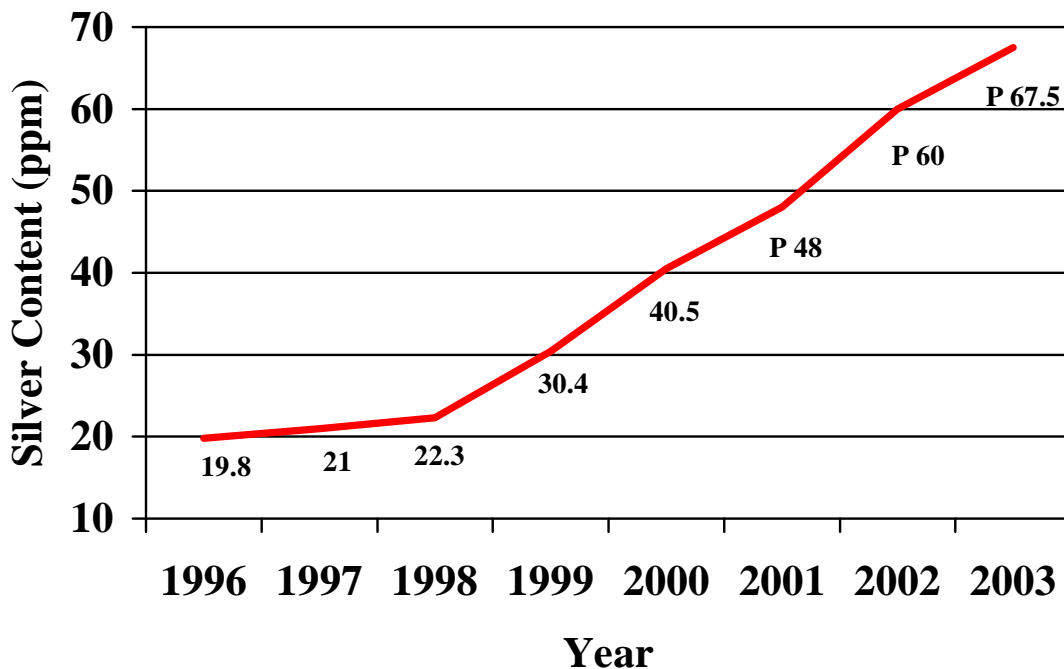
Batteries are designed for maximum performance. In order to meet the rising demands on the battery by automobile designers during the last decade, research has led to stronger and more corrosion resistant grid alloys and improved battery design and construction. In the past few years, for example, lead-calcium-based battery grid alloys have taken over from lead-antimony alloys in the automotive batteries for improved cranking performance, reduced water loss, improved recovery from deep discharge, and reduced corrosion at elevated temperatures (10). This development, unfortunately for the lead recycler, resulted in the introduction of some alloying elements, which have caused problems in the recycling loop of battery scrap. Moreover, other elements entering the sec-



ondary lead process need to be removed or should better be restricted from entering the system because of their effect as a contaminant or due to their safety concern.

Silver

In order to accomplish the current high performance requirements, silver was added to the lead-calcium-tin alloys for positive grids in amounts of 100-450 ppm. This not only reduced the rate of corrosion of the alloy but also prevented changes in the dimensions of the positive grid in creep (grid growth) during service at elevated temperatures. This addition was initiated in the US in 1995/96 with a steadily rising production quantity since then. With a battery service life of minimum 3 years, the first manufactured silver containing batteries started to enter the recycling stream in 1999. Silver enters the recycling process in positive grid alloys, in side terminal die cast alloys and as an impurity from recycled lead, oxide, negative grids, straps and posts and remains in the lead. However, silver is known to retard the oxidation of lead oxide. As an increased amount of silver containing batteries are recycled, they will elevate the silver level in the furnace bullion resulting in contents above a typical US-specification of 50 ppm silver in soft lead. In batteries with long life applications, lead for the production of oxide is even limited to 10 -15 ppm. Figure 6 illustrates the increase of silver in soft lead at observed during the past few years together with pre-



dicted silver content in the next years.

Figure 6 – Silver Content of Soft Lead from RSR Corp. Plant’s (11)



It can be easily seen that the silver content may exceed the battery company specification for pure lead but also for some Pb-Ca alloys from year 2002 on. Despite ongoing research work, there is no economical treatment available to remove low concentrations of silver from lead. Existing methods, which are capable to remove silver, are cost intensive and will result in higher cost. Alternatively, plants may have to start looking into sophisticated methods to segregate metallic lead and handling it separately. In Europe the situation is currently not as critical but higher silver levels in recycled lead will effect everybody in several years.

Nickel, Copper, and Tin

All three metals are subject to specification limits in lead raw materials for the battery industry but also used to a less or larger extent as alloying elements. Especially tin is added to improve the corrosion resistance and conductivity of Pb-Ca-Sn grid alloys, to increase its mechanical properties, and improving rechargeability and deep discharge performance of the battery (11). Besides being recycled with battery scrap, all of these metals can also enter the recycling stream through other sources such as furnace fluxes, as associated materials like battery cables or as contaminating products such as nickel-cadmium and nickel-iron batteries. If these materials are allowed to enter the lead scrap recycling stream in significant amounts, they do have an impact on the recycling efficiency of lead. During smelting nickel, copper and tin are predominantly reporting to the lead contaminating the furnace bullion. Most refineries spent a significant amount of time to remove copper and nickel below the specified concentration level. Tin recovery circuits have not been developed which recover tin pure enough to reuse in high tin containing alloys (4).

Cadmium and Selenium

Both of these elements present significant environmental concerns. In particular, selenium is added to battery alloys as a grain refiner to improve its performance. The toxicity characteristic level for selenium is currently 1 ppm. Selenium is chemically affiliated to sulfur and has similar chemical properties. This presents potential problems to producing non-hazardous products from scrubbing of furnace gases and to the disposal of slag and matte (4). Cadmium is volatilized upon entering especially a furnace and reports to the bagfilter system and is collected in the dust to be recycled. If the cadmium content rises to certain level smelters would be urged to remove the cadmium by existing leaching methods in order to minimize the exposure level of the operators.

Bismuth

Bismuth is normally present in lead at lower initial levels and is uneconomical to remove. Existing methods are time consuming, relatively labor intensive and highly costly. Even primary smelters with higher bismuth contents in the bullion than secondary smelters are trying to avoid the debismuthizing treatment whenever possible. Thus, secondary smelters will avoid taking any materials that contain significant amount of bismuth to prevent their build up in the recycling circuit.



Zinc

Zinc is used in the secondary lead industry in small amounts. In some plants zinc is used for silver removal. Others employ zinc-aluminum alloy for elemental removal, but in the presence of antimony and arsenic and water can generate arsine and stibine gases, which have potentially fatal affect (4). Above a certain tolerance level zinc evaporates from the furnaces and its fume condenses on the ductwork effectively to cause a negative impact on the ventilation system. In cases of elevated zinc concentration in the plant the zinc compounds are fed to the slag reduction furnace in small amounts.

Aluminum

Elemental aluminum and lead oxide react as an extremely violent thermal reaction. When elemental aluminum is being charged to the furnace severe explosions can occur with fatal results. Lead smelters are very caution and constantly checking for elemental aluminum because of its prevalence in materials and its devastating effects.

Chlorides and Fluorides

Chlorides and Fluorides are very problematic for the gas handling system. Acid formation from these elements in combination with sulfuric acid causes significant damage to ducts, bagfilters, fans and control mechanism, and blind most bagfilter bags. Smelters tend to avoid materials containing larger quantities.

Alternative Technologies for Secondary Lead Smelting

During the last two decades substantial research and pilot-scale testing has been carried out and some technologies are still under development.

Electrowinning

In total, at least three leach-electrowin processes have been tested on a pilot plant scale in the past (12, 13, 14). All three processes have a different approach but none of these technologies have been applied in a commercial operation until today. This can be attributed to constant technological and ecological improvements in the existing smelting processes and economical reasons. Today, Engitec is the only company actively pursuing to establish a commercial sized operation of an adapted version of the electrowinning process in combination with elemental sulfur recovery in a bioprocess (8). After breaking the battery scrap in a conventional breaker the paste is treated in a bio-sulphidization, which converts all lead containing salts and/or oxides in the paste into PbS by means of anaerobic bacteria. The precipitated PbS and metallic lead content in the paste is then



leached with the ferric fluoborate solution. Lead is dissolved and an elemental sulphur based residue is generated. The grids and poles fraction is leached separately but also with ferric fluoborate solution. This promotes the distinguished production of refined lead and antimony lead alloys. Subsequently lead is recovered from both solutions by electrolysis in a FLUBOR diaphragm divided cell to produce Pb cathodes in the cathodic compartment and to oxidise the ferrous ion to ferric ion in the anodic compartment regenerating the leaching solution. As described in the literature, the process seems to have certain advantages, but will require controls for the extremely aggressive acid, which is employed. This technology is currently tested in the research lab of THE DOE RUN COMPANY at Viburnum (MO) USA, treating primary lead sulphide concentrate with very promising results but has not been proved economical to date (8).

Plasma Technology

Several companies have developed technologies involving plasma arc furnaces that operate at very high temperature. These have the potential to treat scrap material with low levels of contaminants producing a discard non-hazardous slag. There have been two test furnaces built and operated but the economics has not been proven to be successful until today (4).

Conclusion

Secondary lead smelting involves the recovery of metallic lead from lead bearing scrap material generated by industrial and consumer sources. Close to 85% of all products using lead metals are recyclable making lead one of the most recycled materials utilized today. The majority of the lead from recycled secondary materials is still produced pyrometallurgically in secondary smelters. Presently, the combination of physical concentration, leaching and smelting appears to be the most economic and optimum process for battery scrap recycling. Process configurations for secondary smelters vary greatly from plant to plant, region to region, country to country, and continent to continent. There are always site specific constraints, which affect the decisions of equipment, process and design configurations. However, modern secondary lead smelters in the western world comply with the local environmental regulations on a permanent basis. They are motivated to reduce the generation of waste materials and by-products and converting them into valuable products. Efforts are being made to return by-products to the battery manufacture. Necessary modifications and expansions to the plant process flow sheet have been made at smelters to generate value-added products.



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