Separating residual waste magnetically

Mountains of trash are growing and prices of raw materials around the world are going through the roof. In many countries, households already separate their waste in an effort to support recycling (separation of glass, paper, plastics, biological waste, and residual waste, collection of electronic waste), but many valuable materials still end up in the residual waste. Increasingly sophisticated methods are being developed to extract these materials from the waste and recycle them, although some of these methods involve considerable time and effort.

In chemical terms, residual waste is a solid, heterogeneous mixture of materials. The individual components have different physical properties that can be utilized to separate the mixture. These properties include the grain size, density, air resistance, magnetism, and electrical conductivity. The derived separation procedures are sifting with sieves, the float/sink process, wind sifting, magnetic separation, and eddy current separation.

The two “magnetic” procedures, magnetic separation and eddy current separation, are compared in the following table:

	Magnetic separation	**Eddy current separation**
Suitable for	“Ferrous metals” = ferromagnetic materials Iron, nickel, cobalt	“Non-ferrous metals” = non-magnetic, yet electrically conductive materials Aluminum, magnesium, copper, zinc
Physical principle	Magnetic influence	Magnetic induction
Sample application from class	Separation of a mixture consisting of sand and iron power by means of a bar magnet	This principle is familiar to people, for example, from eddy current brakes.
Principle	If a ferromagnetic material comes into a static external magnetic field, the elementary magnets in the material align themselves in parallel with each other. The magnetic fields of the elementary magnets within the material cancel each other out, south and north poles develop at the edges of the material, and thus the material becomes a magnet itself. Its field is parallel to the field of the external magnet. This results in magnetic attraction. If the external magnet is removed, the material loses its magnetism completely (e.g., pure iron) or partially (e.g., steel).	A conductive, but non-magnetic material is subjected to an alternating magnetic field or moves through a magnetic field. As a result, the magnetic flow through the conductive material changes (the flow is directly proportional to the surface), inducing eddy currents in the material (law of induction). These currents generate magnetic fields themselves (Biot-Savart law). The latter are opposite to the external magnetic field. This results in magnetic repulsion.

	Magnetic separation	Eddy current separation
Technical implementation in residual waste separation	Above the conveyor belt with the residual waste, shortly before the discharge end, there is a small conveyor belt with a powerful permanent magnet arranged in the center (overhead conveyor magnet). Waste fragments made of tinplate (= sheet steel with tin plating) that pass by on the lower conveyor belt are magnetized and attracted by the overhead magnet and thus removed from the main flow of waste material. The small conveyor belt around the magnet transports the attracted fragments out of the magnetic field. They drop and are collected in a separate collecting bin. Other ways of implementation: magnetic tape reel, magnetic drum	An alternating magnetic field is generated by a rotating magnet system (electromagnets or permanent magnets) installed below the conveyor belt shortly before the discharge end. The electrically conductive fragments in the residual waste are accelerated due to the magnetic repulsion resulting from the magnetic fields of the induced eddy currents and propelled from the belt in a farther “discharge trajectory” than the other unaffected fragments. They are guided to separate collecting bins following this method.