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Sampling and Characterization of Fines Created during the Shredding of Non Hazardous Waste

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***Abstract*—**Fines are heterogeneous residues created during the shredding of non-hazardous waste. They are one of the most challenging issues faced by recyclers, because they are at the present time considered as non-sortable and non-reusable mixtures destined to landfill. However, fines contain a large amount of recoverable materials that could be recycled or reused for the production of solid recovered fuel. This research is conducted in relation to a project named ValoRABES. The aim is to characterize fines and establish a suitable sorting process in order to extract the materials contained in the mixture and define their suitable recovery paths. This paper will highlight the importance of a good sampling and will propose a sampling methodology for fines characterization. First results about the characterization will be also presented.

***Keywords*—**Fines, non-hazardous waste, recovery, shredding residues, waste characterization, waste sampling.

I. Introduction

REDUCING the volume of solid waste destined to landfill is now on the French government's environmental roadmap. Considering the ADEME 2015 synthesis report [1], the objective is to reduce by 50% before 2050 this amount, estimated to 19.5 million tons in 2012. It is therefore necessary to determine new ways of valorization for materials that can have a second life.

Abbreviations

CIW	Common Industrial Waste
ELT	End of life tyres
FW	Furniture waste
ISWF	Inert waste storage Facility
MSW	Municipal Solid Waste
NHIW	Non-hazardous industrial waste
NHWSF	Non-Hazardous Waste Storage Facility
SBW	Solid Bulky Waste
SRF	Solid Recovered Fuel

Fig. 1 Abbreviations

For more than 10 years, integrated solid waste management units have been developed in France, not only for households but also the construction sector, bulky waste and waste from economic activities. Those ISWM units, shred and sort those materials for material recovery or energy production.

Integrated solid waste management can be defined as the selection and application of suitable techniques, technologies, and management programs to achieve specific waste management objectives and goals [2].

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The first step in an ISWM is shredding. It breaks material into a mixture of uniform particle size, because shredded material is easier to handle than unprocessed material. Once shredded, this mixture can be sorted using various technologies (magnets, screens or air separators) [3]. Fig. 2 shows an example of ISWM unit analyzed in this project.

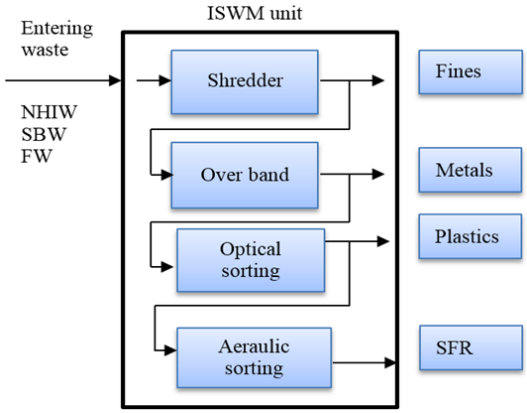

Fig. 2 An example of NHIW management Chain

The entering waste (NHIW, FW and SBW) are firstly shredded then conveyed to the primary separation unit which is a totally enclosed trommel. This step generates two streams: heterogeneous residues called fines and an oversized fraction that is conveyed to the ferrous metal separation system, to an optical sorting and then to an aeraulic sorting process.

The volume of fines is consequent and difficult to manage. It represents up to one third of the total weigh of the incoming waste going to second class landfill center dedicated to store non-hazardous wastes that could be non-inert [4].

II. The ValoRABES Project

The aim of the VALORABES project is to characterize fines coming from ISWM units in order to identify and extract all the material that can be recycled or considered as a source of energy and to minimize the residual part that will be destined to landfill. The best end-of-life strategy will be the one maximizing material valorization and minimizing materials going to landfill while keeping low the environmental impacts of the process.

A. Partners

Sibuet environment is a recycling company based in the Auvergne Rhone Alpes area. It operates in the field of waste management since 1971 according to two axes:

- Collection and transport
- Recycling and sorting

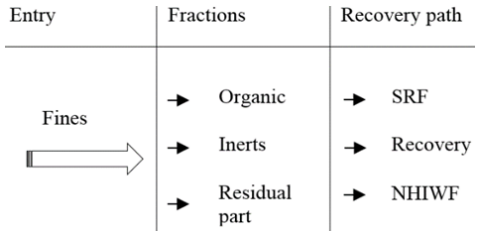

Fig. 3 Fractions contained in fines and their end of life strategy

Sibuet unit is a set of selecting processes to sort and shred various non-hazardous waste to be recovered for recycling or energy recovery. The main streams are transformed into Solid Recovered Fuels (SRF) for cement factories. Sibuet sorting process has generated more than 13,166 tons of fines in 2016, which were destined for landfill center. Their objective with the ValoRABES project is to characterize fines in order to define suitable recovery paths avoiding landfilling.

Another company, RMIS, is involved in this project to design the different processes able to sort materials included in fines. Their objective is to be able to treat high volume of those shredded residues that form highly heterogeneous mixtures with a very small particle size (inferior than 12 mm).

G-SCOP laboratory is interested in system production, eco-design and design for recycling.

Fig. 4 Pile of fines

B. Project Description

The aim of this research is to contribute to reduce landfill tonnages (the objective is a decrease of 10 million tons by 2025 in France), as well as the high economical and environmental cost of landfill.

The framework of this project is composed of three main phases:

- The sampling and the characterization of the waste: Waste characterization is the first step to any successful waste management policy [5] and it needs a good sampling. Indeed, because of the size of the fines, only a few grams can be analyzed compared to the deposit that could weight several tons. Therefore the quality and the care taken for the sampling phase are essential to obtain significant results. The characterization of fines has a great importance in gathering useful, accurate, and appropriate information on the nature, and the different fractions and materials of the deposit [6].

The accessible material fractions (rubble, glass, wood…) have to be sorted and classified following material's categories that can claim the same type of valorization [7]. This is necessary to finally obtain data to characterize fines.

- The development and improvement of the technological processes: the previous characterization will give an indication on the fractions to be separated. Therefore, new technologies able to treat the fines to recover materials have to be developed.
- The identification of the different pathways to valorize the final material fractions.

The long-term objective is to develop a sorting process for fines, draining the entire Rhône-Alpes deposit.

III. Sampling of the Fines

A representative sample of a specific waste stream is important to ensure the reliability of the results obtained, which will serve as the main elements to make decision for the subsequent choice of waste management operations and handling [8]. It is recognized that selecting a representative sample is one of the most difficult tasks associated with a waste stream analysis [9]. The collected sample in our case will have to be representative of the waste management unit under study. So, it is necessary to determine a representative sampling approach. The aim is to determine how, when and where samples should be taken and then to establish a sampling protocol respecting the sampling standards. This is necessary because the quality of waste composition data is highly affected by the sampling procedure.

A. Experimental Procedure

There are number of defined French standardizations to obtain samples of heterogeneous mixtures. Some of the standards are mentioned below:

XP T47-755: Sampling of aggregates from UNRT (Used non-reusable tire) the preparation of the sample consists of mixing several elementary holds at different heights within a big bag.

NF EN 14780: Solid biofuel sampling, the sample is produced by taking several sub-samples at the exit of the conveyor.

NF X 30-437: Household refuse sampling, the characterization of household refuse is based on the MODECOM approach, the sample is carried out according to the random sampling method with homogenization of the bucket.

In the literature, there is no specific method used for specifying the parameters of fines samples for fines' characterization. Based on this and on the expertise of ValoRABES team members, we defined a sampling protocol suitable for the fines.

1. Sampling Method

At the exit of the processing chain there is a kind of pre-sorting which takes place naturally: the heavy particles fall in the center of the pile and the light particles at the border of the piles. So, the dust accumulates near the exit pile and constitutes a layer of lost fines 1. The exit pile is then moved to the stock (except lost fines 1); it is homogenized in the bucket and transferred into the stock. The same phenomenon occurs (heavy particles in the center the light ones at the border); thus, the creation of lost fines for a second time.

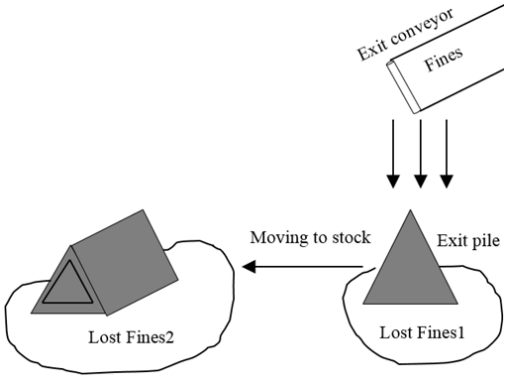

Fig. 5 The creation of lost fines

In order to avoid the loss of light fines (called "dust"), it was decided to take the sample directly at the exit of the chain.

2. Sampling Period

The processing chain is fed with mixtures of NHW, furniture and bulky waste. The proportions of these three streams are the same in volume because the same number of shovels of each stream is collected. The contributions of on-site waste may vary along the year but the inputs on the ISWM unit are always the same. Collecting a sample following a one day production seems to be representative.

3. Number of Samples

In order to increase the chances of determining the different fractions in the fines from the sample, several primary samples have to be taken. It was decided to take a sample every hour during 8 hours, in order to constitute a primary sample of several kilos.

4. Primer Sample Size

While increasing the size of the samples, it increases the precision of the characterization [10]. If it is desired to obtain a representative sample of a production of more than several tons of fines it is necessary to take several kilograms at the exit of the chain and then to reduce the size of the primary sample after homogenization to a few grams. It was decided to make a primer sample of 10 kilos.

5. Final Sample Size

The primary sample should be reduced to a more manageable size as the actual classification of materials will be carried out by hand. According to the normative text NF EN 14780 used today for the characterization of solid biofuels, for the particles with a diameter less than 10 cm, the ideal sample size for characterization must be greater than 150 g (minimum 150 g). For fines, it was decided to make a final sample of 150 g.

IV. Fines Characterization

Waste categorization data are the vital underpinnings of integrated MSW management. With adequate data, informed decisions about recycling can be made, un-due financial risks can be prevented, and progress towards meeting national or local waste reduction goals can be evaluated [11]. The Major problem of fines is the lack of knowledge about their well-defined composition. In order to better understand and define the physical characteristics of fines, ValoRABES' team has taken off three samples (one sample a month).

Following the first sampling step, we used a succession of sieves to separate the fines into three fractions:

- fraction> 6.14 mm
- 2.8 <fraction <6.14 mm
- fraction <2.8 mm

Fig. 6 Fines fractions

Two persons of ValoRABES' team sorted the fractions with a diameter superior to 2.8 mm into various categories of materials: Rubble, Glass, and Wood, Paper/Cardboard, Foam/Textile, Hard Plastic, Soft Plastic, Dust, Plaster, Polystyrene and Metals. The individual components were separated and weighed. The weights are then expressed as a percentage of the original sample.

The hand-sorting of the last fraction (d<2.8) was inaccurate and very difficult because of the too small diameter of the fines. This fraction is called "dust" in our analysis.

Fig. 7 shows the percentage, by weight, of each of the eleven material classes for the fines. Rubble account for over 22% of the global sample of fines.

- This first characterization has shown that the fractions that could be extracted are: The organic elements with high combustion efficiency that can be integrated into the SRF (wood, foam and textiles, cardboard, flexible plastics and hard plastics). Energy recovery is a solution to be studied first for this fraction.
- The inert (rubble and glass) can be placed in an Inert Waste Storage Facility (IWSF) or reused.
- A residual part (dust), reduced to a minimum, which must

be stored in NHIWF or HIWF, depending on its dangerousness.

In order to compare the results, three samples were characterized. The samples were taken-off respecting the same parameters indicated on the sampling approach.

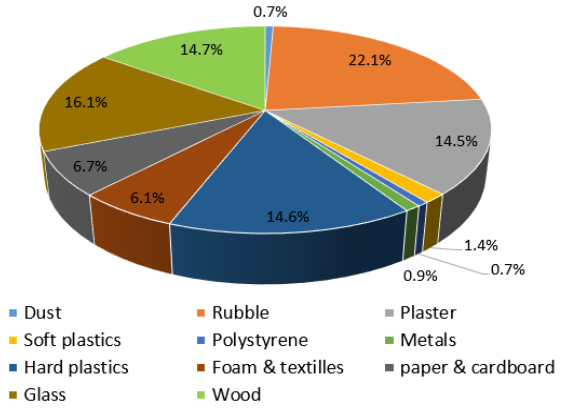

Fig. 7 Composition by material class (sample 1)

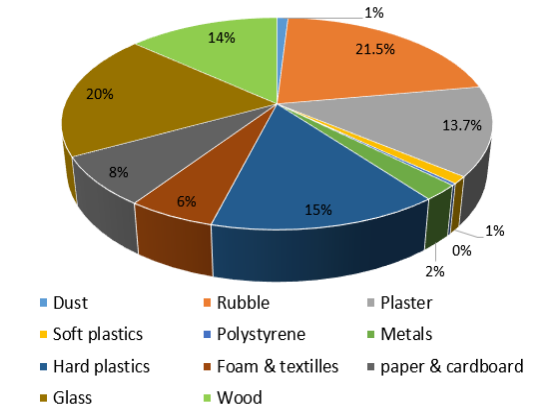

Fig. 8 Composition by material class (sample 2)

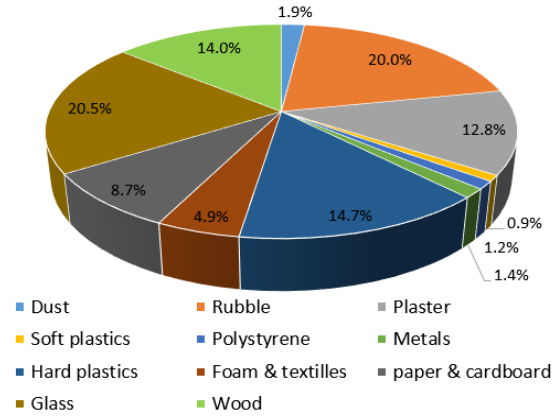

Fig. 9 Composition by material class (sample 3)

The sampling and sorting results are encouraging because the composition of fine is almost the same for the three characterizations. This means that the samples are stable in their composition and certainly representative of the deposit.

The identified proportions that could be sorted for the three characterizations are:

- 40% of inert materials (Glass, rubble).
- 43% of materials with a lower heating value (LHV) (wood, paper/cardboard, foam/Textiles, plastics) that could be mixed with the SRF in order to increase the overall LHV.

This means that there is a real interest to separate those fractions and to value or reuse them for material recovery or to add them to the SRF for energy recovery. Then 83% of the mass of fines would be extracted from the stream destined to Landfill.

V. Conclusion

The progress of this project is part of the government's objective to reduce the amount of waste landfilled. The objective of fines characterization was to analyze and have an indicative value of the potentially recyclable materials included in fines. The results of this characterization have shown that fines contain an average of 80% of recyclable or reusable materials.

Those results will be validated once the sorting process will be defined and the different materials separated on a larger scale. ValoRABES team is now leading tests in order to:

- Define the different sorting technologies to separate the flow.
- Find a solution that allows the fractions to be separated considering their path recovery.
- Test performance in terms of throughput and reliability of the solution for industrialization.

The objective is to study the potential of each technology individually in order to determine the technical feasibility and relevance of large-scale sorting.

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