Assessment of Recycling Potential of Solid Wastes from Steelmaking in the Electric Arc Furnaces

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Abstract: The paper presents an assessment of recycling potential of solid waste (dust) from steelmaking in the electric arc furnaces. There were taken and chemically characterized 6 samples of solid waste, in order to identify the compounds that have recycling potential. It was made a comparative analysis of the results from different solid waste samples characterization. The chemical composition of the solid waste samples varies from one type of steel to another depending on quality and composition of the charge used in the steelmaking, and thus their potential for recycling is different.

Keywords: solid waste, recycling, steelmaking, pollution.

1. Introduction

The steelmaking process in the electric arc furnaces is in the category of significant sources of solid wastes generation. The solid wastes from steelmaking in electric arc furnace are dust and slag.

In accordance with the classification made by the United States Environmental Protection Agency in 1980, dust from steelmaking in the electric arc furnace is part of the category of hazardous waste because it contains lead (> 5ppm), cadmium (> 1ppm) and chromium (> 5ppm) [1]. According to the European Waste Catalogue (EWC), the dust from electric arc furnaces is in the category of wastes from thermal processes and has the code 10 02 07, corresponding to the solid wastes from gas treatment containing dangerous substances [2]. Being considerate as hazardous wastes in most of the industrialized countries, these residues must be stored in specialized landfills.

The generation of EAFD (electric arc furnaces dust) in the world is estimated to be around 3.7 million tons per year. Plants in Europe generate around 500,000 and 900,000 tons of dusts per year. The biggest generators are: Italy (170.000 tons per year), Germany (160.000 tons per year), France (140.000 tons per year) and Spain (115.000 tons per year). About 700.000–800.000 tons per year of EAFD are generated in United States of America, and they increase with 4–6% per year [3].

In the Table 1 are presented the quantities of dusts generated during steelmaking in electric arc furnaces, according to several existing references in the literature.

TABLE 1. Quantities of dust generated during steelmaking in electric arc furnaces

No.	Quantity of dust generated in steelmaking	References
1	20 kg dust/ton of steel	[4]
2	15-20 kg dust/ton of steel	[5]
3	1-2 [%] of the oven charge weight	[6]
4	15-25 kg dust/ton of steel	[7]
5	10-20 kg dust/ton of steel	[8]

According to these data, the amount of dust generated during steelmaking in electric arc furnace is between 10 and 20 kg/ton of liquid steel. If the scrap has poor quality, the generated dusts can reach up to 25 kg of dust/ton of liquid steel.

The total quantity of dusts from electric arc furnaces generated by steel producers continues to grow. The storage of electrical steelworks dusts involves:

- occupying large areas of land;
- contamination potential of all environmental factors;
- expenses related to land storage etc.

In order to eliminate the disadvantages entailed by the storage of mill dusts one must find feasible solutions for their recycling or recovery. In this respect, a first step is their characterization.

The research conducted in this paper are focused on evaluating the potential of recycling dusts (solid waste) generated in the steelmaking in electric arc furnaces, through their chemical characterization. The chemical characterization of EAFD is the most significant factor in determining the potential viability of recycling these wastes to recover metals.

2. Experimental

There were collected and subjected to chemical characterization 6 samples of solid waste (dust), 3 of them coming from making unalloyed and the other 3 come from high-alloy steelmaking. The determination of chemical composition of the dust samples was performed by spectrometric methods. The apparatus used was a spectrometer based on X-ray fluorescence.

3. Results and Discussions

The composition of waste samples is highly variable and depends mainly on the quality of the charge used.

In the Figures 1, 2 and 3 there are presented the chemical compositions of the three dust samples from unalloyed steelmaking in the electric arc furnaces.

From the analysis of figures 1, 2 and 3 it shows that in the dust samples from the unalloyed steelmaking there were identified chemicals compounds in these percentages: 1.1-1.3% manganese oxide (MnO), 2.1-2.4% silica (SiO_2), 3.4-3.9% magnesium oxide (MgO), 0.9-1.5% alumina (Al_2O_3), 9.7-19.2% lime (CaO), 21.3-23.7% zinc oxide (ZnO), 35.2-49.9% ferric oxide (Fe_2O_3 (III)) and 24.8% ferrous oxide (FeO (II)).

The presence in the composition of the dust of a significant quantity of ferric oxide (Fe_2O_3 (III)) and zinc oxide (ZnO), has a major economic importance in terms of saving natural resources.

The iron recovered from these wastes can be reused as raw material in the steelmaking process.

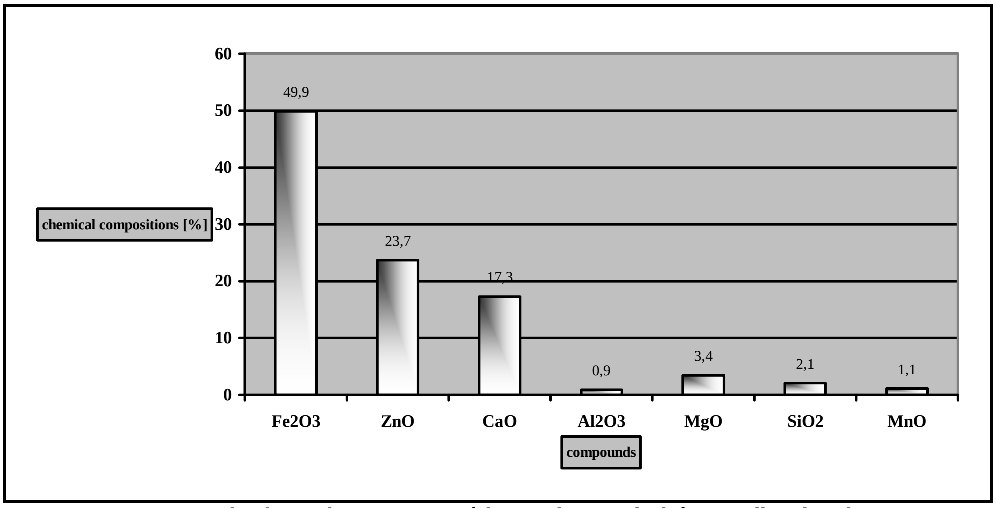

Figure 1. The chemical compositions of the sample 1, resulted from unalloyed steels

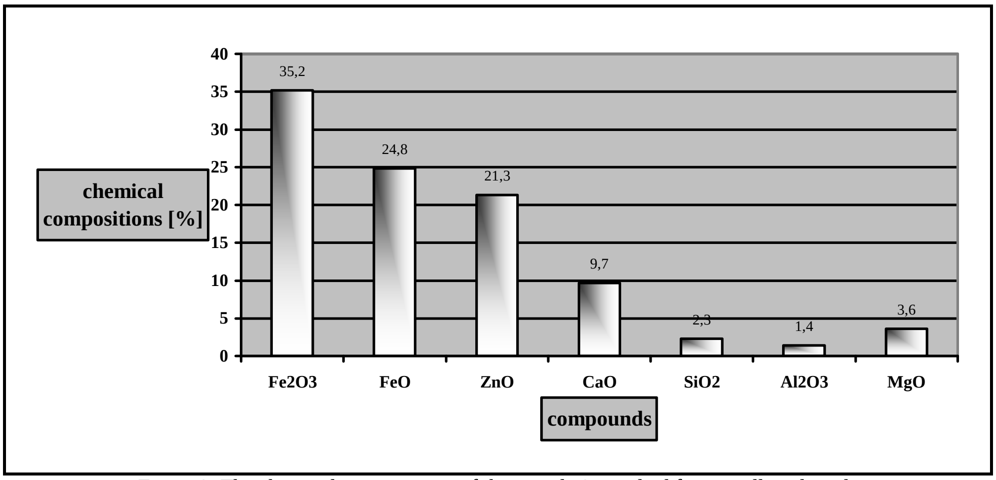

Figure 2. The chemical compositions of the sample 2, resulted from unalloyed steels

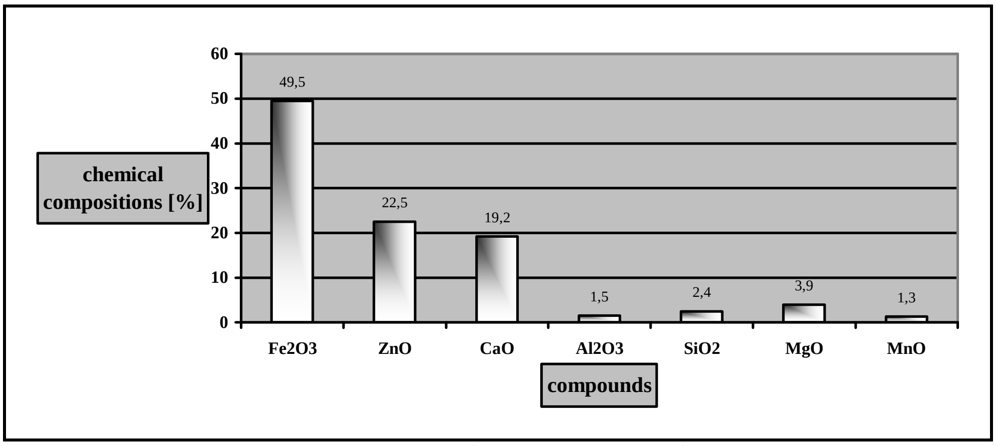

Figure 3. The chemical compositions of the sample 3, resulted from unalloyed steels

In the figures 4, 5 and 6 there are presented the chemical compositions of the three samples of dust from high-alloy steelmaking in electric arc furnaces.

From the analysis of figures 4, 5 and 6 it shows that in the dust samples from the high-alloy steelmaking there were identified chemicals compounds in these percentages: 0.4-5.7% titanium dioxide (TiO_2), 6.4-7.9% magnesium oxide (MgO), 2.3-3.3% alumina (Al_2O_3), 3.5-4.7% silica (SiO_2), 8.4-10.7% manganese oxide (MnO), 8.9-16.8% lime (CaO), 5.7-6.3% zinc oxide (ZnO), 1.3-2.7% chromium trioxide (Cr_2O_3) and 48.8-53.2% ferric oxide (Fe_2O_3 (III)).

In the composition of dusts from high-alloy steelmaking the content of zinc oxide (ZnO) is significantly reduced compared to the unalloyed ones, reaching percentage ranging from 5.7 to 6.3%.

The existing ferric oxide (Fe_2O_3 (III)) in the solid waste is a main source for obtaining iron.

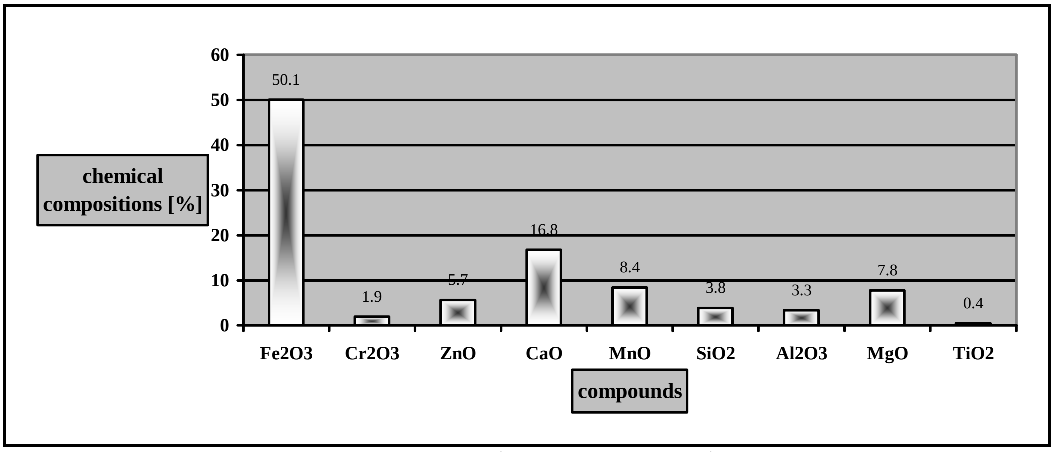

Figure 4. The chemical compositions of the sample 4, resulted from high-alloy steels

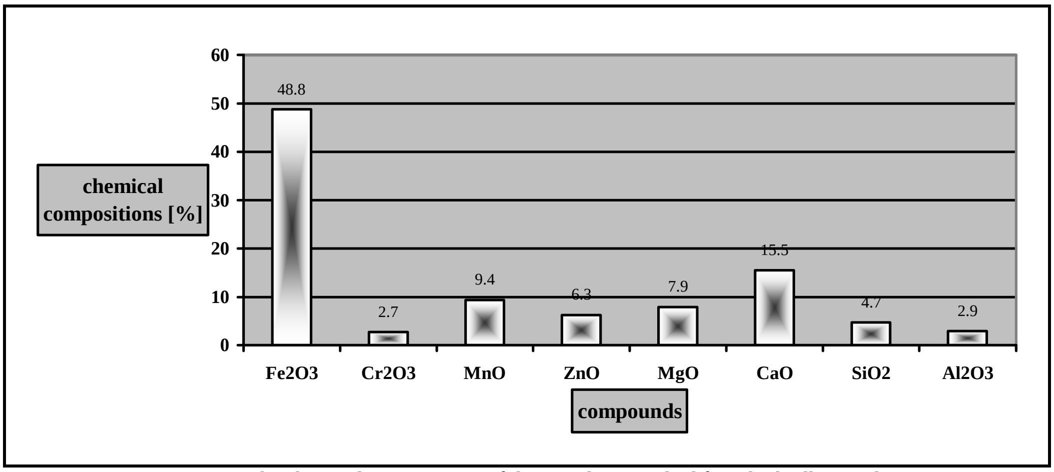

Figure 5. The chemical compositions of the sample 5, resulted from high-alloy steels

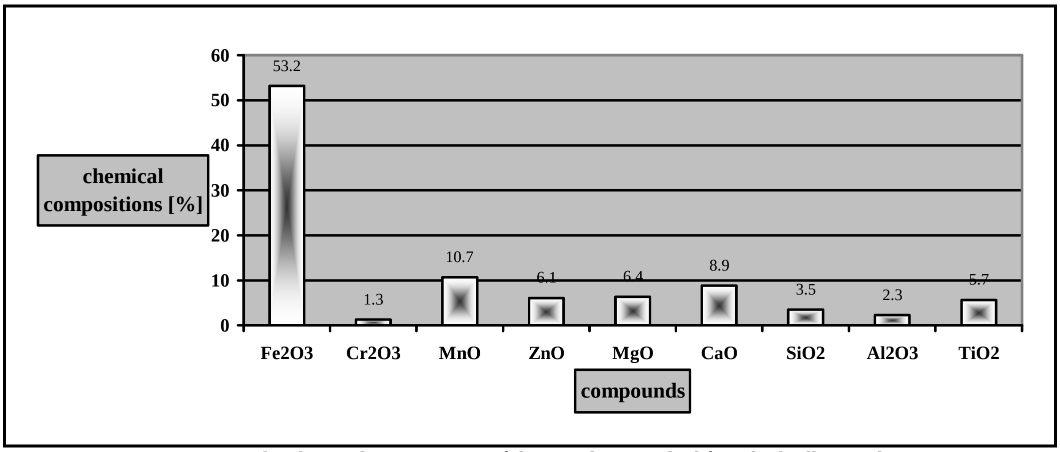

Figure 6. The chemical compositions of the sample 6, resulted from high-alloy steels

4. Conclusions

The results obtained from chemical characterization of the electric arc furnaces solid wastes (dusts) indicated that the percentage of zinc oxide (ZnO) ranged from 21.3 to 23.7%, for samples 1, 2 and 3. Zinc recovery from these solid wastes offers a higher potential value. So, the content of zinc oxide (ZnO), is significant in samples of dust from the unalloyed steelmaking, having also a major economic importance, as an important source for obtaining metallic zinc.

The content of zinc oxide (ZnO), is reduced in dust samples from high-alloyed steelmaking and therefore zinc recovery is not recommended for from this type of waste.

The recovery of the iron may be considered a positive economic factor, when the recycling process involves recharging or injecting of the dust into the electric arc furnace in the melting period.

The disposal of solid wastes is highly expensive and requires a great area, and the valuable components of these are lost forever. Because of this, the desired solution for this waste is recycling.

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