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Original Research Article

Removal of zinc from dusts and sludges from basic oxygen furnaces in the process of ammoniacal leaching

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ABSTRACT

More than 20 kg of dust and sludge per 1 ton of produced metal are generated in the basic oxygen furnaces used in steel metallurgy. In this type of waste there may be many non-ferrous metals, including also zinc. The content of this metal in dusts ranges from 1 to 6%. After lowering the zinc content to a level of about 1%, such type of waste may become a full-fledged iron-bearing material used in ferrous metallurgy. There is also a possibility to recover and manage the zinc removed from waste materials. Recycling of these materials also reduces the risk to the natural environment, resulting from e.g. the transition of metal compounds contained in stored waste materials into the groundwater and soil. The article presents the results of ammonia leaching of wastes from basic oxygen furnaces where the zinc content is 2.82%. Ammonia leaching allows the turn zinc into the liquid phase with minimal loss of iron in this process. The examinations apply three compounds of ammonia (NH_4Cl, $(NH_4)_2CO_3$ and NH_4OH) to analyze the efficiency of the leaching process at different times, temperatures, concentrations of applied compounds and ratios of liquid phase to the solid phase.

1. Introduction

Zinc is widely applied in various fields of human activity. About 20% of world zinc production is consumed in the production of brass, 15% for the production of other alloys and 50% of global production is used for the electroplating process of the steel against corrosion. Steel scrap containing minor amounts of zinc in the form of protective coatings is widely used as a feed component in pyrometallurgical processes to obtain iron and steel. This way realizes the steel recycling process which, however, generates a significant amount of waste in the form of among others dusts and sludge. Depending on the used technology of steel production, these materials may contain lesser or greater amounts of zinc. Generally, it is possible to distinguish two ways for obtaining

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steel. The first way means the processing of feed consisting primarily of iron ore supplemented with appropriate technology additives and a small amount of recycled steel. Devices used in this process are the blast furnaces (BF) and basic oxygen furnaces (BOF). The second method consists in processing a feed consisting primarily of steel scrap subjected to remelt in electric arc furnaces (EAF). Steel production generates a large amount of dust and sludge in relation to 1 ton of produced steel. According to the literature [1], in case of blast furnaces it is 20.3 kg/ton of steel, in relation to BOF it is 22.9 kg of dust and sludge per 1 ton of steel and in case of electric arc furnaces this is 12.8 kg. Dust from blast furnaces generally do not contain large amounts of zinc and its concentration in this material generally does not exceed 1.5%, and usually it is a value located below 1% [2]. Higher levels of zinc are recorded in dust and sludge from BOF. The feed to these devices is molten iron from the blast furnace, supplemented with some amount of scrap steel. Technological process results in obtaining the dust containing up to about 0.4% of Zn and slurries, in which the content of this element may be up to 6 percent. At the same time, both dusts and sludges from BOF may contain from about 50 to as much as 75% of iron, and therefore this waste should be recycled to the process of steel and iron production. The vast majority of zinc in dusts and sludges produced obtained from the recycling of gases in BOF is in the form of ZnO (74%) and only a small part in the form of zinc ferrite $ZnFe_2O_4$ (26%) [3]. Due to the conditions of the process conducted in the electric arc furnaces the content of zinc in dusts obtained in this process can be as high as 40% and usually it is included in the range of 11–27% [4,5]. Cautious estimates allow to determine the annual amounts of material obtained from the dedusting of process gases from the BOF at the level of 6 million tons, and in case of electric arc furnaces – about 4 million tons. Currently, approximately 40% of the zinc rich dusts from electric arc furnaces are processed. The remaining 60% are accumulated in dumps located near the metallurgical plants. More than 99% of dusts subjected to recycling are treated in pyrometallurgical processes (Wealz process) and the final product of this process is pure ZnO. In case of dusts and sludges from BOF we deal mainly with the storage of waste materials in dumps and a few cases of using some amounts as an additive to the feed along with other iron-bearing oxide materials and processing in basic oxygen furnace [6].

2. Material for the research

2.1. *Sludge properties*

For the purpose of research, the sample of sludge was obtained from the treatment of process gases from steelmaking plants. The obtained material was analyzed qualitatively for the presence of the most important components on EDXRF analyzer and it was possible to obtain a spectrum showing the sludge forming elements (Fig. 1). The quantitative analysis was performed by means of atomic absorption spectrometry with the following results: Fe – 58.9%, Zn – 2.82%, Ca – 4.39%, Si – 0.89%, Na – 1.2%.

In the next stage of the research, the phase analysis of the sludge was performed (Fig. 2). The obtained results indicate the existence different forms of iron (Fe, FeO, Fe_2O_3 i Fe_3O_4) and ZnO in the material. It is worth to emphasize that in contrast to similar materials derived from the metallurgy of iron and steel, it was not confirmed the presence of zinc ferrite ($ZnFe_2O_4$) in the analyzed sludge.

Initial researches of the obtained sample of sludge were ended with the sieve analysis of the material, the purpose of which was to determine the fractional composition. The results of the analysis are shown in Fig. 3.

It can be noticed that the researched sludge is a material characterized by high size reduction and more than 50% of its mass is characterized by the grains diameter smaller than 0.2 mm. Among the entire distribution of grain diameters, the three were selected and taken as representative for the coarse grain fraction, medium grain size fraction and the fine fraction:

1.00–0.630 mm – 14.88% in the total mass,
0.16–0.125 mm – 27.08%,
0.09–0.071 mm – 3.46%.

In order to reveal the structure of researched material, these fractions were analyzed using scanning electron microscope (SEM) (Fig. 4). ASA analysis was performed to determine the content of iron and zinc in the test samples. The results of analyzes are shown in Table 1.

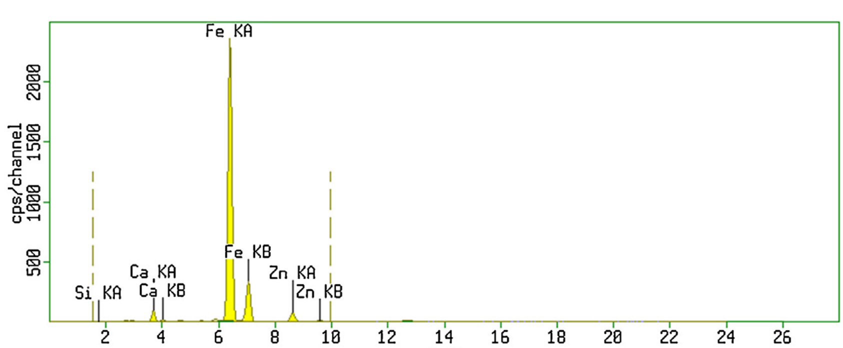

Fig. 1 – EDS of the analyzed sample of sludge.