

Recovery of Noble Metals from Electronic Waste by Pyrometallurgy Process



Engineering

KEYWORDS : waste electric and electronic equipment (WEEE), NaOH salt and copper slag, metal recovery

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ABSTRACT

Growth of electronic waste has become one of the fastest and polluting agents of the environment. In a general scheme it pollutes the environment due to one main cause that is increase in population, and also due to advancement in technology and life style of the people. Recycling of various electronic wastes has been done by various process like hydrometallurgy, biometallurgy and pyrometallurgy process. In this research process recovery of precious noble metals like tin, nickel, lead, silver, copper, aluminum etc. from electronic waste has been extracted by using pyrometallurgy process i.e by smelting. In this the waste electronic PCB (Printed circuit boards) were first crushed and passed through various unit operation to separate the metal and non-metal parts. And further crushing to bring the size of around 4-5mm. Then the metals were introduced in a furnace with a range temperature of 1100-1400 OC inside an alumina crucible. The heating operation is done for around an hour and molten alloy metals are extracted. The recovered metals contend can be examined and studied by using AAS (atomic absorption spectroscopy). In this way we can recover precious metal from waste PCB.

1. INTRODUCTION

Waste electrical and electronic equipment (WEEE) is diverse and complex, in terms of materials and components, and is increasing dramatically. At the same time electronic wastes (E-waste) are also a special kind of resource, for example a typical E-waste printed circuit boards (PCB) usually contain epoxy resin, fiberglass, copper, nickel, iron, aluminum and a certain amount of precious metals, those materials and metals along with electronic parts, are attached to the board by a solder containing lead and tin. There are many methods available for the treatment of electronic waste and scraps like pyrometallurgy, hydrometallurgy and biometallurgy process. In the hydrometallurgical process, the valuable metals contained in WEEE is first leached into acid or alkali solutions, and then concentrated by using various methods like precipitation, cementation, and solvent extraction. While in the pyrometallurgical process, WEEE is melted with several flux (copper slag or various salts, NaOH) components as slag formatives. The molten WEEE containing valuable metals contacts with a molten metal pool into which the valuable metals dissolve and accumulate. The molten metal is called as collector metal. But among the present treatment methods of waste PCBs, pyrometallurgical processing featuring high temperature combustion is most feasible due to its simplicity, high recycling ratio of resources contained in waste PCBs, and high handling capacity and efficiency. However, the pyrometallurgical process needs large amount of additional flux components as slag formatives to easily melt the WEEE. Large amount of waste slag were thus generated from conventional pyrometallurgical processes. Incineration of electronic waste by traditional incinerator is also dangerous. For example, copper is a catalyst for dioxin formation when flame-retardants are incinerated. Recycling is important, not only from the point of view of waste treatment, but also from the aspect of recovering valuable materials.

Here in this paper the pyrometallurgical process is adopted for comparative studies PCBs of waste mother boards of mobile and computer waste. As it only uses copper slag and NaOH beads for control of temperature and to minimize slag formatives.

2. GENERAL TREATMENT METHODOLOGY

The PCBs of waste mother boards from computer and mobile devices is shown in Fig. 1 and 2.



Figure 1: PCB mother board from computer waste.

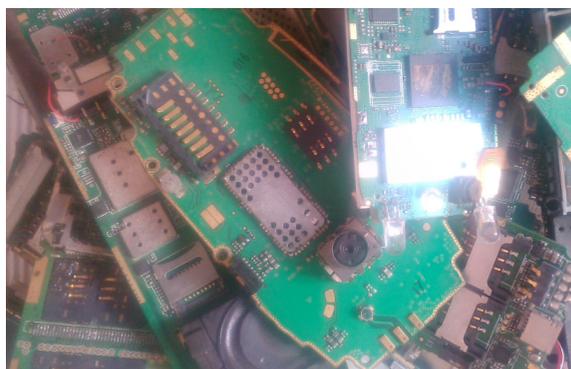


Figure 2: PCBs from mobile waste

There are 3 major steps undertaken before it is melted and analyzed first level, second level and third level.

First level:

Input: Electronic waste (E-waste) like PCB mother boards of computer and mobile devices

Unit operation: This consists of three levels

Decontamination

The first treatment step is to decontaminate e-waste and render it non hazardous. This involves removal of all types of liquids and gases (if any) under negative pressure, their recovery and storage.

Dismantling and segregation.

The decontaminated e-waste or the e-waste requiring no decontamination is dismantled to remove the components from the used equipments. The dismantling process could be manual or mechanized requiring adequate safety measures to be followed in the operations. And after dismantling the components are segregated

Second level:

Input: output of first level

Hammering/ crushing, Density separation and magnetic separation

In this the input is either hammered or crushed for size reduction (4-5mm) of the input waste. Then it is further passed through density separation and magnetic separation process to separate the heavy elements particles. Here unwanted waste like fiber, glass and plastics are removed by this stage.

Third level treatment:

Input: Output from second level

The third level E-waste treatment is carried out mainly to recover ferrous, non ferrous metals, plastics and other items of economic value. The major recovery operations are focused on ferrous and non ferrous metal recovery. Here we use pyrometallurgy process for the recovery method.

3. EXPERIMENTAL PROCEDURE

The experiment was conducted on a muffle furnace with alumina crucible (capacity 250 ml) and heated under a temperature of around 1100-1400 0C, under normal atmospheric condition, Figure: 3 shows the schematic diagram of experimental apparatus used in this study.

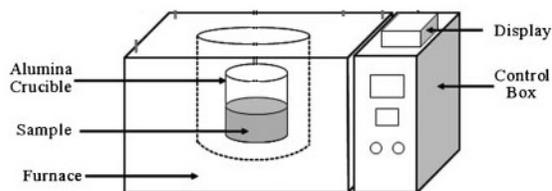


Figure 3: Schematic diagram of experimental apparatus used in this study.

The contend was heated for around 40 minutes for the waste to get completely melted and alloy metal collected at the bottom of the crucible. In this we used two types of input, namely the waste PCB of computer mother boards and mobile PCBs. The reduced sized waste was inserted into a crucible with addition of 12% NaOH salt or copper slag, to control the temperature inside the crucible while melting. During the experiments, it was not possible to avoid partial erosion of the crucible. And finally the metal alloy was collected at the bottom of the crucible and the slag at the top. The photographic view of the metal alloy and slag after melting is as shown in Fig. 4 and 5. And after separation the metal percentage composition was analyzed using AAS (atomic absorption spectroscopy).



Figure 4: Photo graphic view of metal alloy.



Figure 5: Photo graphic view of slag.

4. ANALYSIS

	PCB of Mother Board from waste computer	PCB from waste mobiles phones
E-waste input (g)	98.5	72.3
12% NaOH (g)	11.82	8.68
Total weight (g)	110.32	80.98
Metal alloy recovered (g)	35.12	27.33
Slag (g)	68.30	47.18
Gas evaporated (g)	6.90	6.47
Metal alloy %	31.83	33.74
Slag %	61.91	58.26
Gas %	6.25	7.99
Total %	99.99	99.99

The mass weight distribution percentage of metal alloy, slag and gas is as shown in Figure: 6 and 7

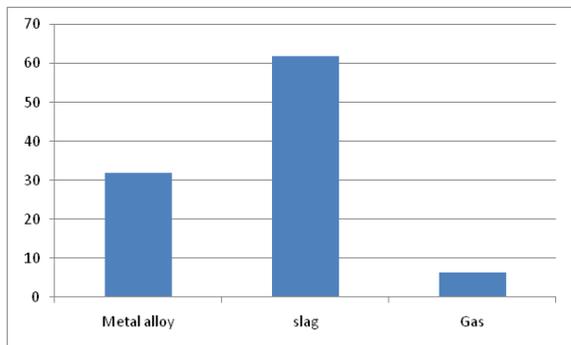


Figure 6: Average mass distribution of PCBs from waste computer mother boards.

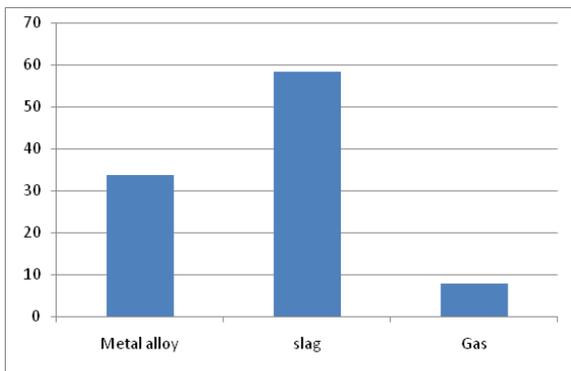


Figure 7: Average mass distribution of PCBs from PCBs of waste mobile phones.

The molten alloy element content of composition from both the sample (by using AAS) is shown in table 1 and 2.

Table 1: Average composition of metal alloy (form PCB mother boards, by using AAS analysis)

Component	% Composition
Copper	46.49
Lead	1.62
Tin	10.47
Zinc	4.41
Nickel	1.58
Iron	15.73

Table 2: Average composition of metal alloy (form waste mobile phones, by using AAS analysis)

Component	% Composition
Copper	82.20
Lead	1.19
Tin	1.48
Zinc	6.31
Nickel	6.35
Iron	0.12

And the graphical view is shown below Figure: 8 and 9

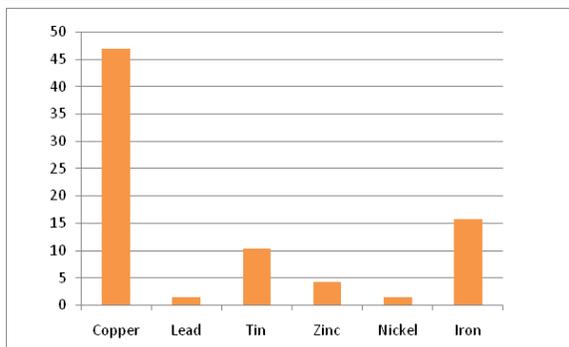


Figure 8: Percentage composition analysis from the metal alloy (form PCB mother boards of waste computer)

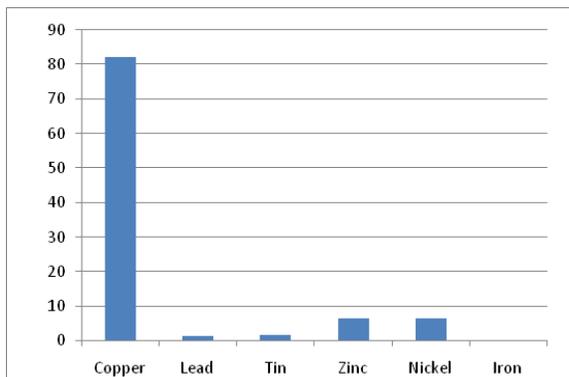


Figure 9: Percentage composition analysis from the metal alloy (form waste mobile phones)

5. RESULT AND DISCUSSION

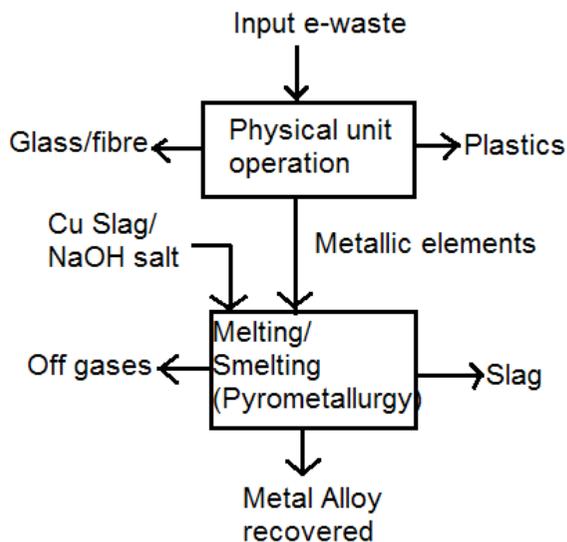


Figure 10: Process flow sheet for extraction of metal (Copper, lead, tin, etc.)

PROCESS DESCRIPTION:

Here the Process flow sheet for recovery of various metals is as shown in figure 10. Most of the plastic, glass fiber elements are separated by physical unit operation process (i.e. first and second level treatment process), and the metallic elements are passed through a Melting/smelting unit (that indicates the third level treatment), and three major phases are recovered from this unit: the metal alloy phase, slag phase and off gases phase. Where copper slag/ NaOH salts are introduced and pre-

cious metal alloy are recovered. The off gases are sent off and proceed for further analysis, and slag is also recovered. Here the slag recovered from this unit contains maximum amount of copper content and therefore can be used as slag input for next operation to control the melting temperature and separation in formation of slag and metal alloy. The metal alloys are recovered and sent for analysis. Generally around 30% of metal alloy is recovered from every result. And plays an important role in recycling of metal and business area.

CONCLUSION:

Metal recovery from PCBs (printed circuit boards) from samples of waste computer mother boards and mobile phones were

studied (shown in table 1 and 2, and figure 8 and 9). In which addition of copper slag and NaOH helped in controlling the melting temperature and in separating the metal and non-metal slag, and most of the non-metal parts like plastic, glass were dissolved in the molten slag NaOH eutectic at around 3500C. Addition of 12% weight NaOH of PCB was also helpful in maximum recovery of copper which was melted at around 1100-4000C. Moreover, molten hydroxides, due to their high basicity, dissolved and trapped many gases such as halogens or carbon monoxide and dioxide. In a pilot plant, the metallic fraction can be easily separated from the molten salt, using an appropriate sieve. And all the results proved that pyrometallurgy technology to dispose PCB deserves further investigation.

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