



Extraction of Soldering Material from Scraped Printed Circuit Board using Photovoltaic Energy

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Abstract: Study on discarded Printed Circuit Boards (PCBs) reutilization has important implication and application values, which can achieve secondary resources recycling and also prevent environmental pollution. Physical methods are much more effective in reutilizing discarded PCBs as compared to chemical and biological methods. PCBs are fundamental part in mainstream electronic systems and are commonly found in consumer electronics, defence applications and medical equipments etc. In this paper, an effective method is suggested prior to physical method in order to recover metals like lead and tin i.e. soldering metals from discarded PCBs using solar photovoltaic energy. These hazardous substances so found can adversely affect human being, causing irretrievable damages. Hence managing PCB waste is becoming a matter of concern due to the toxic nature of materials present and problems relating to disposal of this junk.

Keywords: Solar Photovoltaic, Solar Sun Tracker, Electronic Scrap, Discarded Printed Circuit Boards.

I. INTRODUCTION

As electronic technology is being developed at a high speed of advancement so is the rate of accumulation of electronic waste. Household appliances, IT products etc., have contributed majorly in accumulation of electronic scrap, resulting into severe impacts on environment. Discarded Printed Circuit Boards are the elementary part contributing to electronic scrap and can be found in most of the electronic products.

Demands of effective recycling of discarded PCBs are developing day by day due to following reasons:

1) Rapid growth: According to estimation, annual generation of PCB scrap in the UK is about 50,000 tonnes [1], while China contribute at least 10000 tonnes of PCB scraps of discarded computers each year.

2) Huge values: Discarded PCBs comprises various kinds of plastics, unmanageable oxides and various metals comprising base metals, noble metals, ferrous metals and rare metals. Table 1 enlist the major elements found in random PCB [2].

3) Probable harm to the environment: As mentioned earlier, all kind of materials are being found in PCBs. Improper treatment of discarded PCB's cause's major environmental problems during recycling process and waste managing period, e.g., toxic metals like cadmium, mercury, lead, are responsible for production of flame retardants and various waste gases and by-products.

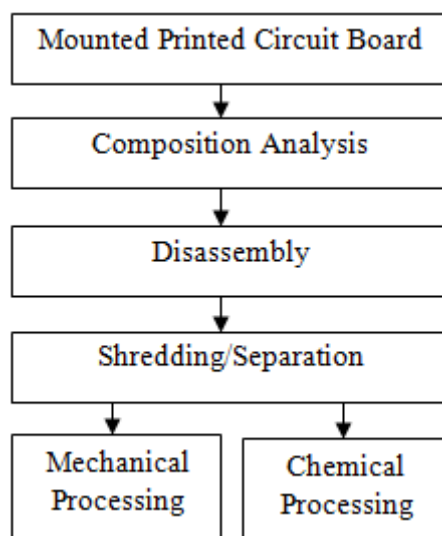
Hence, studying the reutilization of PCBs is not only significant but does posses applicable values, which helps in achieving secondary resources recycling, preventing environmental pollution.

Various methods ranging from physical methods, chemical methods and biological methods, etc. has been developed to recycle discarded PCBs in last several years. Physical methods proved more effective and advantageous on reutilizing discarded PCBs as compared to chemical and biological methods.

Table 1 Elements found in random PCBs

Materials	Lbs/Ton	Material	Lbs/ton
Plastics	600	Cadmium	0.79
Copper	286	Tantalum	0.38
Iron	90	Molybdenum	0.31
Bromine	56	Palladium	0.25
Lead	54	Beryllium	0.18
Tin	44	Cobalt	0.17
Nickel	40	Cerium	0.10
Antimony	22	Platinum	0.07
Zinc	9	Lanthanum	0.06
Silver	1	Mercury	0.02
Gold	1		

Printed Circuit Board traditional recycling process flow chart [3].



Based on experimental study, this paper introduce a non conventional method, utilizing solar photovoltaic energy for extracting soldering metal comprising lead and tin from discarded printed circuit board before being shredded and further being mechanically processed. This method also suggests reutilizing a PCB after components separation.

II. EXISTING PCB RECYCLING METHODS AND PROBLEMS

Present-day discarded PCB recycling process can be categorised into two sub-categories, depending upon the material to be recovered:

1) *Thermal processing*: Including pyrolysis, hydration and metallurgical approach; and 2) *Non-thermal processing* [4]: Including disassembly, shredding, separation and chemical treatment. The resulting products of non-thermal processes undergoes for further chemical treatments. Complex structure and material composition is the matter of concern associated with PCB recycling. Various problems related to this issue are listed below.

- Getting detailed material composition information is extremely difficult, due to complicated structure of PCBs [5]. Composition of one PCB differs widely from another and hence thorough analysis with great extent of accuracy is next to impossible. Several materials under consideration arising from PCBs should be thoroughly revised as technology and materials being used are getting advanced day by day.

- Most of the recycling methods being implemented till date have resulted in recovering metal from PCB scraps at about 28% of the total weight [6]. About 70% of PCB scraps are not being effectively recycled and recovered and are subjected to burning in open or dumped in open land. According to the EPA, in 1997 more than 3.2 million tons of E-waste ended up in U.S. landfills [7]. Therefore there is an utmost need of developing recycling techniques that must possess advanced recycling efficiency.

- Several present-day PCB recycling process, claim to offer convenient resource recovery, however, there claims does not match environmental friendliness.

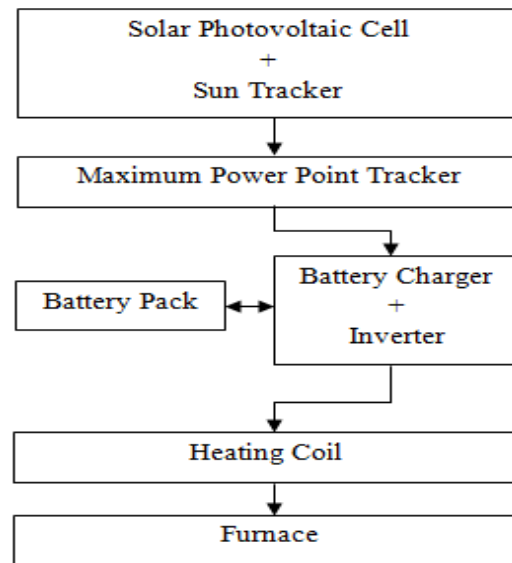
- Automatic disassembly and separation process could not be implemented due to PCB's complex structures and obsolete design principle.

- Various rare and scarce materials like tantalum, platinum, gold etc. are diffused in extremely little quantity in PCBs, making their recovery quite difficult. However recyclers have now realised the importance of precious material and are keen to recover them but they do not have yet identified any efficient recovery method for these precious material from the discarded PCBs [8].

III. EXPERIMENTAL SETUP

Our aim here is, to extract valuable though hazardous metals like lead, tin etc used for soldering components on PCB's before these are burned in open, polluting the environment, in not only a cost effective way but also using a technique that is power efficient and eco friendly both, utilizing renewable source of energy.

Basically, this idea suggests extraction of soldering metal in a solar powered electric furnace. Following is the flow chart description of complete process.



Following are the components being used in this proposed system:

Solar Photovoltaic Panel – Electrically connected solar photovoltaic cells are fixed on a supporting entity which results into formation of a solar panel. Basically solar photovoltaic panel is a unit of connected assembly of solar cells. These panels can be utilized as component forming larger photovoltaic system generating and supplying electricity for commercial and residential purpose. Each module is rated accordingly to its DC output power being tested under standard test conditions (STC), and generally ranges from minimum of 2 to 320 watts.

Solar Tracker - A solar tracker is a device which aligns a solar photovoltaic panel towards the sun irrespective of its constant motion. Sun trackers are basically of two types firstly single axis tracker enabling the motion of a panel in a single axis while the two axis tracker facilitating the orientation of a solar panel horizontally and vertically. These trackers are powered to motion using motors specifically servo motors serving the purpose of precise alignment of panel to achieve direct radiations of sun.

MMPT – In order to achieve maximum possible output power from a single or more photovoltaic devices maximum power point tracking technique is implemented for grid connected inverters, solar battery chargers or other similar devices. MPPT serves the purpose of sampling the output of a cell or unit of cells electrically connected and applying proper resistance (load) in order to obtain maximum power in any given environmental conditions.

Battery Charger - A secondary cell or rechargeable battery is energised using a battery charger or recharger, which passes an electric current through these cell or battery, in order to re-energise them once they are exhausted after serving the cause. The specifications of a charger mainly depend upon the capacity and type of the battery being charged through them.

Battery Pack - A battery pack is an entity of electrically connected any units of identical batteries or individual battery cells. Configuration can be variable ranging from series, parallel or a mixture of both so as to deliver required voltage capacity, or power. End of charging process is usually traced using temperature sensors which are fixed in battery charger.

Inverter – A device that converts D.C. power into A.C. power at desired output voltage and frequency is termed as inverter. Specifications such as input and output voltages, output frequency, and overall power regulating capability are the aspects of designing of device or circuitry. These devices are not at all power generating devices rather these are powered by the DC source in order to serve the cause.

Ceramic Chamber - A ceramic chamber is thermally insulated system, similar in construction to that of an oven, capable of trapping heat generated due to extreme temperatures sufficient for completing a particular process. Process like hardening, drying, melting or chemical changes are being carried out in these ceramic chambers.

Heating Element – Electrical energy is converted into heat energy using heating element utilizing the process of resistive or Joule heating. This heating element offers very high resistance to the flow of electric current through it, as a result of which heat is generated in the element. Nichrome 80/20 (80% nickel, 20% chromium) wire is most used for manufacturing heating elements ribbon, or strip.

Technical specifications of the above listed devices are as follows:

Solar Photovoltaic Panel: Wattage - 2 Watts; Output Voltage - 12 Volts; Output Current - 0.25 Amperes

Battery: Voltage - 12 Volts; Current capacity - 7.5Ah

Inverter: Input Voltage - 12V D.C; Output Voltage - 230V A.C (rated); Output Current - 1.5 Amperes (rated); Output frequency - 50 Hz (rated); Output Power - 360 Watts (rated)

Heating Element: Wattage - 70 Watts

IV. METHODOLOGY

First step towards recycling a discarded printed circuit board in order to extract soldering metal in initial stage of recycling require identification of unused, out of order PCBs. Printed circuit boards which are no longer supporting in a particular system, which are out of order and hence not are serving the cause are discarded printed circuit boards.

Identifying the usable components which are still working even after a PCB is discarded; need to be removed from these PCBs so they can be reused in other applications. Once all the useful components are removed, the user of this suggested system need to place the discarded PCB in the ceramic chamber of the system and placing the lid appropriately. After closing the lid, switch on the inverter of the system which is being powered by a 12 volt battery. This 12 V battery is charged using a solar photovoltaic panel fitted with a single axis tracker. The motion of solar panel by sun tracker is powered using a 12 V D.C., motor completing two revolutions in a minute. On switching on the inverter it powers the 70 W heating elements with approximately 160 volts and 1.5 A of electric current.

Gradually a temperature of the order of 250° C is achieved large enough to melt down the soldering metal from the discarded PCB which is being placed in ceramic chamber. After complete separation of PCB board and soldering metal switch off the system and let the ceramic chamber cool down for a while. Final result of this process is obtained in the form of hardened bits of soldering metal which can be put into use in various other applications in future.

Hence in this manner soldering material is extracted from discarded PCB and these discarded PCB can be moved further for the other various subsequent recycling processes.

V. CONCLUSION

Non Conventional method discussed here tends to serve the cause of reutilizing discarded PCBs advantageously as compared to various other methods stated in this paper. This method enables the extraction of soldering metal which is a composition of scarce and precious though hazardous metals like tin and lead in a cost effective manner relying solely on renewable source of energy. As proposed treating a scraped PCB for extraction of soldering material using photovoltaic energy prior to physical method enables a recycler conveniently extracting tin and lead rather going for chemical processes. The non-conventional method suggested here requires lower investment and operational cost, less manpower hence lower human interference etc. resulting into system which is highly efficient, reliable and more environment friendly.

VI. FUTURE SCOPE

Experimental set-up proposed for extraction of soldering material from scraped printed circuit board using photovoltaic energy posses the potential of offering highly efficient, reliable and more environment friendly recycling technique, which is a utmost need of today's world. The idea suggested here simultaneously offers a vast field of future research which could result into making the system more reliable and efficient.

A further research can be carried out on sun tracking system by designing a low power two axis sun tracker. Research regarding more efficient lead-acid battery can also be carried out.

The proposed method has the ability to meet the needs of modern day PCBs recycling process and must be installed as and where needed.

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