RECYCLING OF LEAD-ACID BATTERIES AND SLAG UTILIZATION: AN INDIAN CASE STUDY

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Abstract

The secondary lead industry has a vital role to play in order to meet the growing demand for lead. This has been prompted by a significant extent by the burgeoning production of automobiles, wherein lead-acid batteries are primarily used, due to technical superiority apart from cost economics. The chief source of secondary lead being scrap battery the necessity for their recycling becomes inevitable.

In the present study the lead distribution in the slag and metal phases has been evaluated during secondary lead refining. Typical applications of the slag produced as well as possible remedial measures for waste management have been highlighted.

Introduction

Lead is a toxic metal. Despite efforts to limit the usage of the metal the demand for lead is globally increasing. This is mainly due to the increasing vehicle population and the usage of the lead-acid battery. Spent batteries can either be treated as hazardous waste or preferably be recycled in a secondary smelter. The procedure of recycling the spent batteries has several advantages. Apart from being an economically profitable process it limits the usage of primary lead. From, an environmental point of view the recycling also ensures that spent batteries are not thrown away and pollute basic resources as groundwater and soil. 80% of the lead in lead-acid batteries are recyclable. The lead in the batteries is in the form of lead-oxide. Reduction is therefore needed and the recycling is a smelting process. Despite environmental advantages the secondary lead industry itself produces lead-containing slag. The lead level as well as volume of slag can be reduced through improved means of production. The present study investigates the partitioning of lead between the metal and slag in one of the secondary lead smelting industries in India as well as the slag characteristics for its disposal, further recycling or use

Smelting

In the industries studied the smelting is carried out in two rotary furnaces and refined in the 4 pit refinery pots. Analyses have been carried out of the raw- material as well as produced metal and slag.

The scrap material used for production is domestically produced and mainly collected from local battery and scrap dealers. During the period when the study was carried out, three categories of scrap were used, battery plates, lead-oxide powder and dross.

Analyses of the materials show that the lead content in the three types of scrap material varied between 70 –80%.

The battery plates consisted of a solid frame portion filled with a powder. The lead was identified to be PbO_2 as well as pure Pb. It also contains iron hydroxide. Minor amounts of carbonate as well as silica are also present. The frame portion predominantly consisted of medium to coarse lead grains.

Production operations

The smelting furnace is of the rotary type. They consist of cylindrical furnace bodies, mounted horizontally, lined with refractory and are rotated during operation. Firing is done in one end, with oil burners. Approximately 2000 kg of scrap along with 50 kg of soda-ash and 75 kg of charcoal is loaded into the furnaces for each batch. The coal is added as a reducing agent and soda-ash as a fluxing agent. Initially the furnace is kept stationary and after some time varying between 1h and 2.5 h, the furnace is rotated with a speed of 1 rpm. The operation follows a schedule of rotation based on experience and type of charge. Tapping of lead is done into boxes that can contain up to 1000 kg of lead. Slag is separated due to differences in gravity as well as viscosity. Rotary furnace slag is crushed, and put in plastic bags and stored outside the factory.

Rotary furnace smelting

For the present study the rotary furnace production was followed and samples taken of the production. Table 1 shows collected data for 15 heats.

Measured	Unit	Minimum	Maximum
Total treatment time	h	2.33	4
Time of rotation	h	0.5	2.9
Tapping temperature	°C	475	550
Lead in slag	%Pb	0.5	44
Lead in metal	%Pb	97.98	99.96
Weight slag	kg	10	250
Weight metal	kg	1480	1800

Table 1 Variation of measured data

The Pb content was at a maximum rate of 44 % but generally the lead content was below 5 %. A lower and smaller range of lead in the slag would simplify the use of the slag for other applications as well as increase the recycling rate.

Figure 1 shows the variation of lead in the slag as a function of rotating as well as total operating time. Tapping temperature is marked for the batches where it was possible to collect data.

In general increase of rotating as well as total operation time increases the Pb content in the slag. According to these results increase in temperature do not effect the lead content in the slag. The % Pb in slag was not related to type of scrap as well. The same operating time and the same types of scrap material still shows a difference of 40% in the Pb content of slag. Further study is therefore needed in order to find measures of how to obtain an even low lead content in the slag.

The chemical analysis of the slag produced at the studied industry varies on a batch to batch basis. Chemical analysis of low and high Pb content slag is shown in table 2.

Parameter	Low Pb (wt%)	High Pb (wt%)
Pb	0.9	41.5
SiO_2	0.2	2.8
Fe_2O_3	0.02	1.8
CaO	0.7	3.0
S	19.2	13.5
Na_2O	19.8	9.2

Table 2 Chemical analysis of Rotary furnace slag from the studied Indian industry.

Lead is present in a complex form X-ray difractogram did not indicate the presence of oxide, sulphide and silicate compounds of lead. Sb and Sn could not be analysed. The level of S is high in both slag samples. Possible sources are the fuel used for burners and used scrap material.

The slag with a high lead content can be recycled economically. Thereby one could avoid high lead containing slag for landfill. In the studied plant, the lead content is estimated by weight and the heavier pieces are occasionally recycled. After recycling, slag is transferred for landfill.

Further usage

Further use of the slag is limited by the leachability of the slag. In order to estimate the risk of leaching, an experiment was carried out. From a slag sample containing 41% Pb 10 g were put in beakers containing 100 ml of water and kept just at the boiling point for 2-8 hours. The same procedure was carried out in both tap water (pH 7.9) and distillated water (pH 6.5). Figure 2 shows the results of the experiment.

The highest lead level,14 ppm, was reached after 8 hours in tap water. From the result one can conclude that the risk of lead leaching at unaccepted levels is very low. Philips also found that lead present in the slag is insoluble. He suggested that the slag could be used in cement and concrete production.

Conclusions

The following conclusions concerning the produced slag at the studied secondary lead smelter can be drawn. The lead-level in the slag is generally less than 5 % and is present in a complex form. This lead is not soluble. Therefore disposal, use in cement or concrete should not be hazardous.

References

1 M.J Philips, S.S Lim, Secondary lead production in Malaysia, Journal of power sources 73 ,1998,

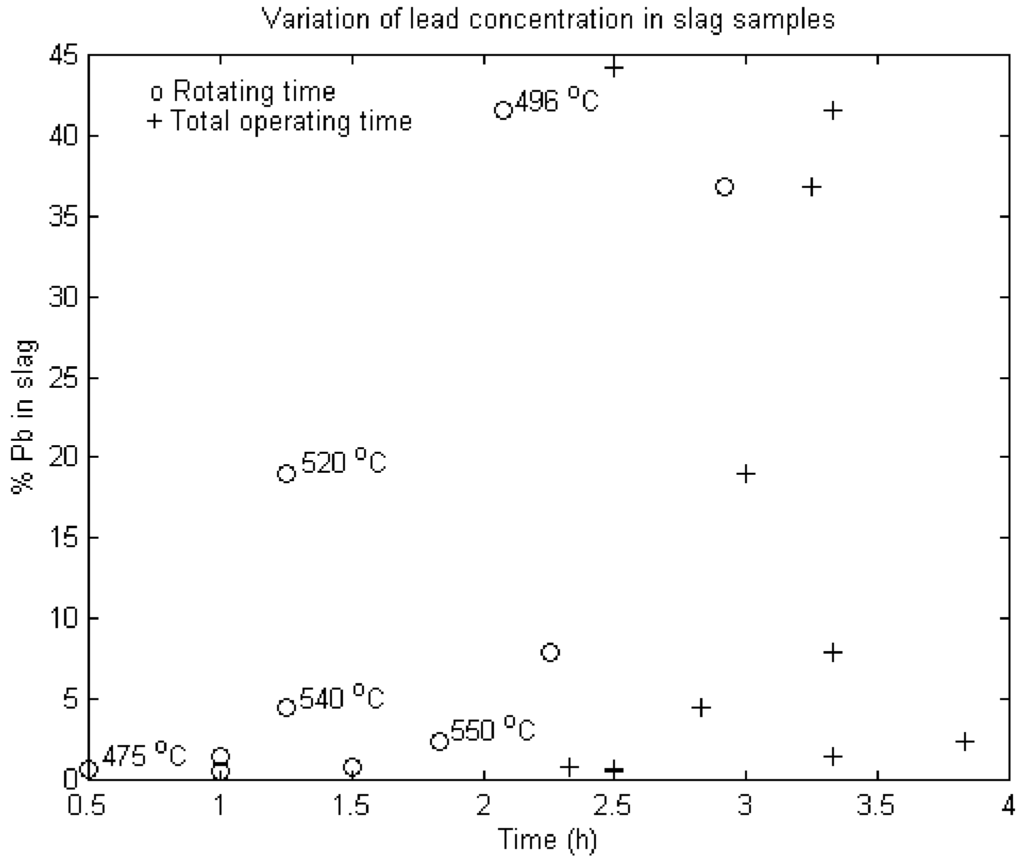

Figure 1 Variation of %Pb in slag with time

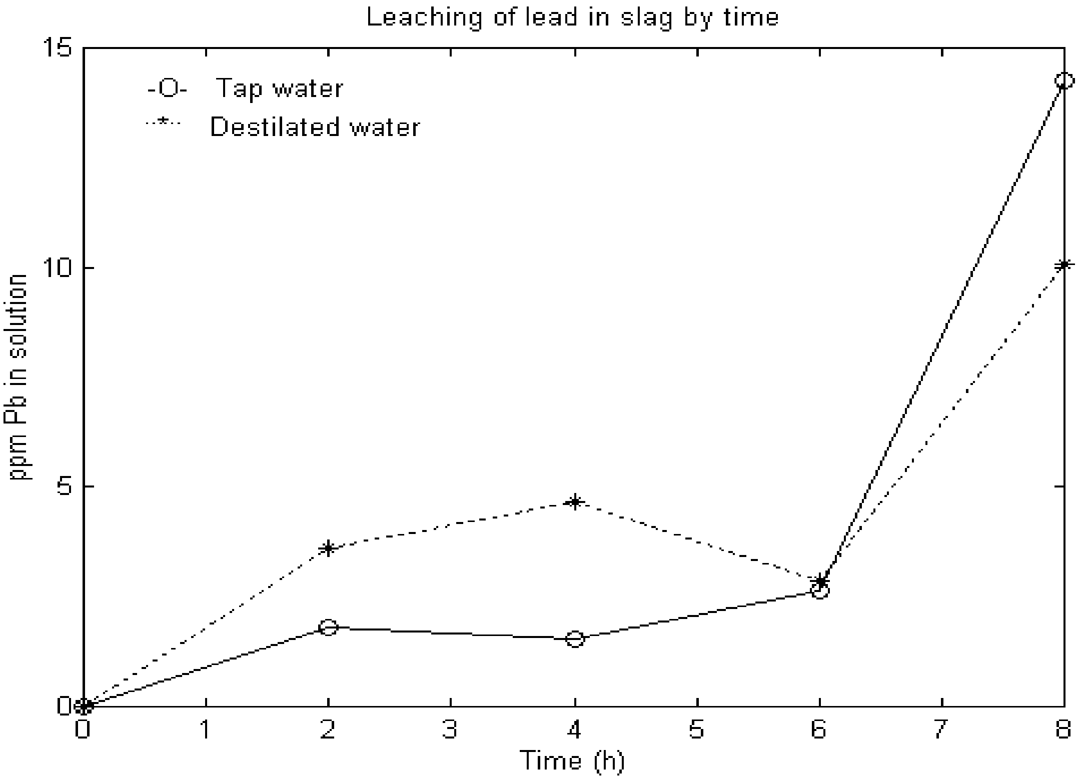

Figure 2 Variation of Lead leaching into solution as a function of time.