SEPARATION PROCESSING METHODS OF WASTE ELECTRONIC AND ELECTRICAL EQUIPMENT

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Abstract: Electronic and electrical equipment for example smartphones, laptops, personal computers, car electronics, etc. represent one of the fastest growing waste (WEEE) stream caused by the accelerated technological development. These devices contain a lot of valuable elements: critical elements (rare earth elements, platinum group metals, In, Ga), precious metals (Ag, Au) and other metals (Cu, Ni, Sn) as well as plastics (polyamide, polyethylene, polypropylene, poly (methyl methacrylate)). The mass ratio of plastics can reach up to even 70% in devices, depending on many parameters, mainly the production year and the application type. Considering mechanical processing methods, sensor-based sorting plays a significant role in waste preparation. The different types of plastics can be separated from each other by applying Near-Infrared (NIR) separators. Present paper gives a literature overview in the field of mechanical processing methods related to WEEE, focusing on NIR separation.

Keywords: WEEE, processing, NIR, separation, recycling

1. INTRODUCTION

Electronic Waste is one of the fastest growing segments of the World's waste stream. Processing of electrical waste is a huge problem in most European country. Due to the technological development every year more and more electrical waste have to treat. It is seen in Figure 1, that the volume of collected and treated WEEE in Hungary increase steadily, however the Crisis of 2008 stopped the growing for some year.

The commonly used method to process the electric waste is disassembling by workers than sell plastic and metal parts for recycling.

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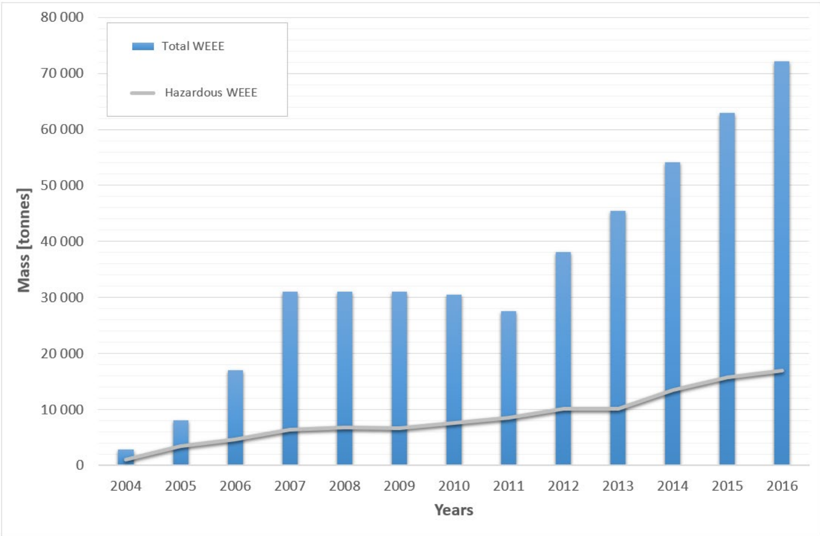

Fig. 1. Non-Hazardous and Total WEEE volume in Hungary (National Environmental Information System, 2018).

1. TYPICAL MECHANICAL PREPARATION TECHNOLOGY FOR WEEE

The first step of the mechanical processing is crushing. Shredders are often used as crushers in order to ensure the appropriate liberation by complex forces. The appropriate liberation is determined by the maximum particle size of crushing product. Table 1 summarizes recommended maximum particle size values for some typical WEEE.

Table 1. **Recommended maximum particle size values for some typical WEEE related to appropriate liberation**

Type of WEEE	Maximum particle size, x_{max} [mm]
Household small appliance	15..20
Telephone	5
Personal computer (PC)	2
Chip	1
Printed circuit board (PCB)	0.5

During mechanical preparation process the particle size becomes finer and finer after each crushing step. According to the mentioned above different machines can be applied to separate the valuable materials (Fe, plastics and non-ferrous metals) considering the particle size. After the first crushing step, belt magnetic separator is suggested for bigger particle sizes, while after the second crushing step drum magnetic separator can be used for smaller particle sizes. Non-ferrous metals can be separated by Eddy current ($x > 3$ ..4 mm) or electrostatic separator ($x < 3$ mm) depending on the particle size of feed material. The flowsheet of typical mechanical preparation technology for WEEE can be seen in Figure 2 (Csőke, 2016).

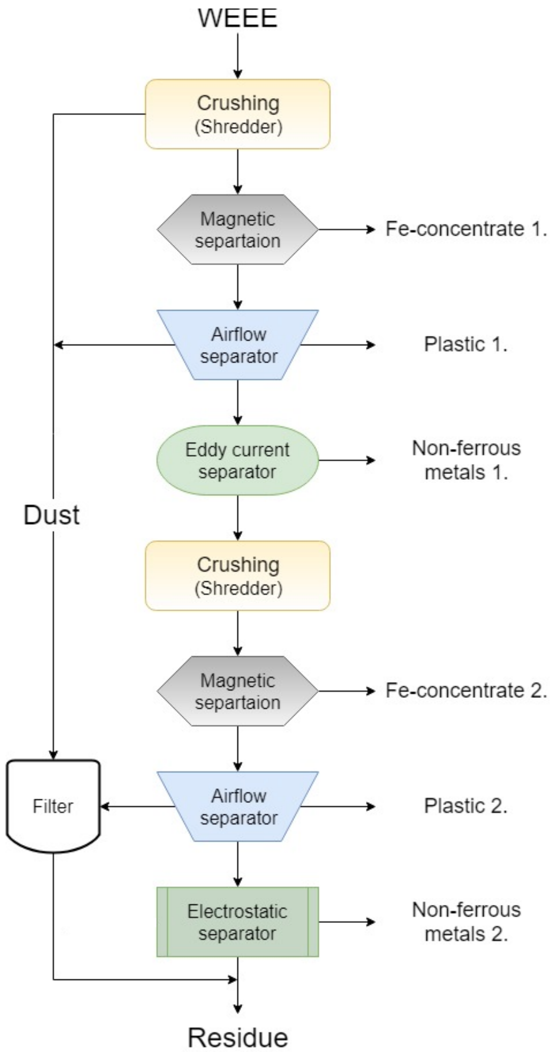

Fig. 2. The flowsheet of typical mechanical preparation technology for WEEE (Csőke, 2016).

2. SEPARATION TECHNIQUES FOR WEEE

2.1. Sorting equipment with eddy current sensors

In this type of separator – like the eddy current separators – eddy current induced in the particles due to a transmitter coil, but this Lorentz force is weaker than the ordinary eddy current separators. In this case, when the transmitter coil induces the eddy current, the electromagnetic sensor (EMS) detects the electrical conductivity of the various non-magnetic metals. After identification, the particles spilling out by an air jet from the nozzles. (Figure 3).

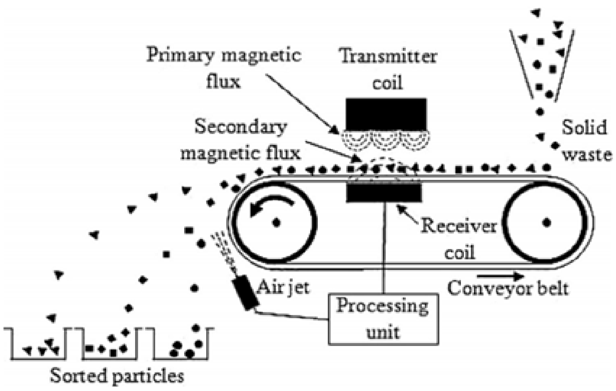

Fig. 3. EMS sensor-based separator (Gundupalli et al., 2017)

2.2. Laser induced plasma spectroscopy

Laser-induced breakdown spectroscopy (LIBS) uses a high-energy laser beam. In 1990, the technology was developed at the Los Alamos National Laboratory, in collaboration with Metallgesellschaft, to identify metal waste. The LIBS system produces a large spectrometry of metal alloys, plastics and treated wood. Advanced atomic spectrometry technique based on optical emission monitoring of a microplasma generated by laser ablation. That is a very short-lived, time-varying temperature and composition source, it is necessary to synchronize with a laser at time with the precision of µs fraction to operate the high-resolution spectrometer that can capture the entire UV and / or visible spectral range simultaneously (Figure 4.).

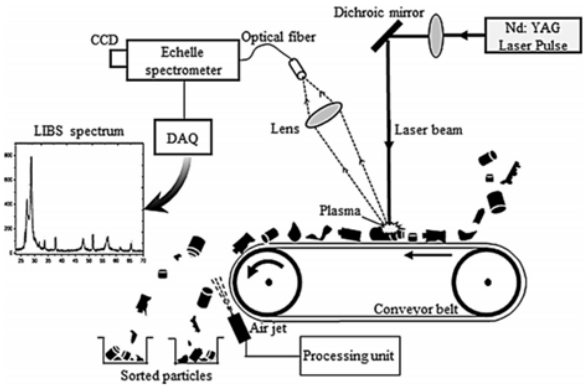

Fig. 4. The LIBS Separator (Gundupalli et al., 2017)

2.3. X-ray separators

Two versions of X-ray separators are known (Figure 5.). Thanks to the X-ray transmission (XRT) system, image processing takes place quickly, in a few milliseconds. During operation, a high-intensity X-ray passes through the material, absorbing some of its energy, while the rest of the weakened X-ray is a tape detector. The atomic density can be determined from the information.

An X-ray fluorescence spectroscopy (XRF - X-ray fluorescence) ionizes the examined sample of electrons on a continuous spectrum X-ray. The kinetic energy of the leaving electron will be the difference between the photon and the electron binding energy.

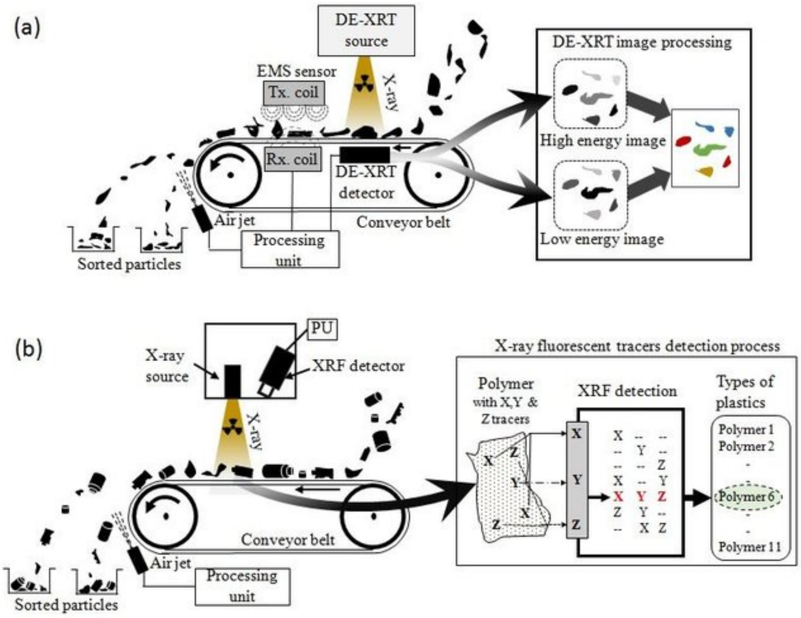

Fig. 5. XRT (a) and XRF (b) Sensory X-ray Separator (Gundupalli et al., 2017)

2.4. NIR separation technique for WEEE

The samples are illuminated by a constant light source and either detects a camera reflecting from the sample. The analogue signal captured by the camera placed above the conveyor is proportional to the wavelength of the beam of light. The selection is provided with two air jet nozzles, so there are three products at the same time for the sorting device. In the arrangement shown in Figure 6.

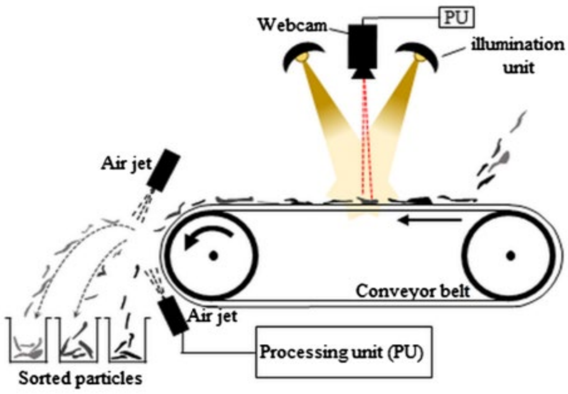

Fig. 6. NIR separator (Gundupalli et al., 2017)

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