Metal Sorting in Waste Treatment – Improvement of Quality and Economical Backbone

Ulrich Kohaupt

Steinert Elektromagnetbau GmbH, Köln

Metallsortierung in der Abfallwirtschaft – Qualitätssteigerung und ökonomisches Standbein

Abstract

Metals are more than ever important for the economical success of a waste management plant, like for RDF, MBT, packaging waste. To make an investment decision more and more life cycle costs has to be taken in account. The major parameters for this are recovery rate, product purity, availability of the machine or even the maintaining effort.

By selecting a performance eddy current separator, e.g., the advantage can easily reach 70.000 € per year. This allows to reduce treatment costs, increase profitability, or to do additional investments to increase profitability.

Even for suspension magnets and sensor sorting systems some major aspects are given to maximise profitability.

Keywords

Metal extraction, metal recycling, eddy current, magnet separation, sensor sorting

1 Introduction

The prices for metal have been booming for the last several years and currently there is no visible clue why these prices should fall significantly within the next years. Compared to classic raw materials like coal and gravel the factor is 100 – 1000 for pure metals. Of course the prices for scrap metal are much lower than the prices for pure metal; they lie at about 50 % of the prices. However, it becomes clear that every technology for metal recovery has to have a direct influence on the profitability of waste treatment plants. Profitability is defined in waste treatment, just as in every other branch of industry, by output and purity of the products as well as by the availability and the maintenance effort of the machines. Therewith, it also becomes clear that profitability is especially a question of technology.

In a common treatment plant firstly the metal is shreddered and then classified by a separator and by sieving stages. After that, different sorting steps are added for each particle size class. Mainly these are metal recovery technologies and to an increasing degree also plastics- and paper recovery technologies. Usually, the process begins with a magnet separation using a magnetic drum or a suspension magnet. After that a non-ferrous metal separator is used and sensor-based sorting has been common for a couple of years. In waste treatment, inductive sorting systems and/or near-infrared sorting systems are used.

2 Material recovery potential

A simple balance of a common refuse derived fuels processing plant in Germany makes clear that at an annual throughput of 90 000 t, a metal content of about 3.4 m Euros worth is passed through the plant.

Opposite to that are costs of 2.8 m Euros which leads to a net contribution margin of around 600 000 Euros. If only 1 % of the contained non-ferrous metal content is lost due to lacking technology, this will have a direct effect on the economic result of the overall process (Figure 1).

Domestic waste sorting, refuse derived fuel recovery

	amount		%	used in/as ...	value [€/t]	balance [€]	remarks
feed:	**90 000**	**t/a**	**100**	**Utilization in**	**values are estimated**		
EBS	45 000	t/a	50	Fuel in cement plant	-50	-2.250.000	Acceptance fee
Water	21 250	m³/a	24	Cooling water	0	0	
Iron	0.85	t/a	0	Blast furnace	80	68	very low
Non-ferrous m	**3 400**	**t/a**	4	**Non-ferrous metallu**	**1000**	**3 400 00**	**"Cash cow"**
Inert	11 050	t/a	12	Streets	0	0	
Dust	1 700	t/a	2	Incineration	-300	-510.000	Treatment costs
Batteries	0.5	t/a	0	Landfill	-200	-100	Treatment costs
	82 401	t/a	92			639 968	Contribution margin
Delta	7 599	t/a	Loss of humidity				

Angaben wurden von einem deutschen Anlagenbauer veröffentlicht

Figure 1 Mass- and recovered material balance in refuse derived fuel processing

With the example of the non-ferrous metal separator or, as it is also called, the eddy current separator the differences in technology can be demonstrated very clearly, as follows later on. On the market there are two systems of eddy current separators. On the one hand there is an eddy current separator with a centric system, as it is propagated worldwide by numerous suppliers. In competition to that and by far more successful on the market there is the eddy current separator by Steinert with the so-called eccentric pole system. This eccentric pole system allows for a better purity of the products, a higher material output and a significantly increased stability. However, the purchase price of this technology is higher.

A simple balance from waste treatment comparing these technologies indicated an additional annual profit of around 70 000 Euros just by applying the more complex, but in the end more cost-effective technology. In this calculation a significant price difference at an investment rate of around 30 % more for the eccentric system and minor increases of 2 respectively 1 % for output and purity were deliberately considered. Also elevated spare parts and personnel costs for maintenance and repairs for the centric system, which after all amounts to a difference of 300 % to the advantage of the eccentric system, were taken into account (Figure 2).

From these briefly described figures results an additional profit of 9 % per annum which represents the described 70 000 Euros. The price difference therefore is paid within six months and afterwards pays off regularly.

Feed	10	t/h					
Non-ferrous metal	4	%					
Throughput per year	38.400	t/a	16h/d; 240d/a	2 Shifts			
	STEINERT eccentric		**others, centric**		**difference to STEINERT NES**		
Investment NES	85.000	€	60.000	€	-29	%	additional costs for technology
Availability	95	%	92	%	-3	%	due to belt and drum cladding
Other investment costs		same					
Spare parts, personnel	3.500	€/a	13.500	€/a	286	%	2 drum claddings per year
Costs per ton throughput	1,4	€/a	1,5	€/t	11	%	
Output	90	%	88	%	-2	%	due to eccentric
ReinheitPurity	90	%	89	%	-1	%	due to eccentric
Production non-ferrous	1.313	t/a	1.244	t/y			
Value non-ferrous	720	€/t	712	€/t			
Total revenues	945.562	€/a	885.404	€/y	-6	%	
Total costs	51.840,0	€/a	57.600,0	€/y	11	%	
Annual profit	893.721,6	€/a	827.804,5	€/y	**-7**	**%**	
Difference at the end of year	**65.917,1**	**€/a**					Advantage eccentric!

Figure 2 Comparison of profitability on the example of the eddy current separator technologies with eccentric and centric pole system

3 Differences in technology, criteria

3.1 Magnet separation

Another criterion of profitability in metal recycling is e.g. in the field of magnetic drums the actually available working width and the power of the magnetic drums. With special construction of the electromagnetic coils within the drum, the working widths of machines can also be used to the maximum and maximum working distances for the extraction of recovered material can be ensured. By using an anodised aluminium strip as conductive material and extremely rectangular coils, an almost unlimited temperature resistance is reached and the magnetizing force is ensured across the whole working width.

The situation is similar for the suspension magnet: here conductive material and a magnetic field elongated by rectangular coils permit long retention times and a reliable separation. These electromagnets work without oil, which suits the low-maintenance and durability.

The main question is here which metal bodies should be separated. It is not enough to only demand information on the magnetic field value “Gauss“, as separation is the task. That means that the extraction behaviour for a certain piece of iron, e.g. for an iron cylinder of 15 times 150 mm, in a certain working distance is much more meaningful. Furthermore, the Gauss value does not offer a basis for derivation of the separation behaviour. This in turn is only possible with the so-called “field gradient“ which every producer can calculate via the course of the magnetic flux lines. Every sample body can be assigned its own field gradient. If this field gradient is crossed by the magnet in a certain distance, it comes to attraction. A depiction of these field gradients in internationally used units like A^2/cm^2 helps to compare as well. For example, a cylinder of 15 x 75 mm requires a field gradient of 3317 A^2/cm^2 and a nut M20 requires 8712 A^2/cm^2.

3.2 Eddy current separation

Two main reasons are the focus of the eddy current separator to ensure profitability: adjustability and availability. The eccentric pole system offers these requirements.

The adjustability offers the possibility to match the effective power to the particle size and particle shape. Output and product purity are thereby increased reliably, an output of up to 30 % more is possible here.

The availability in the case of the eddy current separator is determined by the durability of the conveying belt and the head drum. The simple change of the belt is another important topic. Because of the eccentric pole system the magnetic field is only outside of the head drum of the eddy current separator where it is needed, i.e. only where the piece of metal receives a short strong impulse. At the rest of the girth of the head drum there is practically no active magnetic field. Because of this, ferrous particles cannot, like in the centric system, adhere to the drum and wear out the belt or the drum cladding. The frequent changes of the drum cladding in the centric system are very expensive because of the cladding itself and the, often not planned, down times (Figure 3).

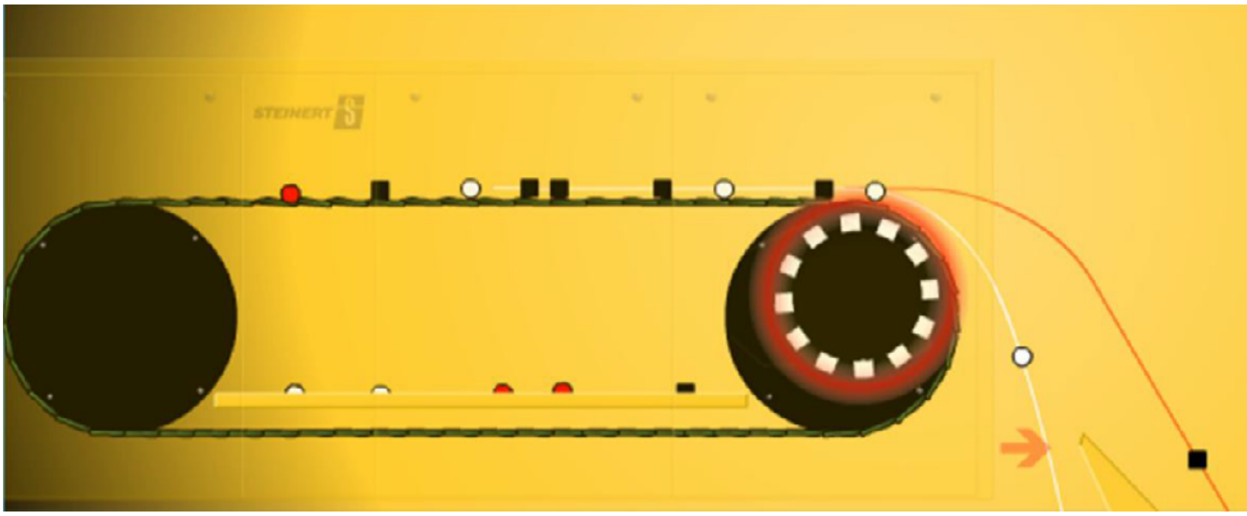

Figure 3 Depiction of the eddy current separator with eccentric pole system, source: STEINERT GmbH

3.3 Sensor sorting systems

Sensor sorting is used everywhere in metal and plastics sorting where so far hand sorting has been common. While hand sorting is limited to an output rate of around 40 %, sensor sorting permits an output rate of more than 90 %. This means that the profitability lies basically in the gain in output. But also the purity corresponds on a large scale to the purity in hand sorting and is partly even superior to it.

Sensor sorting systems work according to the principle that a sensor detects certain material properties set beforehand (e.g. electric conductivity and magnetism) and the detected particles are then discharged via single computer-controlled blasts of compressed air (Figure 4).

Here as well, the life cycle costs have to be taken into consideration, as described before in the example of the eddy current separator. If life cycle costs were taken into consideration more this is currently the case, especially in international waste management, the absolute investment level would become secondary. A price difference of 35 000 Euros as seen with the eddy current separator and an annual gain of 70 000 Euros makes clear that the purchase decision should always be determined by the best available technology, as an operation free from disturbances is also connected to this fact. Many technical details such as belt quality, belt tracking, air jets, reservoirs for compressed air, ease of operation and last but not least the simple maintenance contribute to operating and result safety.

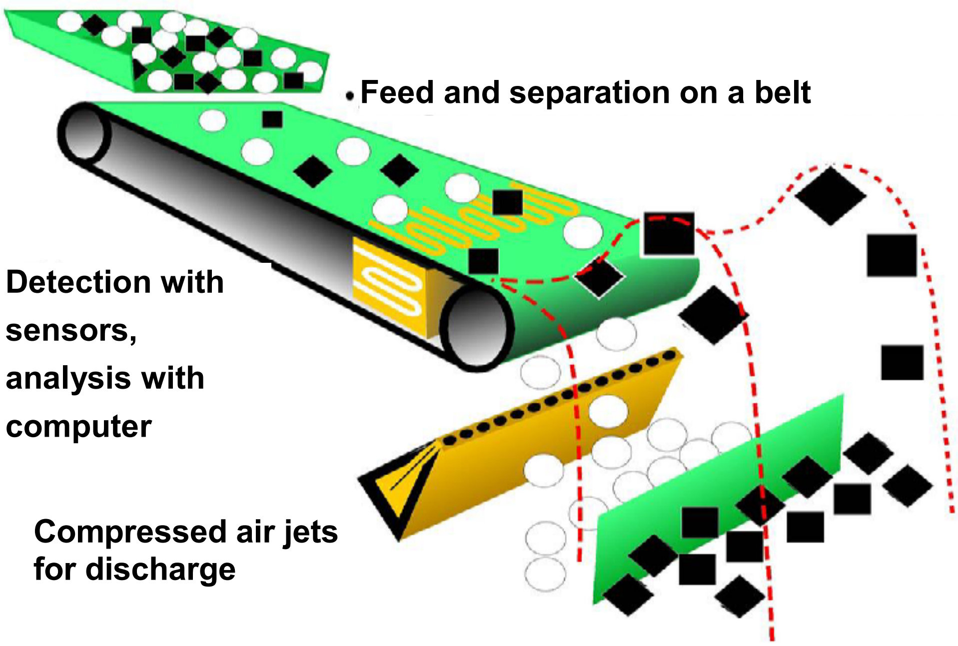

Figure 4 Depiction of the principle of sensor sorting, (source: STEINERT GmbH)

3.3.1 Inductive sorting system

The field of sensor sorting has been contributing for several years to the increase of profitability by applying inductive sorting systems in metal recycling. Trace amounts of contaminants are detected to ensure for example that the refuse derived fuel is metal-free and to protect machines. The narrow metal detectors which are used here detect pieces of metal and then control specifically single jets of compressed air with a working width of 12.5 mm, so that the particles can be removed from the flow of conveyed material. This contributes significantly to metal-free refuse derived fuels and to the discharge of metallic recovered material. Whereas since the introduction of this technology metal detectors with a width of 25 mm have been the only standard, detectors with a working width of 12.5 mm have been available for about one year, exclusively distributed worldwide by the company Steinert. This sensor also contributes significantly to product purity in both the non-metallic and the metallic product and is again a proof for the profitability of a sorting system. In another paper the exact technology will be explained in detail.

Even though these technologies are at first associated with large investments a payback takes in many cases only about 6 months if at all.

3.3.2 Near-infrared sorting system

In addition to that, within the last years near-infrared systems have become firmly established. In this area as well, it is important to use appropriate technologies which ensure product purity as well as output and availability. The company Steinert therefore cooperates with the French company Pellenc, as in that company product and business philosophy but also customer orientation match in large scale. High-resolution NIR-systems as they have been common in PET-processing for years in combination with a thought-through machine construction ensure a maximum result also in this area.

The cooperation of the two companies is not limited to only selling the machines. It is rather the main concern to also ensure the service by the well proven service organisation of the German partner. Thereby, language barriers on plant level have disappeared and spare parts are delivered to the customer mostly the next day

3.3.3 X-ray sorting system

As a further addition in the metal sorting process, especially the X-ray system was developed. This X-ray system works with the transmission of X-rays. Therefore, it is possible to distinguish between light and heavy metals like aluminium and copper, but also between organic and inorganic material, i.e. between plastics, wood and stones, which is interesting in the field of refuse derived fuels. By using X-ray sorting for the separation of aluminium and copper again a rise in value of about 200 €/t is reached. At operating costs of around 18 Euros per ton the investment decision is mainly determined by operating safety and maintenance effort.

4 Overall process of economic metal processing

According to this, an overall process for metal sorting could look like this: behind an eddy current separator in the so-called waste fraction for lost metals and stainless steels two inductive sorting systems are connected in series to extensively recover mixed non-ferrous metals and especially stainless steel (Figure 5).

In the non-ferrous metal flow of the eddy current separator an X-ray sorting system and the so far here not mentioned colour sorting system are added. The X-ray sorting system, as described before, carries out the sorting between heavy and light metals. The mixed non-ferrous metals of the inductive sorting system are also fed into the material flow.

The so recovered heavy metals can then be subdivided by colour sorting into the product groups copper, zinc and bronze.

The more the metals, especially the non-ferrous metals, are sorted by material group the higher is the value added. Roughly between 200 and 500 Euros per ton can be estimated for this rise in value.

It is also possible to carry out a colour sorting on the grey metals (aluminium, zinc) at first and to separate them afterwards into aluminium and zinc using an X-ray sorting system. The decision which process is the right one depends on the individual case and should especially depend on the prevailing mass flows. Referring to the mass flow, colour sorting surely is more cost-effective in operation.

Against this background both a colour sorting system and an X-ray sorting system have already been sold to Russia and Japan as a packaged solution.

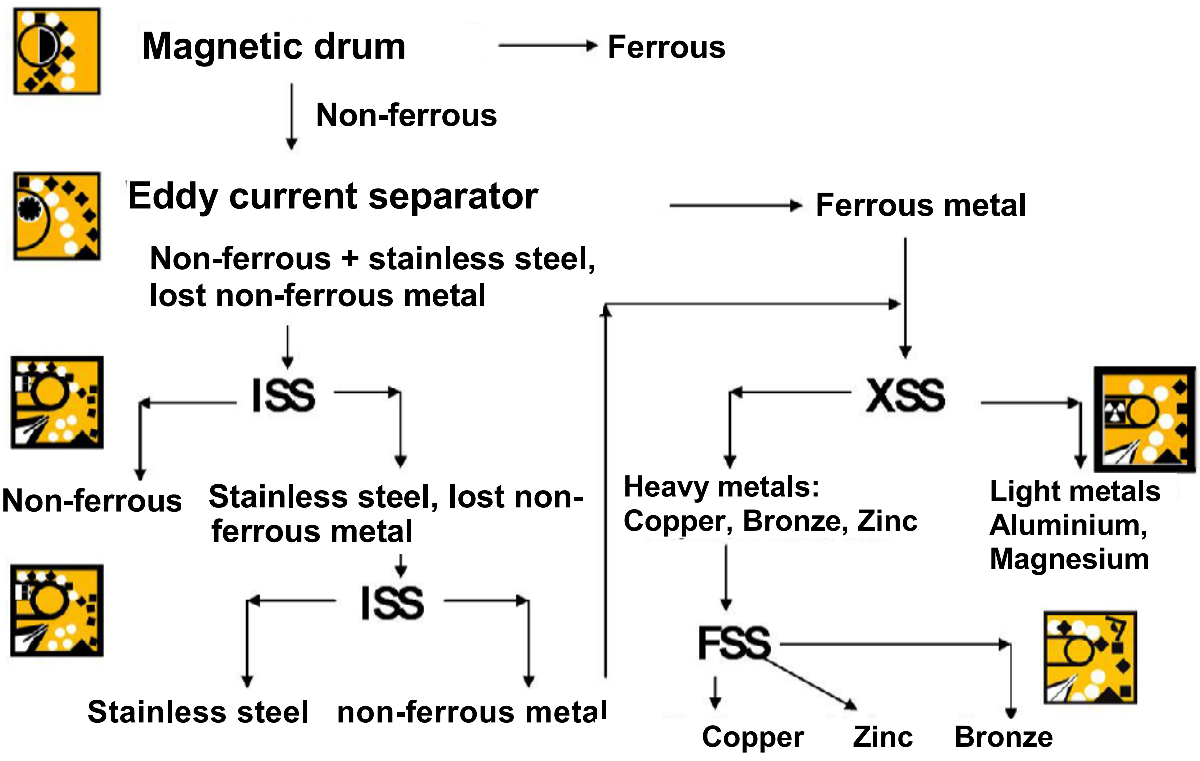

Figure 5 Exemplary depiction of future metal processing, (source: STEINERT GmbH)

Author's Address

Dr.-Ing. Ulrich Kohaupt
Steinert Elektromagnetbau GmbH
Widdersdorfer Str. 329-331
D-50933 Köln
Phone: +49 221 4984-117
Email: kohaupt@steinert.de
Website: www.steinert.de