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Impact Of Ferrous Scrap On The Steel Industry

LUNA-PEREIRA, Henry Orlando[a] [1] , Caicedo-Rolon, Alvaro Junior[b], Palacios-Alvarado Wlamyr[c]

[a] *PhD in Business Administration, Director Director of investigación & Desarrollo Regional IDR Group, Orcid: https://orcid.org/0000-0003-2741-9170, Email: henryorlandolp@ufps.edu.co, Universidad Francisco de Paula Santander*

[b] *Doctor in Engineering, emphasis in Industrial Engineering, Director of productivity and competitiveness research group, Orcid: https://orcid.org/0000-0002-3651-3364, E-mail: alvarojuniorcr@ufps.edu.co, Universidad Francisco de Paula Santander, Cúcuta, Colombia.*

[c] *PhD in Business Administration, productivity and competitiveness research group, Orcid: https://orcid.org/0000-0002-0953-7598, E-mail: wlamyrpalacios@ufps.edu.co, Universidad Francisco de Paula Santander, Cúcuta – Colombia*

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Abstract

The steel industry has had a great boom with the passage of time since it expanded with industrialization, many are those who have experimented in facilitating the production of steel from iron as a mineral, because its manufacture is expensive and is required in different economic sectors. The production process of this industrial sector generates environmentally polluting waste, which has been the subject of study; that is why recycling was used as an input for this type of industry, obtained from disused items, known as scrap, including ferrous and non-ferrous objects, being the interest of the iron and steel industry those containing iron and steel. Thus, since the 40's, ferrous scrap has been included as a raw material in the manufacturing process of the steelworks and it is necessary to determine how this element impacts the process, Therefore, a bibliographic review was carried out to provide the advantages and a priori studies of different experiences in the world with this input and to prove that it contributes positively not only to the steel industry but to the world in general. It was concluded that the recycling of post-consumer equipment favors the environment, reduces costs in the manufacturing process and minimizes the mining exploitation of iron and other elements.

Keywords: ferrous scrap, steel industry, recycling process, circular economy, literature review.

1. Introduction

Iron is the mineral raw material of the iron and steel industry, although it is unknown who discovered this element, it is considered that its appearances date back to the first civilizations; iron as a malleable metal is one of the most abundant elements on the planet, and to be melted it needs to be brought to a higher temperature with coal; initially it was made with charcoal, but with the industrial revolution, with

[1] Corresponding author.
E-mail address: *henryorlandolp@ufps.edu.co*

the entry of mineral coal in abundance, which means that it was much cheaper than vegetable coal, began a series of experiments by English steelmakers to include coal in the process of smelting iron, as initially gave a weak and low quality byproducts [1], which allowed to make use of it, plus the iron was needed to maintain and manufacture the trains and rails of the same.

The iron and steel industry has two processes for the production of steel and iron, one is the integrated one, which is based on the transformation of iron ore in a raw form, and the semi-integrated one, which takes as raw material recycled iron and steel or what is known as ferrous scrap, which comes from industrial elements or household products that have completed their life cycle [2]. Steel is one of the elements that can be 100% recycled after the end of its use cycle, as it is treated by the iron and steel industry as if it were born again without losing its quality.

It is known that the semi-integrated steel industry favors steel production costs; therefore, this research is aimed at determining through a literature review based on different scientific investigations the impact that the use of ferrous scrap has had on the production process of the steel industry in the world and in Colombia, and what are the long-term plans in this economic sector that participates in different production systems, which is necessary and very useful for mankind. .

2. Method

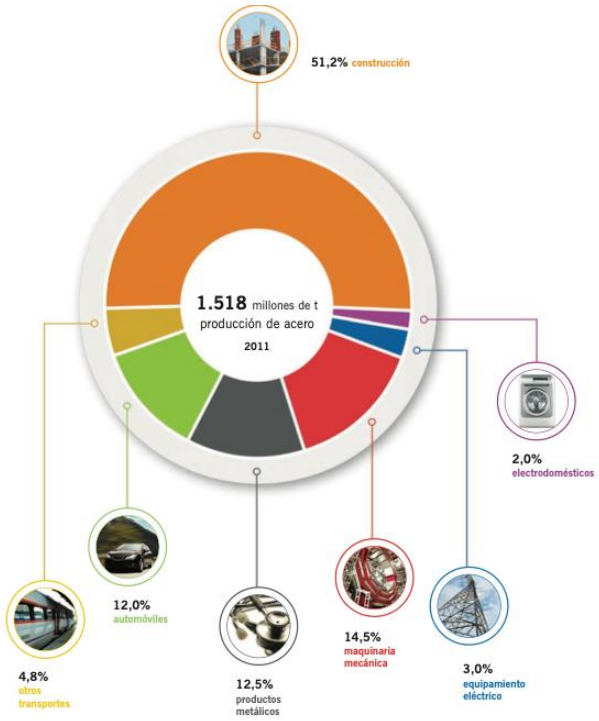
The research was carried out based on a bibliographic review of updated scientific publications in a range of no more than ten (10) years, in order to focus the concept according to developments in the steel industry; the database, Dianelt, Scielo, Google Scholar, Redalyc, SicenceDirect and official reports of different competent agencies in the field were consulted, providing statistics at the global and national levels.

The search was carried out by combining one or more terms such as: ferrous scrap, steel industry, impact, history, report, integrated steel, semi-integrated steel; and additionally the results were filtered with publication dates from 2011 to the current date; as a result, about 150 articles were generated, from which after a quick reading of their summary, 50 articles were extracted to be used as scientific basis in the study at hand

3. Results

The steel industry is one of the markets that are maintained in a country, due to the fact that its finished products are used in the different economic sectors essential for the development of a nation, among which construction, mechanical machinery, household appliances, automobiles and transportation, metallic and electrical products stand out [3].

Figure 1. Steel applications in the world



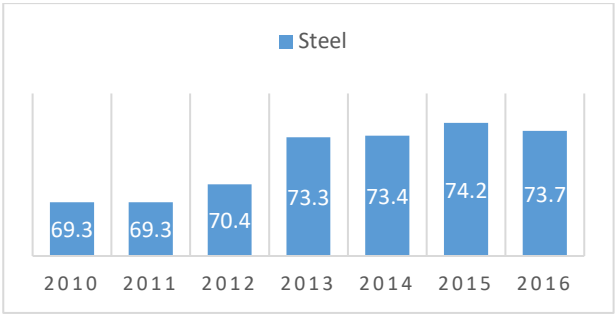
Note: This image was extracted from the study conducted by UNISED in 2013, for Spain IRIS 2013.

Globally, crude steel production for 2018 was 1,789 million tons, with the leading producing country being China with around 927 million tons per year, followed by countries such as Japan, India, South Korea, Germany, Russia and the United States; in Latin America the leading country in steel production is Brazil with almost 35,000 million tons per year, for the case of Colombia its production ranges between 1,000 to 1,300 million tons.[4].

The steel production process can be obtained from the integrated and semi-integrated steel mills; The first one starts from iron ore, which occurs when coal is transformed into coke, which together with iron and limestone complement the process. This type of industry is located near the mining basins where iron and coal are extracted and requires a blast furnace where, through a physical-chemical process, iron is reduced and converted into pig iron (first by-product of the production process) and then melted and converted into liquid steel [5]; This is a method that requires high capital investments and has a significant impact on the environment, as well as requiring highly qualified personnel.

According to the Steel Statistical Yearbook, for 2016 crude steel was produced by the integrated method in the world around 74% [6], and in Colombia on average 19% of the national production; at the national level only one company produces steel by the integrated steelmaking, the others make use of scrap for their productive process. [7]

Figure 2. Steel production by oxygen conversion



Note: The data obtained from the Steel Statistical Yearbook was used to prepare this graph.

For the semi-integrated steelmaking method, the process is based on the smelting of ferrous scrap, using an electric arc furnace, which favors the environment with this electro-steelmaking process;[8] in the world, 27% of the world production of crude steel is produced with electric arc furnaces; countries such as Spain have bet on this way of obtaining steel, being catalogued as the champion of recycling, since 75% of its national production comes from recycled steel [9].

According to its origin, ferrous scrap is classified into three types: first, internal scrap: that which is generated from the waste of the same industry such as offcuts, shavings, or cuttings; second, industrial transformation scrap: it is the result of nonconformity or rejection regarding the quality of the final product; third, scrap in recovery: this comes from materials that have already fulfilled their life cycle such as drainage of buildings, ships, cars, household appliances, etc.; all of them are used in the iron and steel industry. [10].

Steel is a metal that does not lose quality or properties when recycled, which can be reused thousands of times, regardless of its shape, i.e., a drain pipe of a building can be converted into a car door; besides being a metal that can be rescued from waste by magnetism and be separated from solids efficiently; In North America, between 60 to 80 million tons of ferrous scrap are recycled per year [11], and it is estimated that in the world more than 500 million tons are recycled annually, according to the Union of Iron and Steel Companies; in the case of Colombia, this industry recycles around 1 million tons annually.[12]

The recycling of steel or ferrous scrap comes from the obsolescence of the automotive fleet, which on average 75% corresponds to ferrous material [13], but it is a market that has a useful life between 20 and 30 years, therefore, there is little circulation of these items; scrap is also obtained from construction, household utensils and appliances, among others. The recovery rate for steel in automobiles is 106%, for household appliances 90%, for steel cans 66.8%, for structural steel 98% and for reinforcing steel 70%. [14] These data indicate that the recycled material is fully utilized, which is why ferrous scrap is considered as a raw material, being effective for the steel industry.

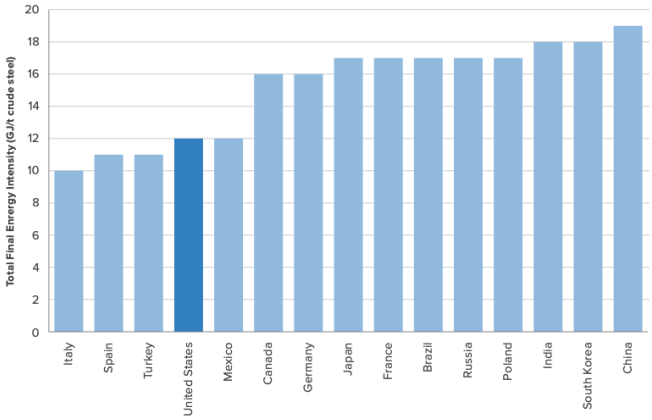
The world produces around 400 tons of ferrous scrap per year, and it is estimated that 86% of steel is recycled, being one of the metals that contributes to the circular economy in a convincing way.[15] The country that exports the most scrap is the United States with 16.9 million tons annually, and the largest importer is Turkey with around 23 million tons per year[16], which indicates that countries in general do not have an efficient ferrous scrap collection policy, since it requires the support of other nations for its manufacture.

In the production process of the steel industry, waste or what is known as fast scrap is generated, such as machining chips, steel slag, steel mill dust and mill scale; Part of this is recirculated in the process and some of it goes to other industries such as cement, construction, ceramics and paints, [17], which reduces the percentage of unused waste from the industry, contributing to the environment, and preventing these wastes that alter the environment from going to landfills; likewise, the water and energy used in the production process is recirculated and generated in the same process, making the steel industry attractive and friendly to the world.

According to one study, making steel from scrap uses 74% less energy, 90% less virgin materials and 40% less water, [18] as it avoids the extraction of minerals needed to make crude steel and its fuel steelmaking coke; it is estimated that recycling one steel food can conserves enough energy to light a 60-watt light bulb for more than four hours.[19] The study also found that recycling one steel food can conserves enough energy to light a 60-watt light bulb for more than four hours.

On an environmental level, recycling steel reduces greenhouse gases, since this industry is responsible for emitting a quarter of the world's CO2, recycling steel from a single automobile reduces greenhouse gas (GHG) emissions equivalent to consuming more than 300 gallons of gasoline. [20] Recycling a single refrigerator reduces GHG emissions equivalent to 225 pounds of CO2.[21]

Figure 3. Energy intensity of the steel industry 2016.



Note: This figure shows the final energy intensity in a 15-country study conducted by Global Efficiency Intelligence in 2016 and published in November 2019.

The table shows the final energy intensity of the steel industry in 15 countries, the lowest being Italy, Spain and Turkey, since they make use of electric arc steel production, which indicates that they base it on the melting of scrap, which needs less energy to produce a ton of steel compared to the process of conversion or oxygen injection. [22] It should be noted that electric arc furnaces also use raw materials such as pig iron and sponge iron, which consume more energy and this means that countries such as China and India are using more energy.

The main energy input is coal, which accounts for almost three quarters of the sector's energy use. Much of the coal consumed is coking coal, which is used to produce coke for blast furnaces as a chemical reducing agent and for its physical properties, although other grades of coal are also used, mainly to provide heat. Coking coal alone accounted for about 16% of global coal demand in 2019, and the steel sector accounted for almost all of its use, which is a major demand sector of the coal industry. Additionally electricity and natural gas accounted for most of the remaining energy demand in the iron

and steel sector to about the same extent. The steel industry accounted for 2.5% of global gas demand and 5.5% of global electricity demand in 2019. [23]

The production of crude steel by the integrated process, the exploitation of minerals in open-pit mines is performed, generating environmental impacts such as changes in the landscape, holes and debris due to explosions; it is considered that for each kilogram of steel produced, 1,623 kg of CO2 footprint is left in the world [24]; while by the semi-integrated process or using scrap for each ton of steel produced, only 0.04 tons of CO2 are generated because it uses a small amount of coal or lime fluxes. [25]

Another factor in favor of the use of ferrous scrap in the production process of the steel industry is that it contributes to the circular economy worldwide, because it seeks to recycle and reuse waste and disused equipment, thus favoring the life cycle and impacting the environment in the decomposition of different materials. [26]

According to the above data, it can be said that ferrous scrap as a raw material for the steel industry generates a positive impact on the production process, because on the one hand it is based on a sustainable model, i.e., it converts all waste elements that have completed their life cycle into resources,[27] so efficiently that its average recycling yield is 65% globally,[28] making it attractive to the industry as it is easier to obtain and shortening the manufacturing process; another aspect to consider is the inputs that intervene together with the scrap in the smelting process, as this is a semi-treated raw material, the process is carried out in an electric arc furnace and uses electricity as fuel, which is friendlier to the planet and many plants generate it in their process and recirculate it, also energy is saved because the manufacture of steel does not start from the exploitation of iron [29]; which means that carbon emissions are reduced to a minimum level; but the steel industry must go hand in hand with the recycling industry because even though scrap is an input that favors its production system, it also has certain shortcomings that make it not easy to access the market, one of the aspects to take into account is that steel is an element with a long useful life, which means that recycled products are scarce and do not cover the total production of crude steel worldwide, and therefore scrap in the world, despite the fact that it has been used for more than a century, it has not been given the proper treatment as a resource for other areas of work [30], at present scrap is still considered a waste which affects the environment worldwide, since the automobiles are being stored in forgotten parking lots generating pollution and end up incinerated without making use of those components that enclose such as plastic, fiberglass, steel, iron and other parts that can be recycled and not end up incinerated, generating more pollution. [31]
The inadequate treatment of all the disused tools or equipment causes the recycling to be wasted or to reach the industries in bad condition, which does not favor the quality for recycling [32]; that is, if the recycled steel or iron does not have an adequate dismantling process, an adequate storage process, it ends up affecting the quality of the steel as a final product; This is why the most urgent concern of the steel industry is to establish governmental and private policies that contribute to the recycling industry [33], where first of all a regulation of the life cycle of the vehicle fleet is demanded and a productive process is standardized from these wastes.

So, we have that the ferrous scrap raw material in the steel production process generates a positive impact because it contributes to sustainability and to reducing polluting emissions in this market, but on the other hand, a negative impact is that steel has a long life, which makes scrap scarce [34] and does not allow increasing the participation of ferrous scrap for the production process by 100% worldwide, which implies that the steel industry continues to depend on the exploitation of minerals such as iron and coal, which are necessary for its manufacture..

4. Discussion.

The ferrous scrap that is generated worldwide, not in its entirety in recycled, part of it goes to composting, combustion or landfills, by 2018 only 33% of the scrap generation was used for recycling,[35] which implies a better management of these wastes to achieve a higher percentage of recycling.

The ferrous scrap together with other elements or metals, which is what is catalogued as non-ferrous scrap, is desired by the steel industry which is responsible for transforming this waste into a new resource for humanity, in fact steel is an element that is being used to replace the excessive use of plastic by manufacturing tools and utensils with this component that makes it hygienic and with greater durability; [36] but in the metallurgical market it has not worked knotted to recycling, because the disarticulation of the obsolete elements are left with residues of other materials and their storage is not adequate, which oxidizes the iron and this implies greater energy and expense in the preparation as raw material [37].

Another aspect to take into account is the import and export of ferrous scrap in steel producing countries, since in some of them the generation of iron and steel scrap is insufficient for domestic production and it is necessary to create policies that control the commercialization inside and outside the country to help each region in the management of this resource. The price of scrap is determined by three variables: its condition, the London stock exchange and the demand for the metal in the market[38]; which for Latin American countries creates speculation in its price, due to the fact that recyclers prefer to sell to international suppliers because it is better paid than leaving it in the country to supply the steel industry; in the case of Colombia, the places where scrap metal is most collected are in the ports and in the coastal zone due to salinity, but the manufacturing companies are located in the interior of the country and due to the road network and transportation costs, it is more economical to export than to move scrap metal in the interior.[39]

In countries like Spain and part of Europe have established policies and rules to promote the recycling not only of plastic and glass but also of steel and aluminum,[40] this has been reflected in the fact that most of its steel manufacturing, we are talking about 75% of the production comes from the recycling of this same element, but other countries are busy not only recycling but also modifying the integrated production process that arises from mining by changing the coal or oxygen needed for combustion for another gas, and this has also contributed to reducing greenhouse gas emissions, although few companies are implementing this modality, its effects have been seen; [41] here we can see that this is not only the way to make a sustainable steel industry, but that it should be promoted because in the long term the exploitation of fossil resources and open-pit mining is prohibited and every year the field of action closes more and more.

India is one of the countries that has started its growth in this industry but part of its production is based on iron products called pig iron and although it uses an electric arc furnace for smelting, its degree of pollution is higher than the use of scrap, so not only the change from oxygen conversion furnace to electric arc furnace guarantees a friendly industry, but it must also be linked to other actions to reduce pollution and generate a circular economy within this market that is so necessary for humanity, being an element that is so necessary for humanity. from oxygen conversion furnace to electric arc furnace guarantees a friendly industry but must be linked to other actions to reduce pollution and generate circular economy within this market that is so necessary for humanity being an element such as hygienic durable steel and of excellent quality. [42]

For the case of Colombia, the commercialization of ferrous scrap is a business that has not been given the appropriate measures, since those who are engaged in the collection of obsolete materials and garbage are personnel of a low socioeconomic level; therefore it has been neglected to protect this population and give them tools for the formation of companies that structure and formalize in a better way this economic activity favoring the quality of life of those involved in it; it is an aspect that cannot be ignored because the steel industry as the recycling industry brings great dividends to the country's economy.[43]

The steel industry is committed to the environmental impact it leaves worldwide, among the alternatives it has implemented to reduce this negative impact is the optimization of the steel smelting process in the integrated mode by injecting oxygen in large quantities to use the smelting time and reduce costs and resources; [44] Globally, ferrous scrap, with an average volume of 600 Mt, contributes to recycling and is the most significant commodity recycling industry activity in the world,[45] which is why steel plants invest in research and development to improve the production system and take advantage of ferrous scrap in their process; also by focusing that the products that are manufactured reduce the percentage of steel in their manufacture, that is to say that less steel is required to produce a product without reducing its quality, as in the case of packaging by reducing its thickness to a minimum level without changing or altering the quality of the product. [46]

Not only have efforts been made to reduce the environmental impact of steel manufacturing, but efforts have also been made to collaborate with other communities by recycling production waste such as car tires, which as we know are part of the waste used in the steel industry, as well as plastic waste and the recycling of carbon derivatives from the combustion of the production process. [47]

Thus, not only the steel industry has sought to solve environmental problems with technology and improvements in the process, but also with the use of its waste in other commercial areas, such is the case, in one study, of the use of metal waste in the manufacture of bricks, which is viable and favors two fields of action with great potential for trade and expansion [48].

5. Conclusions

It can be considered that ferrous scrap is an important part of the production process in the steel industry and is currently being studied, monitored and enhanced by the different iron and steel organizations; regardless of the fact that it has been included in the manufacturing process for over 150 years, the real need to efficiently manage the collection, selection and distribution of disused items to reduce the costs of the steel production process, as well as impacting the environment, is being seen, since it is a real commitment of the industries in the world.

Ferrous scrap needs to have an independent process that guarantees the correct classification for each industry interested in it, and that it does not go on to contaminate the environment, such as a car fleet forgotten in a junkyard without being put to its true use, or household appliances and waste from the steel process ending up in burns and landfills. The circular economy also becomes a vital part of the steel industry to contribute to the improvement of the global environment, and to take advantage of the fact that steel does not deform and its composition allows it to have a long useful life.[49] The circular economy is also a vital part of the steel industry.

The steel industry is positively impacted by the use of scrap in its manufacturing processes, because it drastically reduces the energy needed for its production, as well as the carbon footprint contributed by

the industry to the world is reduced by 80%,[50] which would be a win-win situation; increasing the 34% share of steel manufacturing from scrap is a challenge for the industrial cluster worldwide, countries such as Spain, Germany and others in Europe have already bought the idea and their steel production from recycling is around 75%, and they are committed to reducing CO2 emissions by 2050.

In Latin America, the recycling sector still needs to be boosted in order to efficiently supply the steel industry and not export so much scrap.

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Makalenin Türkçe başlığı buraya yazılır….

Özet

Türkçe özet.

Anahtar sözcükler: anahtar sözcükler1; anahtar sözcükler2; anahtar sözcükler3

AUTHOR BIODATA

Insert here author biodata**.**