# Waste of the secondary glass waste (glass waste [3]): new solutions for a sustainable industrial recovery

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**Abstract** Nowadays glassy sand, obtained from the secondary waste of glass, is well accepted by glass factories. However, a plant producing this kind of secondary glass generates 3% of waste (glass waste [3]) made of all the impurities usually present in glass waste. In particular, the materials not recovered are represented by ceramics, stones, magnetic and non-magnetic metals, paper, plastics, cork, synthetic corks etc., which are not always easily removable Glass waste [3] is therefore made of exploitable product fractions with different particle sizes and physical (such as density, shape and resistance) properties.

This research is based on data collected from the SASIL plant, and is aimed at solving the issue of the waste of this kind of process implementing a pilot plant already present.

Representative samples of feed material (glass waste [3]) and of different products of the pilot plant have been characterized and laboratory tests were executed to improve separation efficiency and to valorise the different product fractions. A new treatment plant has been designed and economic evaluation has been made. The materials to be traded as secondary raw materials (SRM) – such as plastics, metals, synthetic and cork stoppers – are near 90% of the total feed of the plant.

**Keywords:** density separation; jig; new treatment plant design; bath extractor

## 1. Introduction

Most of the glass recycled in Europe today comes from the collection of packaging from the public surface. The selection and treatment of the glass are completed in treatment plants, where the waste is processed into a raw material suitable for glass factories, called cullet(AA.VV 2015, ARPA 2016, Blengini 2012).. Once cullet reaches the treatment plant, it is subjected mainly to the following treatments: manual sorting for elimination of foreign bodies; magnetic separation of ferrous metals; separation of non-ferrous metals by means of induced currents; crushing by means of a roller mill; size classification with a vibrating screen; separation of light materials by means of a cyclone; and separation of glass into different colours using an optical sorter (CO.RE,.VE 2012, 2015, 2016). The material so treated, which must meet the EU End-of-waste regulation and the specifications of the glassmaking industry, is delivered to the glass factories where the recycling process is completed: melting the scrap at high temperatures to be processed into new containers, typically containers for food and beverages.

The impurities in the cullet can be considered not as a waste destined for landfills, but as possible exploitable product fractions (Bharat & Bhargava 2016). Their relocation on the market, in fact, allows businesses to achieve both a reduction in costs due to not paying landfill fees, but also an economic return from their sale to potential re-users. In waste of this kind of secondary glass, there are secondary materials present that are of some value in particular: light plastics, corks, synthetic stoppers, aluminium, iron, heavy plastic and rubber, with estimated economic values, respectively, from 500€/t to 10€/t. Light plastic has the highest value among glass waste. Moreover, according to COM(2015) 614 final of European Commission on the Circular Economy, the recycling of plastics is a key point in the circular economy. The use of this material in the Union has grown steadily, but less than 25% is recycled and about 50% is deposited in landfills.

## 2. Materials and methods

### *2.1. Materials*

Figure 1 shows a flow chart of the actual SASIL plant for the treatment of glass waste [3]. Five samples have been taken from different sections of this plant in order to characterize them and to optimize the process. The plant consists of three sections indicated as: ORV, OVP and CVR of the SASIL plant.

All samples were taken with a shovel sampling, i.e. by taking the material from different points of the pile.

Samples 1 and 2, almost identical to each other, constitute the final waste treatment processes that take place in SASIL and represent the plant feed. These two samples have been collected from the same point of the plant in order to compare the results obtained respectively after manual and automatic sieving.

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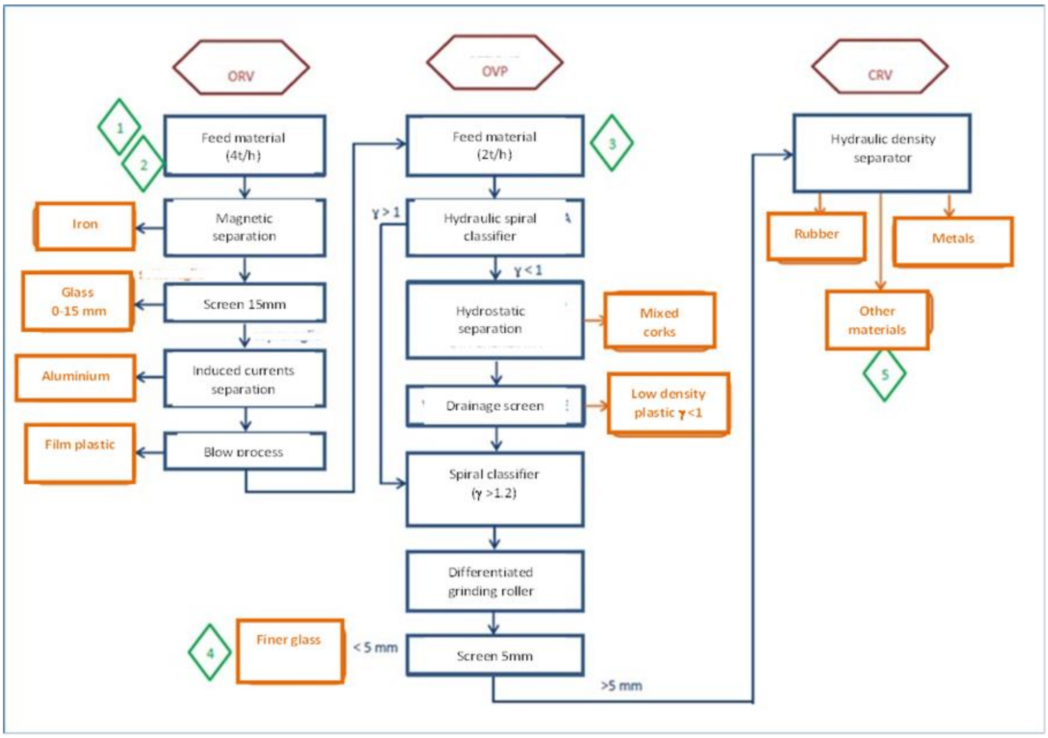


**Figure 1.** Plant operation for the recovery of glass waste [3]: in brown the main section of the plant.

Sample 3 was taken from the feed of the OVP section and was constituted by material that had already undergone some initial treatments, such as: a magnetic separation to remove the ferrous parts present, a sieving with a 15 mm opening, a separation eddy current, to eliminate the non-ferrous metal parts, a blow process to extract the light elements, such as plastic film, paper and fabrics.

Sample 4, collected at the end of the OVP section, was the result of the following wet treatments: a hydraulic separation with spiral classifier, enabling the division of the flow of light (less than the density of water) and heavy materials (greater density of water), a further hydrostatic separation; a drainage screening, to remove part of the water present; differentiated grinding roller which is able to crush hard elements such as glass and flatten soft elements such as rubber. The materials having a size > 5 mm go to the CRV section with another wet separation based on density to separate rubber, metals and other materials. Sample 5 was taken from the final pile of waste from the plant

*2.2. Methods*

The method mainly used for the sampling of the material was coning and quartering, but for smaller particle-sized material the Jones sampling apparatus was used.

In order to characterize the samples taken from the different sections of the plant the following analyses have been performed:

-particle size analysis (manual and authomatic);

-classification by waste type using macroscopic and microscopic observation;

-magnetic separation;

-sink-float.

In order to optimize the plant process and to increase the separation efficiency of the different materials to be valued, the following laboratory tests were performed:

-bar sieving;

-jigging separation;

-bath extractor (new technological solution).

A bar sieve of 16 mm opening was used initially to separate the caps, both synthetic and cork stoppers, from all the other materials: in fact, those having greater thickness are retained by the sieve, while the other thinner ones pass through it. This kind of sieving has been useful in a first formulation of a plant, but in a second plant design the bar sieve with a 16 mm opening has been substituted with a 12.5 mm square-mesh sieve.

The jig separates light plastic, ceramic and glass stones based on density. It works using a fluid medium: the repetition of short cycles resulting from upward water pulses (fixed sieve) on which the grains are separated based on their density.

The bath extractor represents a new laboratory test for lightweight plastic separation (sinking) of synthetic and cork stoppers (floats). The instrumentation is composed of a stator with a rotor inside (with a maximum velocity of 2000rpm), a grid and a tank containing water. The currents generated by the rotation of the rotor within the stator attract downwards materials that are characterized by a density slightly lower than those of water density (r 0.9), while lighter materials are drawn upwards (r 0.3 -0.5). The rotor stator system is essential for the generation of currents favourable to this kind of separation. The presence of vortices in the bath, on the other hand, does not generate similar results, but attracts all the material to the bottom of the bath.

## 3. Results

From the particle size analysis and the sorting of waste type of the new SASIL plant for recovery of glass waste [3] it is possible to point out the following characteristics. The plant feed has materials with a predominant particle size of about 10 mm material; glass is about 40% of the material and is significantly present in the classes between 9.5 mm and 4.0 mm. The fine fraction is very abundant and should be removed before the next stage of the treatment process. The plastic represents slightly less than one-third of all the materials and is more present in larger classes (lightweight plastic), while heavy plastic prevails in the smaller ones . The caps are present only in the first classes i.e. those over 16 mm.

Analysis of sample 3 collected from the second section of the plant (OVP) showed it has an average size of between 16.0 mm and the 6.3 mm. The fine fraction was significantly reduced but still represents a disturbing element for the processes. The non-ferromagnetic metals, as well as the plastic film, were still significantly present, which indicates a poor efficiency of the separator compared to induced currents and the blowing system. The plastic, finally, is the most abundant fraction, and more present in the larger grain size classes, while glass is present in smaller amounts and mainly has dimensions of 6.3 mm.

The final product of the OVP section (sample 4) had a particle size predominantly less than 5 mm and consisted of about 60% glass still containing 40% of impurities, thus representing a non-satisfactory result of the second treatment section.

The final product of the last section, (sample 5) is composed equally of glass, plastic and rubber, indicating an insufficient efficiency of the last separations.

In figure 2 the results of classification by waste type of sample 1 and sample 5 are shown. As can be noted, the percentage of glass decreased from 42%.to 22%. Moreover in sample 5 (which represents the real waste of the plant in at the moment) there is a considerable amount (of about 20%) of plastic and rubber.

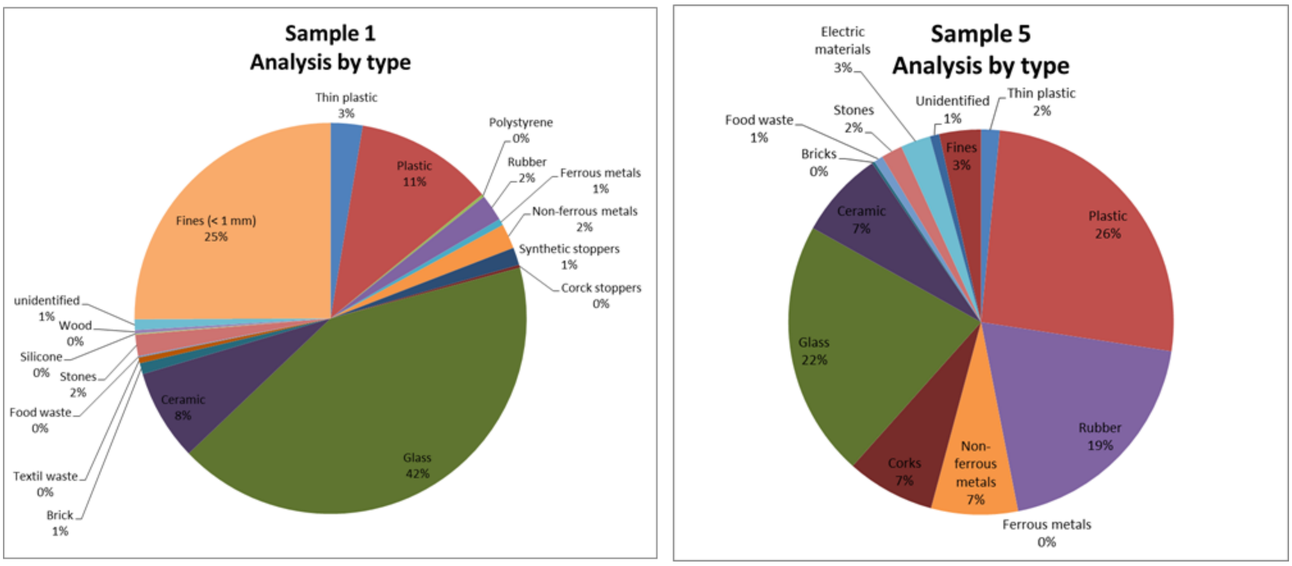


**Figure 2.** Classification by waste type of the sample 1 and 5 from the SASIL plant.

**Table 1.** Jigiing separation of plastic from other materials with minimum dimension of 12.5 mm

| | Percentage of material on jig bed (%) | Percentage of material on jig top(%) |
|---|---|---|
| **glass** | 1471.9 | 86.6 |
| **ceramic** | 304.1 | 49.9 |
| **brick** | 39.7 | 9,5 |
| **stone** | 58.6 | 2.2 |
| **plastic** | 8.24 | 106.5 |

In table 1 the results of a jigging separation executed in laboratory on a sample constituted by glass, ceramic, stone, light plastic of a minimum dimension of 12.5mm are shown: a separation efficiency of 92% can be calculated.

Thanks to the new separation techniques experimented in the laboratory it has been possible to design a new process plant for glass waste [3]. Table 2 shows the apparatus suggested for the new plant and the amount and percentage of the material separated. The amount in percentage of the products with an economic value obtained by the new plant are the 87.5% of the total. They are in particular ferrous materials , non-ferrous metals, glass fine, syntetic and cork stopper, low density plastic , glass, ceramic and stone. Table 3 shows the percentage of the different materials separated with the new plant.

**Table 2.** The new process plant suggested: apparatus, amount and percentage of different materials obtained with the new plant

| Apparatus | Materials | Mass[g] | Percentage on the total material [%] |
|---|---|---|---|
| Magnetic separator | Ferrous metals | 31.4 | 0.8 |
| Induced current separators | Non-ferrous metals | 76.5 | 1.9 |
| Screen with opening of 5 mm | [undersize material] glass finer with impurities | 520 | 12.7 |
| Screen with opening 5 mm | [oversize material] | 3454.6 | 84.6 |
| Blowing apparatus | Film plastic | 114.8 | 2.8 |
| Coclea | Low density material | 509.3 | 12.5 |
| Bath extractor | Syntetic stoppers +corks | 138.87 | 3.4 |
| | Low density plastics | 370.4 | 9.1 |
| Spiral classifier | High density material | 2830.5 | 69.3 |
| Screen with opening of 12,5 mm | Oversize material | 645.2 | 15.8 |
| Idraulic jiigging | [low density] high density plastic + rubber | 109.4 | 2.7 |
| | [high density] glass, ceramic, stone | 535.8 | 13.1 |
| Screen with opening of 12,5 mm | undersize | 2185.3 | 53.5 |
| Idraulic jiigging | [low density] high density plastic+ rubber | 288.9 | 7.1 |
| | [high density] glass, ceramic, stone | 1896.4 | 46.4 |

**Table 3.** List of valuable materials obtained with the new plant

| Waste type | Total mass (%) |
|---|---|
| Ferrous material | 0.8 |
| Non -magnetic material | 1.9 |
| Glass fine not pure | 12.7 |
| Stopper (cork and synthetic) | 3.4 |
| Low-density plastic | 9.1 |
| Glass, ceramic, stone | 59.6 |

Based on the mass of light plastic in table 3, considering a plant processing 4t/h of glass waste [3] and 3.200 h/year of production, 9% of that material with a value of 500€/t represents not only a consistent environment value but also an economic advantage.

## 4. Conclusions

The waste material of the SASIL ( glass waste 3) consists of exploitable product fractions, resaleable as secondary raw materials, which account for approximately 87% of the total input to the system and turn out to be glass, lightweight plastic, ferrous metals, non-ferrous metals, and synthetic and cork stoppers. Plastic in film, heavy plastic and rubber, however, have less economic value: for this reason they do not justify any recovery process.

In order to place on the market the new secondary raw materials, they must have a high degree of purity (average 80%). Treatments such as magnetic separation, eddy current separations, sieving and densimetric separations, which are able to differentiate the product fractions, are used. In particular, the new separation treatments suggested, such as jigging and bath extractor, are characterized by an efficiency higher than 90%.

All the performed separation treatments have given rise to a project for a new plant whose goal is primarily to provide environmental benefits: a lower impact on the environment achieved by a lower use of raw materials, a lower consumption of energy and a reduced contribution of landfill material, as well as a decrease in the emissions generated by all processes. In addition, the sale of the obtained secondary raw materials would provide a considerable economic return, able to support all management costs and to provide a considerable annual gain.

## References


AA.VV. (2015). Approfondimenti settoriali dedicati alle singole filiere di riciclo e recupero - Vetro. *L'Italia del riciclo*

ARPA, P. (2016, 11 14). from https://www.arpa.piemonte.gov.it/approfondimenti/temi-ambientali/rifiuti

ARPA, V. (2016, 11 10). from http://www.arpa.veneto.it/temi-ambientali/rifiuti

Bharat N. & Bhargava V.P., (2016) Effect of Glass Powder on Various Properties of Concrete, *International Journal of Science, Engineering and Technology*, 2016, Volume 4 Issue 4 ISSN (Online): 2348-4098 , ISSN (Print): 2395-4752

Blengini G.A., Busto M., Fantoni M., Fino D. (2012) Eco-efficient waste glass recycling: Integrated waste management and green product development through LCA. *Waste Management* 32 1000–1008

CoReVe. (2012). Riciclo del vetro, spazio all'innovazione. Ecoscienza, 52-53.

CoReVe. (2015). Piano specifico di prevenzione 2015.

CoReVe. (2016). Piano specifico di prevenzione 2016.

European Commission COM(2015) 614 Closing the loop – An EU action plan for the circular economy Bruxelles, 2.12.2015, 23p.