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Electronic Components (EC) Reuse and Recycling – A New Approach towards WEEE Management

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Abstract

Waste Electrical and Electronic Equipments (WEEE) is the fastest growing waste stream in the world. In 2014, a total amount of 41.8 metric kilotonnes of WEEE was generated globally. There are two main parts of a WEEE – a) The Printed Circuit Board (PCB) and b) The Casing i.e. the polymer and/or metal portion that covers the PCB. PCBs contain a lot of components like resistors, transistors, microcontrollers, integrated circuits etc. Once a Electrical and Electronic Equipment (EEE) becomes obsolete; Electronic Components (EC) in the PCB remains unaltered. These ECs can be reused based on their status. In most of the cases, the PCBs end up in the informal sector that employs open burning, acid leaching etc to recover valuable metals from it and the residues end up in landfill which is a malpractice. In this work, two case has been considered – a) Small WEEE (mouse, speakers, headphones, mobile, radio, wires etc) and b) Large WEEE (Laptop, desktops, TV, printer etc). PCBs from these two types of WEEE have been examined. A solution is proposed that will help to enhance the reuse and recycling of the ECs obtained from the PCBs. The proper technique for de-soldering of ECs from the PCB and further testing methods has been discussed. Proper recycling routes of the unusable ECs have also been suggested. Finally, a novel framework has been proposed that will enhance the EC reusability and recycling. The findings will help the stakeholders in decision making, the researchers in considering future research direction and overall a sustainable future for both semiconductor and electronics industry.

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1.0 Introduction

Recent trend of lesser life span of Electrical and Electronic Equipments (EEE) have changed the electronics industry in the past decade as it creates more demand. More demand has created expansion of technology accompanied with short innovation cycles that has produced different version of similar electronic products. Thus, the rate of EEE obsolesce have increased many fold and has generated huge amount of Waste Electrical and Electronic Equipments (WEEE). In the year 2014, 41.8 million metric tonnes of WEEE was generated globally whereas India produced 1,641 metric kilo-tonnes of WEEE (Baldé et al. 2015). It is also considered as the fastest growing waste stream in the world.

WEEE contains a wide variety of elements – 50% iron and steel; 21% plastics; 13%non ferrous metals and 16% other constituents (rubber, concrete and ceramics). Presence of metals like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and flame retardants beyond the permissible limit makes the e-waste to be classified as a hazardous material (Pant et al. 2012). However, the most hazardous part of WEEE is the Printed Circuit Board (PCB). PCBs contain flame retardants, precious metals and lots of electronic components (EC). Electronic components are the components of different shape and size which are soldered on the PCBs. For example, resistor, inductor, capacitor, ICs (Integrated Circuit) etc. These ECs are very essential parts of any PCB. Any electronic device becomes WEEE once it stops working and the device is discarded. If the device is repairable, then it is repaired and sold to other users. These are called Used Electrical and Electronic Equipments (UEEE). Repairing of these electronic items chiefly consists of replacing the inactive or damaged EC. Sometimes unavailability of ECs makes the equipment unusable. However, the WEEE still contains a lot of ECs that are reusable and can be used in repairing or other industries for remanufacturing whereas the inactive ones or the damaged ones should be recycled properly.

In the last decade, WEEE recycling has gained attention of the researchers. Recycling of WEEE can be divided into two categories – a) Physical or mechanical processes and b) Chemical processes. Mechanical processes gained a lot of attention in the beginning of this century and have produced a huge number publications and patents based on mechanical process (Grause et al. 2010). Good review works are present on mechanical recycling of WEEE (Cui and Forssberg 2003). Chemical processes took some time and has now gained pace. In fact, all the chemical processes are followed up by initial physical dismantling processes. The research interests of chemical recycling processes have divided the e-waste into two sections – a) Printed Circuit Board (PCB) recycling and b) Polymer recycling. In general, works on PCB recycling has focused on metal recovery from the PCB. Pyrolysis (Bidini et al. 2015, Hall and Williams 2007, Kantarelis et al. 2011, Rajarao et al. 2014, Terakado et al. 2013), hydrometallurgical techniques (Tunchuk et al. 2012), leaching (Kumar et al. 2014), plasma arc gasification (Kingzett 2010) and plasma torch based treatment (Tippayawong & Khongkrapan 2009) has been attempted by the researchers. Not much work is present on polymer fraction recycling of e-waste. However, pyrolysis has been implemented polymer part processing of e-waste (Jakab et al. 2003). Kinetic studies of thermal decomposition of plastics from e-waste have also been reported (Grause et al. 2010). Bioleaching is another route that has evolved for recovery of precious metals from e-waste that implements different bacteria or mutated bacteria to leach precious metals like gold, copper and nickel (Arshadi and Mousavi 2014, Bryan et al. 2015, Natarajan and Ting 2014, Saidan et al. 2012).

The majority of the works have focused on the WEEE recycling either as a whole or fraction wise i.e. PCB and Polymer part. Works on electronic component reuse and recycle has not been reported so far. Hence, this is a new area of focus for the technologists and practitioners. The research questions that arises are – Is it possible to reuse the ECs after dismantling them from PCB? How the ECs can be reused? What will be the impact of this on the electronic industry? In this study, an attempt has been made to find the answers to these questions. A case study approach has been taken and the findings have been analyzed.

The rest of the paper has been organized in five sections. Section two describes the methodology adopted in this study. Case Studies have been presented in the section that follows. The findings has been analyzed and discussed in the succeeding section. The work has been concluded in the end.