Quality Improvement in RDF and Other Non-metallic Products through Magnet and Sensor Sorting

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Abstract

Solid waste has become a material source for various applications, such as Residue Derived Fuel (RDF), polymers, or wood for chip board production. The removal of components which reduce quality is essential for the widespread use of these materials. A recent feature of sensor sorting systems is magnetic separation, which has become a must for quality-assured RDF. State-of-the-art technologies include inductive sensoring, x-ray transmission and near infrared spectroscopy.

Keywords

Magnetic sorting, eddy current separation, sensor sorting systems, residue derived fuel, wood recycling

1 The Source of Raw Material

In addition to the recycling of raw material, the globally booming waste industry is concentrating increasingly on the use of the energy content of waste. In order to enable an extensive use as alternative fuel, quality assurance has to be a priority. This is the only way residue derived fuel (RDF) can be used as a real alternative to fossil fuel, irrespective of its origin, without risks in operation and without causing emissions. In Germany, this has already been carried out on a large scale and has led to the use of state-of-the-art sorting technologies in the production of RDF. In other countries, especially in the USA, the comprehensive energetic use of RDF is in the start-up phase.

Many other waste substances also have to be free of impurities, especially if the material is to be recycled. Some of these are wood for fuel or for use as chip board material, and also polymers. Slag from waste incineration should be free of metals, too.

Considerable amounts of high-quality materials can be made available if this potential is exploited. The waste bin is thus just one example of a source of raw materials.

2 The Process

Essential process steps in the treatment of waste material are digestion and shredding, classification into particle size classes and sorting. Residue derived fuel also has to be formed into briquettes for transport and dosing. This process is very sensitive to impurities. The main purpose of the classification is to make the subsequent sorting steps more efficient.

It is of virtually no importance whether the separated materials are the end product or the impurities during the set-up phase (fig. 1).

	Process Step:	Solution:	
1	shredding of waste		Standard
	grading into fine, medium and coarse grain sizes		Standard
2	recovery of iron	suspended magnet separator UM/AM™	Standard
3	recovery of nonferrous metals	nonferrous metal separator NES™	Standard
4	recovery of polymers	near-infrared sorting system	Standard
5	separation of metal-containing impurities (stainless steel etc.)	induction sorting system ISS™	Options
6	separation of other impurities (stones etc.)	x-ray sorting system XSS™	Options
	residue derived fuels		

Figure 1: General process diagram

However, the plant operation will be different here, because output and purity differ greatly according to the process principle. In simple terms, a high output can only be achieved with a low purity and vice versa. Differences may emerge here, depending on the method selected.

Coarse iron components are separated with the help of suspension magnets. Depending on the treatment's objective – recovery of metal or separation of metal as impurity – a magnetic drum or a permanent magnetic belt idler may be added to the process, before the eddy current recovers or separates the valuable nonferrous metals (fig. 2).

Sensor sorting systems follow traditional metal separation. Depending on the technology used, it is their task to recover polymers or separate them as impurity, but also to separate metals like stainless steel. In some cases they are also used to separate stones and glass.

Figure 2: Eddy current separator in an RDF plant

3 Sorting Solutions To Date: Magnetic Separation in the Broader Sense

The more sophisticated these machines are, the more successful they are in the sorting process. Particle sizes of 0 to 25 mm or 0 to 40 mm are processed frequently in residue derived fuel. This demands a great deal in terms of magnetic separation and from the eddy current separator.

3.1 Suspension Magnets

The main task of suspension magnets is to recover free, lightly bound marketable iron. Composite material like a nail in a piece of wood usually remains in the material flow, although this depends predominantly on the distance between magnet and material and on the magnetic forces. It is also important to emphasise that a suspension magnet has to be suspended lengthwise above the end of the belt and not at a different point across the conveying belt (fig. 3). This is due to the fact that, at the dropping point, the material is loosened up and the iron can move through this loosened layer without much resistance. The discharge area and all machine parts within the magnetic field have to be made from non-magnetic material, e.g. austenitic steel. This applies especially to the belt idler and the dividing plate at the dropping point. Otherwise, secondary magnets form and attract the iron particles, hindering their movement considerably.

Figure 3: Suspended magnet positioned lengthwise above dropping point

In a crosswise arrangement (fig. 4), the tare weight and, in particular, the weight of the overlying layers counteract the magnetic force of attraction. In this case, the iron recovery is drastically reduced.

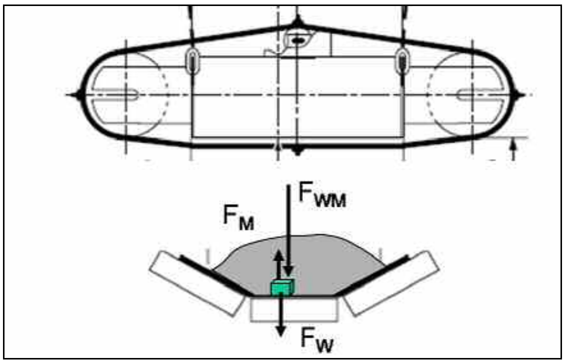

Figure 4: Load of conveyed material on an iron particle: F_M Force of attraction, F_W: Weight, F_{WM}: Weight of overlying material

The magnetic field should be sufficiently long in order to increase the time of exposure and to cover the whole width of the belt conveyor. This can be best achieved with rectangular coils.

3.2 Eddy Current Separators

The eddy current separator has been a standard method in waste treatment for about twenty years and can be considered a magnetic separator in the broadest sense, since the separating force is generated by an alternating magnetic field. The material, e.g. an aluminium tin, is repelled in the drop from a short conveying belt.

Therefore, different parameters have to be considered for purposes of selection and operation. The first important aspect is the particle movement at the discharge point, because bigger particles fall off the belt sooner than smaller ones due to their inertia, as shown in figure 5. The same applies to heavy and light particles. At this point, the eddy current has to alter the particle movement, no sooner and no later.

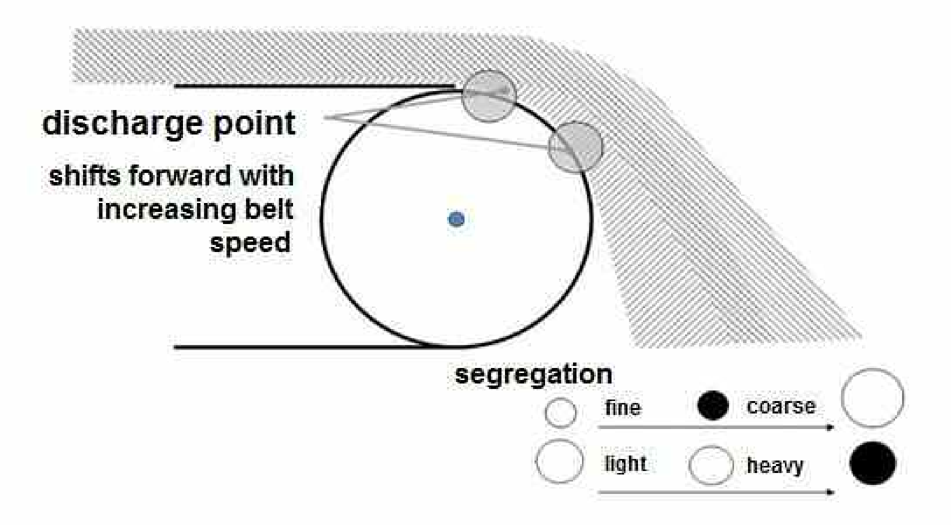

Figure 5: Particle behaviour at the discharge; the discharge point shifts

The finer the material, the later it drops off the belt and falls down in according proximity to the belt. With higher belt speeds, the material leaves the belt earlier. The effectiveness of the alternating magnetic field changes if it is distanced only slightly from the belt. This is why the point of force application of the eddy current separator has to be adjustable, especially if particle sizes of more than 50 mm are to be separated. The same applies to the speed of the belt. It can thus be concluded that effective sorting requires a narrow range of particle sizes.

Only eddy current separators with an eccentric pole system can fulfil these requirements; only these can be adjusted, which explains the wide success of this technology. In order to enable an eccentric arrangement, the belt fastener has to be very large (fig. 6).

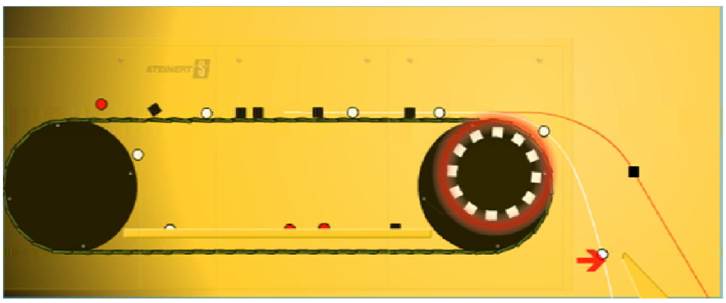

Figure 6: Eddy current separator with an eccentric pole system; adjustable; magnetic field only acts at the dropping point; red: iron particles can move freely

Since nonferrous metals are valuable, a high availability of the eddy current separator must be guaranteed. These machines can be sensitive when it comes to remaining iron.

If an eddy current separator with a centric system (fig. 7) is used, a high-frequency magnetic field acts around the whole belt fastener, attracts iron particles and causes them to rotate and bore, which produces a “singing” noise. The possible scattering of iron particles under the belt naturally wears out both the belt and the belt fastener.

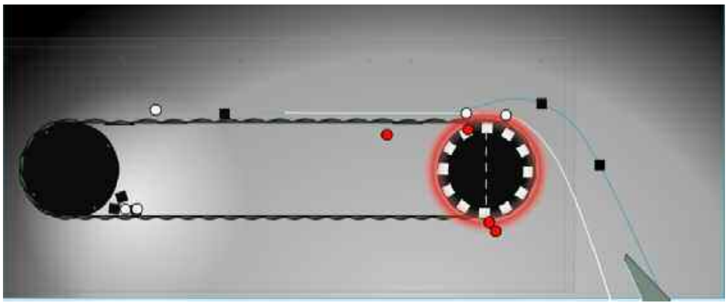

Figure 7: Eddy current separator with a centric pole system and magnetic field around the belt fastener; red: adhering iron particles.

In order to remove adhering iron particles from the belt, centric eddy current separators have several discharge strips on the belt. These throw the material under the eddy current separator, from which point it has to be removed manually.

Despite this, the durability of belt fastener and belt of eddy current separators of this kind is considerably reduced. Both components usually have to be replaced frequently.

Availability and separation efficiency also have economic advantages, as shown in the following table.

Table: Comparison of eddy current separators with eccentric and centric pole system

feed	10	t/h					
nonferrous material	4	%					
feed per annum	38.400	t/a	16h/d; 240d/y	2 layers			
	STEINERT eccentric		**others; centric**		**difference to STEINERT**		
Investment machine	85.000	€	60.000	€	-29	%	additional investment
Availability	95	%	92	%	-3	%	due to drum body and belt
Other investments, personnel, energy, depreciation		similar					
Replacement parts, personnel	3.500	€/y	13.500	€/a	286	%	2 drum bodies per year - centric
specific costs €/t	2,5	€/t	2,8	€/t	13	%	
Output	90	%	88	%	-2	%	due to adjustability
Purity	90	%	89	%	-1	%	due to adjustability
Production	1.313	t/y	1.244	t/y			
Value	720	€/t	712	€/t			
Total revenue	945.562	€/y	885.404	€/y	-6	%	
Total cost p.a.	96.768,0	€/y	109.056,0	€/y	13	%	
Profit p.a.	848.793,6	€/y	776.348,5	€/y	**-9**	**%**	
Annual difference	**72.445,1**	**€/y**					Advantage STEINERT

4 Sensor Sorting Systems open up New Possibilities

Near-infrared sorting systems follow classic metal separation, both in order to recover polymeric resources, and to separate impurities such as PVC. However, high-resolution near-infrared sorting systems can only remove part of the chlorine content along with the PVC. However, this step remains essential, because it is the only way to observe limit values.

Nowadays, additional sensor-based technologies represent another option. The most important technologies are the induction sorting system ISS and the x-ray sorting system XSS. All above-mentioned systems are in use today for residue derived fuel and other materials.

The indispensibility of effective metal separation can be seen very clearly in figure 8. The stainless steel, exposed to the briquetting press, can be recognised. The destructive action of such pieces cannot be overlooked.

Figure 8: Shredded wood with metal

The principle of sensor sorting systems is represented in figure 9. Sensors, in this case a multitude of metal detectors, measure certain material properties and control compressed-air nozzles that remove the detected particle from the material flow if necessary.

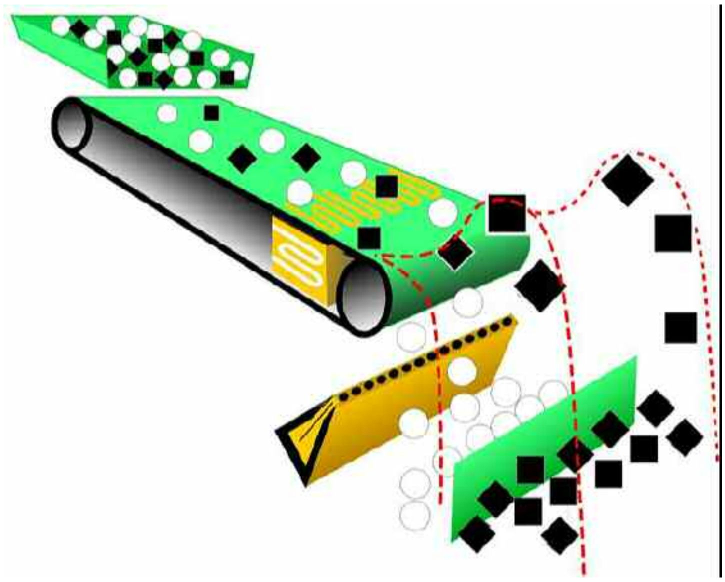

Figure 9: Principle outline of a sensor sorting system, Induction Sorting System (ISS)

If, for instance, an x-ray sorting system detects different materials, they can be sorted with the help of a calibration curve, as shown in figure 10.

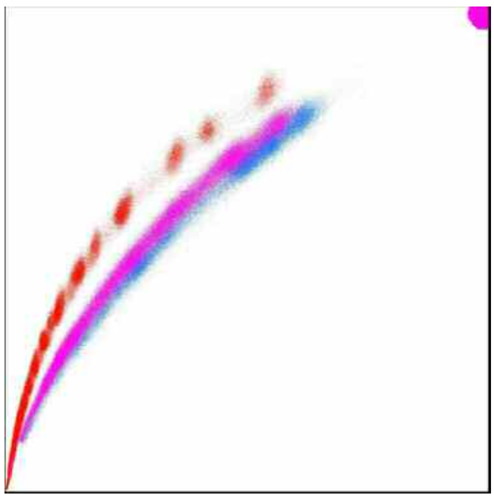

Figure 10: Calibration curves for distinction of materials through different intensities at different energy levels.

In the case of RDF and wood, this can be stones, PVC or rubber. The basis here is the transmission of particles by x-rays and the analysis of material specific attenuation of the exiting radiation on two different energy levels (Dual Energy). The heavier the chemical element, the larger the adsorption of the radiation becomes. Dual Energy compensates differences between atomic mass and material thickness and thus facilitates an evaluation regardless of thickness.

The material distinction is performed mainly on the basis of the atomic mass of the main chemical elements (fig. 11).

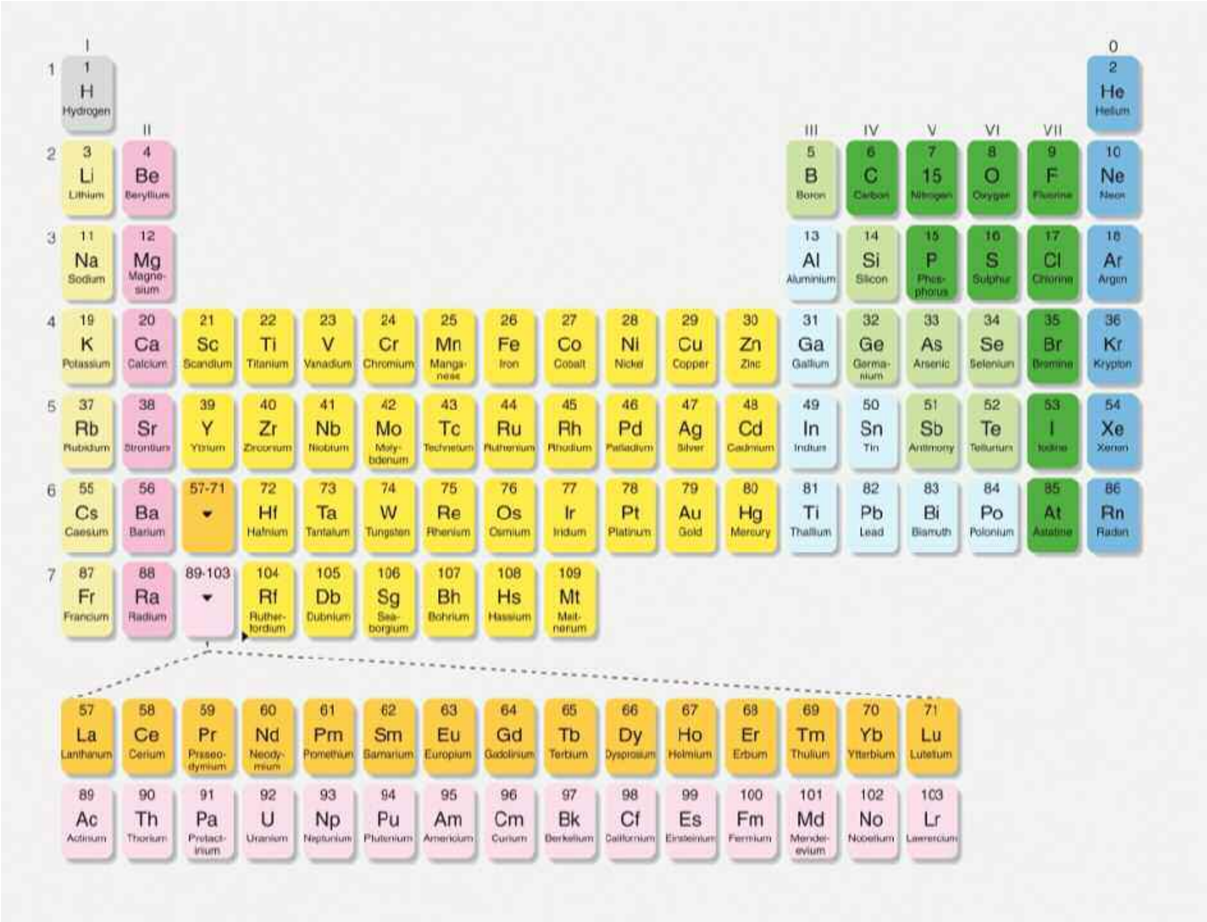

Figure 11: Periodic system of chemical elements as basis for the X-ray Sorting System (XSS)

An in-line arrangement of eddy current separation and induction sorting system is shown in figure 12 in a residue derived fuel processing plant in Germany. In this case, the induction sorting system was complemented by a near-infrared sensor technology, in order to separate remaining metals as well as PVC from packaging material.

Figure 12: View of an RDF plant with an eddy current separator on the left and an induction sorting system combined with a near-infrared camera on the right side

5 Conclusion

An understanding of the sorting steps and the product requirements allows the processes to be coordinated. However, this is based on the assumption that the technologies are understood at their interfaces and that they can be chosen freely. A selection of all the available sorting technologies makes this easier.

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