[1.]Ionuţ-Ovidiu MARCOSANU, [2.]Valeriu-Gabriel GHICA,
[3.]Mircea-Ionuţ PETRESCU, [4.]Gheorghe IACOB

INCREASING THE PRODUCTIVITY OF THE ELDAN INSTALLATION – CASE STUDY

[1-5.]Faculty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Bucharest, ROMANIA

Abstract: The recycling of materials is the object of activity of Remat Bucharest; here being processed approx. 150-160 tons of copper cables, 50-ton aluminum cables and 150-200 tons of used tires per month. The ELDAN installation started its operation in the second semester of 2010, demonstrating a greater flexibility than expected, in terms of materials to process. The material introduced on the ELDAN installation goes through the following technological flow: chopping, granulation, electrostatic separation. Electrostatic separation is based on the difference between the conductivity of the materials that make up the mixtures of ground materials from cables: conductive metals and non-conductive plastics. The productivity of the installation has increased considerably due to two improvements: a) the introduction of calcium carbonate ($CaCO_3$) in the technological process of processing car cables. Because the temperature inside the schredder (MPR) is very high (due to friction) the cable sheaths stick together and sometimes even melt, so that their processing becomes impossible; by introducing this dust on the conveyor belt we managed to process approximately 5.5 tons of car cables on an 8-hour work shift; b) proposing and manufacturing of a Ø5 mm sieve, which made it possible to process new types of cables (cords). The standard sieves, offered by the manufacturer of the installation were Ø4, Ø6, Ø8 and Ø10 mm. These improvements are reflected in the increased productivity of the plant.
Keywords: productivity, ELDAN, copper wire, recycling

INTRODUCTION

The widespread use of copper, processed in different forms, leads to the accumulation of significant amounts of waste. Recycling is important not only in terms of reducing the amount of waste, but also due to the reuse of copper products, because the production of copper from recycled products requires 85% less energy than the production of copper ore. Recycled copper has the same characteristics as mining copper [1].

The copper industry is at the forefront of industries committed to reducing the environmental impact of its operations. Today, a third of the energy consumption in the copper manufacturing process in modern Europe is used to take measures to protect the environment [2].

Due to its very high electrical conductivity, the main field of use of copper is the production of metal conductors for the energy industries. It is a durable material that continues to function throughout the life cycle of a product, without significant loss of performance. In general, copper waste from electrical cables is recycled and reintroduced into the production process of electrical wires and cables but can also be used in other applications, such as copper castings [3].

Metallic copper is produced in many countries. Figure 1 shows the continental distribution of primary copper production. About 88% of copper production comes from the processing of copper-containing ores. The remaining 12% is provided by the recycling of copper from waste [4, 5]. Currently, the copper mining industry is relatively small but efficient in Europe, and smelters and refineries (copper producers) are world class. In fact, European companies are the pioneers of many metallurgical processing technologies now used around the world. Europe boasts a prominent semi-finished sector, which turns both copper and waste into a wide range of Cu and Cu alloy products for further use in the value chain [1, 2, 6, 7].

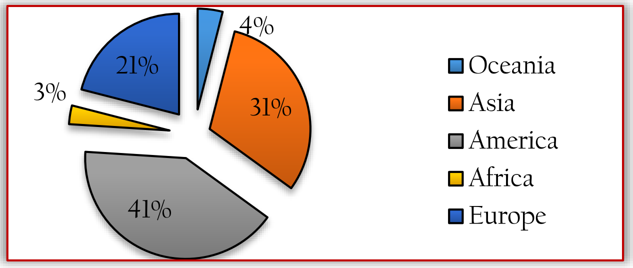

Figure 1. Distribution by continents, of primary copper production

Recycling remains a key element in covering the copper requirement. Copper can be recovered from most of its applications and reintroduced into the production process without losing quality in recycling. With very limited access to primary sources of copper in domestic markets, EU industry has traditionally paid close attention to so-called "surface mines" relying heavily on waste supply to reduce the trade gap in raw materials for Cu [2, 8].

According to some studies, it has been estimated that 95% of the old copper waste that is available is recycled. In 2015, 44% of total copper demand in Europe was secured from recycling. The energy required for recycling represents about 20% of that required for primary production (from mining). Moreover, the relatively high value of copper, combined with easy recyclability, is a key factor in the recovery and recycling of products that have reached the end of their life cycle, which would otherwise be lost [9, 10].

According to statistics, the electronics and electrical engineering industries are the most important in terms of the amount of copper processed, using almost 60% of the total amount of copper processed in the EU (Figure 2) [2, 11-13].

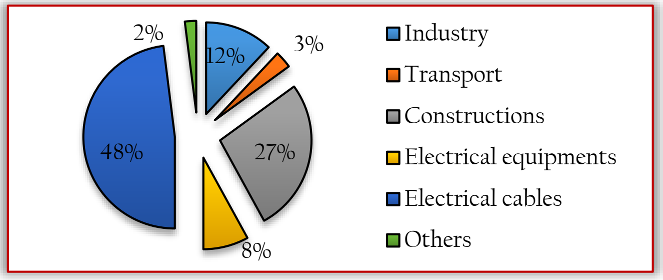

Figure 2. Copper consumption in Europe

In 2010, 2.25 million tons of copper were reused - a 14% increase in one year - from end-of-life products and waste recycled directly to the factory (from direct smelting). This high percentage of copper recycling is determined by the increasing use of metal in European society [2, 4, 13].

Cu and Cu alloys castings accounted for only 5% of castings production in Romania in 2011 [1].

Innovations, close cooperation with customers, plus anticipation of market needs, have become the attributes of success for the semi-finished copper industry in Europe. All this requires investment in product research and development, plus flexible equipment, able to meet the highest quality requirements [14, 15].

The research and testing of new concepts developed by the copper industry, results in a constant flow of innovations that can completely transform the way some equipment is manufactured and how it works. These innovations can make processes cheaper or minimize the impact on the environment, reduce energy consumption or improve design. Whatever they do, they are only due to the superior properties of copper. Innovations based on copper and copper alloys are applied in many other industries and help those in these sectors to design and manufacture new products and applications that will continue to improve our daily lives [16, 17, 18].

MATERIALS AND METHODS: Copper cables

This waste comes from factories specializing in the production of automotive electrical installations and equipment. Today REMAT Bucharest processes approx. 150-160 tons of copper cables, 50 tons of Al cables and 150-200 tons of used tires per month.

In the case of recycling electrical cables, if we recycle cables whose conductors are made of thicker copper wires (Figure 3a), then mechanical separation is sufficient. If flexible cables with many very thinner copper wires are recycled (Figure 3b), or telephone cables or waste from the electronics industry are recycled, mechanical separation is not efficient enough.

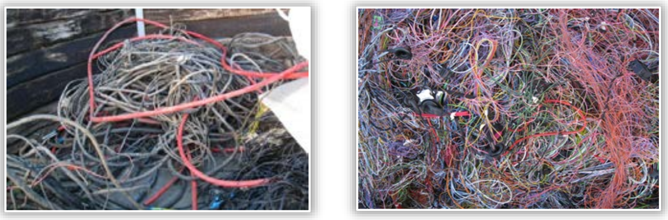

Figure 3. Copper cables

In such a situation electrostatic separation is a particularly efficient solution. Using this method, the various plastics can also be separated (Figure 4).

ELDAN installation

The material introduced on the ELDAN installation goes through the following technological stages: chopping, granulation, and electrostatic separation. The ELDAN installation has shown greater flexibility than expected in terms of materials to process.

The principle of operation consists in loading with electric charges for a certain time the surfaces of non-conductive materials, either by bombardment with ions or electrons, 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), 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.

Separation occurs because different electrostatically loaded materials give way to the charges with which they are charged at different time intervals. In this way, being forced to cover a certain distance on a rotating metal drum electrically connected to the ground, they detach from the drum at different times.

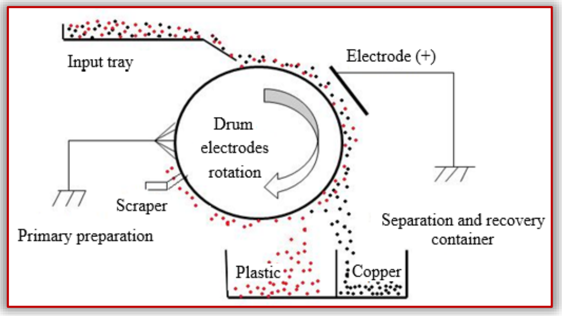

Figure 4. Copper electrostatic separator

The main equipment that is part of the ELDAN installation is the following:

- Dimensional homogenization system of the raw material (Figure 5a and 5b) S1000 rough grinding system composed of input belt; shredder; vibrating trough and conveyor belt; magnetic belt; EC electrostatic separator and conveyor belt.
- MPR 120W system composed of input belt; MPR pregranulator; vibrating trough and conveyor belt; magnetic belt; and filter system.
- HG169 fine grinding system composed of feeding silo; heavy granulator / fine granulator and pneumatic transport system.
- Separation installation composed of feeding silo; separation table; annexes to the separation table (classifier, exhaust belts, pneumatic transport for return); filter system.

The ELDAN Super Chopper is designed to process more volume and hard waste. It chops the material to a size that is easier to handle. The purpose is to facilitate transport or increase capacity in the recycling plant.


Figure 5. a) Super Chopper, b) Vibrating trough and conveyor belts

Cable / wire waste is loaded using a graft machine directly into the Super Chopper's feed tank. The chopped material is evacuated by means of a vibrating trough and is transported by means of belts in the silo of the MPR pregranulator. The material resulting from the MPR pregranulator has dimensions between 15 and 20 mm, is driven on a vibrating trough where a second magnetic strip separates the remaining ferrous metal fraction and is transported by means of belts in the feed silo of the fine granulator. The granulated material between 4 and 7 mm resulting from the fine granulator is transported through a pneumatic transport system to the silo that feeds the separation mass. On the separation table the non-ferrous metal fraction separates from the non-metallic fraction, and an intermediate fraction is sent by pneumatic transport again to the fine granulator. The non-ferrous metal fraction (Cu for copper cables or Al for aluminum cables) is evacuated by means of a conveyor belt which has at the end an electromagnetic drum for separating the remaining iron and stainless steel, in different containers. The non-metallic fraction (which has a low content of non-ferrous materials) is sent to a classifier where through a sieve system combined with motion / vibration it purifies the non-metallic fraction (plastic) separating it from non-ferrous materials entrained with it to the classifier.

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

RESULTS AND DISCUSSIONS

The diameters of the copper cables used were within the limits of 10 - 40 mm for thicker cable (Figure 3a) and 2 – 12 mm for the thin ones. These were composed of a set of copper wires covered with an insulating layer of PVC, PP or PE, followed for some types of cables, by a layer of steel and a coarse PVC jacket. This waste comes from factories specialized in the production of DIY electrical installations, from the dismantling of Electrical and Household Waste, the decommissioning of telecommunication networks, etc. (Figure 3).

To improve the productivity of the ELDAN installation and to be able to process the cables, we have brought the following improvements:

— For the first batch we proposed and manufactured an Ø5 sieve (Figure 6), which made it possible to process some types of cables (cords).The standard sieves offered by the manufacturer of the installation were Ø4, Ø6, Ø8 and Ø10.Due to this, we were able to process an additional 152,398 tons, which represents an increase of 8.34% compared to the usual production.

Figure 6. Manufactured Ø5 sieve

— For the second batch we introduced calcium carbonate ($CaCO_3$) in the technological process of cables processing. Since the temperature inside the chopper is very high (due to friction) the cables become sticky, sometimes they even melt, so their processing is impossible. Therefore, by introducing this powder on the conveyor belt, we are currently able to process approximately 5.5 tons of cables in an 8-hour work shift. In 2020, due to this improvement, the ELDAN section processed in addition to the usual production 85.973 tons, which represented an increase of 4.71%. For the first batch, were obtained the following quantities of recovered materials after processing 7.047 tons of copper cables:

— Copper granulates: 3.939 tons (56.32%) - (Figure 7a).
— Steel waste: 0.300 tons (4.26%).
— Plastic (grinded insulation): 1.958 tons (18.30%).
— Classifier 2 (fine Cu10%+Plastic 90%): 0.183 tons (2.60%).
— Losses (dust + fine plastic): 0.050 tons (0.75%).


Figura 7. Result after processing: a) Batch 1; b) Batch 2

For the second batch, were obtained the following quantities of recovered materials after processing 10.893 tons of copper cables:

— Copper granulates (stranded wire): 7.843 tons (72.56%) - (Figure 7b).
— Steel waste (including lower stainless steel): 0.012 tons (0.14%).
— Plastic (grinded insulation): 1.958 tons (18.30%).
— Classifier 2 (Cu stranded wire 7% + Plastic 93%): 0.487 tons (4.56%).
— Losses (dust + fine plastic): 0.593 tons (4.84%).

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

Table 1. Chemical compositions of the recovered material

No. crt.	Symbol	CC1	CC2	CC3	ACC
1	Al	0.618			0.206
2	P	0.036	0.058	0.075	0.056333
3	Fe	0.059	0.050	0.160	0.089667
4	Cu	99.15	99.00	99.24	99.13
5	Sn	0.064	0.353	0.095	0.170667
6	Ni		0.426	0.106	0.177333
7	Cr			0.066	0.022
8	Zn			0.176	0.058667
9	Pb			0.069	0.023
Total		99.927	99.887	99.987	99.93367

In conclusion, through the contribution to the ELDAN section, we managed to produce an increase of 13.05% compared to the normal production capacity before these changes.

In April 2021, 121.41 tons of copper cables were purchased and processed. The processing resulted in 79.63 tons of copper granules (54.78%). The total purchase price was 294,327 Euros. Following the sale of the copper granule, 546,953 Euros were obtained. The total processing cost for April was 26,710 Euros.

CONCLUSIONS

By using ELDAN installation for recycling copper cables were obtained superior results, the reduction of processing costs, low energy consumption and maintenance costs. The metal losses were minimal, and the purity of the metal was 99.5%.

The metal is mechanically processed by chopping and electrostatically separated with the addition of calcium carbonate to limit the adhesion to the cutting knives and on the conveyor belts of the non-metallic sticky parts. In addition, by adding Ø5 mm sieve, a significant amount of metallic material could be recovered.

At the same time, the ELDAN plant demonstrates greater flexibility than expected in terms of materials to process. Today, the system can also successfully process used tires.

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