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EFFECTS OF A REDUCER TYPE ON COPPER FLASH SMELTING SLAG DECOPPERISATION

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In the paper, results of investigations on coke dust, anthracite dust and coal flotation concentrate application in the technology of copper flash smelting slag processing are presented. The results show that the selected reducers can be used as substitutes for the conventional coke.

Keywords: reducer, copper flash smelting, slag decopperisation, coal flotation concentrate, anthracite dust

INTRODUCTION

A change in perception of the industry – environment relationship, observed for many years, has resulted in a high interest in minimisation of technological waste amounts and management of existing waste materials. In the case of metallurgical technologies, an important issue becomes raw material recycling, i.e. processing of waste materials and products to obtain their original source materials. Examples of such materials are slags that are generated in almost each pyrometallurgical technology of metal production and refining. They can constitute initial materials that are as valuable as various types of scrap metals have already become. At present, the latter materials are significant resources for steel, lead, aluminium and precious metal production. The best examples of these are used car batteries, electronic scrap and used catalytic converters [1, 2]. In copper production technologies, slags of diverse chemical compositions are generated, which depends of their role in a given process. The differences basically refer to their alkalinity and contents of various metal compounds. The slags are frequently processed with the aim of copper, lead, iron, cobalt, chromium, zinc etc. recovery [3 - 11]. A typical feature of slag that is formed during copper flash smelting is not only a higher copper content (above 12 %) – increased contents of lead and iron are also observed. The slag is processed in the electric furnace and a product of this process is the Cu-Pb-Fe alloy. This technology is costly and therefore, all activities aimed at decreasing its costs can be readily justified. One of the solutions is application of cheaper charge materials than those being currently used. In the paper, results of investigations on the discussed slag reduction using, as reducers, waste fine-grained carbon-bearing materials, i.e. coal flotation concentrate from the coal-enrichment process, coke dust and anthracite dust, are presented. A unit price of these wastes is only 50 % to 80 % of the currently used coke breeze price.

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RESEARCH MATERIALS AND METHODS

For the investigations, industrial slag containing 11,6 % mass Cu, 3,25 % mass Pb and 10,63 % mass Fe was applied. The proposed waste reducers are already utilised as alternative to breeze coke fuel in iron-ore sintering processes [12 - 13]. Chemical compositions of the applied reducers are presented in Table 1.

Table 1 **Chemical compositions of the applied reducers**

	Fractions of individual components / % mass			
	C	S	Humidity	Ash
Coal flotation concentrate	64,3	0,45	26,5	8,71
Coke dust	88,5	0,6	0,3	10,3
Anthracite dust	71,5	1,7	5,4	25,1

A charge component was also limestone which enhances the slag decopperisation process. The charge material additives (reducers and limestone) were added in the amounts equivalent to the proportions used for industrial process conditions. All experiments were conducted using the resistance furnace, at 1 573 K. After each experiment, the slag and the Cu-Pb-Fe alloy were analysed for copper, lead and iron contents.

STUDY RESULTS AND DISCUSSION

In Tables 2 and 3, mean concentrations of post-reduction copper, lead and iron (both in the alloy and in the slag) are presented, while in Figures 1-3, graphic interpretations of the obtained results against the trend curve for reduction processes conducted using coke breeze, i.e. an industrial-type reducer, are shown [14]. For lead and copper, the analysis of results with respect

to changes in slag compositions showed high reduction degrees for their oxides. In the case of copper, as early as after one-hour reduction and after five-hour reduction, slag containing less than 1,2 % mass Cu and 0,4 % mass Cu, was obtained, respectively, for all the reducers. Under industrial conditions, this value is 0,5 – 0,6 % mass. According to Kucharski [15], decopperisation yielding up to 0,0067 % mass Cu on the coke breeze-slag boundary at 1 573 K can be observed considering the industrial conditions. For lead, Pb reduction to less than 1,2 % mass and 0,53 % mass after 2-hour and 5-hour processes, respectively, was obtained for all the reducers. These results are very promising as under the industrial conditions, the lead content is only reduced to approx. 1 %. Considering the equilibrium conditions in the slag that is in contact with coke breeze or the electrodes, it is possible to remove lead to the level of 0,023 % mass at 1 573 K [15]. A high discrepancy between the technological results and the results of laboratory investigations, conducted using various experimental setups, suggests considerable problems with simulation of industrial electrical furnace operational conditions in the laboratories. The slag composition following a 5-hour reduction process was approx. 72-77 % mass Cu, 13-16 % mass Pb, 4 - 6 % mass Fe and it was comparable to the final alloy composition obtained under the industrial conditions, particularly for the copper and lead fractions.

Table 2 **Mean Cu-Pb-Fe compositions after the reduction process**

Reduction time / h	Coke dust	Anthracite	Flotation concentrate
Cu / %mass			
1	69,9	75,08	77,03
2	72,80	69,28	71,76
3	80,10	65,73	70,23
5	77,30	74,24	72,57
Pb / %mass			
1	25,25	12,92	13,65
2	18,71	19,99	21,16
3	14,54	14,44	15,31
5	16,23	13,48	13,72
Fe / %mass			
1	0,25	1,89	2,25
2	0,92	3,81	4,88
3	3,88	4,29	4,97
5	4,59	5,63	6,03

Table 3 **Mean slag compositions after the reduction process**

Reduction time / h	Coke dust	Anthracite	Flotation concentrate
Cu / %mass			
1	2,48	1,63	0,87
2	1,19	0,71	0.66
3	0,54	0,27	0.38
5	0,30	0,19	0,40
Pb / %mass			
1	0,91	2,4	1,28
2	0,88	1,13	0,73
3	0,51	0,73	0,56
5	0,45	0,17	0,53
Fe / %mass			
1	11,35	13,11	14,46
2	10,59	11,42	10,83
3	8,29	9,51	9,23
5	4,51	7,74	6,56

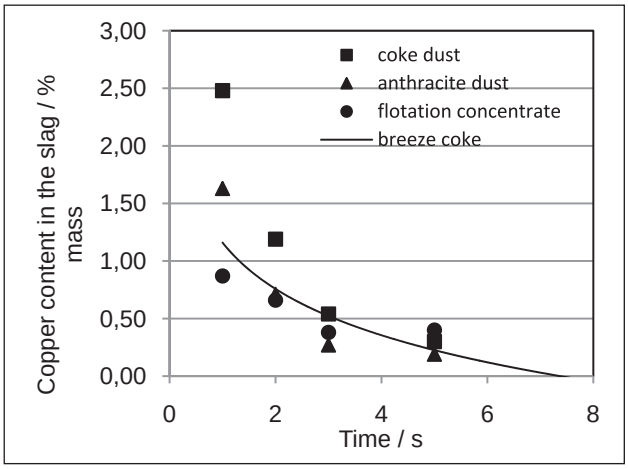

Figure 1 Effects of reduction time on the copper content in the slag

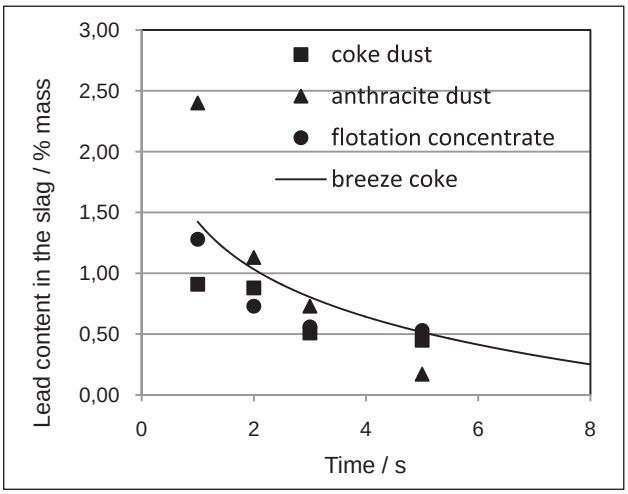

Figure 2 Effects of reduction time on the lead content in the slag

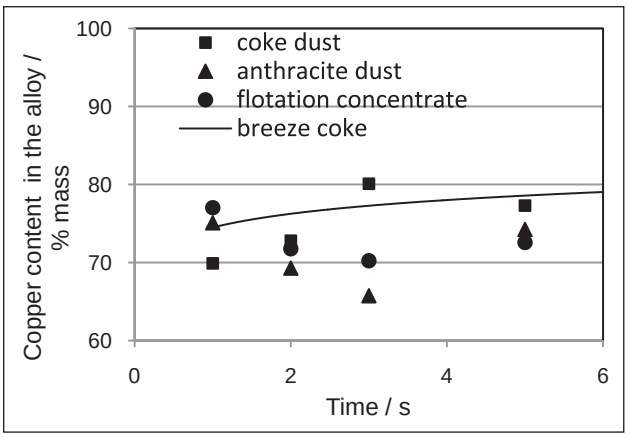

Figure 3 Effects of reduction time on the copper content in the Cu-Pb-Fe alloy

SUMMARY

Based on the experimental results, a potential for anthracite dust, coke dust and coal flotation concentrate application as alternative carbon reducers in flash smelting slag processing was demonstrated. The obtained results of copper and lead elimination from the slag during its smelting reduction were comparable to the results observed under the industrial conditions. However, these results need to be further verified at a semi-industrial level using the electrical furnace as the investigations performed with this device showed that the rate of the discussed process might be affected by the reducer type [16]. Other factors that may impede direct, practical application of these reducers are their compositions and limitations of the composition of the gaseous phase generated during the technological process.

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Note: Nowak P. is responsible for English language, Katowice, Poland