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SCRAP METAL FROM CLASSES E1 AND E3 USED FOR STEEL MANUFACTURING IN CONNECTION WITH EUROPEAN LEGISLATION AND CLIMATE POLICIES

Mariana BUȘILĂ
Centre for Nanostructures and Functional Materials (CNMF) from the Interdisciplinary Research Centre in the field of Eco-Nano Technology and Innovative Materials (CC-ITI), "Dunarea de Jos" University of Galati, Romania
e-mail: mariana.busila@ugal.ro

ABSTRACT

To meet the challenges of the steel industry in the European Union related to natural resources and carbon resources, scrap recycling is crucial. Grade E1 (heavy iron) and E3 (mixed iron) are two of the scrap categories used in electric arc furnaces (EAF), a process that uses up to 70% recycled material. This significantly reduces the dependence on minerals and lowers CO_2 emissions compared to traditional blast furnace (BOF) processes.

In the European Union, scrap recycling accounts for around 40% of steel production, and most of the recycled material is used internally in the industry, with a recycling rate of up to 90%. Advanced sorting technologies, including artificial intelligence and hyperspectral imaging, improve the quality of scrap and reduce impurities, which can affect the final properties of the steel. This process also contributes to the circular economy, reducing waste and promoting the sustainable use of resources.

European climate policies, such as the Green Deal and circular economy regulations, support the use of scrap to decarbonise the steel industry. For example, EAF, which uses recycled iron, has a much lower environmental impact compared to traditional processes, saving up to 75% of carbon emissions, a key element of the transition to a greener and more sustainable steel industry in Europe. Thus, recycling scrap, mainly E1 and E3 grades, not only supports local economies and reduces costs, but also contributes significantly to achieving the European Union's climate goals, playing a role in the transition to a circular economy and reducing carbon emissions.

KEYWORDS: metal recycling, circular economy, CO_2 emissions, sustainability, European Green Deal, steel industry

1. Introduction

A strong and competitive steel sector is important to Europe's industrial base. The EU is the second largest steel producer in the world, producing over 177 million tonnes of steel per year, representing 11% of global production [1, 2]. Steel is also part of industrial value chains and is closely linked to many industrial sectors, such as automotive, construction, electronics, mechanical and electrical engineering [2, 3]. This has an important cross-border dimension: 500 production sites in 23 Member States make the steel industry truly European [1, 2]. The European steel sector is in a challenging situation today. The current economic crisis has led to a significant drop-in production activity and associated steel demand, which remains 27% below pre-crisis levels [4].

Steel has been a primary raw material in construction and manufacturing for a long time and will continue to be so in the foreseeable future. However, certain trends in steel production technology and usage could impact its demand. The development of collaborative projects and innovative manufacturing techniques are expected to be the main driving forces behind these trends [5]. Opportunities for innovative steel products will persist with the construction of power plants, transmission lines, and housing and transportation sectors, including onshore and offshore wind farms. [6].

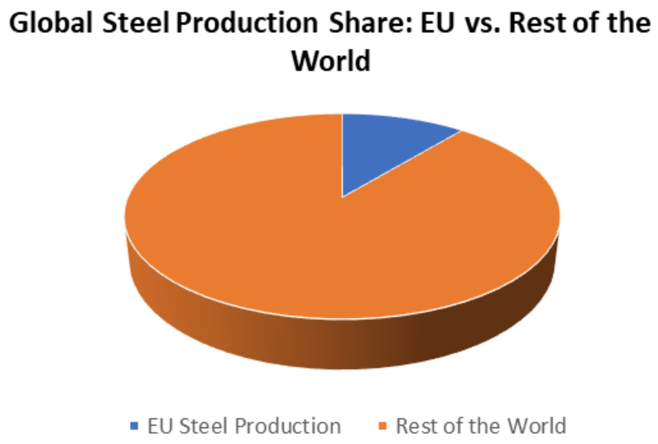

Fig. 1. *Global steel production share: EU vs. Rest of the World*

Even though innovation remains a major factor in the development of new products and new markets, as well as increasing efficiency, it is not the only factor that determines future trends in production. Access to raw materials and energy sources, as well as their prices, will determine, among other things, future trends, and since Europe depends heavily on imports, these prices are likely to remain high for some time [5]. The use of recycled waste as raw materials for steel production [increasing electric arc furnaces (EAFs)] and the use of gas instead of coking coal [when obtaining direct reduction iron (DRI)] could be significant technological trends in the future [7]. The efficient use of resources and climate policies will also be major factors in technological change.

In the short term, increasing the use of recycled waste and disseminating the Best Available Techniques (BAT) could contribute to achieving climate policy goals and improving the sustainable use of scarce resources [5].

2. Recyclable ferrous materials used in the steel-making process

Recycling ferrous materials is an important component of the steel-making process, significantly contributing to resource efficiency and sustainability. Ferrous scrap, which includes various grades of recycled steel, plays a vital role in modern steel production, particularly in Electric Arc Furnaces (EAFs). The EAF process is known for its ability to utilize scrap metal as a primary raw material, with approximately 70% of the input material often being ferrous scrap [8-11]. This method not only reduces the need for virgin materials but also lowers energy consumption and greenhouse gas emissions compared to traditional blast furnace methods [11, 12].

The composition of ferrous scrap can vary widely, affecting the quality and properties of the steel produced. Common impurities in recycled ferrous materials include copper, tin, and other alloying elements, which can adversely impact the mechanical properties of the final product [10, 13]. For instance, elevated copper levels in scrap can lead to issues such as hot shortness during rolling, which compromises the ductility and overall integrity of the steel [13]. Therefore, effective management of scrap quality is essential for maintaining the desired characteristics of the steel, necessitating advanced sorting and processing techniques to minimize contamination [10, 13].

The recycling process itself is facilitated by the inherent properties of steel, which can be recycled indefinitely without significant loss of quality. This characteristic is a cornerstone of the circular economy model, where the goal is to maximize resource use while minimizing waste [14, 15]. The recycling rate for iron is notably high, with estimates suggesting that over 90% of steel products are recycled at the end of their life cycle [16]. This high recycling ratio is attributed to well-established collection and processing systems that efficiently handle ferrous scrap [16].

Technological advancements have also played a significant role in enhancing the recycling of ferrous materials. Innovations such as hyperspectral imaging and artificial intelligence are being employed to improve the characterization and sorting of scrap, allowing for more precise control over the input materials used in steel production [13]. These technologies enable manufacturers to better predict the quality of the scrap and optimize the recycling process, thereby reducing the risks associated with impurities and enhancing the overall efficiency of steel production [13].

One study investigated the effect of the percentage of direct reduced iron (DRI) in the metallic charge on various steelmaking parameters and consumption figures in an electric arc furnace (EAF) [17]. The results showed that the percentage of DRI had a significant impact on electric energy consumption, oxygen consumption, coke consumption, and fluxing materials consumption. This study highlights the importance of considering the metallic charge composition in optimizing the steelmaking process and reducing resource consumption [17].

Another study focused on the production of sponge iron powder by reducing rolling mill scale. The reduction of mill scale allowed for the reuse of this material as metallic load in steel manufacturing or as a raw material in the production of iron-based powder metallurgy parts. This research demonstrates the potential for utilizing mill scale as a metallic charge to reduce waste and improve resource efficiency in the steel industry [18, 19].

Furthermore, a study investigated the influence of emulsol type on energy-power consumption and surface contamination in DC01 steel cold rolling on a continuous four-stand mill. The use of emulsols with higher kinematic viscosity was found to reduce the specific consumption of electricity in some cases. This research suggests that optimizing the properties of emulsols used in the rolling process can contribute to reducing energy consumption and improving the efficiency of electric mills [20].

Moreover, careful selection of the metal charge in electric furnaces, including the use of direct reduced iron (DRI) or recycled metallurgical waste, plays a key role in optimizing resource consumption, reducing pollution and improving the overall efficiency of the steelmaking process. This approach also contributes to significant savings by reducing the costs associated with raw materials and energy. In addition, recycling of ferrous materials supports economic development by creating jobs and stimulating growth in the recycling industry, highlighting its importance in the economic landscape and the sustainability of industrial processes.

Given the essential role of scrap recycling in optimising the steel production process and reducing environmental impact, it is important to understand how different scrap grades, such as E1 and E3, contribute to these processes. The percentages of use of these grades can vary depending on industrial sources and regions, and here is how these values can be approached and where relevant references can be found.

1. Grades E1 and E3 in standards:

- Grades E1 and E3 are defined according to the European standard EN 13920 for scrap metal, and their use is well documented in steel industry reports.
- E1 is predominantly used due to its higher weight and purity, being favoured for electric arc furnaces (EAF).
- E3, being a mixed grade, has a more varied but often lower utilization due to impurities.

2. Sources for statistical data:

- World Steel Association (worldsteel.org): Publishes annual reports on scrap metal recycling and consumption by region and category.
- Eurofer (European Steel Association): Includes information on ferrous material recycling in the EU, according to European standards.
- Local industry reports: Companies such as Liberty Steel or ArcelorMittal publish data on raw materials used, including scrap percentages.

3. General estimates:

- According to industry reports, E1 represents approximately 30-50% of scrap used in EAF due to its higher density and quality (Figure 2).
- E3 can contribute 15-25%, being more often used in combination with other grades, to balance costs and mechanical properties (Figure 2).

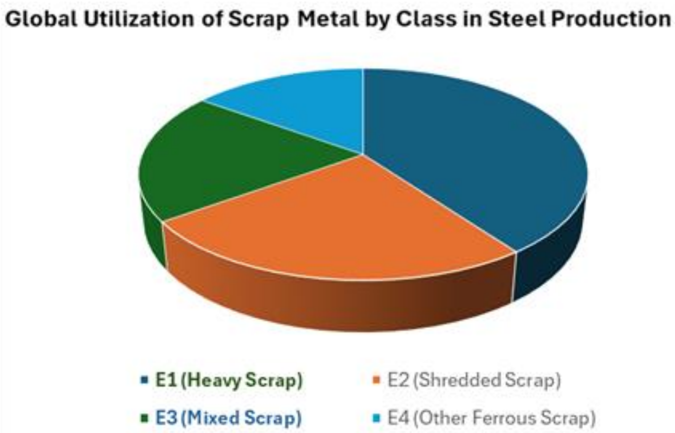

Fig. 2. *Global utilization of scrap metal by class in steel production*

3. Advanced technologies in recycling and production

Advanced technologies in recycling and production enhance the efficiency of ferrous metal recycling, reduce operational costs, and minimize environmental impact. Sorting systems based on hyperspectral imaging and artificial intelligence allow for the precise identification of impurities and the separation of materials. They facilitate the recycling process by increasing sorting efficiency and reducing material contamination [18].

Integrating recycled metals with other recycled materials, such as direct reduced iron (DRI), helps reduce energy and raw material consumption. This approach not only optimizes the production process, but also reduces CO_2 emissions associated with the extraction and processing of virgin minerals [18].

These technologies not only optimize the quality of the steel produced, but also contribute to reducing operational costs and environmental impact. For example, the use of scrap metal instead of raw ores reduces CO_2 emissions and limits the degradation of ecosystems.

4. European legislation and climate policies

The European Union places a strong emphasis on reducing carbon emissions and using resources efficiently through strategies such as the Green Deal and circular economy regulations. These policies encourage the use of scrap in the steel production process, a sustainable practice that aligns the industry with climate goals [21, 22].

European regulations also impose strict standards on the quality of recycled materials, requiring advanced sorting and processing technologies. This approach stimulates the adoption of Best Available Techniques (BAT), increasing the competitiveness of the industrial sector and reducing the environmental impact [21, 22].

5. Conclusions

Recycling scrap metal in classes E1 and E3 represents a pillar of sustainability in the steel industry, significantly contributing to reducing emissions and promoting a circular economic model.

Recycling ferrous materials is integral to the steel-making process, driven by environmental sustainability and economic efficiency.

The scrap metal materials undergo the melting process to create new or other steel products, which not only helps to reduce carbon emissions and waste but also aligns with the current European climate policies.

The ability to recycle steel indefinitely, combined with advancements in technology and a focus on quality management, positions the steel industry as a leader in the transition toward a circular economy. As the demand for sustainable practices continues to grow, the role of ferrous scrap in steel production will likely expand, further enhancing its significance in the global materials landscape.

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