DETERMINATION OF THE CHEMICAL COMPOSITION OF THE DUSTS FROM THE ELECTRIC ARC FURNACE

LIS Teresa, NOWACKI Krzysztof, ŁAKOMY Karolina

Silesian University of Technology, Faculty of Materials Engineering and Metallurgy, Katowice, Poland, EU
teresa.lis@polsl.pl, krzysztof.nowacki@polsl.pl, karolina.lakomy@polsl.pl

Abstract

The problem of environmental pollution due to increased industrial activity is the subject of attention in the country and around the world. The main purpose of waste management should be reclamation of valuable raw materials and, consequently, protection of natural environment by reducing consumption of deposits and energy. The metallurgical industry generates considerable quantities of waste containing iron i.a. dusts from the electric arc furnace (EAFDs). EAFDs are among the most troublesome products of electric steelworks. Possibilities of EADs depend, among others, on their chemical composition. This article presents the results of the chemical composition of EAFDs from the steel mill and foundry.

Keywords: Metallurgical industry, utilization dust, electric arc furnace dusts

1. INTRODUCTION

The metallurgical industry is one of the largest sources of wastes such as sludge and dust from waste gas purification processes conducted in sintering plants, blast furnaces and steelmaking shops equipped with both converters and electric furnaces. Comprehensive list of criteria for the classification of metallurgical wastes [1] should be the basis for the development tasks of the management of waste.

Utilization of steelmaking dusts generated in the steel manufacturing processes taking place in electric arc furnaces is one of the most urgent issues. Electric arc furnace dusts (EAFDs) are among the most troublesome products of metallurgical processes being particularly difficult to store and transport as well as posing a serious environmental threat [2]. Recycling of dust (waste) depends, inter alia on their chemical composition. This article presents results of the chemical composition of EAFDs from the steel mill and foundry now operating.

2. TRENDS IN UTILIZATION OF STEELMAKING DUSTS

In the steel industry dusts occur at many stages of the production cycle. **Figure 1** shows the estimated percentages in the generation of particulate matter in the national metallurgy of the main technological operations [3]:

- preparation of raw materials (transport, storage, crushing, sorting, grinding, averaging drying);
- ore sintering;
- coking coals;
- the production of pig iron and cast iron in blast furnaces and cupolas;
- steel production (steel) in converters and electric furnaces;
- smelting of copper;
- electrolysis of aluminum.

Dusts contained in exhaust gas, depending on whether formed as a result of mechanical operations or by thermal processes are substantially different particle size. The particle size of dust generated by the operation motor is of a size to several tens of micrometers, and dust resulting from thermal changes are made up of very fine particles having a particle size of approx. several tens of microns.

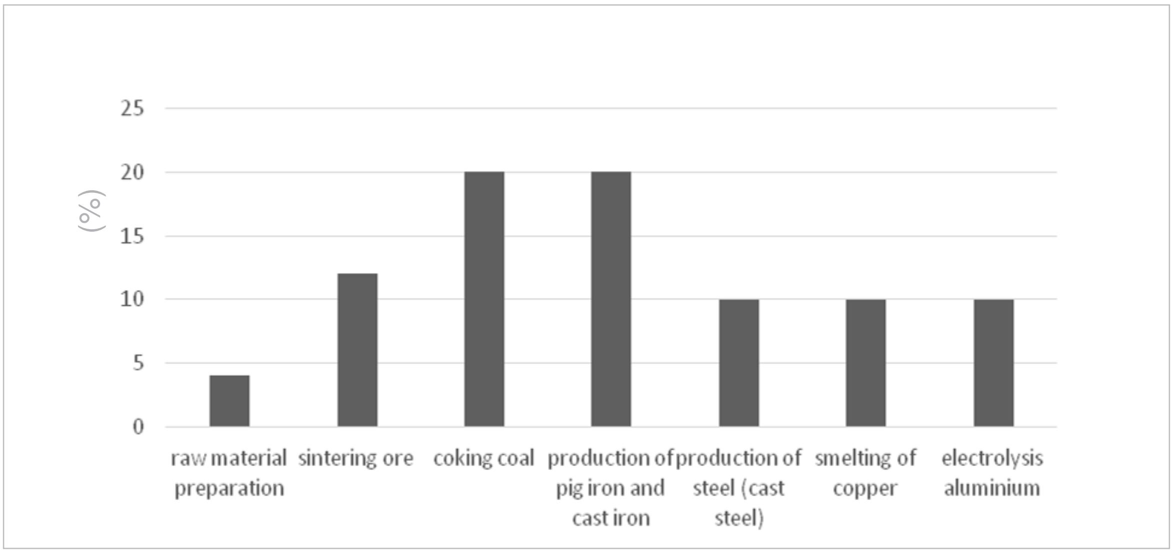

Figure 1 The share of the most important technological operations in the formation of dust in the national metallurgy

The most common flue-gas dust is precipitated in a range of dust collection equipment. The restructuring of the domestic steel industry and the application of EU environmental protection requirements resulted in the use of more efficient dust collection equipment, and thus increase the amount of dust deposited by the steel plant. It is estimated that there are currently one of Mg steel produced in the EAF dust is generated amount of 10-20 kg. In the case of waste with a very low grade they are separated by up to 25 kg dust /Mg steel [4].

EAFDs are production wastes which can be utilized in various ways depending primarily on the dust's content of zinc. The utilization options are as follows:

- furnace recycling by introduction together with other charge materials for the dusts of zinc content up to 4% (feeding of blast furnaces, converters, EAFs);
- zinc recovery from dust of zinc content exceeding 20%, e.g., in a rolldown furnace or by application hydro-metallurgical methods including Ezinex [5];
- recycling in other non-metallurgical processes for the dust of zinc content from 4 to 20%.

In accordance with current legislation, the holder of waste shall, in the first place to prevent waste (**Figure 2**), and then - the preparation for reuse, recycling and other recovery methods (ie. Energy reuse). At the end of the permitted waste disposal - disposal is acceptable only when it is not possible to carry out reuse [6, 7]. As is clear from the Framework Directive of 19 November 2008 of the waste [6], recycling and other recovery should be a priority in waste disposal. Still growing waste stream puts increasing demands for creators processing methods of various fractions.

The concept of recycling is defined in that Directive (94/62 / EC) [7] according to which recycling is the reprocessing of waste materials in the production processes in order to obtain materials for the original purpose or

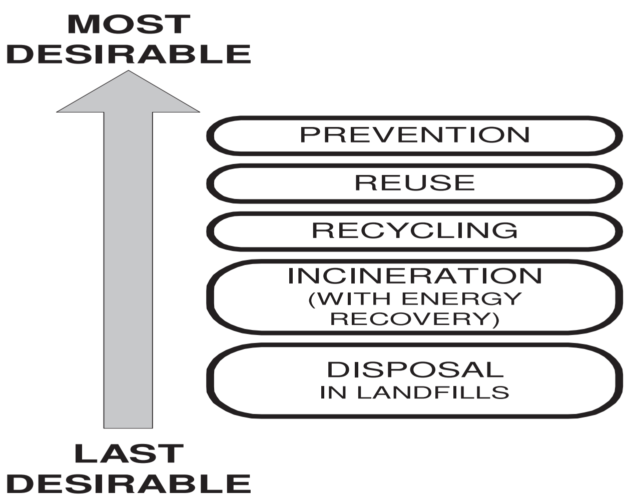

Figure 2 European hierarchy of waste [6, 7]

for other purposes, recycling is one of the forms of recovery. The difference between the recovery and recycling is that the recycling of a new product is obtained. In contrast, recovery has to process waste resulting only change their nature or composition (reclamation, blending), including the treatment of hazardous waste.

In the steel industry currently the most important is the recycling of raw materials and material. Production of steel, cast iron alloys are subject to almost 100% recyclable and waste production processes to a much lesser degree, and many of them (sludge, dust steelmaking) can be a valuable source of iron - as the feed material. Recycling of metallurgical waste generates the following benefits:

- reduction of consumption of natural resources,
- reduction of landfill sites,
- the reduction or elimination of costs associated with waste disposal and / or purchase of raw materials for production.

EAFDs are waste materials from the steel manufacturing process. What is referred to as dust is a collection of solid particles of various sizes and different origin which remain suspended in gas for some time. Basic physical and chemical properties of dust include: shape and dimensions of particles, grain composition, mass density, porosity of a dust layer, angle of repose and angle of slide of heaped dust as well as hygroscopicity [8]. In accordance with the applicable EU regulations, the solutions recommended for EAF mainly include environmentally friendly activities aimed at reduction of quantities of dust being generated and ensuring its reclamation through various forms of recycling and utilisation. In this aspect, the chemical composition of EAFDs plays a leading role.

3. THE RESULT OF CHEMICAL ANALYSIS OF EAFDs

Dust steelmaking come from process of dry dedusting. They are solids with light brown to dark brown and a density of from 4 to 5 g/cm^3. The study of the chemical composition were subjected to dust arising from the melting of steel in electric arc furnace in two steel mills (S1, S2) and two foundries producing cast iron and cast steel products (F1, F2).

Before performing the test samples were dried. Samples were dried at 105°C for 24 hours. The moisture content (H_2O) is shown graphically in **Figure 3**. The analysis found a much higher H_2O content in the dusts of the foundry than in dust from the steel mill. Probably the water content of the dust depends on the conditions of storage.

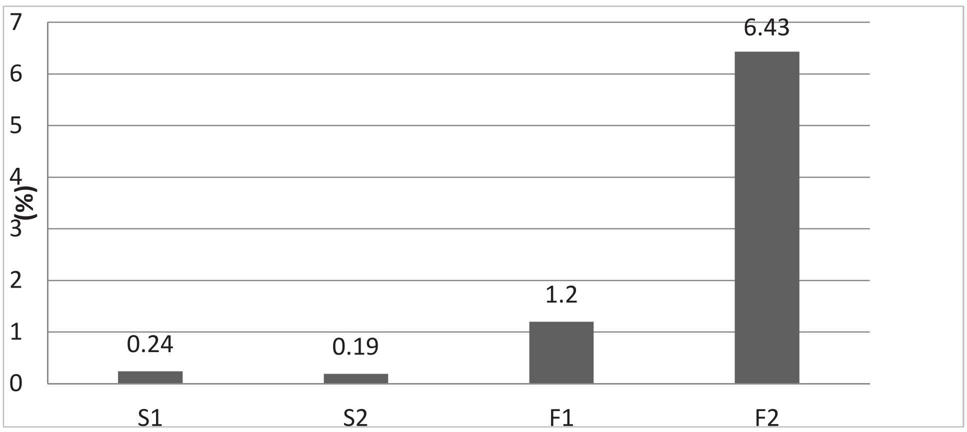

Figure 3 The moisture content in EAFDs

In order to obtain the accurate results of chemical composition, three 0.1g samples were taken from each of the examined materials. The samples were analysed and the mean value and the standard deviation of the elements concentration in the samples were determined.. Analysis of chemical composition was performed by means of:

- carbon and sulfur analyzer LECO CS 844;
- oxygen analyzer LECO ONH 836;
- a scanning electron microscope Hitachi S-3400N equipped with EDS detector Scientific Thermo Noran System 7, and WDS MagnaRay.

Figures 4 ÷ 7 show the results of qualitative analysis of the chemical composition of the tested dust from electric arc furnaces, and in **Table 1** results of the quantitative analysis of chemical composition along with a standard deviation of element concentrations in the test samples of dust. The research material has been glued to the titanium washers, in effect, this element was excluded from the results of quantitative X-ray microanalysis (excitation area is so large that in addition to the test material also includes a substrate to which the attached material). **Figure 8** shows the percentages of the various elements in all tested dusts.

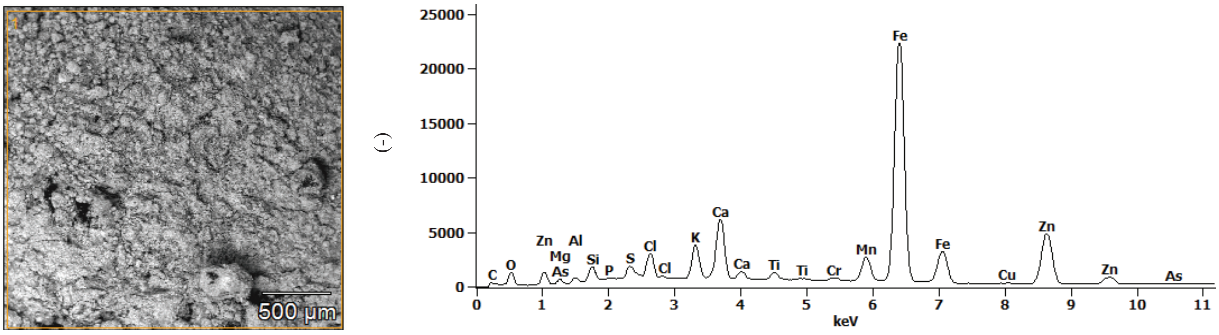

Figure 4 View sample under microscope and EDS studied EAFDs S1

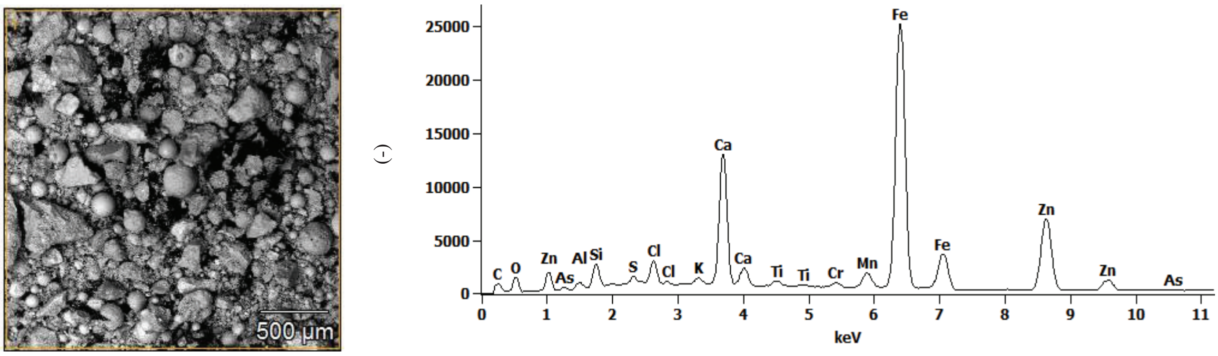

Figure 5 View sample under microscope and EDS studied EAFDs S2

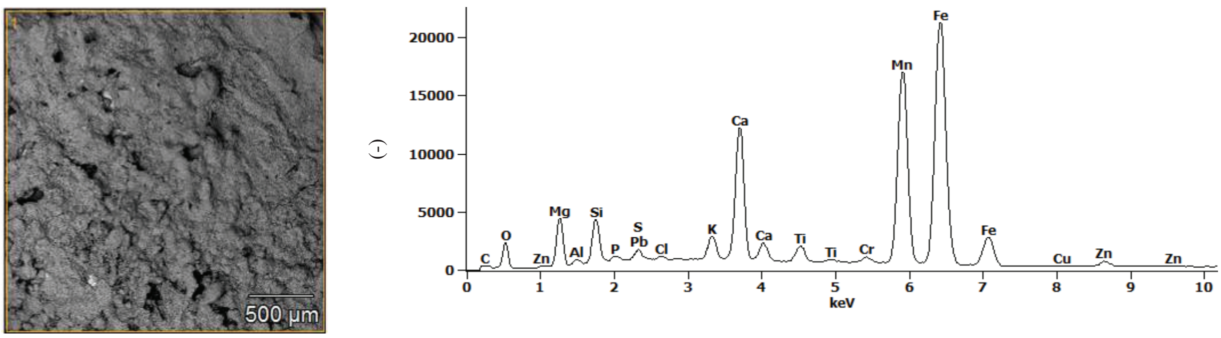

Figure 6 View sample under microscope and EDS studied EAFDs F1

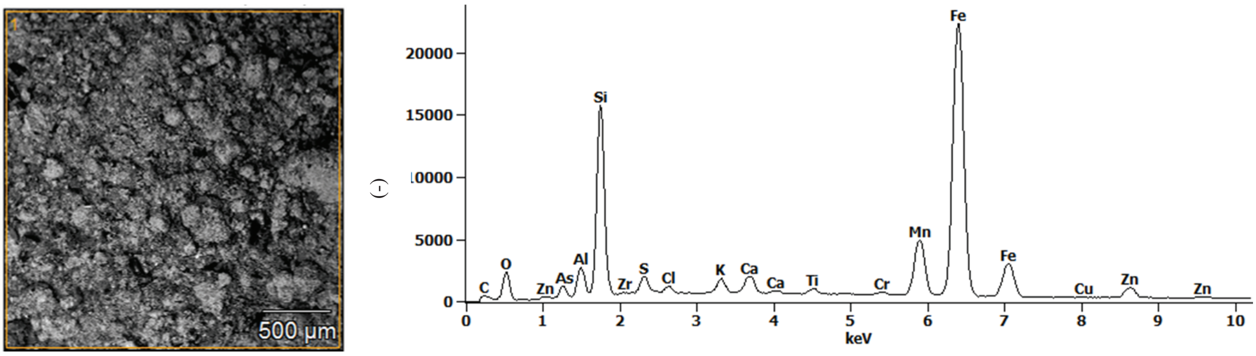

Figure 7 View sample under microscope and EDS studied EAFDs F2

Table 1 Results of the quantitative analysis of chemical composition along with a standard deviation (σ) of element concentrations in the test samples of EAFDs

Element	S1		S2		F1		F2	
	[%]	σ	[%]	σ	[%]	σ	[%]	σ
Fe	53.43	0.38	41.67	0.76	30.93	0.15	38.73	0.92
Zn	23.30	0.46	24.00	0.26	1.47	0.06	3.10	0.10
Al	0.63	0.06	0.77	0.06	0.40	0.00	2.70	0.20
Si	1.90	0.00	1.97	0.12	2.97	0.06	14.70	0.79
Mn	4.63	0.06	1.93	0.06	23.70	0.10	6.90	0.40
S	1.30	0.00	0.70	0.10	0.50	0.00	1.27	0.06
Cl	2.23	0.06	1.57	0.06	0.20	0.00	0.40	0.00
K	3.03	0.06	0.40	0.00	1.20	0.00	0.93	0.06
Ca	6.53	0.40	10.07	0.06	7.83	0.12	1.17	0.06
Cr	0.2	0.06	0.40	0.01	0.53	0.06	0.20	0.00
As	1.00	0.10	0.47	0.06	<0.01	0.01	0.30	0.20
C	4.60	0.13	5.20	0.26	0.80	0.01	5.36	0.07
O	15.7	0.99	10.83	0.99	22.73	0.99	23.63	2.75

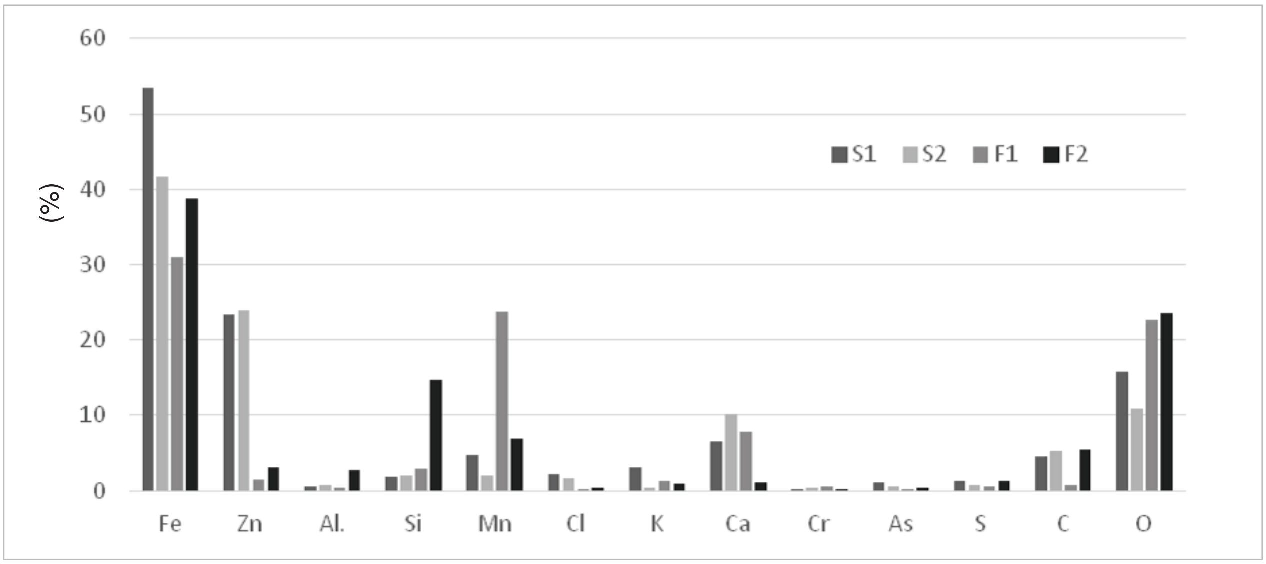

Figure 8 Percentages of the various elements in all tested EAFDs

SUMMARY

The study of the chemical composition of particulate matter generated during the manufacturing process in electric arc furnaces that dust can be a valuable raw material iron. In the studied dust obtained from the steel mills iron content is the highest and amounts to about 40-50%. In the studied dust from electric arc furnaces foundry was recorded slightly lower iron content, at the level of 30-38%.

At the same time studied dust from the steel plant producing steel reported significantly higher zinc content than the steel casting. In the studied dust obtained from the steel mills zinc content is at the level of 23-24% Zn, while dust from the foundry at the level of 1.5-3.0% Zn. Zinc dust content above 4% are not suitable for reuse of iron bearing materials as in the steelmaking process.

Dusts with zinc content of over 20% can be used for zinc recovery - but it is worth considering whether, at such a high iron content is not worth it to develop technology enabling the recovery of this element.

The zinc content in the dust obtained from the foundry indicates the most rational way to use the dust as iron-containing material for subsequent heats. The character of this waste in the form of dust prevents direct use - the technology to be developed briquetting or granulation dust.

Element of which the contents impedes direct application of EADS, is chlorine. In the studied dust obtained from the steel mills chlorine content is 1.57-2.23% Cl. In the studied dust from electric arc furnaces foundry a lower content of this element of 0.2-0.4% Cl was recorded, the chlorine content enables the direct application of these dust into the steelmaking process.

Quite a different alkali metal content, ranging up approx. 3% eliminates the possibility of using the dust as a raw material of iron to the blast furnace process; the alkali metal content is also not acceptable in an electric steel making.

The study analysis of the chemical composition of EDs shows that they can be a valuable resource, after the development of appropriate technology to use them.

ACKNOWLEDGEMENTS

This publication comprises references to results obtained while performing project PBS3/B5/0/2015 entitled "Research and development of environment-friendly technologies of iron recovery from iron-bearing waste materials and waste plastics."

REFERENCES

[1] Gajdzik B.: Compressive classification of environmental aspects in a manufacturing enterprise, Metalurgija, vol. 51, No 4, pp. 541-544.

[2] Lis T., Nowacki K.: Determination of Physical and Chemical Properties of Electric Arc Furnace Dusts for the Purposes of Their Utilization, Steel Research, 2012, No. 9, pp. 842-851.

[3] Mróz J.: Recykling i utylizacja materiałów odpadowych w agregatach hutniczych, Wyd. Politechniki Częstochowskiej, Częstochowa 2006.

[4] http://ippc.mos.gov.pl/ippc/custom/BAT9 (15.04.2016).

[5] www.engitec.com (15.04.2016).

[6] Dyrektywa Parlamentu Europejskiego i Rady 2008/98/WE z 19 listopada 2008 r. w sprawie odpadów oraz uchylająca niektóre dyrektywy (Dz. Urz. UE nr L 312/3).

[7] Dyrektywa Parlamentu Europejskiego i Rady 94/62/WE z 20 października 1994 r.

[8] PN-ISO 4225:1999. Air quality. General aspects. Vocabulary.