

# Treatment of shredded electronic cards by electrostatic drum separator

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**Abstract:** Electrostatic separation of copper, aluminum and electrical insulating materials is a cost-effective technology for environmental protection, as it offers high-quality recycled plastic and better efficiency for metal coating than conventional electronic card processing methods. Nowadays, insulating-metal electro-separation represents a modern technology for recycling waste materials from industrial waste; it is considered to be the best option used for separating a mixture of metal-insulating granules.

The purpose of this study is to highlight the need to treat WEEE appropriately, as it often contains valuable materials such as non-ferrous metals, which can be recovered and recycled. By assessing the ability of this drum separator to effectively separate and recover these valuable materials, you are contributing to the development of sustainable solutions for the management of WEEE.

**Keywords:** Waste of electronic equipment, drum separator; recycling; insulating materials, environmental protection

## 1. INTRODUCTION

Electrostatic techniques have been widely used for the dry separation of small particles offering a wide difference in conductivity (Louati et al.,2020) and (Bouhamri et al.,2019). Electrostatic separation is an umbrella term for an important class of material processing technologies, widely used for sorting granular mixtures using electrical forces acting on electrical forces acting on charged or polarized particles. (Ben Abderrahmane et al. ,2020)

WEEE has vast recycling potential. This waste contains around 80% recyclable materials, such as plastics, ferrous metals, precious metals such as gold, silver and platinum, and rare earths such as lanthanum and neodymium. Collecting these materials not only reduces the use of new natural resources, it also promotes the transition to a circular economy, where products and materials are continuously reused and recycled. (Mimouni et al.,2017)

This research aims to create and improve advanced WEEE treatment technologies. Electrostatic separation, pyrolysis, energy recovery and precious metal recovery are just some of the methods used. The aim of this research is to propose innovative solutions for more sustainable management of electronic waste, focusing on increasing the efficiency of materials recycling and reducing environmental impact.

## 2. MATERIALS AND METHODS

The variable parameters of the electrostatic drum separation process can be mechanical (vibro-transporter, cylinder and collector), material (particle conductivity, particle shape and size, bulk density), environmental (temperature, humidity and dust) and electrical (active electrode, neutralisation electrode and high voltage). (Dascalescu,1991).

Figure 1 shows the particle discharge mechanism in the corona discharge field. in the corona discharge field. As the voltage

between the electrodes increases, intense ionisation occurs by gas shock with the appearance of the corona electrode, then decreases more and more with the electric field. It then decreases more and more with the intensity of the electric field in the direction of the conducting electrode (Delon,1966)

The charge on a particle increases until the ions no longer couple together. As the charging time and the number of ions deposited on the particle increase, the increase in field strength

created by the charged particle is directed towards the conductive electrode. When these intensities become equal, the particle stops receiving new ions. It therefore ceases to be charged. At this point, the particle has the maximum possible charge (Morar et al.,1993).

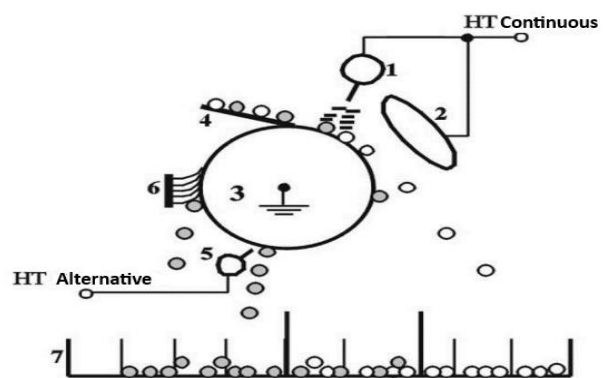


Figure 1 Descriptive diagram of the electro-separator and its constituent parts:

- (1) Crown electrode connected to a source of HV, (2) Static electrode connected to the same source of HV, (3) Cylindrical electrode connected to earth, (4) Vibro-transporter, (5) Neutralization electrode connected to an alternating HV source, (6) Brush, (7) Particle collector.

Figure 1 shows the different components that make up the separator and the role of each of them.

Electric charges are created by ionization of the air by the corona discharge generated by the spiked electrode (1), known as the corona

crown electrode. The granules deposited on the rotating cylinder (3) by the vibro-transporter (4) all acquire an electrical charge of the same sign as potential, and behave differently depending on whether they are electrically conductive or not. depending on whether they are electrically conductive or insulating.

1/ The insulating granules remain "stuck" and adhere to the surface of the drum thanks to the force of the electrical image. They fall into the part of the collector (7) reserved for them when the force of gravity overcomes the image force. To ensure that these particles fall, some electro-separators are equipped with another spiked electrode, called a neutralization electrode (5), to eliminate the q charge by neutralization. Particles that do not fall and remain "stuck" are removed from the drum surface by a brush (6).

2/ Conductive granules

rapidly lose their charge as they pass through the earthed cylinder into the electrostatic field generated by the elliptical static electrode (2).

By electrostatic induction, they acquire a charge of opposite sign to the high voltage potential, and are then attracted by the elliptical electrode and collected in the

They are then attracted by the elliptical electrode and collected in the right-hand part of the collector. cylindrical electrode connected to earth, which introduces it into the electric field zone.

Two charging mechanisms are used simultaneously: "ion bombardment" and "electrostatic induction". The first is for insulating particles only, passing through the corona discharge; the second concerns only conductive particles in contact with the drum in the presence of an external electric field, i.e. the electrostatic field generated by the the elliptical electrode(Nadjem,2018).

Enrichment tests by electrostatic separation were carried out in the Plasma Applications, Electrostatics and Electromagnetic Compatibility Laboratory at the University of Sidi Bel Abbes, with the following parameters

1. Type of active electrode: wire electrode with a position  $\alpha_1=10^\circ$
2. Neutralisation electrode type: static electrode with a position of  $\alpha_2= 45^\circ$
3. Electrical voltage: variable.
4. Roller rotation speed: Variable.
5. Particle size: 0.125 mm.
6. Temperature: 25 °C.
7. Humidity: 2%.
8. Roll radius: 15 cm and the separation valves are set so that the initial product is divided into conductive and non-conductive products.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Based on tests carried out using electrostatic separation with the corona effect, Table 1 shows that the best results are obtained with the following parameters: Rotation speed 35 r/min and electrical voltage of 10 kV, copper content 89.2% and bromine 70.99%.

**Table 1: Results of XRF analysis after electrostatic separation**

| Speed (rev/min) | Voltage (KV) | M <sub>recover</sub> (g) | Br-KA  | Cu-KA  |
|-----------------|--------------|--------------------------|--------|--------|
| 25              | 10           | 85,9                     | 28.23% | 52.33% |
| 25              | 10           | 9,9                      | 75.25% | 8.45%  |
| 25              | 15           | 81,2                     | 31.56% | 55.26% |
| 25              | 15           | 17,5                     | 68.45% | 9.15%  |
| 25              | 20           | 73,7                     | 30.76% | 52.26% |
| 25              | 20           | 24,29                    | 71.45% | 11.15% |
| 30              | 10           | 90,9                     | 28.56% | 58.26% |
| 30              | 10           | 8,59                     | 69.45% | 8.35%  |
| 30              | 15           | 84,7                     | 36.56% | 59.26% |
| 30              | 15           | 14,2                     | 70.45% | 11.15% |
| 30              | 20           | 64,9                     | 31.56% | 55.26% |
| 30              | 20           | 33,8                     | 68.45% | 9.25%  |
| 35              | 10           | 89,2                     | 18.45% | 61.25% |
| 35              | 10           | 9,3                      | 70.99% | 11.02% |
| 35              | 15           | 82                       | 31.56% | 55.26% |
| 35              | 15           | 14,6                     | 68.45% | 8.15%  |
| 35              | 20           | 79,9                     | 31.56% | 55.26% |
| 35              | 20           | 17,8                     | 68.45% | 7.15%  |

By using a high AC voltage varying from 10 kV to 20 kV, it becomes possible to distinguish the different constituents present in the waste mixture by observing their distinct spectral properties. To do this, we implemented the experimental set-up described in figure 1, generating two samples for each test. In what follows, we present two spectra for each experiment: Spectrum A: Sample of particles remaining stuck to the surface of the drum after separation. Spectrum B: Sample of particles attracted to the elliptical electrode after separation.

The sample of the separated product was collected on the right-hand side of the collector and analyzed in the M4 TORNADO spectrometer. The results are detailed in Table 1 below and illustrated in Figure 2.

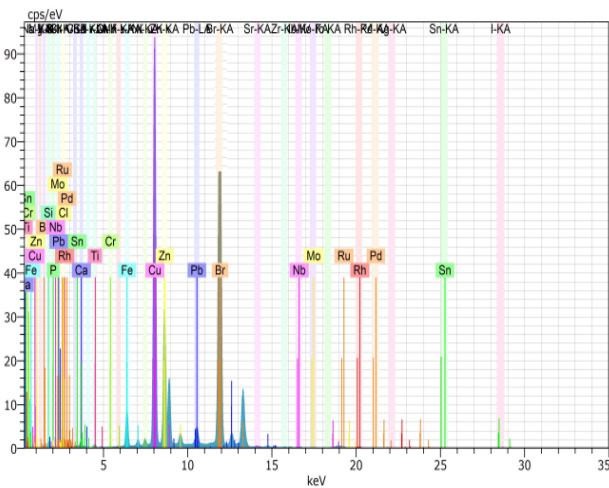


Figure 2. X-ray fluorescence spectrum of a sample of the product separated and collected on the conductive side

The optimum sample is mainly composed of 61.25 % copper (Cu-KA), 10.90 % zinc (Zn-KA), 7.25 % iron (Fe-KA) and 18.45 % bromine (Br-KA), and also fluoresces due to the presence of 0.34 % rhodium (Rh-KA). The source of rhodium fluorescence is attributed to the characteristics of the spectrometer tube, where fluorescence is generated by the anode material. It should be noted that during the measurement, no filter was used between the tube and the sample, leaving air as the separator between the X-ray source and the sample.

While the rest of the elements present in the spectrum are present in very small, insignificant proportions. The metals represent a percentage of 82% roughly in relation to bromine, even though bromine is an essential element in the electronic circuit boards of cathode ray tube televisions.

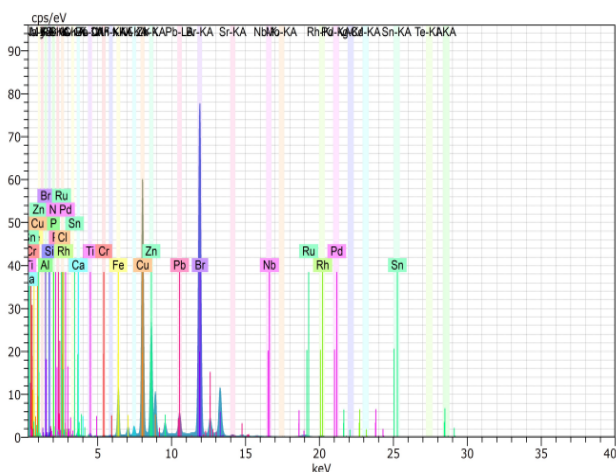


Figure 3: X-ray fluorescence spectrum of a sample of the product separated and collected on the non-conductive side

The sample of the separated product, collected at the left side of the collector, is analyzed in the M4 TORNADO

spectrometer. The results are detailed in Table 1 below and illustrated in Figure 3.

The sample is composed of 70.99% bromine (Br-KA) and 28% metals (copper, zinc and iron). Interpretation of fluorescence spectrometry analyses in the context of WEEE separation by a Drum Separator can help to assess separation efficiency, purity of recovered fractions and compliance with environmental regulations. This information is essential to assess the potential of the eddy current separator as a WEEE sorting solution.

Figure 4 is a high-resolution 1200x1200(SEM) digital image, which clearly shows the presence of copper, iron, zinc and bromine in both samples after electrostatic separation.

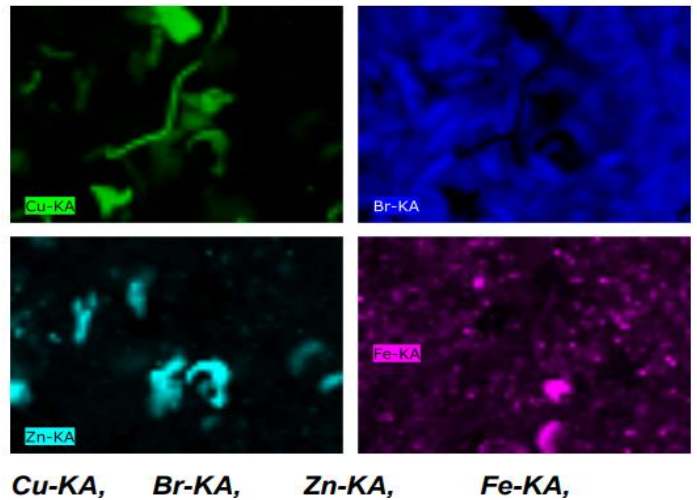


Figure 4: X-ray fluorescence spectrum of a sample of the product separated and collected on the non-conductive side

#### 4. CONCLUSIONS

The electrostatic drum separator represents a major advance in the field of materials separation. Its efficiency, versatility and environmental friendliness makes it a preferred choice in a variety of industries, including recycling and mineral processing. Although there are challenges and limitations, the long-term benefits in terms of operational efficiency and environmental sustainability are undeniable. The continued integration of technological innovations into these separators promises to further broaden their applications and improve their performance, contributing to a more sustainable and environmentally friendly future.

The general conclusion of this research work can be formulated as follows: thanks to control of the three physical mechanisms that ensure the electrical charge of powder mixtures (corona effect, electrostatic induction, triboelectric effect), electrostatic field separation is an effective process for purifying raw materials in the agri-food industry and for recovering materials contained in waste electrical and electronic equipment. In addition, this non-polluting process is characterized by low operating and maintenance costs, as well as low energy consumption.

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