THE RECOVERY OF WASTE GENERATED WITHIN THE STEEL INDUSTRY

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Abstract: *The development of our century's technology is based, to a great extent, on the usage of steel, which must comply with conditions very diversified and, in some cases, very arduous.*

The production of steel has ceaselessly increased, as a result of the growing requirement for metallic materials. This increase also led to amendments regarding the quality of the steel produced and the elaboration technologies.

The transmutations of the current century, regarding the development of the metallurgical technologies, must be in a relationship of interdependence with the requirements of the industrial ecology.

It is desirable that, after the elaboration of pig iron and steel, the residual materials/alloys may be used in other scopes.

The slag is the main by-product for the ferrous metallurgy and its recycling brings uncounted benefits, both economically and ecologically.

Keywords: *Steel, Slag, Technology.*

1. Introduction

The development of our century's technology is based, to a great extent, on the usage of steel, which must comply with conditions very diversified and, in some cases, very arduous.

The production of steel has ceaselessly increased, as a result of the growing requirement for metallic materials. This increase also led to amendments regarding the quality of the steel produced and the elaboration technologies.

Concurrently with the development of the metallurgic industry, innumerable major issues arise from the negative impact of the waste on nature. It would be advisable that the notion of waste cease to exist.

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The environmental concept applied to the engineering of industrial systems infers the development of all these closed-loop protection process flows within which no resource is excluded, all the materials are ceaselessly re-used, no waste or any other product is evacuated to the environment, what can be retrieved in the scholarly literature under the term of "waste free steel industry" or "zero waste steel industry". Thus it is pursued the contiguity to the concept of the natural systems, within which the substances follow a closed circuit. Finding economically and environmentally effective solutions for the steel industry's process flows must allow an affirmative answer to the question: "Is metal a green material?" "[Ilie, 1999]".

2. Waste resulted from the elaboration of steel - the slags

Steels are alloys of the iron with carbon, having a maximum content of 2.11% C, which contain also other elements, such as: Si, Mn, P, S, Cr, Ni, Ti, etc. and present eutectoid transformation in solid state. For the purposes of ensuring that steel becomes an ecological material, effective methods must be implemented, that render possible the retention of all resources with iron content within the production, use, re-use cycle.

Amidst the waste that results from the elaboration processes of cast iron and steel there are also the slags, which appear during different stages of the elaboration processes within the furnace, converters, electric arc furnaces and during the processes of secondary metallurgy.

The slag is the main by-product for the ferrous metallurgy and its re-use brings countless benefits, both economically and environmentally.

Slag is a secondary non-metallic product, resulted from the metallurgical processes of extraction and elaboration of metals and alloys, characterized by a particular chemical-mineralogical composition. It represents a mixture of various oxides, resulted following the melting, from the ore tailings, cinder of fuels, flux and hot heel, that can also form chemical compounds, eutectic solutions and mixtures “[Carcea, 2006]”.

Slags have high temperatures during the elaboration process. The foundry slag reaches a temperature of approximatively 1600^0 C, and the blast furnace slag circa 1480^0 C, this thing providing homogeneity.

Slags are formed mainly of CaO, SiO_2, Al_2O_3, MgO and FeO oxides, hence they can be considered complex oxidic melts. Also, they contain Mn, Ba, Cr, P, Ti, V, B oxides and can have in composition, alongside FeO, superior oxides of the iron, Fe_3O_4 and Fe_2O_3. Within slags, sulphur can be found in the form of Ca, Mn and Fe sulphides and sulphates.

Irrespective of the steel elaboration aggregate, the foundry slags are melts with countless components - oxides and their combinations; sulphides, nitrides.

CaO, MgO, FeO, SiO_2, MnO, P_2O_5 are the main components of the foundry slags. A relatively high amount of metallic phase can reach the slag, a fact which determines difficulties in the slag’s subsequent processing.

According to their chemical character slags are divided into: acid slag, for $b<1$; neutral slag, for $b\approx1$; basic slag, for $b>1$ “[Carcea, 2006], [Gara, 1996]”.

The chemical character of a slag is provided by the ratio between the content of basic and acid oxides, which bear the designation of basicity ratio (the basicity), b and it is expressed by the reference “[Ilie, 1999]”.

$$b=\frac{\%(CaO+MgO+FeO+MnO+CrO+Na_2O+K_2O)}{\%(SiO_2+P_2O_5+TiO_2+V_2O_5)} \quad (1)$$

where: b=basicity index (defined as the ratio between the percentage amount of the components with basic and acid character)

The chemical character of a slag can be also expressed by the agency of the notion of acidity, which is the reverse of the basicity“[Carcea, 2006], [Gara, 1996]”.

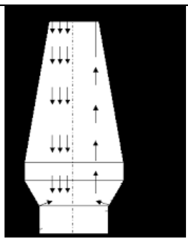
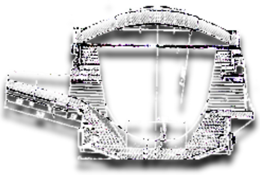
$$a=\frac{1}{b} \quad (2)$$

The majority of foundry slags is characterised by $CaO:SiO_2$ ratios comprised within the limits 1.0 - 1.3 and $(CaO+MgO):(SiO_2+Al_2O_3)$ between 0.85 - 1.20.

The chemical composition of the slags is very useful but inefficient, because it does not provide enough indices related to their behaviour at processing.

The most important fields in which the steel slags can be used are: constructions, agriculture and land-improvement works, protection of the environment, the steelmaking sector (the retrieval of metallic iron by electromagnetic division; recycling at the aggregation and furnace of the oxidic fraction from the slags with a high content of FeO as substitute for ore and flux).

Chart 1. *The slag generated from the steel's production flow at British Steel (kg/t product)*

Source of origin - by-product (slag)		Kg/t
FURNACE		262
BASIC OXYGEN FURNACE		127
ELECTRIC ARC FURNACE		101

Within the integrated mills an amount of circa 450 - 500 kg of by-products per ton of raw steel accumulates, 375 kg/t of this amount being represented by the slag and around 65 kg/t by dusts, slurries and mill scale. From the total amount of solid by-products, the most part (70 - 80%) is represented by slag, which is directed mainly to the industry of cement and the rehabilitation of soils "[Gara, 1996]".

In the process of melting steel in an EAF (Electric Arc Furnace), the non-metallic components in the melted mineral end up forming a layer of slag which is discarded after pouring, mostly from the purging outlet.

Considering the increasing emphasis laid on quality during steelmaking, the presence of slag in the ladle has become an increasing issue for the steel plants, also, the slag (waste) raises countless issues worldwide as regards its impact on the environment.

The foundry slags contain a large amount of metallic phase, besides the oxidic phases, which raise difficulties in the processes of slag re-use. These present typical characteristics which reduce the slag's possibilities of capitalization (difficulties in the direct processing from liquid state by simple methods: high viscosity, namely rapid solidification, that inhibits the water granulation; difficulties at the processing by crushing, due to the metallic inclusions and the large scale of the pieces of slag solidified at the waste heap; the limitation of the possibility of their usage in constructions, due to the instability conferred by the presence of Ca and Mg oxides in certain combinations, the limitation of their recycling within the metallurgical flows as additions in the agglomeration charge or furnace, due to the high content of phosphorus, chrome, alkaline elements) [4].

The removal of the metallic phases of the foundry slags is necessary, so as to be able to process these, with a view to their capitalization.

To be able to process the foundry slags with a view to their capitalization, the removal as advanced as possible of the metallic fractions from these ones is required.

3. Conclusions

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References

1. [Ilie, 1999] Ilie, A.L., *Cercetări privind valorificarea superioară a materialelor pulverulente din siderurgie,* Teză de doctorat, Universitatea "Politehnica" București, 1999
2. [Carcea,2006] Carcea, I.,Roman, C., Chelariu, R., *Ingineria proceselor metalurgice*, Editura Performantica, ISBN 978-973-730-326-4, Iaşi, 2006.
3. [Gara, 1996]Gara, S., Schrimph, S., - *Treatment of residues and waste in the iron and steel industry*, Balatonszplak, Ungaria, 3-6 iunie 1996.
4. http://cyd.ro/valorificarea-zgurilor-de-otelarie/