THE CHEMICAL COMPOSITION OF IRON SLUDGE DEPOSITED FROM THE CURRENT PRODUCTION OF STEEL INDUSTRY

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Abstract

The main objective of waste management is the recovery of a valuable component (eg. metal, energy). Thanks to the use of waste as raw materials in certain industrial processes prevents their storage, and also creates the possibility of liquidation of existing landfills. A characteristic feature of the examined waste - sludge from the steel industry - is significant iron content. This article presents the results of chemical composition of the deposited sludge and from current production. Knowledge of the chemical composition is the basis of proposals for their development.

Keywords: Steel industry, sludge, chemical composition

1. INTRODUCTION

In June 2013 the European Commission published a policy paper, which stresses the importance of the steel industry for the development of the economies of the European Union. Polish steel industry, having a long tradition is an important element of the processing industry and the entire economy of Poland [1]. The steel industry is a sector in which next to the mining and energy, generate large amounts of waste. In summary consumption of steel metal part is over 92 wt. %, hence the steel industry is one of the sectors of the economy that generate the most waste. A characteristic feature of the waste materials is a significant content of the element, comparable to its content in natural raw materials. Waste materials differ, however, between them both chemical composition and character of occurrence (dusts, slurries), which creates problems and determines the manner of its management.

2. WASTE FROM THE STEEL INDUSTRY

In Poland, on the basis of the Regulation of the Minister of Environment on waste catalog from 12.09.2014 r. [2] wastes from the iron and steel (10 02) belongs to a group of thermal waste. These are:

- slags from smelting processes (blast furnace, steelmaking),
- the raw slag from other processes,
- solid wastes from gas treatment containing dangerous substances,
- mill scale,
- waste from cooling water treatment containing oil,
- sludges and filter cakes from gas treatment containing dangerous substances,
- other sludges and filter cakes,
- dross from the iron,
- waste ferrous sulfate,
- wastes not otherwise specified.

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 wt. % 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 waste metallurgical generates the following benefits:

- reduce the 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.

Currently, country metallurgy, produce waste such as dust, sludge, scale.

Sludges and muds generated during the production of iron and steel and their treatment can be divided into the following groups [3-5]:

- sludge ferruginous, pure iron content above 60 wt. %, which include: sludges from wet flue gas cleaning converter steel mill, wet sludge troughs scraper sinter,
- ferrous-contaminated sludges - the most common contaminants are alkaline, zinc, oil - containing iron in the range of 25 - 60 wt. % .; these sludges include: sludges from blast furnace gas, other sludges eg. the neutralization of chemicals used in some technologies, the production of steel,
- gangrenous oily muds that arise mainly in installations continuous casting, rolling; grade oil content exceeding 10 wt. % at a water content of 25-30 wt. %; the iron content of the scale exceeds 60 wt. %,
- sludge generated during machining of metal parts for example. Mules blasting material containing 10-15 wt. % coolant,
- sludges from cleaning refrigeration equipment for metallurgy,
- water content of about 30 wt. % of the iron content of the scale in excess of 60 wt. % by weight.

Depending on the chemical composition of the sludge, impurities and their water content, their use as a secondary raw material and the preparation for recycling technologies are varied [6].

3. THE STUDY OF THE CHEMICAL COMPOSITION OF IRON SLUDGES

Studies of the chemical composition was subjected to three types of sludges:

A - sludge from the mixer coming from the current production generated on the electric steelworks,
B - sludge deposited for many years on the sludge plot (sedimentation tank), the origin of the sludge the same as A,
C - sludge from cleaner castings, from cast steel and cast iron.

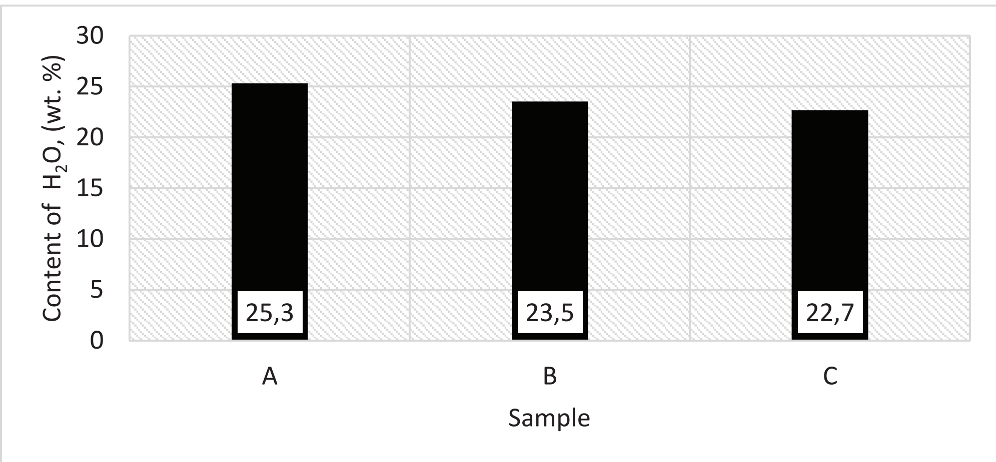


Figure 1 H_2O in the studied iron sludges

From the material for the test samples, which were drained from excess moisture by double several times their drying in an oven at. 105C during 24 h. Drying possible to determine their moisture content - graphical obtained results are shown in **Figure 1** H_2O was found similar in all samples, comprising in the range of 22-26 wt. %

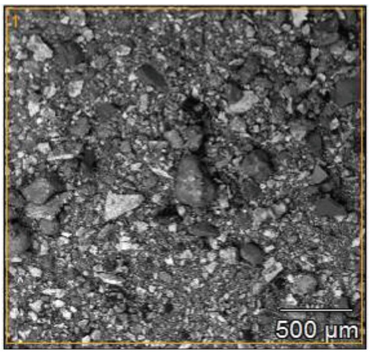
The material forming part of each sample was tested by chemical composition analysis with the use of:

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

In order to obtain accurate results from the material incorporated in each of the samples collected following three attempts ~ a weight of 0.1 g, which were subsequently analyzed. The research material has been glued to the titanium washers, resulting element has been excluded from the results of quantitative X-ray microanalysis. Each sample was tested in three locations average values with standard deviation of concentration of elements in each of them are shown in **Tables 1 - 3** and **Figure 2 - 4**. For each measurement includes a predetermined carbon content CLECO and oxygen OLECO, and the results of the quantitative X-ray microanalysis (sum of concentrations of all elements) have been assigned to the value of 100.00 wt. % - (C_{LECO} + O_{LECO}).

Table 1 The mean value of the concentration of elements in the sample with a standard deviation σ_A (wt. %)

	C_{LECO}	O_{LECO}	Mg	Al	Si	P	S	K	Ca	Cr	Mn	Fe	Ni	Cu	Zn
A	4.92	18.97	0.17	1.53	10.37	0.93	0.27	0.30	0.60	0.27	0.60	59.87	0.17	0.57	0.50
σ_{14}	0.04	1.02	0.06	0.06	1.02	0.06	0.06	0.00	0.00	0.06	0.10	0.81	0.06	0.06	0.00

a 

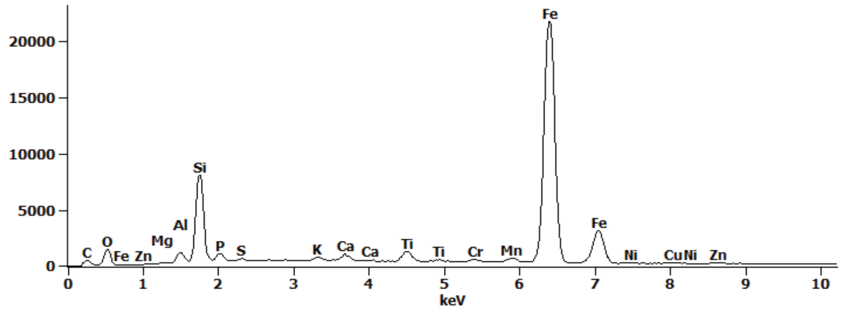
b 

Figure 2 The sludge from the mixer coming from the current production generated on the electric steelworks (sample A); and - view SEM, b - EDS spectrum

Table 2 The mean value of the concentration of elements in the sample with a standard deviation σ_B (wt. %)

	C_{LECO}	O_{LECO}	Mg	Al	Si	P	S	K	Ca	Cr	Mn	Fe	Ni	Cu	Zn
B	1.88	16.80	0.17	0.77	8.90	0.27	0.50	0.10	0.73	0.23	0.60	67.57	0.33	0.73	0.40
σ_B	0.02	1.66	0.06	0.06	0.44	0.06	0.00	0.00	0.06	0.06	0.00	0.25	0.06	0.06	0.00

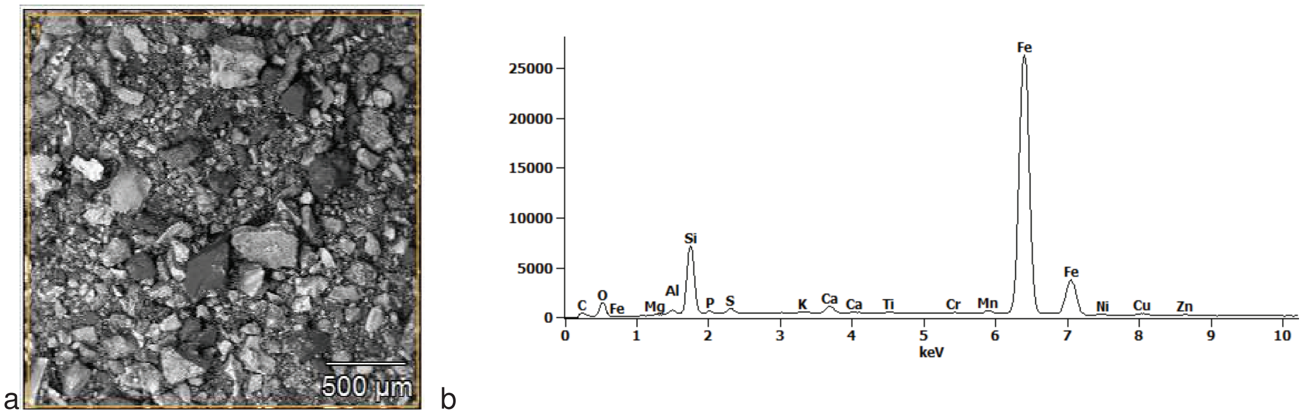


Figure 3 The sludge deposited in the sump, the generated electric arc furnaces (sample B); and - view SEM, b - EDS spectrum

Table 3 The mean value of the concentration of elements in the sample with a standard deviation of σ_C (wt. %)

	C-LECO	O-LECO	Mg	Al	Si	S	K	Ca	V	Cr	Mn	Fe	Zr
C	1.18	37.17	0.67	6.03	17.67	0.30	0.43	0.33	0.10	10.77	0.57	24.13	0.67
σ_C	0.01	2.37	0.06	0.25	0.80	0.00	0.06	0.06	0.00	0.23	0.06	0.12	0.06

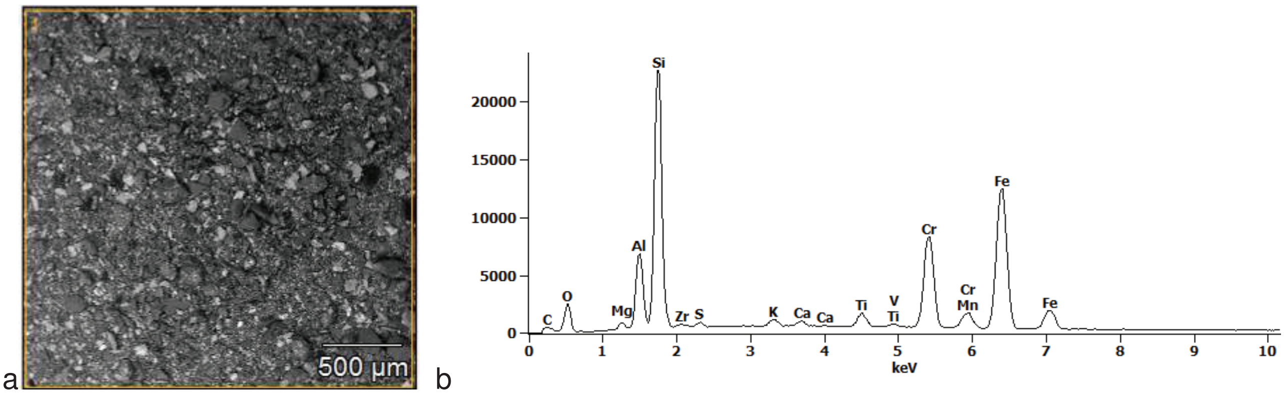


Figure 4 The sludge from cleaner castings, foundry generated (sample C); and - view SEM, b - EDS spectrum

Based on the results of a comparative analysis of the content of each element, and as expected it was found that the highest concentration analyzed in the sludge, there is iron (**Figure 5**). Greater concentration of iron was observed in the sludges coming from the mixer with electric arc furnaces, regardless of whether they are running sludges or deposited (sample A - 59.87 wt. % Sample B - 67.57 wt. %). That why iron content justifies taking action for the recovery and re-melted in an electric furnace or a cupola. Iron present in the sludge is probably bound in the form as oxides, as evidenced by the oxygen content of the sludges (18.97 wt. % sample A, the sample B - 16.80 wt. %). Because of the relatively high content of oxygen in the sludges, may be an economical direct reduction to form a slurry of sponge iron.

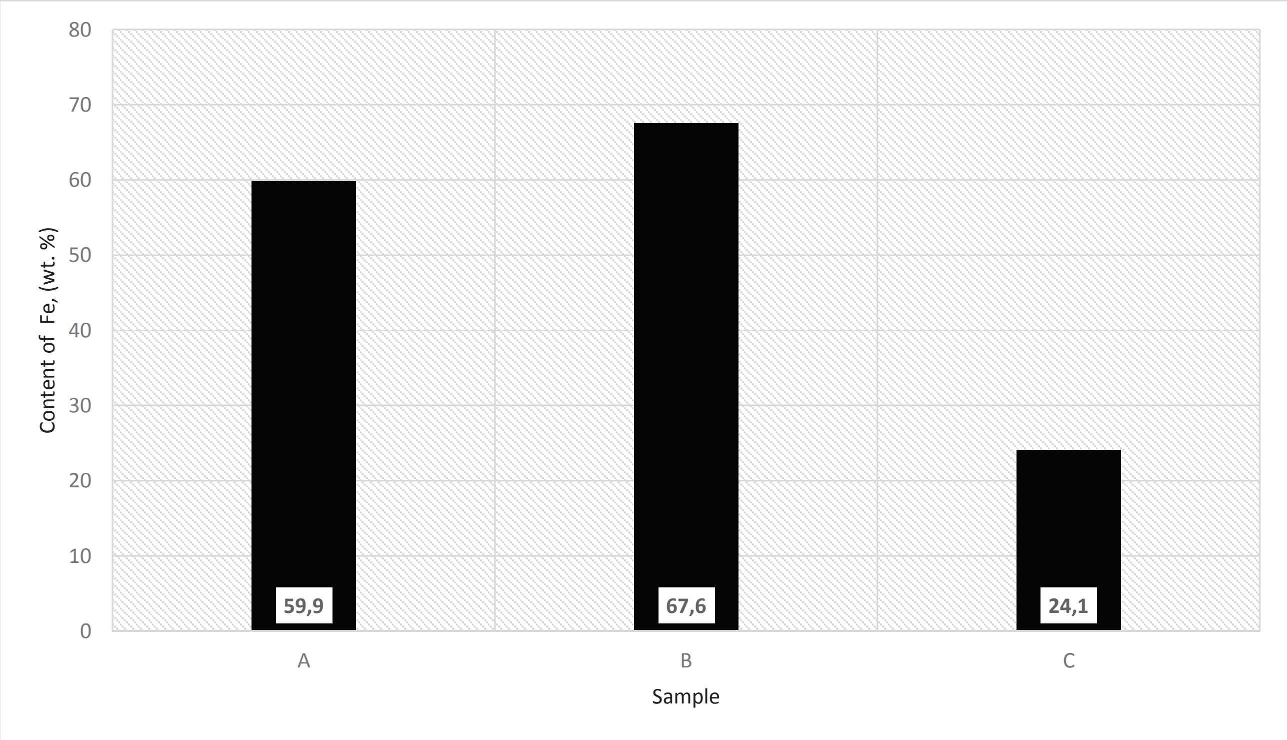


Figure 5 The iron content in the iron sludge

Obtained results of sludge deposited on the sludge field (sample B) For comparison purposes, reference to the same tests performed five years earlier of samples taken at from two other locations and showed a comparable concentration of iron (**Figure 6**). Therefore, it is reasonable to conclude, on the whole sludge field (settler natural) there is a similar concentration of iron, which justifies action taken by at its recovery and rehabilitation of the land.

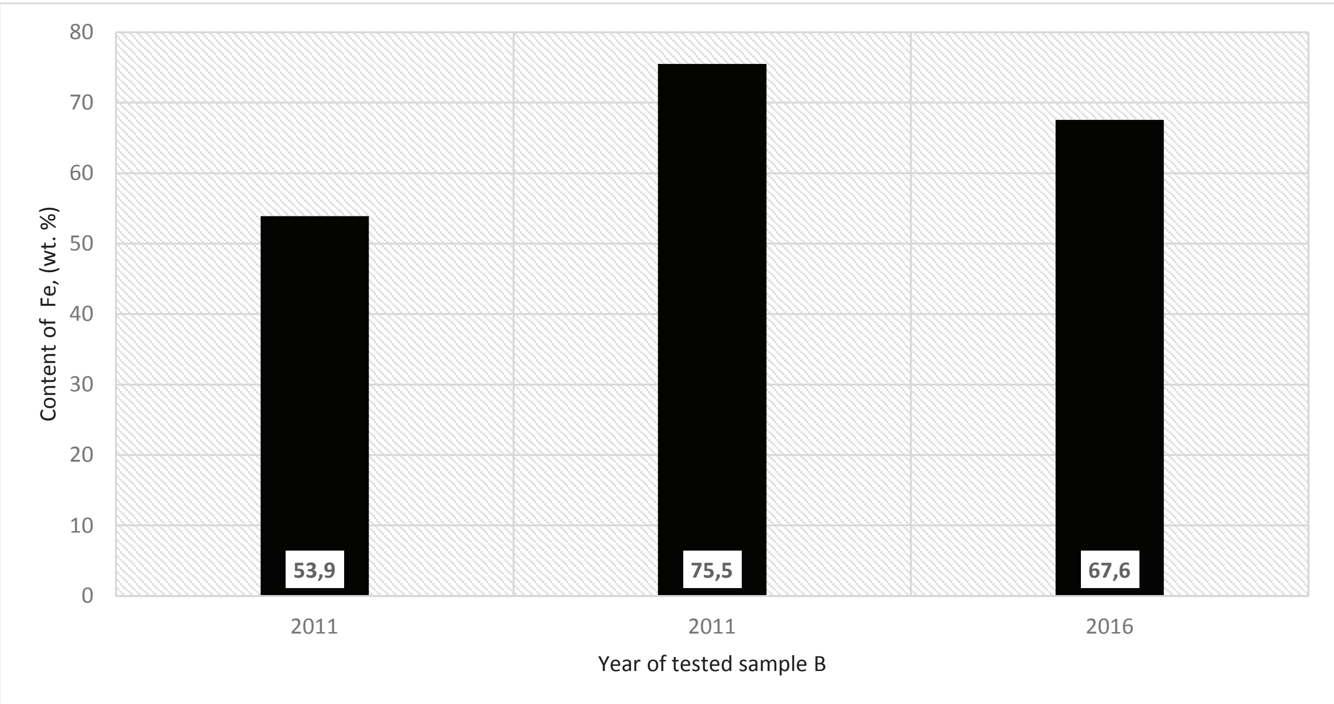


Figure 6 The average concentration of iron in the sludge deposited on the sludge field

The sludge from cleaner castings from the standpoint of recovery of iron is useless. Its usefulness determines the type of steel / cast iron, which is dominant in the range of foundries. In the analyzed case, on the basis of the results obtained, it can be stated that in the foundry are produced steel alloy. Evidence of this high chromium content (10.77 wt. %) - valuable alloying element. Moreover, in the analyzed sludge are other alloying element - silicon concentration of 17.67 wt. %. High concentration of oxygen (37.17 wt. %) in the studied samples of sludge from cleaner castings when melting occurs partially reduce aluminum concentration of 6.03 wt. %, and the aforementioned silicon.

CONCLUSION

Based on the results of the study of the chemical composition of iron of sludge and comparative analysis found; that:

- sludges coming from the mixer with electric arc furnaces, both automatically generated and deposited in the sump, due to the concentration of iron in them may be used for the recovery of iron,
- sludges from the cleaner castings, due to its high content of alloying elements, depending on the species produced steel / cast iron, may be used for the recovery of valuable alloying additives.

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