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RESEACH INTO THE USES OF SANDBLASTING WASTE

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Abstract: This article deals with an investigation into the recycling possibilities of sandblasting waste. As part of this, we are investigating the loss of mass of components or the materials in the waste. Furthermore, the potential for the use of these substances in different industries will help to reduce environmental pressures and meet the high demand for raw materials.

Keywords: *sandblasting, grain scattering, raw material, sand, recycling*

1. Introduction

The idea of writing this article is a joint project work, LIMBRA project, involving students from Hungary, Poland, the Czech Republic and Slovakia, and their teachers together with BPI Group Hungary and the University of Miskolc, Institute of Machine and Product Design. Within this framework we have been involved in the investigation of sandblasting technology and its generated waste. Hence this became the basic idea for this article theme. The company mentioned above cleans metal parts by sandblasting which at the end of the process produces a significant amount of waste, which is stored in landfill. Deposit of this waste is not the targeted way as the company is focused on environment. The question may therefore be arisen: whether the waste contains any recyclable raw materials? Of course, when examining the process, it is clear that it contains. As the starting material of the sandblasting in this case is glass beads or broken glass, they certainly appear in most of the waste and are likely to contain materials useful for other raw materials. It is worth thinking about how sandblasting waste can be the raw material of a new product or how it can appear on the market as a finished product.

2. Testing of the material used

We started our work by examining the material used for sandblasting. The pre- and post-use status of the substance was also examined. First, we did microscopic examination scans of the samples we received. In *Figure 1 (a)* you can see the macroscopic image of the material used (taken with a normal camera). One of the microscopic images can be seen in *Figure 1 (b)*.

(a) (b)

Figure 1
(a) Pre-use condition, clearly visible that it is not sand but broken glass,
(b) microscopic recording

The microscope scans were taken using a Zeiss Discovery V12 type microscope. With the help of a program called Axio Vision for the microscope we were able to make measurements of the particle size of the resulting sample. The measured values are clearly visible in *Figure 1 (b)*, the material used had approximately 0.5 to 0.6 mm particles initially. Observing the shape of the particles you can see sharp, pointed surfaces. Particles of this shape can function as the edge of a cutting tool during sandblasting. The BPI Group Hungary has also given us a sample classified as waste. The consistency of this is almost flour-like. Classification of granular substances can be carried out on several scales (Atterberg, Krumbein, ISO14688-1) [1]. The microscopic recording is shown in *Figure 2*.

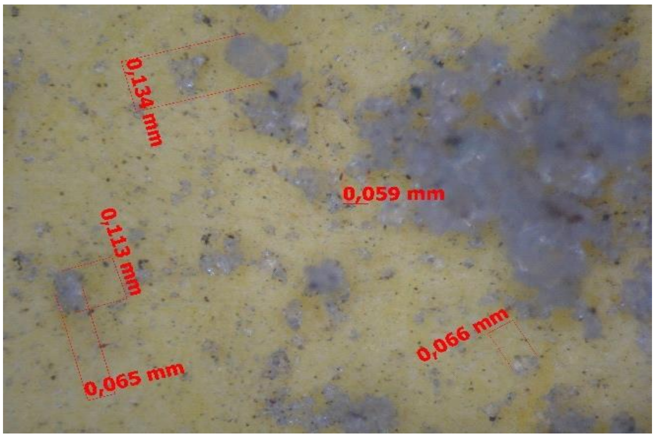


Figure 2
The broken glass after usage

3. TESTING OF RESULTING WASTE USING A SCANNING ELECTRON MICROSCOPE

We hypothetically assume that there are also components in the waste that are not indicated in composition data received from BPI, so the waste was tested using a scanning electron microscope. *Figure 3* shows the resulting waste sample at a magnification of 20 times. Let's look at what we can see in the microscope image: it is clear that there are two types of material that make up the waste, one is the glass used for cleaning, which appears in grey and the other is illuminated in white, these are metals in the waste. The majority is silicon, but also significant amount of potassium came from the glass raw material (potash-glass). As a result of the test we can conclude that a measurable amount of material is removed from the surface of aluminium components by the particle dispersion technology. Material removal changes the dimensions of the purified elements. The mass of the component is reduced.

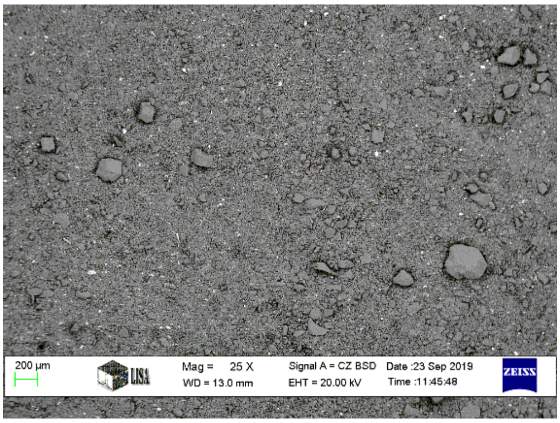


Figure 3

Image of scanning electron microscope 20× magnification

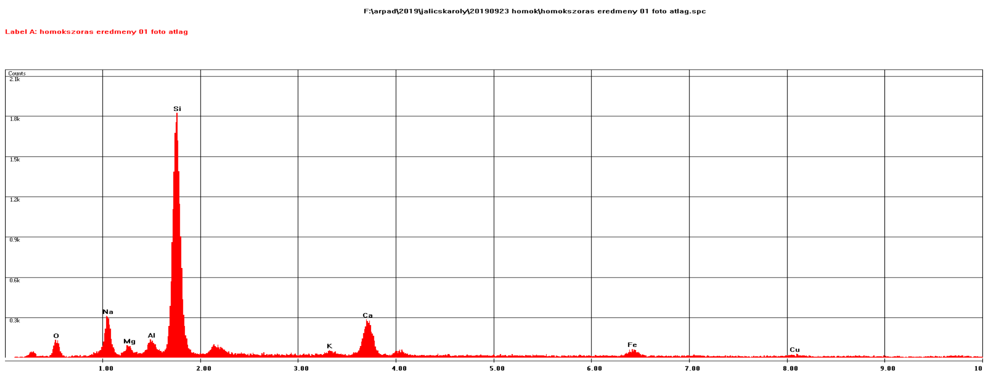


Figure 4

Composition of waste shown in Figure 3

4. SEPARATION OF WASTE INTO CONSTITUENT ELEMENTS, FINDING POSSIBLE SOLUTIONS

As part of the LIMBRA project Slovak-Czech team members carried out experiments to separate the waste with hydrochloric acid. We would like to present a description of the experiment we performed, the course of the tests and their results are summarized below. Exact description of the experimental method is:

- 20 grams of uncleaned glass waste was measured and placed in beaker. 50 ml of 1 : 1 hydrochloric acid solution was added to the waste then thoroughly mixed and then allowed to dissolve for 15 minutes.
- The solution was filtered, so the acid solution was separated from the solid glass. The filtration was carried out with filter paper type 388 (84 g/m^2).
- The remaining glass was washed with water and then filtered.
- Drying was carried out at room temperature and allowed to dry for 48 hours.

The result is presented in *Figure 5*. You can see that the colour of the waste has changed (less dark) and it has become cleaner.

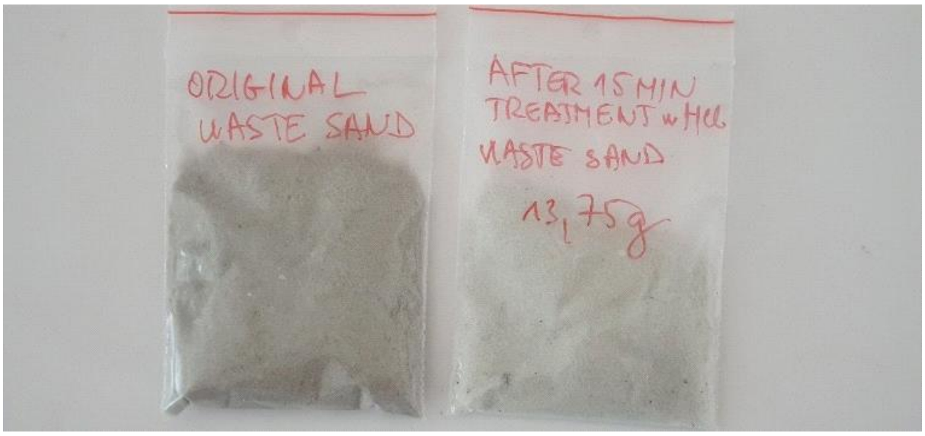


Figure 5
The result of the experiment after acid-treatment, filtering and drying

We can conclude that it is possible to clean up, so that not only the mixed material but also the purified material can be used for new applications.

5. WAYS TO USE THE WASTE

In the previous chapter we could prove that waste consist of variety of substances. We will look at the possibilities of using this waste. To make the subject clear we need to make assumptions as follows:

- Waste is not tested in its current mixed state but in a purified state;
- We assume that there are technologies to separate individual substances in waste;

- We take into account the main constituents and also as if they could be completely separated from other impurities.

Based on these assumptions the main ingredient in waste is the glass used for sandblasting, so its uses fall under primary attention. Of course such attention will also be paid to metals that appear in significant quantities in waste.

6. RECYCLING OF GLASS AS A SANDBLASTING MATERIAL

Here the primary goal is to produce particles of the same size as the original. Of course, this will be a procedure that can be quite costly since melting requires very high temperature, which entails a high energy requirement. In the process of producing glass different materials are fused and after cooling the fluid material we get the glass which can be melted again. That's a very important property. The temperature required for melting and glass cleaning depends on the exact composition but varies between 1,300 and 1,550 °C [2]. Since the heating of furnaces is traditionally achieved by burning fossil sediments it is necessary to look at the energy demand. This is important so that we can see how much energy is needed to produce glass but if we approach the same from the side where recycling does not need new glass significant energy can be saved. The melted glass is cooled and shaped to form depending on the technology: a large block is formed and then cut to the right size, broken or machined straight to the right size, i.e. the formation of a glass bead from the melt.

7. RECYCLING OF GLASS IN THE CONSTRUCTION INDUSTRY

Construction is specifically a sector where there is a high demand for raw materials, and it can make very good use of the properties of glass. There are many benefits to reusing glass in the construction industry. The main advantage of this is that we can reduce the need for raw materials during the construction of building materials or constructions. This is very important aspect when you consider that the earth's energy reserves are finite and therefore, we do not have an unlimited amount of raw materials. If you look at the simplest case glass waste can be used as a filler for various fillings and foundations. However much better solutions can be found in this industry so the next way to use it is to produce glass wool. Glass wool is made from a mixture of raw materials in the glass industry: glass tiles, limestone, sand, dolomite, sodium carbonate and boron oxide or boric acid [3]. Unusable damaged and mixed glass debris may be used for road construction when mixed with asphalt. The so-called glass asphalt made in this way complies with professional standards and has the same property and durability as conventional asphalt. In its manufacturing part of the natural additive is replaced by glass debris. However, its most important use can be observed in the production of concrete. This is of particular importance, since concrete production requires a lot of raw materials, so we can replace them, resulting in significant savings in raw materials. Natural additives can be replaced by glass waste. In cement production when milled glass is mixed with cement it increases the strength of large concrete bodies and dams. The second case is a technology called

“Geofil Bubbles”. “Geofil Bubbles” is a glass-based expanded gravel additive from recycled waste with a high glass content of industrial and communal waste (from the collection of packaging waste).

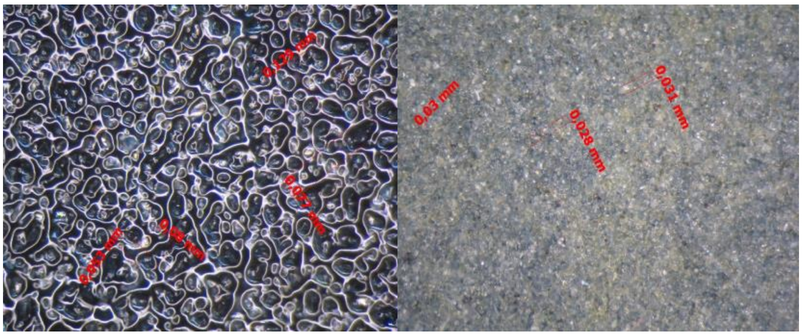
Figure 6
Geofill Bubbles

Glass waste with a high glass content mixed with contaminated paper and caps is milled to appropriate particle size, homogenised with gas-forming waste and then granulated. After heat treatment of the granules, a material with a high specific surface is applied as the last layer in order to control the ability to absorb water. After drying, a rotary oven with adjustable rotational speed and slope angle is heat treated and cooled abruptly. The density of the foam gravel thus produced shall vary between 200–1,200 kg/m^3, water absorption capacity is between 0.1 and 45% by weight as needed.

8. Glass as an abrasive raw material

Particle with such sizes which are no longer possible to use for machining metals may be used for sandblasting of other surfaces. Use the Mohs hardness table: most of the grains used in sandblasting are in 7th hardness level, which is quartz, but in the factory a small amount of corundum material is also used for sandblasting. So, we can conclude that the tiny grain-sized glass could be suitable for glasses, window panes, etc. sandblaster, which can be used to engrave any pattern or possibly letters in the glass.

Let us take a closer look at the abrasive paper for the purpose of producing such a product from existing purified glass. As we look at the structure of the sandpaper itself, it can be said that the substrate of a good part of the abrasives on which the particles are fixed is paper or canvas, on the surface of which the abrasive particles of various materials and sizes are encapsulated in a special binder layer. Abrasives can be divided into three groups according to their fineness. The fineness grade may be determined by the number of particles per 1 mm^2.



(a) (b)

Figure 7
(a) P400 sandpaper at 100× magnification,
(b) P1200 sandpaper at 100× magnification

Here we can consider the results to be significant. This means that the particle size on P400 sandpaper is adequate, or that any finer sandpaper can be produced with further milling of the existing crystals. Since the desired particle size has already been achieved, the focus should now be placed on the granules. In general, 4 different materials are used as abrasives: Silicon carbide, Al-oxide, zirconium ores and ceramic corundum [4]. The most common substance of these is also silicon carbide. The classification of particle varieties by hardness, toughness and area of use can be examined in *Figure 8*. Since we have silica, which is not as hard as silicon carbide, it is clear that it would wear out faster during use. However, the hardness difference is not so large so we can say that our material could clearly be used as abrasive material as it has been used for a long time.

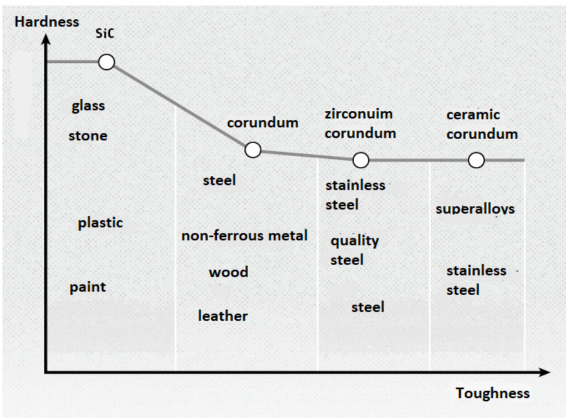
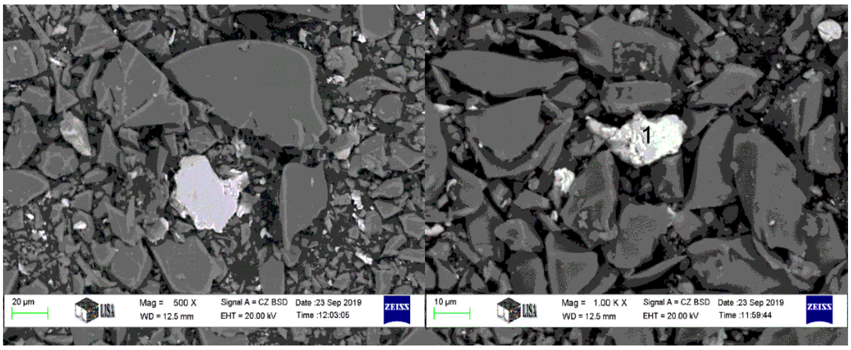


Figure 8
Classification of grain varieties

9. SCRAP METAL USES

The most basic option is to sell metals on the market in their sorted form so we can melt these metals and serve as the raw material for any product in the future. Of course, this is the easiest way. Here we can mention any industry that works with metals the automotive industry is the simplest example, but to connect to BPI we can also produce new generator housings, self-starter housings or brake callipers from these metals. If we start from the particle sizes it can also be said that in the sinter technology, we could use these particles as raw materials or in metal printing, thus finding new industrial applications for scrap metal. However, there is a very important industry where particles of different metals could be widely utilized. It's the paint industry. Take some basic knowledge of the production of paints with special attention to the production of coloured paints. Paints consist of 3 main components: binder, pigments, solvents. The quality and quantity of pigment determine ink/dye properties such as colour, colour strength, colour durability and opacity. Pigments are predominantly micronin so we need to look at the size of our available particles [5]. *Figure 9* shows the size of two different metal particles.



(a) (b)

Figure 9

(a) a Fe grain at 500× magnification,
(b) a Zn grain at 1,000× magnification

According to the results the average size of the particles varies from 10 to 30 micrometres, so this is too large for paint. However, if you continue to reduce the size, they may be suitable for this purpose.

10. SUMMARY

Based on the above chapters we can conclude that the blasting technology removes a significant amount of material from the surface of the cleaned parts. Removed material is present in the waste. Furthermore, the most significant part of the waste is the sandblasting material, the glass. As you can see in this article it is an important question in today's raw material hungry world to ponder how these materials could be recycled. We were able to find many solutions for both glass and scrap metal.

Thus, in summary certain substances in sandblasting waste could be used very widely and these uses would make a major contribution to reducing waste emissions, thus reducing the environmental pressures. It could also be an important link to the European Union's new Green Deal plan.

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