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THE POTENTIAL OF THE BALLISTIC SEPARATOR TYPE STT6000 AS A FIRST STEP FOR THE RECOVERY OF REFUSE DERIVED FUEL FROM LANDFILL MATERIAL: A CASE STUDY AT MONT SAINT GUIBERT LANDFILL (BELGIUM)

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Introduction

Landfill mining has received a growing interest in recent years due to previous investigations, which show that landfills could deliver a stream of secondary raw materials and energy.[1] Factors such as the age of the landfill, type of landfill and its location have an impact on the type of materials stored and, hence, its landfill mining potential. The uncertainty of the composition of a landfill can complicate its mining activity and increase the risks and the costs of a mining project. One of the possible revenues from landfill mining projects comes from the recovery of Refused-Derived-Fuels (RDFs). RDF can be used as a (partial) replacement of fossil fuels in cement plants, conventional thermal power plants, industrial plants; for incineration in furnaces with energy recovery; and in gasification and pyrolysis. While Solid-Recovered-Fuels (SRFs) must comply with the classification and specifications established in the EN 15359 standard,[2] RDF doesn't need to comply with any standard or specification, but should only meet the specifications established between the producer and the user of the fuel. SRF/RDF consist of mixtures of waste materials such as plastics, paper, textiles and wood, which can be ideal to replace traditional fuels provided the following characteristics are met: high calorific value, low moisture and ash content, high biomass content and low content of chlorine, sulphur and heavy metals. Among the advantages of the utilisation of RDF are the reduction of the use of fossil fuels, the reduction of greenhouse gas emissions, the recovery of the energy contained in waste and the possibility of receiving subsidies for the production of energy under special regimes. The disadvantages include the perception that the energy recovery from these fuels is opposed to recycling and that the facilities must be subject to more restrictive emission limits when replacing traditional fuels, making it necessary to install more complex gas treatment systems. RDF can be obtained from Municipal Solid Waste (MSW) by different treatment types. Generally, these treatment processes consist of a particle size reduction, a thermal drying process and the final preparation of SRF/RDF, resulting in:

- Removal of inert fractions and incombustible materials by the use of different sieves, air sifters and ballistic separators;
- Removal of materials containing undesired elements like Cl, S, Hg and PVC by sensor based sorting technologies (*e.g.* NIR);
- Removal of non-ferrous metals by eddy current separators;
- Adjustment of the moisture content as requested by the client, *e.g.* for pelletisation processes;
- Reduction of the particles size by a shredder or a cutting mill;
- Homogenisation through mixing.

However, these processes are extensive, complex and costly when applied in landfills since the composition of the material is very heterogeneous and, in many cases, the waste presents a high moisture content. Besides, the uncertainties that landfills keep in relation to their composition make the mechanical processing more challenging. Therefore, new technologies/strategies have to be employed to adopt proven technologies and to enhance the production of RDF from landfills.

The case study presented in this paper is studied in the EU MSCA-ETN NEW-MINE Project and attempts to draw the reader's attention to recent advances in mechanical processing achieved through the use of a Ballistic Separator, type STT6000, as a first step for the production of RDF from excavated waste of a landfill. The main objective of this test was to study the efficiency of the Ballistic Separator as the initial step of the mechanical treatment without a pre-shredder, keeping the original particle size of the material throughout the pre-processing. A secondary objective, which is not included in this paper, is the possible validation of the geophysical measurements with the results of the material characterisation after the sampling campaign.

Materials and methods

Ballistic Separator STT 6000

A ballistic separator, as seen in Figure 1, is a processing unit designed to separate solid waste depending on the characteristics size, density and shape. It consists of inclined paddles with specific mesh sizes, which carry out a circular movement induced by two crankshafts located transversally at the top and bottom of the ramp.

The inclination of the equipment and the oscillating movement of the paddles allows the gravimetric separation of the flow in three different fractions: 3D fraction (rolling and heavy, 2D fraction (light and flat) and the sieved fraction (fines).

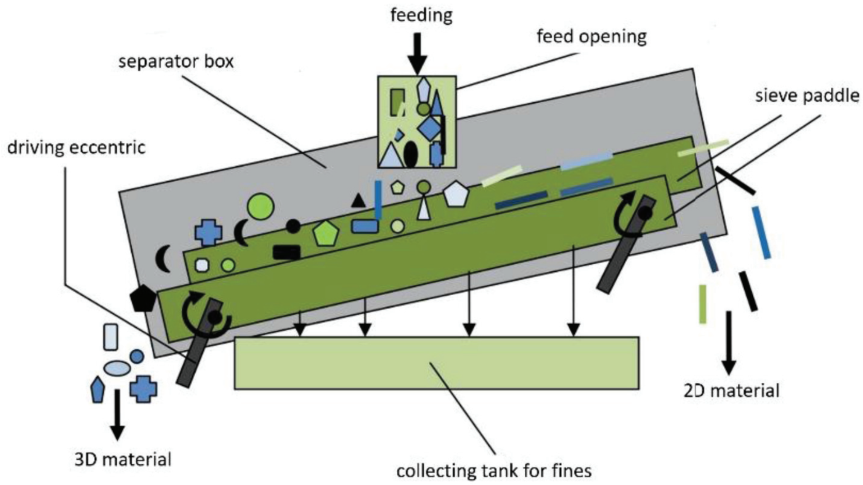

Figure 1: Schematic diagram of a ballistic separator adopted from M. Hans[3]

The ballistic separator STT 6000 (Figure 3), developed and built by Stadler Anlagenbau GmbH, is a robust and resistant separator to process large waste streams from construction and demolition (C&D), as well as MSW and industrial waste. The STT6000 was tested at the landfill site of Mont-Saint-Guibert (MSG) in Belgium and it showed a treatment capacity of 180 Mg/h with landfilled C&D waste (bulk density, ρ_1 = 1.20 Mg/m3) and *ca.* 80 Mg/h with mixed landfilled MSW (ρ_2 = 0.60-0.80 Mg/m^3), directly after the excavation and without pre-treatment.

Excavation site description

In September 2017, 200 m^3 of landfilled material was excavated from the MSG landfill. The firstly excavated area, which is described in this paper, had dimensions of 5x6x8 m (l*w*h), from which the top 4 m consisted of a clay cover layer, which was previously removed. The excavation point was selected based on the information obtained from geophysical measurements. The gathered geophysical data showed lateral differences in bulk conductivity which are an indication for different waste materials. The excavated material was classified visually *in-situ* and identified as prevailingly mixed MSW, including some C&D waste. Directly after the excavation, the material was transported to the ballistic separator as the first step of the mechanical processing, in order to separate the waste into different fractions, which after being characterised will help to correlate the geophysical information with the real composition of the disposed waste materials.

Mechanical processing and sampling

The processing consisted of two ballistic separation steps, one with a 200 mm and another with a 90 mm screen cut. After the ballistic separation, a mobile MSW shredder, TANA Shark 440DT, was used to reduce the particle size of the output flow 2D > 200 mm first to 275 mm (see Table 1) and secondly to 70 mm (not included in the Table 1). The shredder with the 70 mm sieve served as a preparation step for future tests in a thermochemical conversion process, while the 275 mm shredder fraction was used for the material characterisation. Figure 3 depicts the flowchart of the implemented methodology.

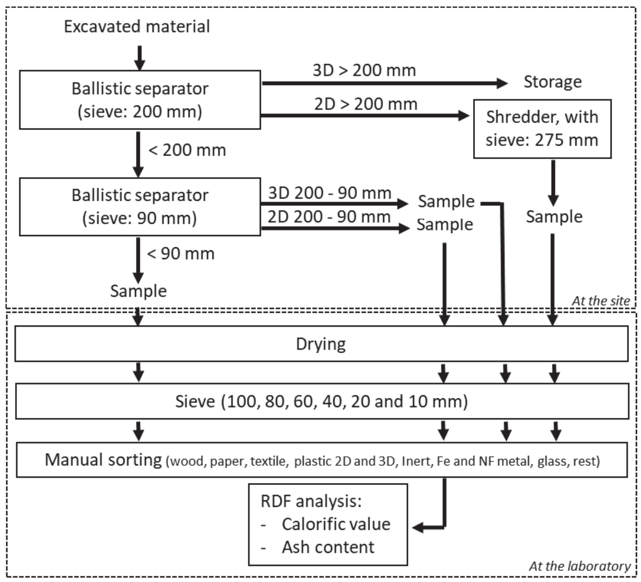

Figure 2: Flowchart of the methodology

Sampling of the output streams of the ballistic separator and the shredder was done according to the German Directive “LAGA PN 98” and “PN 78”, with exception of the output 3D > 200 mm, which could not be sampled according to the protocol due to the large size of individual pieces. In this case, the composition was calculated by manually sorting and weighting of individual pieces. The samples taken from the output flows 2D < 275 mm and 2D 200-90 mm were further analysed to study their potential use as RDF.

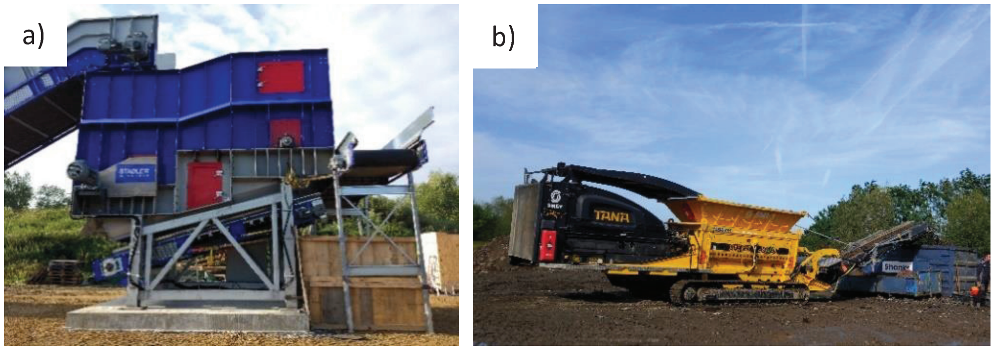

Figure 3: Equipment used during the mechanical treatment with: a) Ballistic separator STT 6000 and b) Shredder TANA Shark 400 DT

Results and discussion

Characterisation of the output flows of the Ballistic Separator STT6000

The composition of five output flows was studied: 3D > 200 mm, 2D > 200 mm, 2D 200-90 mm, 3D 200 - 90 mm and < 90 mm. The materials have a moisture content of 31 wt%, 32 wt%, 12 wt% and 28 wt%, respectively. After the material was dried and sorted into categories, two promising flows were detected as potential RDF recovery flows without the need for further treatment: 2D> 200 mm (referred as "2D < 275 mm" in Figure 4) and 2D 200-90 mm. These flows had a higher concentration of combustibles (wood, paper, textile, plastic 2D and rest) than the other three flows.

A high share of fines (< 20 mm) in the flows < 90 mm, 2D < 275 mm (or 2D > 200 mm) and 2D 200-90 mm was found with a concentration of 75 wt% dm, 36 wt% dm and 31 wt% dm, respectively. Possibly, the shredder cut the big pieces of different categories into small ones, while losing some of the RDF to the fine fraction, which could increase the number of fines in the last three flows. Besides, the 2D plastics tend to retain more impurities than other fractions, which contaminates the flow of fines < 20 mm. In Figure 4, the composition of each output flow is compared. Figure 5 shows examples of materials found in the < 90 mm flow.

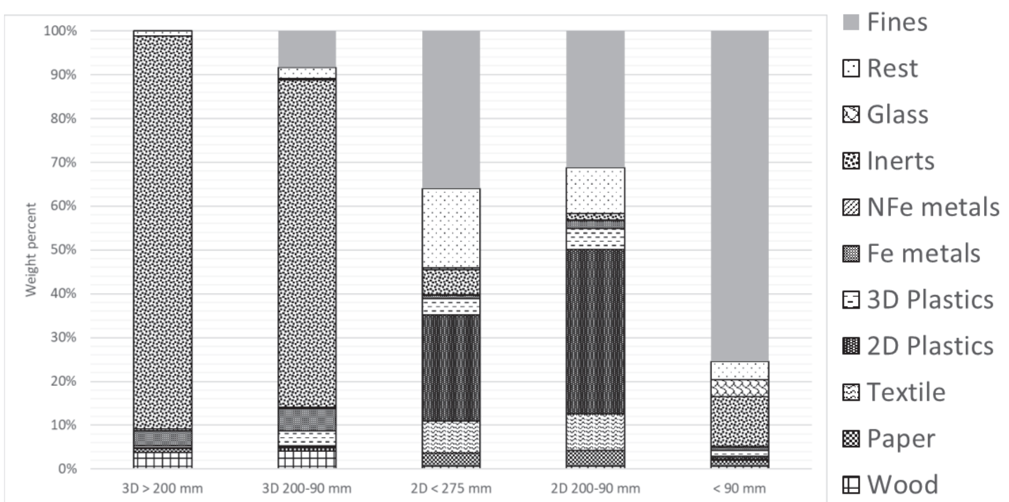

Figure 4: Composition of all the output flows of the mechanical process

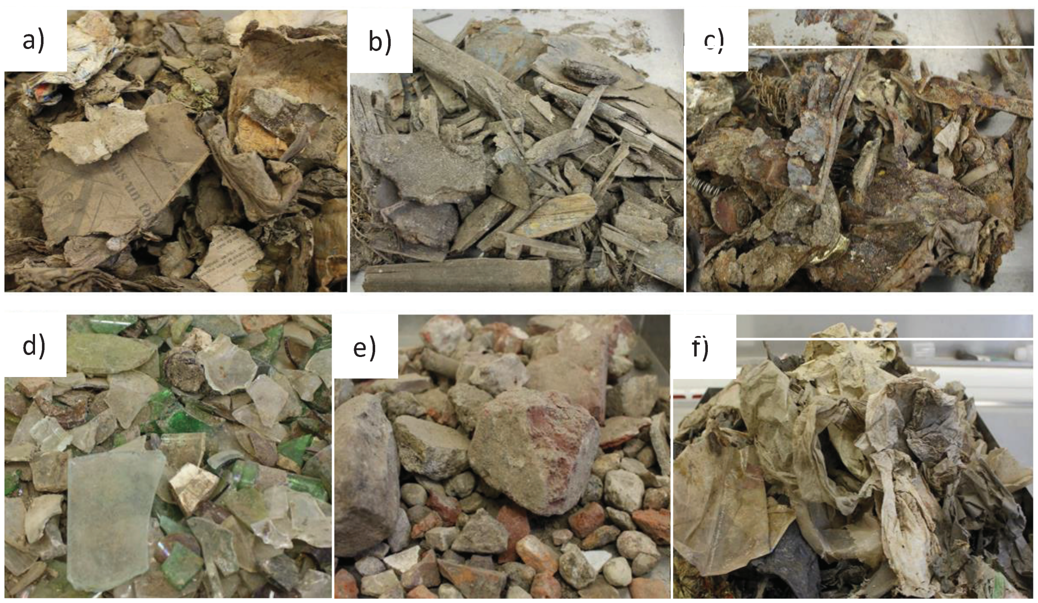

Figure 5: Example of material categories after the drying process, with: a) Paper, b) Wood, c) Metals, d) Glass, e) Mineral fraction, f) 2D Plastic

RDF Analysis

For the evaluation of the use of the 2D 200-90 mm and the 2D < 275 mm fractions as RDF, several investigations were carried out according to the European Standard CEN/TC 343.[2] The composition (wt% dm) and the gross calorific value (GCV, kJ/kg dm) of two samples from the 2D 200-90 mm output stream are shown in Table 1. The results of the RDF analysis are summarised in Table 2.

Table 1: Composition and GCV of two samples from the 2D 200-90 mm flow

		Wood	Paper	Textile	2D Plastic	3D Plastic	Rest	Fines <20 mm
Samp. 1	Mass (w% dm)	0%	3%	10%	32%	7%	12%	32%
	CV (kJ/kg)	16066	15356	23024	40953	33101	23360	1981
Samp. 2	Mass (w% dm)	1%	2%	3%	45%	2%	7%	38%
	CV (kJ/kg)	17866	15108	22399	41009	28194	23294	1890

Table 2: RDF characteristics of the 2D 200-90 mm flow

Sample name		B1: 2D 200-90 mm (1)	B1: 2D 200-90 mm (2)	
Particle size	mm	200 – 90	200 – 90	
Entry date		07.12.2017	07.12.2017	
Parameter	Unit			Test method
Investigation results:				
Moisture content	w% ar	33	32	DIN EN 14346
Dry matter	w% dm	67	68	DIN EN 14346
Loss on ignition 550°C	w% dm	63	57	DIN EN 18122
Calorific value, GCV (wf)	kJ/kg d	**22105**	**22683**	DIN 51900

From the results obtained in this study, it can be concluded that processing excavated landfill material with ballistic separation, as a first step of the mechanical treatment, can yield fractions with appealing calorific values, such as 22,105 kJ/kg and 22,683 kJ/kg, from high throughputs and without the need of additional equipment, making the recovery of RDF in landfill mining projects more efficient. Further information about the influence of the initial moisture content on the GCV and the concentration of chlorine, sulphur and mercury has to be obtained, in order to determine the quality of the produced RDF. This information will be published in future publications, together with the results of the output flow 2D < 275 mm.

Acknowledgements

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3. M. Hans, D. Goldmann, *Recyclingtechnik: Fachbuch für Lehre und Praxis*, Springer Fachmedien Wiesbaden, 2016.

Annex

Table i: Composition (wt% dm) of each output flow of the ballistic separator STT6000

Output flow	2D < 275 mm	3D >200 mm	2D 200-90 mm	3D 200-90 mm	<90 mm
Total mass (w%)	2%	4%	4%	10%	80%
Wood	**1%**	4%	**1%**	4%	1%
Paper	**3%**	1%	**4%**	1%	1%
Textile	**7%**	0%	**8%**	0%	0%
2D Plastics	**24%**	0%	**38%**	0%	1%
3D Plastics	4%	1%	5%	3%	1%
Fe metals	1%	3%	2%	5%	1%
NFe metals	0%	0%	0%	0%	0%
Inerts	6%	90%	2%	75%	11%
Glass	0%	0%	0%	0%	4%
Rest	18%	1%	10%	3%	4%
Fines < 20	36%	0%	31%	8%	75%