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Recycling of lead/acid batteries in a small plant

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Abstract

In this paper, the recycling process of lead/acid batteries in a small plant is described. The efficiency of such a recycling facility, as far as environmental regulations are concerned and its profitability considering the reasonable investment required, are demonstrated.

Keywords: Recycling; Lead/acid batteries; France; Costs

1. Introduction

In this paper a recycling facility which has a lead production capacity of 10 000 tons is illustrated. It corresponds to the recycling of 18 000 tons of undrained old batteries, that is to say 1 200 000 batteries. The manufacturing process — wastes and effluents of such a process — and economical aspects will be described.

2. Manufacturing process

The manufacturing process is made up by: breaking equipment; rotary furnace for smelting and reduction of lead materials, and kettles for alloy manufacturing and casting machine.

2.1. Breaking equipment

This equipment operates in two shifts; its productivity amounts to 5 tons/h. The mixture obtained is treated in a hydrodynamic classification system that separates the component parts, namely:

(i) lead materials: the metallic fraction (grids and poles), and the paste slurry that contains lead oxide and lead sulfate;

(ii) polypropylene from the cases;

(iii) residues (separators, ebonite, fibres, etc.), and

(iv) acid: the first fraction is free acid drained from batteries when discharging is collected, filtered and pumped to storage facilities, and the second fraction is dissolved in the breaker's process water. The process water is neutralized and reprocessed in the breaker.

2.2. Rotary furnace

The rotary furnace is designed to produce crude lead from the metallic fraction and the paste slurry. The rotary furnaces are the most suitable tools for recycling plants, with a production capacity between 10 000 and 30 000 tons.

This already, well-established technology can be simplified for a 10 000 ton production or it can incorporate automated materials-handling systems for a 30 000 ton capacity.

The main advantages of a rotary furnace are: (i) the working of the furnace can be interrupted without consequences; (ii) different types of materials can be used (drosses, flue dust, filter-press cakes), and (iii) it allows reduced emissions, and a lead content in the surrounding air conforming to the environment regulation to be achieved.

The B.J. Industries technology process gives careful attention to the extraction of the furnace's surrounding air and to the kettles.

The rotary furnace conceived is fitted out with a gas/oxygen burner which, among other functions, significantly reduces the gas process volume to be cleaned. Being a tilting furnace it can facilitate the pouring metal and slags into the ladles.

Before filtration through a bag filter, process gases are mixed with the surrounding air in order to decrease the gases' temperature to approximately 100 °C.

For a plant of 10 000 tons a furnace of a usable capacity of 3 m^3 will be installed.

For a plant of 30 000 tons two furnaces of 5 m^3 capacity (CEAc and Muldenhütten plants) have been installed. In such a plant the loading is a fully automatic, computer-controlled device.

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In the ladles, the slags are easily separated from the melted metal. After this operation, the still liquid crude metal is directly poured into the kettles for the refining process.

2.3. Refining

Traditional refining techniques are used to produce a range of alloys meeting the mechanical characteristics and the chemical composition required by the clients' specifications.

The liquid metal will be refined with the help of stirrers at specific temperatures. The kettles are equipped with integral hoods allowing the extraction of the fumes towards a filter. The refined metal is pumped towards a casting machine, producing ingots. The different treatments produce refining ashes which are recycled in the loads of the rotary furnace.

All the stages of the refining operation are continuously checked by a spectrophotometer.

3. Wastes

The wastes generated by the process are either re-used or eliminated.

3.1. Re-used wastes

(i) Polypropylene takes the form of lumps from 5 to 200 mm. The produced quantity represents 4 to 5% of the weight of broken batteries. The polypropylene waste is sold to the recycling industry.

(ii) Free acid, after settling, can be sent to a possible user.

3.2. Eliminated wastes

These wastes eliminated, in approved disposal places, are:

(i) breaking residues (separators, ebonite, rubber, fibres, etc.). The produced quantity represents 4 to 5% of the broken batteries, and their lead content is less than 1%.

(ii) rotary furnace's slags are alkali slags and classified as hazardous waste. They are a serious problem for European secondary lead smelters because the approved places for the disposal of hazardous waste materials in Europe become scarce and the cost of disposal is rapidly rising. However, slagfall in pyrometallurgical secondary lead processing cannot be avoided. The quantity of slags represents between 20 and 30% of the crude metal produced in the rotary furnace. Their lead content is less than 5%.

4. The effluents entering the natural environment

The effluents are liquid effluents and emissions of gases.

4.1. Liquid effluents

They are the waters coming from roofs and roads inside the plant area which have to be settled before being rejected into the natural environment. They should be conform to the major following standards: pH = 5.5–8.5; particles under suspension < 30 mg/l, and lead < 1 mg/l.

A simple setting of these waters in a collecting pool is in general sufficient to meet these standards.

Table 1
Investment for a recycling facility with an annual capacity of 10 000 tons

Buildings		
Batteries storage (m^2)	400	
Storage for metallics, paste and other (m^2)	300	
Breaker (m^2)	100	
Rotary furnace, kettles (m^2)	900	
Offices, maintenance workshop (m^2)	300	
Total m^2	2000	FF 4700000
Outside infrastructure, settling pool (m^2)	2000	FF 800000
Cost for buildings		FF 5500000
Equipment		
Breaker		
Rotary furnace (3 m^3)		
Filters		
Loading devices		
Kettles (50 t)		
Casting machine		
Tooling outfits		
Front loader, forklifts, cranes		
Cost for equipment		FF 23500000
Total costs		FF 29000000

4.2. Emissions

They are the process and cleaning gases of the furnace and of the kettles. These gases are evacuated into the atmosphere after being filtered.

The present major standard concerns the dust content < 5 mg/m^3. The existing available filters enable us without any difficulty to conform to these standards. At least 98% of the sulfur in the charge is captured with soda slags.

5. Economical aspects

After having described the process and the main working processes, the economical aspects are considered.

In Table 1 is reported a brief description of the investment in buildings and equipment and the costs on the basis of the present conditions in France.

Table 2 gives a description of the staff required for the running of such a plant.

Table 3 shows the working costs per ton of metal produced.

Considering the depreciation allowances and the financial costs, the total cost to produce one ton of metal from the

Table 2
Staff required for the running of a recycling plant

Department	Number of employees
Management/Administration	6
Maintenance	2
Production	18
Breaker	(4)
Rotary furnace	(10)
Refining	(4)
Total staff	26

Table 3
Specification of the operation costs, per ton of metal, in FF

Direct costs	460
Energy (gas, O_2, electric power)	
Fluxes and reductant products	
Slags deposite costs	
Fixed costs	650
Staff	(400)
Operating costs	(250)
Depreciation costs	480
Buildings (20 years)	(30)
Equipments (5 years)	(450)
Financial costs	160
Total	1750

recycling of batteries is FF 1750. This amount is an essential figure. It is entirely independent of the lead rates and of the cost price of old batteries.

One may observe that the operation of such a plant is well balanced in the present context of the European market. The London Metal Exchange for crude lead is presently around FF 3000 per ton, the cost price of old undrained batteries is around FF 500 per ton which leads to a price of around FF 1000 for one ton of recovered lead content.

Unfortunately the economics of recycling are not as favourable when the prices at the London Metal Exchange decrease.

6. Conclusions

The profitability of plants of such a capacity has been proven. There are different advantages to their development.

(i) Thanks to the compactness of the plant and, above all, to an efficient study of the materials flow, one can help the control of environmental problems (the lead content of the workshop's surrounding air, the right characteristic of the effluent water).

(ii) Such a plant has an annual consumption of about 1 200 000 batteries. This represents the quantity of old batteries produced in Europe in an area of average car density, which would be within a radius of 250 km. The fact of collecting old batteries on a rather small territory allows the costs of collection and transportation to be reduced considerably.

(iii) Basic regulations have made cross-border transfers of old batteries difficult, if not impossible. Thus some countries have the obligation to invest in the building of recycling facilities. With the B.J. Industries process the investment is financially possible and has already been implemented in Indonesia and Algeria.