

Application of conventional mineral treatment processes in Printed Circuit Boards (PCBs) recycling

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The proposed paper presents a prototype and novel processing procedure, suitable for the recycling of Printed Circuit Boards (PCB) Wastes. Its operation is founded on the implementation of mineral processes and specifically in the processes of flotation, of magnetic separation and electrostatic separation.

Printed Circuit Boards consists a significant part of electrical and electronic equipment (WEEE) waste stream. Worldwide, PCBs are used intensively to form conductive pathways connecting electronic components in almost all electronic equipment (Tsakalakis et al., 2016). Computers, televisions, or mobile phones, as well as larger devices, like electronic equipment of modern aircrafts, are to be mentioned here. On average, a PCB accounts almost from 3% to 5% of the overall weight of a WEEE (Cucchiella, 2016), while the estimations for the future expected volume of WPCBs are enormous and accountable in several million tons (J Cui, J. et al., 2008). Their manufacturing process is very complicated, involving many special chemicals and valuable materials, like precious metals. For this reason, PCBs wastes are considered as a resourceful waste (Riedewald F. et al, 2015). Although there is no average scrap composition available, typically PCBs contain 40% of metals, 30% of organics and 30% of ceramics (Luda M.P., 2011). In terms of metal's substances, on average, they contain about 5% weight of Fe, 27% of Cu, 2% of Al and 0.5% of Ni, 2000 ppm of Ag 80 ppm of Au (Luda M.P., 2011). Some of the metals (Pb, Cu, Hg, Cd, Ni etc.) contained, are toxic to life and all of them are valuable resources.

After their end-of-life cycle, PCBs waste processing is considered a topic of worldwide concern, attracting the interest of many researchers. Hence, several different physical and metallurgical processes have been investigated for recycling printed circuit boards and many other are being suggested (Parsons, 2006; Sohaili et al., 2012; Kumar & Shah, 2013; Khaliq Abdul et al., 2014, Mc Coach et al. 2014). All of them are aiming to recover the valuable materials contained and their prevention from landfill, that may result in the leaching of toxic materials.

In this context, the present paper aims to contribute in the research activity on the current field, proposing a new recycling processing procedure of PCBs. Design, development and implementation of the procedure is a result of a research program carried out in the Laboratory of Mineral Processing of National Technical University of Athens. Outcomes of this research, proved that the proposed recycling process can be reliably used as a preliminary treatment procedure on pulverized Printed Circuit Boards, providing increased metal recovery for the majority of PCB's metal substances.

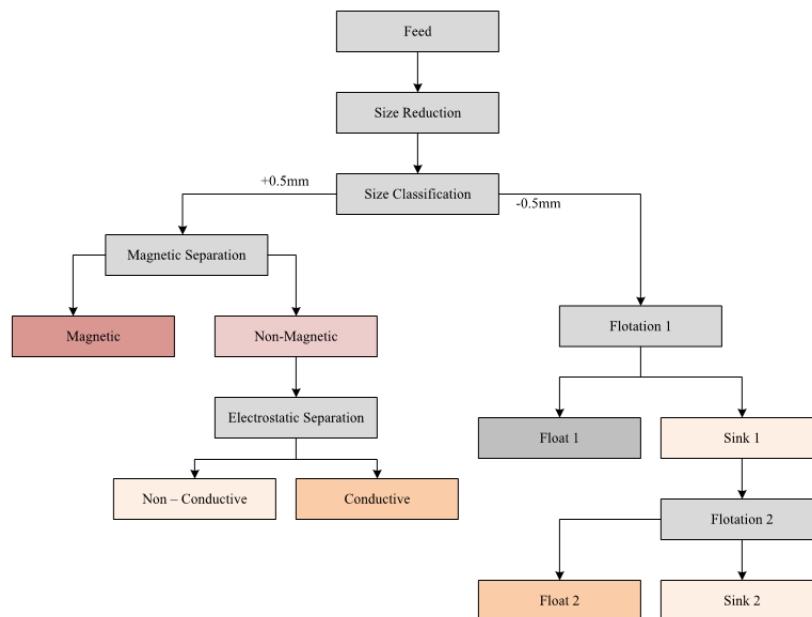


Figure 1: Flow diagram of Proposed Recycling Processing Procedure

Following all aforementioned arguments, the paper describes all the implementation stages of the proposed procedure, concerning the pre-treatment of Printed Circuit Boards wastes as well as the results of the carried-out research.

All the processes, incorporated in the proposed procedure, are commonly used in the processing of mineral ores. Their operation principles are based on the exploitation of the different physical characteristics that the various PCBs' metallic substances present. As a result of their implementation, the separation of the different substances can be achieved without any change in their chemical composition. The findings of this preliminary research, showed that the proposed processing procedure can be successfully applied as a preliminary treatment procedure on PCBs' wastes, while obtaining accepted metal substances' recovery.

For the needs of the research, a suitable experimental setup was used. Several samples of pulverized PCBs, of about 200g each, were processed according to the proposed recycling process. The results and the outcomes of the research carried out are described in the paper. Their analysis and assessment reveals that the application of the proposed procedure, under real-life circumstances, can provide, in the future, a reliable alternative process for the recycling of Printed Circuit Boards.

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