

## Processing of wastes from lead/acid battery production

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### Abstract

Experience in the recovery of scrap and wastes from lead/acid battery production suggests that an electrothermal method has good prospects. This process is characterized by a high degree of lead and antimony (approx 98%) extraction, by effective gas cleaning and dust collection, and by full dust returning to the furnace. The electrothermal method is also distinguished by the high reliability of electric furnaces, the useability of any type of secondary lead battery scrap and wastes, and the possibility of process mechanization and control. In this paper, a description is given of the main technical and economical factors of soda-reduction smelting in an electric furnace, a technological scheme for wastes recovery, and the charge composition and features of the process.

### Introduction

In the production of lead/acid batteries, it is difficult to avoid lead losses in the form of foundry kettles dross, dust from mills and drying plants, electrode pastes, defective pasted/dried/formed plates, and lead-containing compounds in the purification works. Generally, such wastes are sold to battery-scrap processing plants. Taking into consideration the substantial difference in the cost of wastes and secondary lead or lead alloys produced from such wastes, however, it is sometimes economically feasible to conduct the processing on site at the battery plants.

Various methods are known for the processing of battery scrap or wastes, e.g., in shaft furnaces along with the raw materials or, separately, in reverberatory, short drum-type or electric furnaces. In addition, some firms use electrochemical reduction procedures.

Blast smelting has the advantages of being applicable to a wide range of burden types, processing high production efficiency, and guaranteeing continuity of the process. The method does, however, suffer from a number of limitations, the main being: a necessity to sinter small-sized waste fractions, excessive slag content, low degree of sulphur removal. These result in an increased yield of matte and sprue. By contrast, when using a reverberatory

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furnace small-sized wastes can be treated without the need for precursory agglomeration. Unfortunately, however, a considerable quantity of lead is sublimed during smelting and the lead content in the slag is rather high.

Processing wastes with a rotary short drum-type furnace is a more efficient and advanced smelting procedure than that employing a reverberatory furnace. This is because of the closer contact between the burden components and the higher furnace temperature. The limitations of the drum-type furnace are relatively low metals' extraction to alloy, low capacity, and high slag yield.

Technical and economical studies conducted in the Metallurgy and Beneficiation Institute, Kazakh Academy of Sciences (Alma-Ata) and in the All-Union Scientific Research Accumulator Institute (Leningrad) have demonstrated that smelting in electric furnaces is most promising. The electrothermal reduction of lead wastes is based upon oxidizing-reduction processes: the reduction of lead oxide-sulphate compounds by both solid carbon and products of its partial oxidation in the presence of sodium carbonate, as well as the reactive interaction of lead oxides and sulphates with lead and sodium sulphides. The basic chemical reactions taking place during this process are:



Since the wastes from lead/acid battery production contain little sulphur; the role of soda in the smelting process is mainly concerned with the formation of a slag melt. In the reducing medium, part of the lead sulphate is reduced to sulphide which is distributed between slag and lead. To extract lead from its sulphide, iron scrap is periodically introduced into the slag melt. This gives rise to the following reaction:



The processing of lead wastes involves the technological operations shown schematically in Fig. 1. The preparation of wastes for smelting includes grinding to a certain size and mechanized feed by means of screw conveyors, or blade transportation pipes, to the receiving bin of the furnace. The grinding mill, the conveyors, the electric furnace and the dust arrester are sealed. In addition, a low pressure is maintained inside the system to eliminate dust ejection.

The ground materials, in batches of given weight, are mixed with coke breeze, limestone, soda and other burden components in an appropriate weight relation (Table 1). After preparation of the burden and mixing of its components, the smelting begins. If the wastes include only pastes the

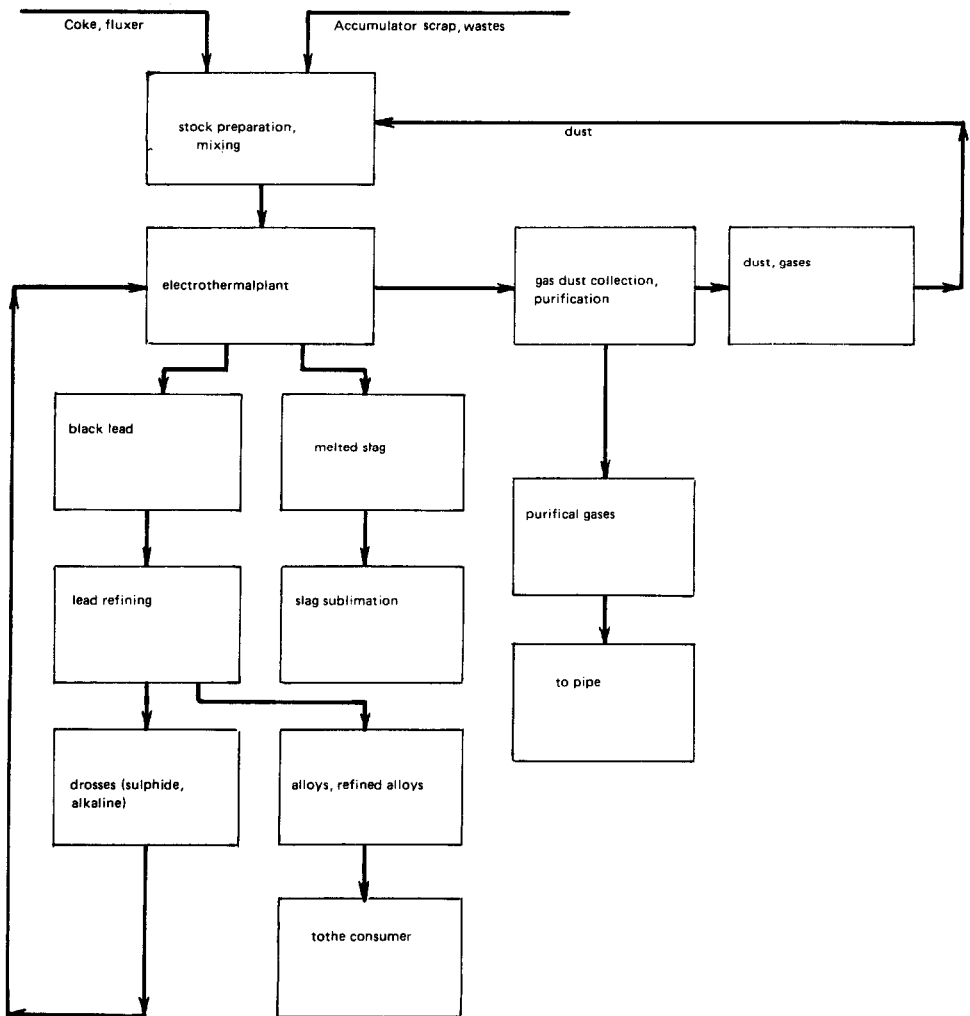


Fig. 1. Flow diagram for the electrothermal processing of lead/acid battery scrap and wastes.

latter are nodulized in drum nodulizers. Here, a certain quantity of binders is added.

Smelting of the battery waste is executed through direct burden heating by electric current, as well as by heating from organic carbon-containing fuel combustion. The electric furnace operates with a closed arch and, in a first approximation, represents a heating bath filled with immiscible slag-matte and metal layers.

During the burden smelting, liquid phases are produced and are vertically distributed in the bath in accordance with their specific gravity. The degree of phase separation depends upon the speed with which these phases

TABLE 1

Suggested burden composition

Wastes	100
Soda	3
Sand	1
Lime	0.5
Coke	5.0

are formed, the motion and separation of droplets, the speed of lead sulphate liquefaction from metal, and the speed of chemical transformations in the slag.

The electric smelting operates at  $1200 \pm 50$  °C (the temperature of the bath surface). The temperature difference between the slag surface and the lead at the hearth should be 500–600 °C. Such a difference provides good sedimentation of liquid immiscible phases. Thus, the location of tap-holes should be: 150–200 mm from the hearth for lead tapping and 550–650 mm for slag. This location of the tap-holes makes it possible to tap low-sulphide lead at temperatures of 650–700 °C and well-formed slag-matte at a temperature of  $1050 \pm 50$  °C.

The rough lead–antimony alloy and slag-matte melt are tapped periodically from the electric furnace as they accumulate. Further on, the lead alloy is fed to the kettle for rough refining. Here, copper is initially removed by a liquefaction method (rough de-copperization followed by refining by means of elementary sulphur). Next, removal of tin is effected by treatment with caustic soda.

For extraction of process gases from the furnace at the butt-end of the furnace, a secondary combustion space is installed through which the kiln gases and sublimation products are channelled to a gas-pipe system and bag filters. The hoses are made of 'Oxalon' synthetic fabric which is resistant to aggressive chloride media at temperatures up to 180 °C. In order to meet safety standards, the gases are directed into the bag filters with stream blowing (of the RFSP type). This guarantees a 99.95% degree of cleaning. The dust from the secondary combustion space, bins and bag filters is continuously removed and returned into the melt through the burden.

The electric smelting furnace (Fig. 2) has three electrodes. It is water-jacketted at the melt level and is under-pressurized. Electric power is supplied by a three-phase transformer. The nominal voltage is  $10\,000 \pm 10\%$  V in the three-phase current circuit and  $220 \pm 10\%$  V in the auxiliary circuits. The total nominal power is 1800 kW, 50–60 Hz.

Clean water is supplied for cooling the water-jackets and the electric holders. The water undergoes an additional cleaning stage in order to prevent the formation of scale. The latter would lessen the cooling of the furnace walls and hence result in over-heating and rapid wear/burn-out of the walls. The walls and the arch of the furnace are made from chromic-magnesite refractory bricks, while magnesite bricks are used for the hearth.

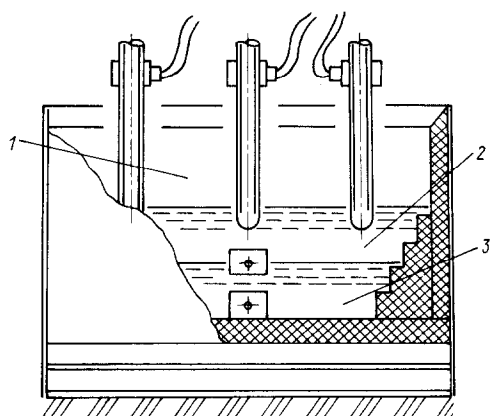


Fig. 2. Electric smelting furnace: 1, mixture; 2, slag; 3, lead.

Using the furnace instrumentation, it is possible to monitor: the load; the current strength; the high and low voltage of the furnace transformer; the temperature of the lead level, matte-slag bath and sub-arch space, the temperature in the secondary combustion space and before the bag filters.

The basic technical characteristics of soda-reduction smelting of lead wastes in electric furnaces are given in Table 2. The output of one electrothermal plant is 7000 to 10 000 t lead, annually.

Thus, the primary advantage of electric smelting lies in heat concentration and reaching the required high temperature in almost no time. In the case of electric smelting, there is no need to feed air for coke (fuel) burning which is the main reducing agent. Thus, only small quantities of gas are generated and dust ejection is low. In other words, heat and dust losses via gases are much reduced by comparison with blast smelting. In addition, the heat utilization, as well as the direct extraction of metal into a rough lead-antimony alloy is higher. The electric smelting makes it possible to save fluxes and leads to lower (by a factor of 2.5 to 3) slag yield. It does not require high coke consumption. Finally, the cost of processing lead wastes in electric furnaces is considerably less than that of blast smelting.

TABLE 2

Soda reduction smelting of lead wastes

Soda semi-product consumption (%)	5
Coke consumption (%)	3.5-4
Electrodes consumption per 1 t of lead (kg)	16-18
Electric power consumption per 1 t of lead (kW/h)	600
Degree of dust arresting (%)	99.5-99.8
Loss of lead with slag (%)	0.1-0.5
Yield of slag from burden (%)	10-16
Lead extraction (%)	97.5-98