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Recovering Aluminium for Recycling in Reusable Backyard Foundry that Melts Aluminium Cans

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Abstract. In a world which is increasingly demanding sustainability, nonferrous metal recycling has become a very important practice. Millions of tons of nonferrous scrap are recovered annually and used by smelters, refiners, ingot makers, foundries, and other manufacturers. Secondary materials are essential to the industry's survival because even new metals often require the combined use of recycled materials. The recovered materials are melted down in a furnace, poured into casters and shaped into ingots. These ingots are either used in the foundry industry or they can be transformed into flat sheets and other wrought products, which are then used to manufacture new products. Aluminium offers intelligent and practical solutions to recovering for recycling. The main activities described in this article are carried out during the experimental phase of the research and they are oriented towards the recovering aluminium for recycling. The objective of the research is to develop some recycling facilities for re-smelt and re-cast of aluminium by using charcoal briquettes into a mini metal foundry, designed and manufactured in laboratory. In this research we experimented a reusable backyard foundry that melts aluminium cans (soda and beer) easily and safely.

1. Introductory notes regarding the recovery of recycling metal resources

Recycling is a modern concept in the waste management, emerged as one of the possibilities to limit waste and to use resources more efficiently.[1–3] It has become increasingly clear that the industrialization and the sustained growth of the population have led to the consumption of increasingly large amounts of resources. An economic development without metal resources is inconceivable in the 21st Century and it is not possible to be in the global competition, with about 75–85% of the world economy depending on these resources. Recovery and reusing of recyclable resources are means of solving the contradiction between the requirements of the economic growing process and the restrictive nature of natural resources. [1–5] In this broad context, non-ferrous metals and their alloys are in the center of modern life and in many developments of high technology, especially in high-top industries.

The policy concerning waste aims for reducing resource consumption and favors the practical application of the “waste hierarchy”, which classifies the various waste management options from the best to the least good for the environment. [1–3] According to this hierarchy (Figure 1), the priority is to prevent waste generation, followed by their preparation for reuse and recycling and, lastly, disposal. Although the waste hierarchy is not a rigid rule, the aim of moving to a recycling and recycling society means that materials should be preferred to disposal by storage. Thus, products considered being waste because they have lost their value of use can be reintroduced into the economic circuit through re-use or recycling. [1–9]





Figure 1. The “waste hierarchy” policy concerning waste

Researches on identifying solutions, designing and implementing innovative technologies for recycling and reuse of non-ferrous metal based raw materials are numerous. [1–3] The specific strategic objective of capitalizing recyclable metal resources – including the non-ferrous metal raw materials area – is the implementation of new concepts and new technologies for sustainable processes in the non-ferrous metals industry and environmental protection (standards and best practices in the non-ferrous metals industry) through new technologies and innovative solutions on: [1,2]

- substitution of critical metals;
- the efficient use of natural resources;
- improving metal recovery by recycling and reuse of raw materials;
- replacing raw materials with attractive commercial alternatives with low impact on the environment;
- the development of new materials through material capitalization;
- techniques for the manufacture of metallic materials;
- prevention and minimization of metal waste;
- rehabilitation of polluted areas through metallurgical and / or mining activities;

According to the principles of the “waste hierarchy”, the management of non-ferrous metal waste includes activities such as: [1–3]

- providing the best options for waste collection in order to make the most efficient use of waste;
- reusing, recycling and treatment for the proper recovery of non-ferrous metals from waste;
- preventing uncontrolled disposal, thus preventing the loss of potentially useful materials;
- implementation of measures to prevent the generation of waste, ensuring its recovery and recycling;

Recovery of non-degradable waste is a pressing issue of mankind and in the last century the concern for this subject has increased steeply. [1–3] The depletion of natural resources is generated outside the natural transformation circuit, which can cause major imbalances occurring when human activities create artificial movement outside the ecosystem, producing waste. Thus, the concept of recycling, from the point of view of recycling and recycling of reusable resources, comprises two categories: [1,2]

- the open-circuit transformation, possible when the environment is able to accept waste for recycling without causing imbalance in the environment. This type is not proper for any metal waste;
- the closed circuit transformation when some waste from human activity does not naturally decompose into the ecosystem and cannot integrate into it, artificially created products must be artificially transformed. This type is often identified as the actual recycling of metal waste.

Aluminum is one of the few materials (along with steel and copper) for which recycling costs are exceeded by the sales price of the recycled product. Aluminum is the most expensive recycled product and recycling of aluminum is economic: it uses less energy and recycling is self-sustained due to the high value of the aluminum used. In other words, it is worth recycling it from all points of view: it is easy to carry, recyclable, infinitely reusable, it does not rust. For this reason, aluminum is rarely lost.

2. Recycling metal recipients

Aluminum is the most precious metal that is used in packaging, because this package has many advantages for both beverage and a consumer manufacturer, which neither PET nor glass has. [1–3] For

example, the aluminum can for beverages is a lightweight, unbreakable package, cools quickly in the refrigerator, protects the content of factors such as light and air, has long life, maintains the effervescence and freshness of beverages, requires no labeling, and not last it is easy to recycle. [4,5,8,9] Aluminum cans are recycled in a closed circuit after the recycling process, and aluminum can be re-injected again or can be used for other products. Recyclable aluminum can come from a wide range of sources, including industries and private households. They also include metal containers used as packaging by large beverage manufacturers (juice and beer). [1–3,4,5,8,9]

Aluminum beverage cans are, like PETs, omnipresent, but similarities stop here. Unlike plastic, aluminum can be recycled to infinity without degrading at all. The process is simple: the boxes are sorted, then washed to remove the contaminants and then melted. The molten metal is converted into ingots which are then transferred to another processing unit and pulled into thin sheets, which can then take the form of beverage cans. On the whole, the process is very fast, a beer can deposited at a waste collector is recycled and reaches the market again. [4,5,8,9]

There are many initiatives involved in improving the return of aluminum waste and the industry is an active player in this area. Recycling empty beverage cans is only an example. Aluminum dosages are an important and extremely valuable resource, representing an important source of secondary aluminum. Once the beer or juice is consumed, if the empty can is properly collected and subsequently recycled, it can be revalued indefinitely without losing anything. Thus, aluminum cans can become raw material. Aluminum packaging has an intrinsic quality and cannot be said about it as a waste, but as a resource, being 100% recyclable. [1–9] Thus, out of all recyclable packaging, aluminum cans have become the most innovative and durable packaging. Aluminum can be recycled indefinitely without losing its properties unlike other recyclable materials such as plastic, paper or glass, which can be recycled for a limited number of times. The aluminum industry has all the interest to promote recycling as part of the industrial strategy. In Europe, about 50% of the total aluminum used to produce new beverage cans and other aluminum packaging products comes from recycled aluminum. [1–3]

However, a large proportion of packaging waste is generated in households, which requires a separate waste collection infrastructure from metallic cans which are mixed with other household waste or separately through locally developed networks. [1–3,7–9] The volume / weight ratio for aluminum metal dosages is quite high: one aluminum box has 13–15 grams, the boxes are made of 0.17 millimeter aluminum sheet. Thus, a pound of aluminum cans consists of approx. 60–70 pieces, which can be collected, flattened or even perforated. That is why the sustainable solution for fulfilling the recycling obligations and, implicitly, increasing the recycled quantities is the further extension of the population's access to the selective waste collection services. Creating and promoting the market for recycling and developing recycled materials from these packaging are fundamental. Thus, aluminum cans are an important resource that is also extremely valuable.



Figure 2.
Recycling
aluminum cans
by melting

The aluminum can is the most recycled beverage packaging. [1–5,8,9] Obviously, this is only possible if they are collected and (re)introduced into the recycling circuit. If a can is left in nature, obviously it cannot fulfill its recycling potential. All the cans are 100% recyclable once they have been collected and reached a recycling point, even the smallest piece of aluminum is not lost. There are several forms to recycle beer or soft drinks cans. [1–3,6] As a rule, they can be melted and reused by an infinite number of times without losing quality (Figure 2).

In the European Union the recovery rate of these wastes varies between 40–70%, the latest statistical data indicating that the rate of recycling of aluminum cans reaches approx. 65%. [1,2] Worldwide, two out of three cans are recycled, but only one in three is recycled in Romania, or about 30–35%. [1,2] In 2007, the Recycling Standard for Romania required recycling at least half of aluminum waste by 2020. The recycling rate was then 3%, then rose to 5% and only in 2010 the growth was more significant, reaching 10%. [1–3] Nowadays a recycling rate of approx. 35% of the quantity placed on the market due to the sustained increase of the industry's contribution to a coherent and efficient system of selective collection of packaging waste, capable of meeting these obligations through the development of waste management services for recycling purposes. This is due to the efficiency of the partnership with over 200 management companies that carry out waste collection, sorting and transport services for recycling purposes. [1–3]

In Romania there are only small collection centers for aluminum cans, but there are also small units processing them. [1–3] Our country is lacking in recycling facilities, so the 33 or 50 centiliters cans are taking the road to Europe, to European recyclers that actually do the recycling of can bales, the aluminum being melted in factories with special technologies. This raw material is brought back in the form of an aluminum sheet and is transformed into another can. [1–4,8,9]

3. Construction and exploitation of the holding aggregate

Recycling is the reprocessing of materials in new products. [1–9] Thus, in order to carry out the recycling process of collected non-ferrous metal waste, aluminum waste melting facilities are required. This enables cost efficiency and faster recycling of waste from aluminum. [1–9] In this direction we propose a micro station for melting of aluminum wastes from the beverage cans. Research refers to a process for obtaining secondary aluminum from waste, by directly melting it into an experimental aggregate designed in the Faculty of Engineering.

To achieve the “melting unit” we need a cylindrical support with refractory lined walls. A gas cylinder was used to carry the aggregate, which was previously cut to the top, an oxyacetylene flame operation. (Figure 3) At the top two handles were welded. The cover of the oven was made of steel sheet fixed by the aggregate by means of a hinge, which allows its sliding. The following materials were used to make the inner linings of the aggregate: chamotte brick, refractory mortar, silicon sulphate. Due to the small size of the chamotte brick aggregate, it was cut into 57.5mm / 30mm strips to be able to reproduce the radius inside the aggregate. (Figure 4, Figure 5)



Figure 3. The “melting unit” – The achievement of the metallic “body”



Figure 4. The “melting unit” – The materials preparation for the refractory walls

The crucible was made of a 90 mm diameter steel pipe. At 10 cm from the bottom of the furnace a hole of 12 mm diameter was made where an air blowing installation will be installed. (Figure 6) To fix the crucible, a steel mounting plate was drilled in the middle so that the crucible's mouth would pass through it. On the fixing plate, holes were made to prevent air during the melting process. Through a hole, a pipe is inserted at the end of which we mount a vacuum cleaner to increase combustion. In this experimental melting aggregate, the crucible is placed in the center, over a layer of coal briquettes. A lot of charcoal briquettes are placed around the crucible until they are filled. The charcoal is ignited and when the crucible is hot, the aluminum cans are introduced. Melting takes place at a temperature of 680–750°C. (Figure 7) Aluminum melting slags are periodically evacuated, avoiding entrainment of molten aluminum. (Figure 8)



Figure 5. The “melting unit” – The achievement of the refractory walls



Figure 6. The experimental melting aggregate, the air blowing installation and the crucible



Figure 7. The melting of the aluminum cans



Figure 8. The aluminum melting slags

Figure 9. The melted aluminum

When the crucible is filled with molten aluminum, it is gently picked up using a pliers and poured the pure aluminum content carefully in the prepared forms. (Figure 9) Thus, small ingots or secondary

aluminum chips are obtained. The aluminum remained will overturn on a concrete board and the crucible can be used for a new melting. The resulting melt may be transferred, prior to molding, to a holding furnace where corrections of the composition can be made. From 40–45 cans, an amount of approx. 500 grams of fused aluminum can be obtained. Varnishes and paints for marking the packaging can be removed by injecting a hot air stream at approx. 500°C, directly onto the waste before it is introduced into the melting crucible. Thus, the volume of slag involved in the melting process can be reduced.

4. Concluding remarks

Since many of the metals are widely used and natural reserves are for some, less and less important, the importance of recycling is increasing. Depending on the quality and the composition of the materials procured for recovery, the decision is made as to how the waste is to be processed. Recycling must include the following:

- the flow of raw materials must be managed in such a way as to facilitate optimal reuse and recycling, thus avoiding the waste and the depletion of natural resource deposits.
- the waste management must play a very important role, as it also represents a possible source of secondary raw materials.

The urban and industrial development of the cities, as well as the general increasing of the standard of living for the population, lead to the production of increasingly large amounts of waste – this is well known and undisputed. Waste of any kind, resulting from many human activities, is a nowadays theme, both due to the increasing in the quantities and their types, as well as to the significant quantities of reusable materials that can be recovered and introduced into the economic circuit. The big advantage of recycling is that old metal can be recycled many times without losing its attributes. Non-ferrous recycling, especially aluminum, offers smart and practical solutions to modern life, having many properties that do not alter by turning it into a product.

Containers and cans (beverages and beer), all made of aluminum, are so widely used worldwide that we cannot even imagine life without this light metal. However, not everyone is aware of the value of a single empty can. That's why, even the wild places in the country are suffocated by these cans that do not take the right path after they're used. Beyond the volume of recycled aluminum cans, it is more important to realize the benefits of recycling and transforming the collected aluminum cans into a routine. The extensive liability of the manufacturer is effective in the field of recycling, the interest in collecting and recycling packaging waste being constantly increasing.

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