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A Study on Recovery of E-Waste by Hydrometallurgical Process

G. Guna, P. Sivakumar, Dr. D. Prabhakaran and Dr. M. Thirumarimurugan

Department of Chemical Engineering, Coimbatore Institute of Technology, Coimbatore, India

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ABSTRACT

In the present scenario of resource recycling and environment protection it is essential to extract the valuable metals from waste electric and electronic scraps (WEES) which include certain considerable amount of metals such as silver, aluminium, zinc, iron etc. In this paper, extraction of metals by hydrometallurgical process has been experimented. The recovery of metals from hydrometallurgical processes contains two stages, leaching and electrode deposition. We have mainly concentrate on recovery of silver and aluminium from both computer and television printed circuit boards.

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INTRODUCTION

Like hazardous waste, the problem of E-waste has grown to be an immediate and long tenure concern as its unregulated accumulation and recycling can lead to an important environmental tribulations endangering human health. The Information Technology has revolutionized the way of life, work and communicates bringing countless benefits and wealth to all its users. The conception of pioneering and emerging technologies and the globalization of the economy have made a whole range of products available and affordable to the people altering their lifestyles significantly (E.C., 2000). New electronic products have become an essential part of our daily lives providing us with more comfort, security, easy and faster acquisition and learning of new information. But at the same time, it has also led to unrestrained resource consumption and an alarming waste generation. Developing countries like India face the problem of E-waste management. The rapid growth of technology, up gradation of newer technologies and a high rate of obsolescence in the electronics industry have led to one of the best growing waste streams in the world which consist of end of life electrical and electronic products .It consists of a whole range of electrical and electronic items such as refrigerators, washing machines, computers and printers, televisions, mobiles, i-pods, etc., each of which contain toxic materials (Cui, J., E. Forssberg, 2003).

Most of the trends in consumption and production processes are unsustainable and pose serious challenge to environmental and human health. Optimal and competent use of natural resources, minimization of waste, development of cleaner products and environmentally sustainable recycling process and disposal of waste are some of the issues which need to be addressed by all concerned while ensuring the economic development and enhancing the quality of life. E-waste consists of all wastes from electrical and electronic appliances which have attained their end-of-life period or are no longer fit for their original planned use and are meant for recovery, recycling or disposal. It includes computer and its accessories such as keyboards, Central Processing Units (CPUs), monitors, printers, typewriters, compact discs, headphones, batteries, mobile phones and chargers, remotes, LCD/Plasma TVs, air conditioners and other household appliances. The composition of E-waste is miscellaneous and it falls under hazardous and non-hazardous categories. As the fastest growing component of municipal waste over the world, it is estimated that about 50MT of E-waste is globally generated every year (EPCEU, 2002; SVTC, 2007).

II.Processes for the Recycling of WEEE:

The following methods for the treatment of electrical and electronic scrap are applied: thermal treatment, mechanical separation, electrochemical treatment and hydrometallurgical treatment (Niu, X., Y. Li, 2007).

2.1 Thermal Treatment:

Pyrometallurgical processes consists of incineration, smelting in a plasma arc furnace or blast furnace, drossing, sintering, melting and reactions in

Corresponding Author: P. Sivakumar, Department of Chemical Engineering, Coimbatore Institute of Technology, Coimbatore, India
Tel: 9750609418; E-mail: chemsiva13@gmail.com

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a gas phase at elevated temperatures. The process descriptions for the term are as follows:-

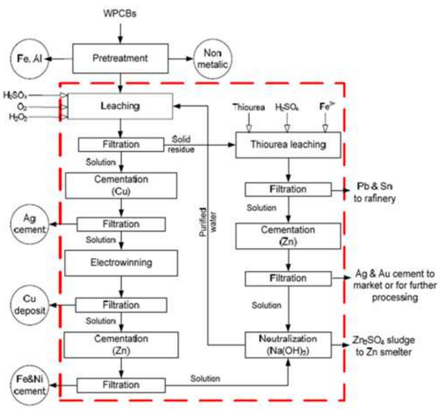

Fig. 1: Block diagram for hydrometallurgical recovery of base and precious metals.

Table I: Weight composition of metals for different electronic scrap samples from literatures.

ELECTRONIC WASTE	WEIGHT (%)					WEIGHT(PPM)			Ref.
	Fe	Cu	Al	Pb	Ni	Ag	Au	Pd	
TV board scrap	28	10	10	1.0	0.3	280	20	10	
PC board scrap	7	20	5	1.5	1	1000	250	110	
Mobile phone scrap	5	13	1	0.3	0.1	1380	350	210	
Portable audio scrap	23	21	1	0.14	0.03	150	10	4	
DVD player scarp	62	5	2	0.3	0.05	115	15	4	
Calculator scrap	4	3	5	0.1	0.5	260	50	5	
PC main board scrap	4.5	14.3	2.8	2.2	1.1	639	566	124	
Printed circuit boards scrap	12	10	7	1.2	0.85	280	110	-	
TV scrap(CRT's removed)	-	3.4	1.2	0.2	0.038	20	<10	<10	
Electronic scrap	8.3	8.5	0.71	3.15	2.0	29	12	-	
PC scrap	20	7	14	6	0.85	189	16	3	
Typical Electronic scrap	8	20	2	2	2	2000	1000	50	
E-scrap sample1	37.4	18.2	19	1.6	-	6	12	-	
E-scrap sample2	27.3	16.4	11.0	1.4	-	210	150	20	
Printed circuit boards	5.3	26.8	1.9	-	0.47	3300	80	-	
E-scrap(1972 sample)	26.2	18.6	-	-	-	1800	220	30	
E-waste mixture	36	4.1	4.9	0.29	1.0	-	-	-	

2.1.1 .Incineration:

Is a process which involves the combustion of organic substances contained in waste materials. Incineration of waste materials are converted into flue gas, ash and heat. The ash is generally formed by the inorganic constituents of the waste, and is usually in the form of solid lumps or particulates carried by the flue gas. Before they are exposed into the atmosphere, the flue gases must be cleaned of particulate and gaseous pollutants.

2.1.2. Smelting:

Is a process extractive metallurgy its major use is to produce a base metal from its ore. This includes production of silver, iron, copper and other base metals from its ore. Smelting make use of heat and a chemical reducing agent to decompose the ore, driving off other elements as gases or slag and just leaving the metal base behind. The reducing agent is commonly a source of carbon such as coke, charcoal.

2.1.3. Sintering:

Is the process of compacting and forming a solid mass of material without melting it to the point of liquefaction by heat and pressure. Sintering happens basically in mineral deposits or as a manufacturing process used with the help of ceramics, plastics ,metals and other materials.

2.2. Mechanical Separation:

Mechanical processing is an combined part of this stage in which e-waste scrap is shredded into pieces using hammer mills. Metals and non-metals are divided during this stage using techniques alike to that used in the mineral dressing, e.g., screening, magnetic, density separation and eddy current techniques. The final stage in the recycling chain of e-waste is the end processing, in which the non-metal and metal fractions of E-waste are processed further (Williams, J.,).

2.2.1. Limitations of Pyrometallurgical Processes:

1. Pyrometallurgical routes are generally more economical, ecoefficient and maximize the recovery of PMs; however, they have certain limitations that are presented here;
2. Recovery of plastics is not possible because plastics replace coke as a source of energy.
3. Iron and aluminum recovery is not easy as they end up in the slag phase as oxides;
4. Special installations are required to hazardous emissions such as dioxins to minimize environmental pollution;
5. Instant burning of fine dust of organic materials can occur before reaching the metal bath.
6. Ceramic components in feed material can boost the volume of slag generated in the blast furnaces,

which thereby increases the risk of losing PMs from BMs;

2.3. Hydrometallurgical Treatment:

Hydrometallurgical is a process which involves acid or caustic leaching of solid material. This process normally requires a minute grain size to boost the metal yield. From the solutions the metals are isolated and concentrated by the processes such as solvent extraction, precipitation, cementation, ion exchange, filtration and distillation. Leaching solvents are mainly composed of H_2SO_4 and H_2O_2, HNO_3, NaOH, HCl etc (ISRI, 2003).

2.3.1. Limitations of Hydrometallurgy Route:

1. Hydrometallurgical routes have been successfully used to recover PMs from e-waste but it has some limitations to: -
2. Hydrometallurgical routes are slow and time consuming and impact recycling economy but it has still concerns.
3. Cyanide is a dangerous leachant and should therefore be used with high safety standard.
4. Halide leaching is difficult to implement because of strong corrosive acids and oxidizing conditions.
5. The use of thiourea leachants is limited in gold extraction due to its elevated cost and consumption.
6. The consumption of thiosulfate is comparatively higher and the overall process is quite slower, which restricts its application for gold extraction from ores as well as from e-waste.
7. There are risks of PM loss throughout dissolution and subsequent steps, therefore the overall recovery of metals will be affected.

2.4. Electrochemical Treatment:

Electrochemical treatment methods are refining steps and they are carried out in aqueous electrolytes, sometimes in molten salts. Only a a small number of processes are found in literature which uses shredder scrap directly in electrolysis. Example iodide electrolysis where an aqueous KI/KOH solution is used to recover gold, silver and palladium from plated or coated metal scrap. Another process in the Fe-process where in the presence of trivalent iron, copper based scrap is leached in a solution of sulphuric acid. The leach solution is the electrolytically regenerated (Hoffmann, J.E., 1992).

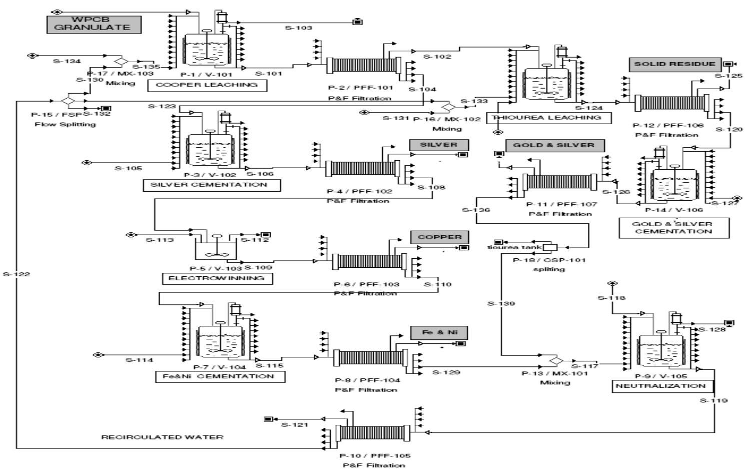

Fig. 2: Outline of hydrometallurgical process from WPCBs.

III.Conclusion and Future Work:

In this paper a comparative analysis of Hydrometallurgical process with pyrometallurgical process and bio leaching is studied. Among those methods Hydrometallurgical process provides good results with high efficiency in the recovery of Precious metals (silver, aluminium) when compared with the performance of other metallurgical processes. If the bath is maintained with a proper voltage and current source the recovery of metals might be better. Hence the future work is generally based on maintaining the optimum temperature, current and voltage readings using proper control which adapt to this process.

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