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Research Article

Recycling of lead from spent batteries in the Trepça complex in Mitrovica, Kosovo

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Abstract:

In this paper, research has been done on the possibilities of recycling lead from secondary materials, with special emphasis from spent batteries and that through pyrometallurgical processes. The recycling of lead from spent batteries is different in different countries, for example. in America it is 85%, while in Germany, France, Italy it is about 90%, and Japan with 95%, but there are also companies that base their production mainly from secondary lead materials and from spent batteries, pipes, plates, rods, etc. Such a process is designed for the recycling of spent batteries in the former Mining and Metallurgical Combine "Trepça" in Mitrovica, where the production rate was about 15,000t/y, but the max. capacity. of production was up to 20,000 t/y spent batteries. The battery plant is in good condition, but the rotary furnace and connected off-gas treatment systems are not operating and the old refinery is in a poorer condition, so the design is done for all operations in the new refinery. Mass and heat balance was also done. For the purpose of defining the demands of the unit for the bag filter, in the rotary furnace. The work is reasonable not only from the economic aspect of the exploitation of useful metals, but also from the environmental aspect, due to the fact that the toxicity of such a material is even wider.

1. Introduction

The industrial development as well as the general socio-economic development, poses the need for the research of new possibilities for the processing of secondary lead materials, namely the regeneration of metals from these materials [1-3]. Such a study, for the recycling of spent batteries, was undertaken in the lead smelter in the Trepça complex in Mitrovica. In the past, the processing rate of spent batteries was about 15,000 t/y [2,4]. The economic evaluation for the possibility of processing over 20,000 t/y of spent batteries shows that the studies is sustainable [1-4]. So, the study is based on the processing of recycled batteries with the supply of spent batteries in the production of refined lead [2]. The growing demands for the reduction of gases released in the environment with the aim of protecting the environment, has imposed the need to reduce the production of cars that use liquid or gas fuel as fuel, thus enabling the production of cars that use electricity. While for the production of electricity today, modified methods are used, such as: photovoltaic, then geothermal, hydro, wind energy, biomass etc. In both cases, the equipment used for energy accumulation are storage equipment or accumulators, therefore based on these data in the following decades the market will develop even more and is welcome for the case study of the processing of 20,000 t of spent batteries in the year. Production efficiency is derived from industrial information and such production efficiency has not been achieved in the past and considerable training effort is required to improve overall efficiency through workforce productivity [2,5,6,7].

2. Material and Methods

The battery is taken from the factory area, where the acid is then removed during the emptying

operation by flowing down the sloping, acid-resistant floor to the collection point.
The batteries are loaded in the bunker and unloaded from it in the stainless steel area and then go through the crushing process. The obtained product then goes to the rotary dryer, where the heating of the dryer is done with gas, the dryer is equipped with an internal screen in the ignition. In the first stage of separation, the lead product is removed and then washed.
The combined material from the dryer through the size screen is fed through a conveyor to the first rotary separation drum. The pipe has two sections. In the first section, plastic and lead ebonite are separated and float in a liquid mass.
For the most effective removal of plastic and ebonite from metal pieces, the highest specific gravity is used. To obtain a more correct density, battery paste is used, while acid is used to obtain a more accurate pH. battery acid is used for adjustment along with purchased acid.
Plastic and ebonite pass from the first rotating drum to the second. The lead is conveyed with a raised screen to the second section of the first rotating drum, the lead is washed in the second section and then discharged from the rotating drum to the bunker tank, while the washing water returns to the discharge hole.
Plastic and ebonite are separated from the liquid mass in the first section of the second rotating drum in the bunker warehouse.
The liquid mass is returned to the warehouse for recycling of the first stage of separation. Plastic and ebonite pass to the second section where they are washed and then unloaded. The water from the wash returns to the first drain hole.
The washing water from the different stages of cleaning collects in the first of the three emptying holes. The pieces of paste attached to the washing water fall down progressively and settle at the bottom of the hole. The clay is periodically removed and combined with the paste before processing. Clean water is returned to the various washing stages during the separation stage.
The factory is equipped with a collector for collecting lead dust, which is drawn into the system. of the bag filter with an induced fan, the dust is collected in small buckets and transported by rolley to the paste collection bunker for further processing in the rotary furrnace

3. Results and Discussions

3.1 Rotary furnace

The processing plant and related equipment with two rotary furrnace in the new refinery building will be rehabilitated in order to enable separate processing of battery metallurgy and paste products.
The metal and paste product are lifted with an electric overhead motion (EOT) neck and discharged into separate storage buckets. Flues are also picked up and transported to the warehouse of individual buckets.
The factory also has a mixing control system for the preparation of independent metallurgy and paste fillings for both rotary furnace.
After the process of filling the furnace, the process of heating it begins with fuel oil (heavy fuel oil) and the temperature necessary for melting the material is reached, which is around 950^{o}C, where these chemical reactions take place:

$2PbSO_4+C+4NaOH\rightarrow$
$2Pb+2Na_2SO_4+CO_2+2H_2O$
$3PbSO_4+6C\rightarrow 3PbS+6CO_2$
$2PbS+C+4NaOH\rightarrow 2Pb+2Na_2S+CO_2+2H_2O$
$PbS+Fe\rightarrow Pb+FeS$

Reduction of lead oxide and reactions to lead
$2PbO+C\rightarrow 2Pb+CO_2$
$PbO+Fe\rightarrow Pb+FeO$
$8CH_2CHCl+20O_2+4PbO\rightarrow$
$16CO_2+12H_2O+4PbCl_2$
$4CH_2CHCl+5O_2\rightarrow (CH_2CH_2)2O+4CO_2+4HCl$
$4HCl+2PbO\rightarrow 2PbCl_2+2H_2O$
$(CH_2CH_2)_2O+5O_2\rightarrow 4CO_2+4H_2O$

The role of caustic soda results in the formation of a sulfur mixture that contributes to the composition of molten metal waste. Iron reduces the sulfides formed in the bath and plays the role of reducing agent.
Coke plays the role of a reducer, while silicon affects the lowering of the melting point.
Component PVC $(CH_2CHCl)x$, where x-represents the number of plastic molecules separated into dioxin $(CH_2CH_2)_2O$ and reacts with lead oxide to form lead chloride.
When the smoke passes through the fuel oil (hfo) area of the ignition process, the toxic organic compounds are separated by the presence of oxygen.
Polypropylene is a component of the general plastic filling. The structure of polypropylene is ($H_3CCH : CH_2$)X, where x-is no. Of connected molecules.
In the rotary furnace, polyethylene will react as follows:
$2H_3CCH : CH_2 + 9\ O_2 = 6CO_2 + 6H_2O$ -920 kcals/sign of each ethylene molecule
The reaction will result in the release of heat energy that would actually contribute to the reduction of fuel oil consumption. Molten metal waste and metal leave the rotary furnace in blocks and jars,

respectively, the metal molds are transferred to the refinery and the metal waste is removed from the jars and transported to the waste container. Another cover is provided for the collection of smoke released during the process of exiting the waste of mixtures and metals. The gasless oven is combined with smoke from the filling and exiting covers and passes through the induction fans in front of the bag filter section. The gas temperature is reduced by means of a trombonist gas/air heat exchanger.

The goal is to reduce the gas temperature below 175°C, in order to protect the material of the filter fabric. The off gas passes through the bag filter section of the main induced fan and the collected mass. The dust collected in the bag filter unit is recycled in the rotating furnaces. It is transported with a molded carrier to the collection machine and returned to the bunker and warehouse, the warehouse buckets [8]

3.2 Refinement and Formation

Molds for modeling metals in rotary kilns are transported to the area of the old refinery in 260 t cups. The refining process is relatively simple, since the only element that must be removed from the metal is antimony, arsenic and tin. These metals are used in different degrees of alloy in the preparation of the battery. The molds are placed in cups and melted. The source of heat is fuel oil, which burns tangentially around the base of the cup. The cup is positioned on a bent support, which will enable expansion during heating and the refining process. When the metal softens, the cup stirrer is positioned inside the bath and the shaking begins. The stirer leaves of cup and the waste is removed by hand. The proportion of the metal is tested and if it is in the specified quality of the required metal, it is transformed into the mold for forming (modeling). Lead can also be mixed with added arsenic, antimony and tin to produce metal alloys that meet specified requirements for alternative industrial applications. The molten lead is pumped from the molding cup to the automatic molding wheel and the strip molding machine. The molds are removed, measured, rolled and stored before distribution [9].

3.3 Mass and Heat Balance

The mass balance is taken for all processes. The heat balance is undertaken specifically for rotary furnace operations.

3.4 Battery Factory

The balance for the battery recycling factory in the Trepça complex has given both the mass and heat balance.The information is a reflection of Zveçan's operation. However, the main difference is that the factory efficiency assumption can be improved to ensure that the amount of plastic material passing through the metallurgical products is reduced to a minimum.

The contents of the battery, especially the distribution of plastic, PVC, ebonite and bakelite, may be different from the composition used in normal European operations. This happened due to the change in battery technology used in Europe and the high frequency of recycling.

4. Conclusions

The study of the process of recycling lead from secondary materials in the Trepça complex, with special emphasis on the battery factory, was made on the basis of economic evaluation and can be presented through the following conclusions:

The battery factory is in a good condition, but the old refinery is in a poorer condition, therefore the study was done for all operations in the new refinery, with the aim of eliminating process defects in the old refinery.

The design for the recycling of spent batteries in the former Mining and Metallurgical complex "Trepça" in Mitrovica, was with a production rate of about 15,000t/y, but taking into account the economic evaluation, a study was made for the maximum capacity. of production up to 20,000 t/y spent batteries.,

Also, the study of the spent battery has assumed that the operation will be in accordance with the standards of the European community for the production of lead, this is in correlation with the working conditions and emissions in the environment.

With this work, it is foreseen that in the future the pollution of the environment from the number of spent batteries, which are in warehouses or other spaces, not intended for this purpose, will be eliminated.

The demands of the European community for the reduction of gases from cars as well as alternative methods of obtaining energy have imposed the need for more storage devices-batteries that ie. that this is in correlation with the increase in the number of spent batteries.

An important factor for achieving the required levels of environmental protection will be the removal of polyvinyl (PVC), through its capture in bag filters.

The study only calculated the presence of polyvinyl chloride as a plastic material, in order to estimate the maximum impact of harmful plastic.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
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References

[1]Boliden (2016):Metal for modern life htpp://www boliden.com/Documents/Press/Publikations/Metals %20 for%20modern %20life/337-6514 %20Metals %20for %20 modern% life%202016_EN.pdf:32
[2]Linden, D. and Reddy, T. B. (ed.), Handbook of batteries, 3rd edition, McGraw-Hill, New York, 2002.
[3]Institute of Pb-Zn in the Trepca complex in Mitrovica, Kosovo.1990.
[4]Fisher K. (2006). Battery waste management life cycle assessment, Environmental resources management, (www.epbaeurope.net).
[5]Battery recycling in Canada, Environment Canada, 2009 (www.ec.gc.ca).
[6]IBellin:L'automobile recycle. La recherché, Paris,1993
[7]Battery recycling (www.wyre.gov.uk).
[8]Treatment of batteries within the Basel convention, 2009 (www.nema.org).
[9]Dillon C., The ecological impact of batteries, 1994 (http://repository.cmu.edu/ece)