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Life Cycle Assessment of Aluminium Recycling Process: Case of Shredder Cables

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Abstract

Life cycle impact of European generic primary and secondary aluminium are well defined. However specific recycling processes are not available in literature. In this study, the environmental assessment of cable recycling processing is examined. The data come from a recycling plant (MTB Recycling) in France. MTB process relies only on mechanical separation and optical sorting processes on shredder cables. On the one hand, the study demonstrates huge environmental benefits for aluminium recycled in comparison with primary aluminium. On the other hand, the results show the harmful environmental influence of the heat refining by comparison with cold recycling process.

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Keywords: Life Cycle Assessment, recycling, aluminium, metal refining

1. Introduction

The purpose of this study is to document the environmental impact of a recycling aluminium process, using the Life Cycle Assessment (LCA) methodology. Today, the life cycle impact of European generic primary and secondary aluminium are well defined through the work of the European Aluminium Association (EAA) [1]. However specific recycling processes are not available in literature. In this study, the environmental assessment of cable recycling processing is examined. The data come from a recycling plant (MTB Recycling) in France. The specific and innovative process was developed by MTB Recycling engineers and is sold as a process solution in different countries. The specificity of MTB process relies on the absence of fusion for metal refining. Nevertheless, it reaches standard aluminium purity up to 99.6%. This performance is obtained using only mechanical separation and optical sorting processes on shredder cables. Environmental impact assessment is done using ILCD Handbook recommendations [2]. Three systems are compared: European primary aluminium data from EAA aggregated in Ecoinvent 3.1, secondary aluminium from European remelter data from EAA aggregated in Ecoinvent 3.1 and MTB cable recycling process.

On the one hand, the study demonstrates huge environmental benefits for aluminium recycled in comparison with primary aluminium. On the other hand, the results show the harmful environmental influence of the heat refining by comparison with cold recycling process. The study demonstrates the interest of recycling by sector rather than in blend.

The European demand for aluminium has been growing over the past few decades at a rate of 2.4% per annum [3]. This increase is mainly supported by the rise of recycling which growth was in the same time about 5% per annum [3]. The abundance and the versatility of aluminium in various applications have made it one of the top solutions for lightweight metal strategy in various industries [4]. In the cable industry, substitute copper for aluminium can considerably reduce the linear weight without degrading too much the

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electrical properties [5]. To obtain optimal electrical conductivity, aluminium use for cables has a purity above 99.7% [6]. Because secondary aluminium does not meet the quality requirements for aluminium cables manufacturers; only primary aluminium is used for the aluminium cables supply chain. Nevertheless, improvement in recycling could help reach quality targets, by using new sorting technologies.

Aluminium properties are not deteriorated by recycling. However, in most cases aluminium parts are mixed together at the end of life step without considering their provenance and use. According to this, the 7 series of aluminium are mixed together in waste treatment plant. All aluminium series do not have the same purity and alloying elements pollute aluminium. When aluminium series are mixed together, the cost-effective solution for refining use furnaces. As the metal is molten, the separation is done by using the difference of density and buoyancy (decantation methods, centrifugation, filtration, flotation, etc.). [7] Despite the technology optimisation, a fraction of metal is unrecyclable [8]. Some alloying elements are lost in the process [9] and this results in a drop of quality which is akin to a down-cycling [10]. The solution lies in a better separation of aluminium series upstream from the recycling chain. This strategy should enable products to be guided through the best recycling path and maintain the quality of alloys.

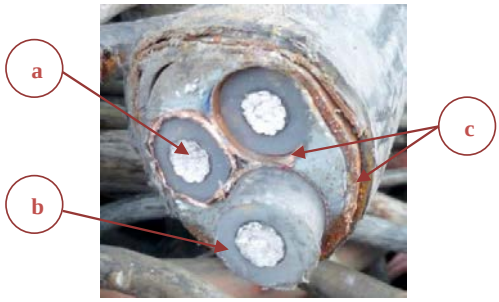

Fig. 1 Section of a cable having multiple beams of aluminium.

The cable is composed of an aluminium core cable (a), covered with a polymer thick layer (b) as illustrated in Fig. 1. Additional metallic materials (c) are coaxial integrated in order to finish the definition of this composite product. These cables are manufactured by extruding together all the materials that compose it.

Aluminium in cables represents between 35 and 55% of the total weight. Other metals are mainly steel, lead, copper, zinc. The variety of plastics contained in the sheath is even stronger than for metals: silicone rubber, Polyethylene (PE), cross-linking PE (xPE), Polychloroprene (PCP), vulcanised rubber, Ethylene Vinyl Acetate (EVA), EthylenePropylene Rubber (EPR), flexible PVC, etc. [11]

Although aluminium cables represent about 8% of aluminium products in Western Europe [12]. The inherent purity of aluminium used for cables justifies differentiate recycling channels to optimise processing steps and improve cost efficiency. At the end of life, the challenge concerns the separation of materials from each other. The most economical way to separate different materials relies on a smelting purification.

An alternative process for cables recycling uses only mechanical steps instead of thermal and wet separation, as developed for several years by MTB Recycling. The aluminium obtained by recycling cables is specially appreciated by the smelter. Its high purity makes it easy to produce a wide variability of aluminium alloys. Recycled aluminium can then be used in a large number of aluminium products and not only in applications requiring high alloy aluminium.

Numerous studies were conducted concerning the sustainability of aluminium recycling in comparison with primary aluminium. Outcomes about global and local environmental impacts show decrease up to 90% by using recycled aluminium [3,13]. However, systems modelling always relate to the standard melting solution for recycling aluminium. In contrast this study focuses on the environmental assessment of cable recycling in MTB specific process.

The objective of this study is, therefore, to examine the environmental benefits and energy savings of the MTB recycling system. Additionally, LCA was conducted in order to help the company to highlight environmental hotspots of the system and try to design new solutions to decrease environmental impact of aluminium produced. The data collection method does not allow the use of the results for other cables recycling processes. The results are representative only of recycling solutions developed by MTB.

2. Analytical Framework

2.1. Functional Unit Proposal

As part of this study, the functional unit used is as follows: producing one ton of aluminium intended for end-user applications, with a purity of > 97% using current industrial technologies (annual inbound processing > 10,000 t) located in Europe. The matching quality of the compared products can meet the same function as a high purity aluminium can be used for producing a large number of alloys without refining. We selected three scenarios that meet all the conditions of the functional unit:

- Scenario 1 or primary: primary aluminium, resulting from mining.
- Scenario 2 or secondary: secondary aluminium from recycling by melting.
- Scenario 3 or MTB: MTB Aluminium, from recycling using MTB processes.

The primary aluminium production is used as a reference for guidance on the quality of production. Foremost, our analysis is intended to compare methods of recycling. Comparison with scenario 1 should help translate environmental benefits of recycling.