

# Aspects regarding the capitalization of the powdery wastes in steelmaking

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**Abstract.** The metallurgical industry is experiencing major issues which are not related to a crisis of the raw materials and energy resources, but to the stringent requirements for the environmental protection.

The small-sized and pulverous wastes, stemming mainly from the steel industry but also from the mining industry, respectively the energy industry, due to their high content of iron, manganese, carbon and various oxides, should be named by-products and be deemed as constituents of natural capital, because they can be capitalized in the steel industry.

The optimization of the steelmaking process can have radically different approaches, depending on the specific conditions of a steel plant during a specific period of time.

The production of steel is continuously increasing worldwide, due to the development of the machinery industries.

The steel manufacturers use furnaces that produce steel from various ferrous wastes, instead of traditional raw materials, because the method is effective, given that it assumes low costs.

## 1. Introduction

The metallurgical industry is experiencing major issues which are not related to a crisis of the raw materials and energy resources, but to the stringent requirements for the environmental protection. The development of the metallurgical industry is conditioned by the settlement of the major issues that ensue from the relationship industry-environment, being strictly targeted on the pollution control and the protection of the natural and energy resources. The small-sized and pulverous wastes, stemming mainly from the steel industry but also from the mining industry, respectively the energy industry, due to their high content of iron, manganese, carbon and various oxides, should be named by-products and be deemed as constituents of natural capital, because they can be capitalized in the steel industry [1].

The optimization of the steelmaking process can have radically different approaches, depending on the specific conditions of a steel plant during a specific period of time. When the main objective is to cut the costs, the optimization can be focused on decreasing the energy inputs and the consumption of oxygen, carbon, natural gas etc., with minimal effects on the production.

If the objective is to increase the production, the strategy must be different, other factors being taken into consideration, such as the electrical equipment, including the transformer, the reactor and the limitations of the electricity line. Usually, irrespective of the main objective, the primal goal of the optimization mission is finding the balance point of the necessary adjustments for the maximizing of benefits within each heat and the existence of a system that possesses the flexibility to adapt its operation when changes are performed on the conditions [2].



## 2. Aspects regarding steelmaking

The production of steel is continuously increasing worldwide, due to the development of the machinery industries [3].

Steel is the easiest metallic material to recycle worldwide, from the household waste to those resulted following the demolitions of certain buildings all steel waste can be collected and processed with a view to their re-use.

The steel manufacturers use furnaces that produce steel from various ferrous wastes, instead of traditional raw materials, because the method is effective, given that it assumes low costs.

The possibility of using waste iron as primary charge is also one of the main advantages of the electric arc furnace (EAF), which allowed its development and establishment as a steelmaking aggregate.

A long time ago, the wastes from within the plant were meeting the demand for ferrous wastes and by the steelmaking process a significant quantity of internal wastes was generated, derived from the actions as such or as a preparation that could not be sold. Nevertheless, the metallic wastes acquired in this manner did not manage to meet the entire demand. Under these circumstances, over the years, various organizations emerged and refined themselves in the preparation and establishment of metallic waste stocks for the steel plants. The majority of ferrous wastes are found in various industrial sources (initially from the rail transportation sector and installations, then from the producers of packaging and the automobile manufacturers).

Related to the development of the steelmaking technologies, the demand for metallic wastes increased robustly, which determined the development of an infrastructure of gathering, processing and sale of the wastes to steel plants and other markets, with a view to recycle.

A close interdependency, based on demand and offer, was created between the steel producers and the ferrous wastes supply units. Due to the recycling infrastructure, the steel industry receives a constant flow of ferrous wastes.

Steelmaking is performed on two major important routes (Figure 1):

1. the method “from iron ore to steel” or the traditional or “integrated” route for the so-called “crude steel” (primary) in which the point of departure is set on iron and coal and the furnace and oxygen converter are used;
2. the method “from waste to steel” or the route of “the electric arc furnace”, for the so-called “secondary steel” (recycled) within which the ferrous wastes constitute the main raw material used in the electric arc furnace.

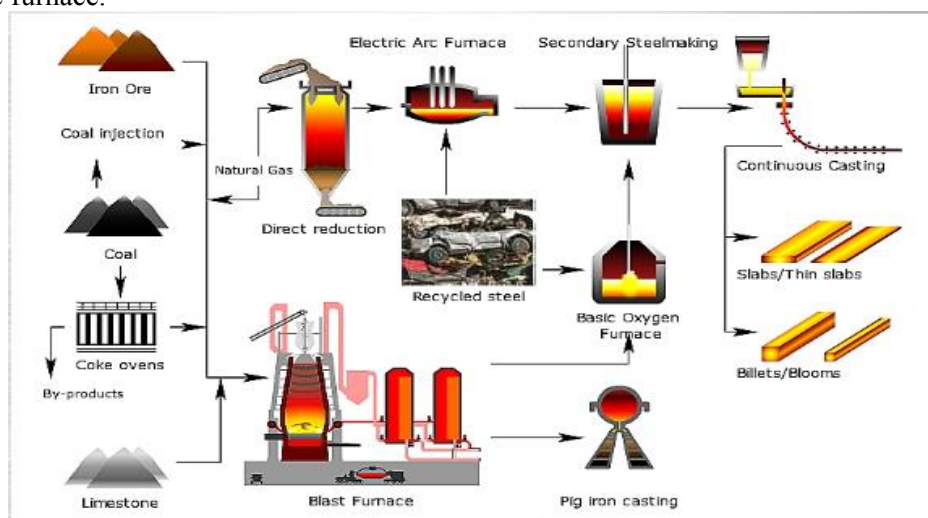


**Figure 1.** Routes of steelmaking [4]

The second method of steelmaking is called “from waste to steel” and, as we previously mentioned, the most suited technological aggregate for the melting of wastes is the electric arc furnace. By the

agency of the melting phase, steel wastes are converted into high quality steels, with the aid of the electric arcs.

In 2004, 1/3 of the global production of steel was achieved by the flow that uses the EAF and in the USA there was a larger quantity of steel produced from recycled wastes than from iron ores. The economic and environmental benefits are originated from the recycling of the ferrous metallic materials. Steels produced in the EAF are both low alloy steel and high alloy steel, acquired from secondary materials. Their production capacity is variable and correlated with the capacity of the furnaces (50-150 tons).

The rise in productivity and economic yield of the electric arc furnaces was possible by the implementation of some solutions, of which we can mention: the increase of the installed electrical output; the use of oxygen and additional fuels; the replacement of the refractory linings with water-cooled components; the possibility of stirring the metal heel and processing under foaming slag; the recovery of the heat from the water circulating in the cooling systems and the off-gas; the preheating of wastes; the slag-free discharge by an eccentric bottom tap-hole; the optimal management and process control by the agency of the computer [5].

The power of the transformer is determined by the capacity of the furnace and the specific energy consumption for the melting. The power of the transformer ( $P_t$ ) for the electric arc furnaces is computed with the ratio [6]:

$$P_t = \frac{W}{t \cdot \eta \cdot \cos \varphi} \quad (\text{KVA}) \quad (1)$$

where:

W - is the total intake of power consumption during the melting phase (kWh);

t - is the melting time (h);

$\eta$  - is the yield (0,8...0,9);

$\cos \varphi$  - is the power factor (cca. 0,85).

### 3. Capitalization potentials of wastes

Figure 2 presents a an overview of the pyrometallurgical, namely hydrometallurgical proceedings applied with a view to capitalize on the pulverous wastes [7], [8].

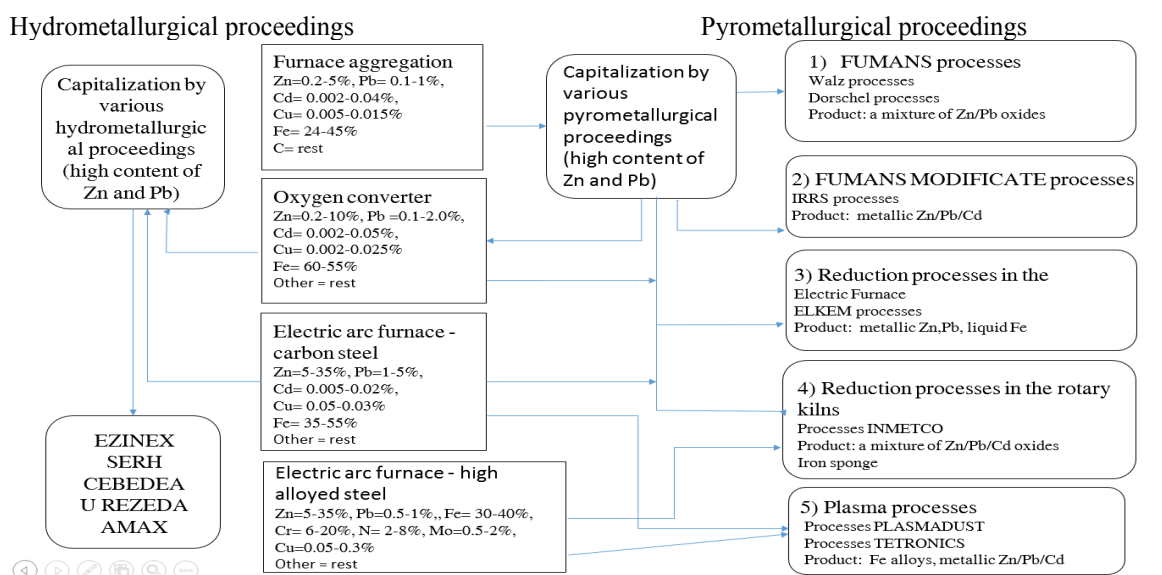


**Figure 2.** Pyrometallurgical and hydrometallurgical proceedings applied with a view to capitalize on the pulverous wastes generated in the siderurgical processes [6]

Albeit the EAF is the most suited technological aggregate for the conversion of steel wastes into high quality steels, these are major producers of pollutant emissions which have a negative impact on the environment.

Of all the pollutant emissions, the ones that have the strongest impact on the environment are dusts (powders) resulted during the operations of charging the raw materials and during the operations of steel's melting, stirring, alloying and discharge, that contain heavy metals (Cr, Ni, Zn, Pb, etc.), and the gasses resulted from the melting and stirring processes [5].

The improvement of dust's gathering from the process gasses within the work area and from the furnace leads to the diminution of the pollution level.

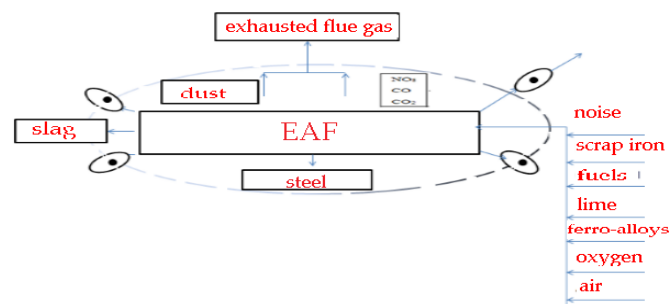


**Figure 3.** The main figure of environmental pollution by the agency of the EAF



**Figure 4** Steelmaking routes (EAF)

#### 4. Conclusions

Steel is the easiest material to recycle worldwide, from the household waste to those resulted following the demolitions of certain buildings all steel waste can be collected and processed with a view to their re-use.

The steelmakers employ furnaces that produce steel from various ferrous waste.

The possibility of using waste iron as primary charge is also one of the main advantages of the electric arc furnace (EAF), which allowed its development and establishment as a steelmaking aggregate.

The second method of steelmaking is called “from waste to steel” and the most suited technological aggregate for the melting of wastes is the electric arc furnace.

The economic and environmental benefits are originated from the recycling of the ferrous metallic materials.

The rise in productivity and economic yield of the electric arc furnaces was possible by the implementation of some solutions, of which we can mention: the increase of the installed electrical output; the use of oxygen and additional fuels; the replacement of the refractory linings with water-cooled components; the possibility of stirring the metal heel and processing under foaming slag; the recovery of the heat from the water circulating in the cooling systems and the off-gas; the preheating of wastes; the slag-free discharge by an eccentric bottom tap-hole; the optimal management and process control by the agency of the computer.

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### References

- [1] Socalici A V 2016 *Contribuții privind îmbunătățirea calității oțelului*, University Politehnica Timișoara, Habilitation Thesis
- [2] Martinez F and Fernandez G 2016 *Technologies for EAF Energy Optimization*, 11th European Electric SteelMaking Conference&Expo, Venice, Italy, May 25-27
- [3] Rau A, Cosma D and Ilin G H 1967 *Elaborarea Oțelului în cuptoare electrice cu arc*, Editura Tehnica, București
- [4] \*\*\*<http://www.steelconstruction.info>
- [5] Ioana A, Nicolae A (coord), Predescu C, Sandu F, Sohaciu M and Calea G G 2002 *Conducerea Optimală a Cuptoarelor cu Arc Electric*, Editura Fair Partners, București
- [6] Martino M and Peri R 2013 Refrattari per bruciatori: caratterizzazione ed evoluzione, *La Metallurgia Italiana* **9** 37-44
- [7] Hepuț T, Socalici A, Ardelean E, Ardelean M, Constantin N and Buzduga M 2011 *Valorificarea deșeurilor feroase mărunte și pulverulente*, Politehnica Timișoara
- [8] Hepuț T, Socalici A et al 2007-2013 Prevention and fighting pollution in the steel making, energetic and mining industrial areas through the recycling of small-size and powdery wastes, Proiect de cercetare nr. 31-098, Programul 4 „Parteneriate in domenii prioritare”