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PROCESSING OF ALUMINUM CABLES USING THE ELDAN INSTALLATION

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Abstract: Even though there are many types of cables that end up in recycling centers, regardless of their nature or shape, they follow approximately the same processing steps: shredding - magnetic / electrostatic / gravimetric separation - granulation. After granulation and separation, the metal fraction obtained in the Eldan installation has a purity of minimum 99.1%. The obtained material was chemically characterized on site by means of X-ray fluorescence spectrometer (Portable XRF Thermo Scientific Niton XL3t). The obtained granules were thermally processed by remelting and refining and subsequently after casting and solidification of the metal followed a drawing process to obtain cables of different sizes (Ø7.6; Ø6.1; Ø5.6; Ø5.1). The samples taken were analyzed compositionally and with an optical microscope. Most of the samples corresponded to the required requirements, but there were also defective samples - oxide films, inclusions and overlapping material.

Keywords: productivity, ELDAN, aluminum wire, recycling

INTRODUCTION

Aluminum is the most abundant metallic element in the earth's crust and the third most abundant chemical element. Bauxite is the ore from which more than 95% of world aluminum production is extracted. According to their aluminum and iron content, bauxites can be white (very rich in Al_2O_3, 60-70%), red (rich in Fe_2O_3, 20-25% and poorer in Al_2O_3, 40-60%) and gray (poorer in Fe_2O_3 and Al_2O_3 than the red ones, but richer in SiO_2).

Currently the most common technology for obtaining alumina is based on the Bayer process.

The Bayer process for extracting alumina from bauxite is carried out in three stages:

- obtaining sodium aluminate by chemical reaction between bauxite aluminum oxide and caustic soda;
- decomposition of the aluminate solution into aluminum hydroxide and sodium hydroxide, under certain conditions of temperature, concentration, reaction time and addition of primer (fresh aluminum hydroxide);
- calcination of filtered aluminate hydroxide at high temperatures to remove the water of crystallization and obtain calcined alumina.

— The principle of obtaining aluminum from alumina

Under industrial conditions, aluminum is obtained by melt electrolysis of alumina dissolved in an electrolyte at about 950°C.

The technological process of manufacturing aluminum has two distinct phases:

- processing of raw materials with aluminum content in order to obtain alumina;
- electrochemical separation of aluminum from alumina by electrolysis.

The electrolyte consists of a mixture of sodium fluoride (NaF) and aluminum fluoride (AlF_3) which is in a proportion similar to that corresponding to cryolite ($AlF_3 \cdot 3NaF$).

The electrolysis process is carried out by passing a high current of direct current - usually up to 700,000 A - and under low voltage of about 4 V. The installation in which the aluminum deposition process takes place is called an electrolysis cell or tank.

— Aluminum recycling

Recycling aluminum means 95% less energy than producing primary Al. Recycling began in the 1900s, expanded during World War II, and exploded with the use of cans for bottling.

Sources of recycled Al include: airplanes, cars, bicycles, boats, cooking utensils, cables, metal joinery, etc. Even though used Al beverage containers make up the bulk of recycled waste, there are many other components that are suitable for this operation, such as electrical cables.

Of course, in the market economy the possibility of recycling is directly related to the recovery of residual values, in the sense that it will be directly proportional to the willingness to make efforts for such a process. From the perspective of recycling, aluminum and its alloys are exceptional materials, as the number of recycling without significant quality deterioration is indefinite.

Almost all the energy absorbed in the first stage of metal production, more precisely 95%, is preserved in the material and ready to be reused at the time of melting. As a result, the production of one kilogram of recycled aluminum has an energy requirement equivalent to 5% of the production of one kilogram of electrolytic metal.

For these reasons, the market exploitation of aluminum waste deserves to be taken into account and is economically viable. We can describe the virtual cycle of light metals, which is frequently described as an energy bank, given that the energy absorbed during production is conserved, which is subject to optimization processes over the years. Energy is saved during manufacturing processes and can be recovered during recycling.

The end result is that the use of secondary aluminum provides not only huge savings in resources, but also an ecological benefit, with reduced emissions compared to the electrolytic process and the guarantee that the material will re-enter a production cycle, therefore without the risk of an ecological impact.

It is estimated that in 2016, in Italy alone, at a production of approximately 600,000 tons, the greenhouse effect was reduced by reducing CO_2 emissions by over 6.5 million tons and saving the energy equivalent of over 2.3 million tons of oil. It should be recalled that in Italy, aluminum producers, especially manufacturers and users of packaging, have complied with national and European provisions and the Consortium of Aluminum Packaging (CiAL), which offers guarantees to companies operating in the process of recovery and recycling and which, by the development of post-consumer recovery of aluminum, contributes to the exploitation of the intrinsic characteristics of the metal in the context of a competitive system.

Also, in the period 2013-2014, the European Union devoted itself very much to the debate on recycling, from which arose the opportunity to complete the existing directives with a new approach, focused on materials rather than flat products at the end of life cycles. In this phase, aluminum has excellent opportunities from the perspective of sustainable development from an economic, social and ecological point of view, given its intrinsic properties that make it advantageous in use, in terms of resource conservation and environmental protection.

Within SC Remat Bucharest South SRL, approximately 1000 tons of aluminum are recovered annually from different types of waste. With the help of the Eldan installation, the cables from different electrical installations are processed, finally obtaining aluminum granules.

In 2021, the aluminum market was growing (the variation of the aluminum stock exchange prices is shown in the figure 1), Remat Bucharest South managing to process 335.22 tons of Aluminum cables on the Eldan installation.

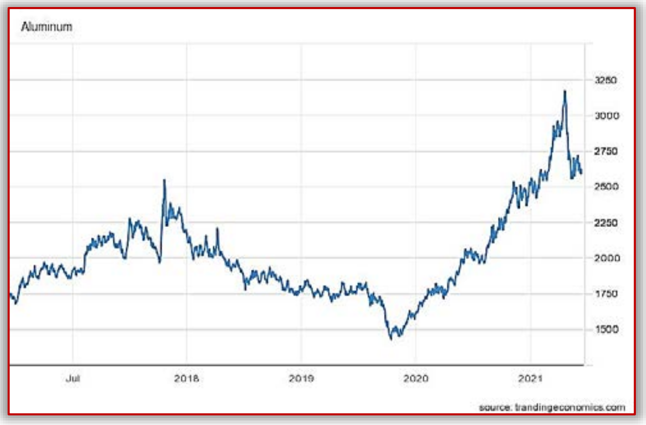

Figure 1. Stock exchange prices for aluminum [4]

Following their processing, 149.19 tons of aluminum granule were obtained. The granule brought revenues amounting to 237,361 euros.

MATERIALS AND METHODS

There are many different types of cables with a variety of different material compounds: flexible wire cables, household cables, power cables, underground cables, copper and aluminum cables, and high-voltage cables with V-PE sheaths. Inherently, the strands in the core are valuable as a secondary raw material due to the high metal content. In most cases, the individual materials in the cable or flexible wire adhere very closely to one another. To expose and process these fractions requires recycling technology that produces small grain sizes for optimum separation.

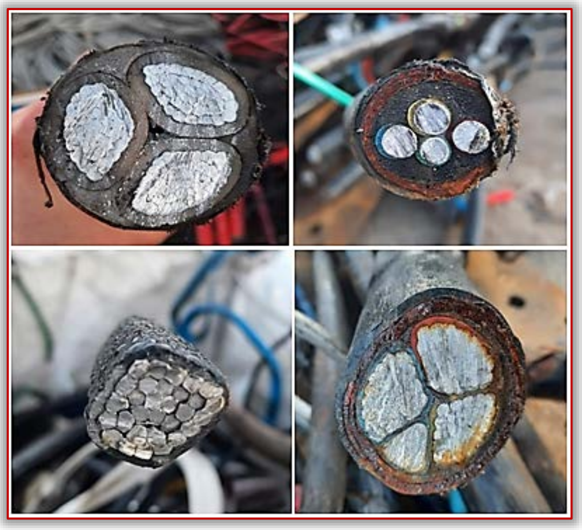

Figure 2. Different types of aluminum cables

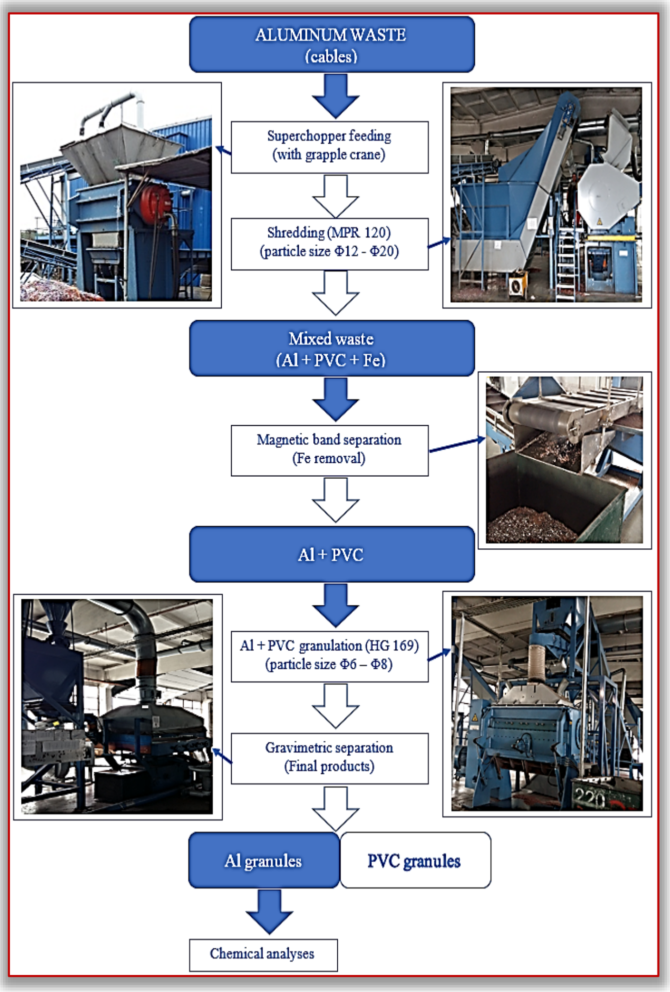

Figure 3. Technological scheme of the process

The Eldan installation has shown greater flexibility than expected in terms of the materials it can process. Today, the system can also successfully process used tires. The waste of Al cables (Figure 2) is loaded with the graft type machine in the Super Chopper tank where they are chopped to dimensions that allow their feeding in the Shredder. A conveyor belt system is used to transport the material. At the exit of the Shredder the ferrous fraction is collected by means of the magnetic belt, and the Al fraction is collected at the end of another conveyor belt.

The cables were processed according to the technological flow shown in Figure 3.

The material introduced on the Eldan installation has the following technological flow: it is chopped, granulated, after which it is electrostatically separated. Electrostatic separation is based on the difference between the conductivity of the materials that make up the mixtures of ground materials in cables: conductive metals and non-conductive plastics.

The principle of operation consists in loading with electric charges for a certain time the surfaces of non-conductive materials, either by ion or electron bombardment, or by friction and thus, the charged particles can be separated from the other uncharged (non-conductive ones).

The particles move in a field generated by an electrode of direct current and high voltage (over 35 kV), being loaded with electric charges. The conductors will be unloaded immediately and will be removed from the drum under the action of centrifugal force. The non-conductive particles will adhere to the drum, being maintained by their own load, and from here they will be directed to another area by brushing.

In 2020, approximately 500 tons of aluminum cables were processed on the Eldan installation, from which: Al granules - 114 tons (Figure 4); Fe - 42 tons; PVC - 344 tons.

Figure 4. Al (Ø8) cable processing sieve and aluminum granules

The obtained material was analyzed to determine the constituent elements by means of X-ray fluorescence spectrometer (Portable XRF Thermo Scientific Niton XL3t).

Al granules processed at Remat Bucharest South were shipped to processing units in order to obtain wire drawn from Al. After processing (melting + correction of the composition, see table), drawn wires of a large dimensional variety were obtained - Ø7.6; Ø6.1; Ø5.6; Ø5.1.

The drawn wire samples were analyzed under an optical microscope, at room temperature, without attack, at magnifications of x25 and x200 and also in terms of chemical composition to determine the purity of Al wires.

Most of the samples corresponded to the required requirements, but there were also defective samples (oxide films, inclusions and overlapping material).

RESULTS AND DISCUSSIONS

The aluminum processed in the Eldan plant, resulting in the form of granules, was analyzed compositionally on the spot using the portable device Niton 3XL3t.

Table 1. Chemical compositions of the recovered material

Element	CC Top	CC2 Middle	CC3 Base	Mean
Al	95.89	96.18	95.96	96.01
Si	2.440	2.420	2.390	2.417
Fe	0.598	0.633	0.622	0.618
Zn	0.056	0.055	0.055	0.055
Zr	0.003	0.003	0.003	0.003
Sb	0.026	0.028	0.032	0.029
Pb	0.006	0.009	0.008	0.008
Total	99.019	99.328	99.070	99.139

Three analyzes were performed from several areas of the material pile (top, middle, base) averaging these values.

The constituent elements by means of X-ray fluorescence spectrometer (Thermo Scientific Niton XL3t) were presented in Table 1.

After reprocessing the Al granules by melting - refining - drawing processes to obtain different types of cables, which will be reused mostly for the same applications, the purity of the material was established by performing standardized chemical analyzes. The chemical composition of recycled aluminum in the form of cables is shown in Table 2.

Table 1. Chemical compositions of Aluminum cables

Elem.	S1	S2	S3	Mean
Cu	0.0033	0.0035	0.0036	0.0035
Fe	0.0853	0.0937	0.0911	0.09
Si	0.0495	0.0522	0.0484	0.05
Mn	0.0010	0.0010	0.0010	0.001
Mg	0.0010	0.0010	0.0010	0.001
Zn	0.00484	0.00526	0.00491	0.005
Ni	0.0028	0.0033	0.0029	0.003
Cr	0.0010	0.0010	0.0010	0.001
Ti	0.0010	0.0010	0.0010	0.001
V	0.00198	0.00207	0.00196	0.002
B	0.00701	0.00703	0.00697	0.007
Pb	0.00197	0.00205	0.00197	0.002
Ga	0.0071	0.00697	0.0070	0.007
Al	99.8322	99.8199	99.8272	99.8264
Total	100	100	100	100

Samples were prepared from the defective areas of the drawn cable samples for microstructural analysis. Various material defects were highlighted: oxide films (Figure 5b), material overlaps (Figure 5c) and non-metallic inclusions (Figure 5d).

Materials with major defects have been returned to the manufacturing cycle.

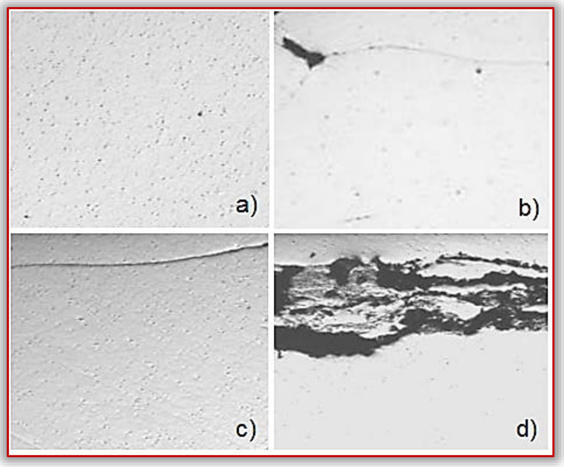

Figure 5. Optical microstructures of analyzed samples:
a) without defects, 25X; b) oxide films, 200X; c) overlaps of material, 25X and d) non-metallic inclusions, 25X

CONCLUSIONS

Recycling aluminum means 95% less energy than producing primary Al. Cable recycling not only preserves and conserves valuable resources; it also significantly reduces energy consumption. Recycling the metals in cables and wire requires only a fraction of the energy that must be expended to initially mine and extract ore. The use of secondary aluminum provides not only huge savings in resources, but also an ecological benefit, with reduced emissions compared to the electrolytic process and the guarantee that the material will re-enter a production cycle.

After reprocessing the Al granules by melting - refining - drawing processes to obtain different types of cables, which will be reused mostly for the same applications, the purity of the aluminum was 99.82%. Most of the products obtained (electrical cables) were made in the required parameters, with some small exceptions, where the defects in the material - oxide films, inclusions and overlapping material - returned it in the manufacturing cycle.

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