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ABSTRACT

This study investigates the efficiency of the electrofragmentation technology for the up-cycling of concrete waste. Tests were performed at continuous scale at various operating conditions and showed that high liberation and recovery rates of aggregates were obtained after just one treatment step performed at 1 kWh/t. These results confirmed then the potential of the electrofragmentation technology for the selective recovery of the natural aggregates contained in concrete waste.

Keywords: Electrofragmentation, construction and demolition waste, selective fragmentation

INTRODUCTION

The traditional recycling circuits for the stony fraction of the construction and demolition waste are based on processes such as manual sorting, crushing, screening, removal of metallic elements and light materials by means of respectively magnetic separators and pneumatic systems. During the crushing process, different types of particles are generated: homogeneous particles (also called “liberated particles”) or particles still composed of two or more materials (also called “middlings” or “bound materials”). The amount of middlings decreases the sorting efficiency in the following sorting/separation steps causing several problems. Indeed, if they are not removed then the amount of impurities in the final products is increased and the final product can only be recycled in low-grade applications; but if they are removed then the recovery rate of the material that could be recycled is reduced.
A better liberation of particles could be reached by increasing the size reduction of the input materials. However, this additional comminution step has several drawbacks on the whole treatment plant such as an increase of the total energy consumption and an increase of the proportion of fine particles which are difficult to valorize and which also impede the following recovery systems. The selective fragmentation of Construction and Demolition Waste (CDW) is therefore crucial for the implementation of an efficient recycling system.

This study investigates the electro-fragmentation as a potential breakthrough technology for liberating the natural aggregates contained in concrete waste. The process uses high intensity electrical pulses to a material immerged in water. Depending on the electrical properties of the constituents, the pulses cause dielectric breakdowns along material discontinuities which generate cracks at the grain boundaries allowing full liberation of components. The efficiency of this technology was proven for different kind of materials (Andres et al., 1999; Andres et al., 2001, Wang et al., 2012, Dal Martello et al., 2012), which led in some case to the construction of an industrial plant. Regarding concrete waste, only lab-scale tests were previously performed by Touze et al. (2016) with the objective to get clean aggregates for improving the quality of the products in which there are incorporated. The efficiency of this innovative technique has then to be assessed at the continuous scale. This study aims to study the influence of the operating conditions of a continuous electrofragmentation treatment on the selective fragmentation of concrete waste.

MATERIAL AND METHOD

Sample. The sample was collected by Lafarge on a site collecting CDW located close to Rennes (Brittany). The sample was prepared by firstly using a jaw crusher and then sieving it to the size fraction 2-40 mm.

The materials before and after treatment are characterized by measuring the particle size distribution and the liberation rate. In particular, aggregates liberation is quantified by manual sorting of the clean aggregates (aggregates free of cement paste) in the size fractions 5-8 mm and 8-16 mm.

Electro-fragmentation equipment. Tests were performed with an equipment called Pre-Weakening Treatment Station (PWTS) designed to process 2 t/h. Input and output materials are carried by conveyor belts. The PWTS produces electrical discharges of short duration and very high voltage (several tens of kV) between electrode and counter-electrodes.

Two operating parameters were studied here: the capacitance which represents the amount of energy contained in each high-voltage pulse and the discharged energy which is the energy related to all the pulses discharged during the duration of the treatment. Table 1 reports the operating conditions of the tests. All these continuous tests were performed on a sample amount of 20 kg, with a voltage of 150 kV and a frequency of 10 Hz.

Table 1. Operating conditions of the continuous tests on concrete waste.

	Discharged energy (kWh/t)	*Capacitance (nF)*
Test 1	2.0	60
Test 2	2.0	110
Test 3	2.0	140
Test 4	1.0	110
Test 5	5.0	110

RESULTS

Influence of the capacitance. The influence of the capacitance was studied at a discharged energy of 2 kWh/t. Figure 1 shows that an increase of the capacitance from 60 nF to 110 nF led to an increase in the fragmentation but a further increase of the capacitance from 110 nF to 140 nF had almost no influence on the particle size distribution. Regarding the liberation of the aggregates (Figure 2), an improvement of the liberation rate was observed mainly for the size fraction 8-16 mm when the capacitance was higher than 110 nF. This led to a marked increase of the recovery rate of the aggregates with a size 5-16 mm after just one treatment step (Table 2), these recovery rates being 27.7% and 48.4% for a capacitance of 60 nF and 110 nF respectively.

Figure 1. Particle size distribution of the fragments obtained at various capacitances.

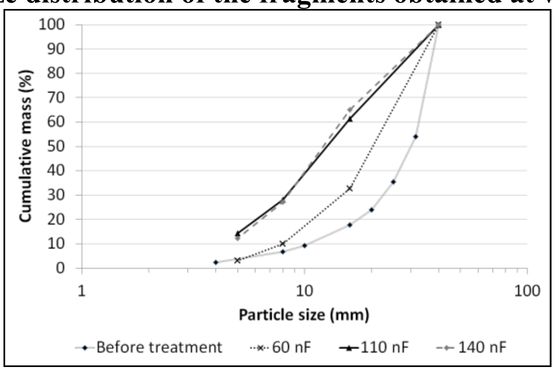


Figure 2. Liberation rate of the aggregates in the size fractions 5-8 mm and 8-16 mm at various capacitances.

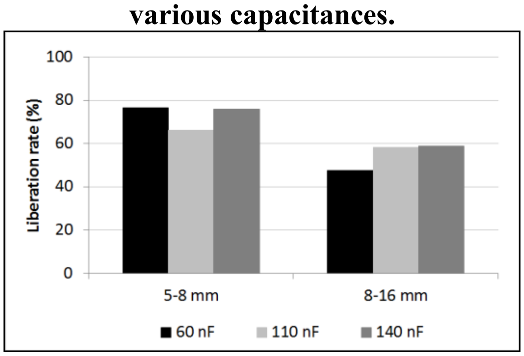


Table 2. Recovery rate of the 5-16 mm aggregates (considering the whole sample).

Discharged energy (kWh/t)	*Capacitance (nF)*	*Recovery rate (%)*
2.0	60	27.7
2.0	110	48.4
2.0	140	58.5
1.0	110	51.1
5.0	110	47.7

Influence of the discharged energy. The influence of the discharged energy was studied at a capacitance of 110 nF. Results are given in Figure 3 and Figure 4. It can be seen that the discharged energy had a small influence on the particle size distribution of the fragments after treatment and almost no impact on the aggregates liberation rate. In particular, the recovery rate of the aggregates with a size 5-16 mm after just one treatment step is about 50% for the three studied discharged energies (Table 2). These results confirm the feasibility of this innovative technique for the selective fragmentation of concrete waste, even at a discharged energy of 1 kWh/t.

Figure 3. Particle size distribution of the fragments obtained at various discharged energy.

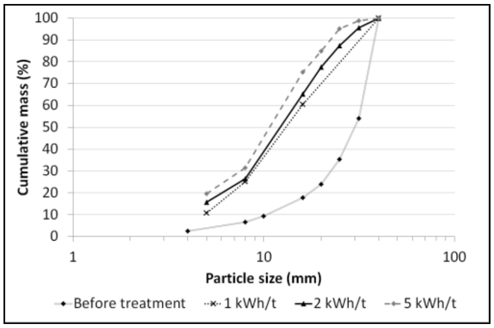
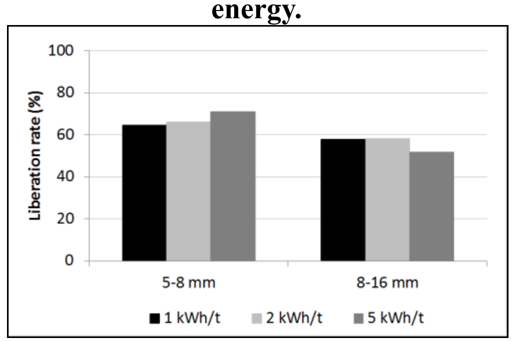


Figure 4. Liberation rate of the aggregates in the size fractions 5-8 mm and 8-16 mm at various discharged energy.



CONCLUSIONS

The work carried out in this study allows assessing at a continuous scale the efficiency of the electrical fragmentation technology for the selective fragmentation of concrete waste. In particular, more than 50% of natural aggregates were recovered after just one treatment step performed at 1 kWh/t which suggests promising results if a recycling loop was implemented. The next steps will be to perform tests with the products obtained after the treatment to check their suitability for making new concrete and to carry out a technico-economic analysis of this new pathway for being able to compare it to a conventional treatment plant.

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