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REDUCTION OF COPPER SLAG WITH THE USE OF CARBON GRANULATES

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Preliminary Note – Prethodno priopćenje

The investigation results on the reduction of slag from flash smelting furnace and the use of carbon granulates obtained from fine-grained waste materials of both the coal enrichment and coking processes have been presented in the paper. The investigation results on the reduction of slag from flash furnace and the use of carbon granulates obtained from fine-grained waste materials of both the coal enrichment and coking processes have been presented in the paper.

Keywords: copper, slag, reduction, flash furnace, carbon granulate

INTRODUCTION

The processes of metal recovery from primary raw materials are inevitably connected with the large scale generation of harmful wastes. This in turn means destruction of environment. At the same time the character of the processes require large amount of unrenewable natural resources such as metal ores and coal. Their exploration has a negative effect on environment and reduces the existing natural deposits. Over the last decade coal deposits have been reduced by 50 % which is illustrated in Figure 1.

Having analyzed how fast the metals ore reserves are depleted, it is almost sure that their production will have to be seriously reduced in the forthcoming 20 years. Figure 2 presents the relevant data. One of the ways to reduce the over-exploration of mineral raw materials under discussion is the recycling of scrap iron and metal bearing wastes. The reduction of energy consumption in the course on the two mentioned above processes or the use of alternative fuels might also help solve the problem.

The investigation have been carried out for many years, specially with regard to technology of pig-iron and steel production as well as lead recovery form scrap wastes [1 - 9]. Numerous research reports proved that the thermoecological cost of many types of waste materials used in the process can be significantly lowered in comparison with the processes which make use of primary raw materials [10 -14]. The investigation results on the reduction of slag from flash furnace and the use of carbon granulates obtained from fine-grained waste materials of both the coal enrichment and coking processes have been presented in the paper. The slag generated during the blister copper production is characterized by a considerable amount of this metal, at times up to 16 % mass. The authors discuss the potentiality of replacing the breeze, which is currently used, by carbon granulates made of cheaper waste materials containing carbon. The introduction of such reducers might significantly lower the unit cost of copper smelting since the average price of anthracite dusts is ca. 90 euro/Mg and the price of breeze 50 Euro/Mg. The cost of caking operation reaches 30 Euro/Mg.

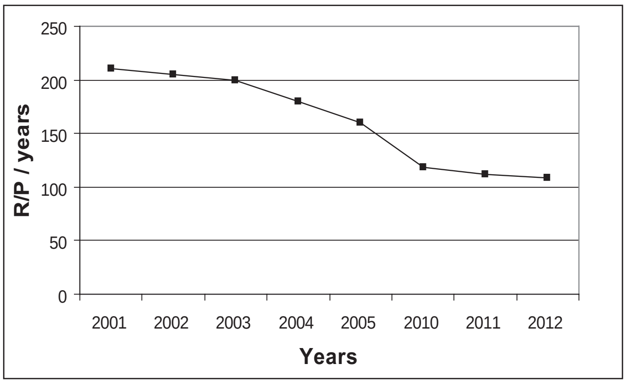

Figure 1 Coal reserves

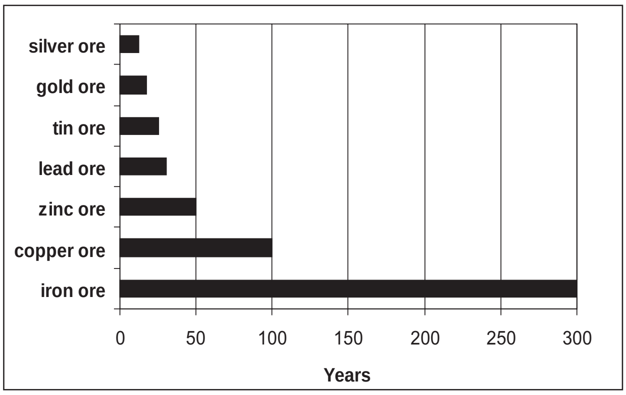

Figure 2 Sufficiency of non-ferrous metal ores

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THE EXPERIMENTAL PART

In Table 1, a composition of flash smelting slag that was used in all the experiments is presented. As carbon reducers, coke and anthracite dusts were applied.

Table 1 **Chemical composition of the investigated slag**

Fractions of individual components / %mass	Copper slag	Coke dust	Anthracite dust
Cu	11,6		
Pb	3,25		
Fe	10,63		
S	0,03	0,6	1,7
CaO	13,28		
SiO_2	31,84		
MgO	5,08		
Al_2O_3	8,95		
C		88,5	10,3
Ash		60,0	25,1

All reductive smelting processes were performed in a PT 40 electric furnace. The smelting process involved two basic operations:

- ✓ Introducing a reducer and limestone into the melting pot preheated to a required temperature.
- ✓ Pouring liquid copper slag over the components.

The operations have been performed in the system similar to technological process realized at KGHM ‘Polska Miedz’. Before smelting, reducers were subjected to the agglomeration process in a balling disc using the following parameters: disc rotation = 28 rpm, disc slope angle = 40 degrees.

STUDY RESULTS AND DISCUSSION

In Table 2, post-reduction copper, lead and iron contents in the slag are presented. Based on these values, a so-called slag reduction degree was estimated using the following equation:

$$S_R = (C_m^0 \cdot m^0) - \frac{C_m^k \cdot m^k}{C_m^0 \cdot m^o} \cdot 100\% \qquad (1)$$

where:

m^0 and m^k – initial and final slag mass, respectively

C_m^0 and C_m^k – initial and final metal content in the slag, respectively

In Figures 3 and 4, graphic interpretations of the results against the reduction curve determined based on the results of smelting processes with coke breeze are presented. For all applied carboniferous materials, the copper reduction degree was above 80 % as early as after one hour. For 5-hour processes, the value of this parameter was higher than 97 %. The lead reduction degree depended on the process duration and was as follows: 25 % to 84 % for one hour and 83 % to 92 % for 5 hours. The experimental findings also showed that for the granulated reducer, the reduction degrees of both copper and lead were higher than for the fine-grained reducer, which was probably a result of better kinetic conditions of mass transfer in the gaseous phase in the reduction process of the discussed oxides.

Table 2 **Contents of selected components in the slag after the reduction process***

Charge material	Time / h	Cu content in the slag / %mass	Pb content in the slag / %mass	Cu reduc. / %	Pb redu / %
Slag + bulk coke dust	1	0,024	0,018	83,21	56,52
Slag + bulk coke dust	5	0,003	0,0068	98,00	83,86
Slag + coke dust granulate	1	0,003	0,0059	97,84	84,84
Slag + coke dust granulate	5	0,0015	0,0038	99,10	91,87
Slag + bulk anthracite dust	1	0,0123	0,013	90,66	64,80
Slag + bulk anthracite dust	5	0,0021	0,0047	98,51	88,14
Slag + anthracite dust granulate	1	0,0034	0,0332	97,90	26,96
Slag + anthracite dust granulate	5	0,002	0,0059	98,90	88,41

* - Mean values from two experiments

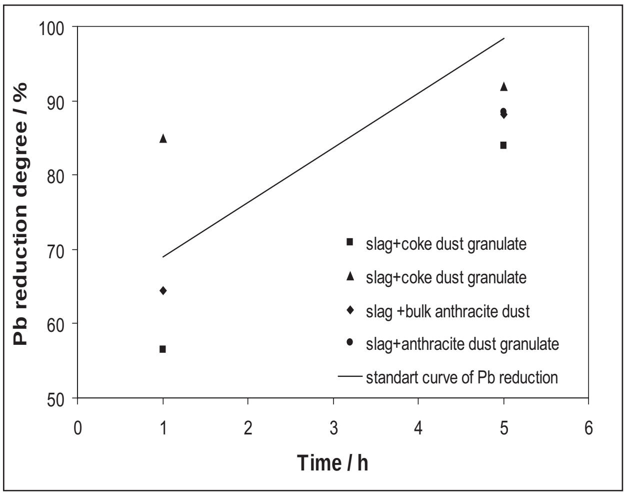

Figure 3 Results of lead reduction from industrial oxide slags

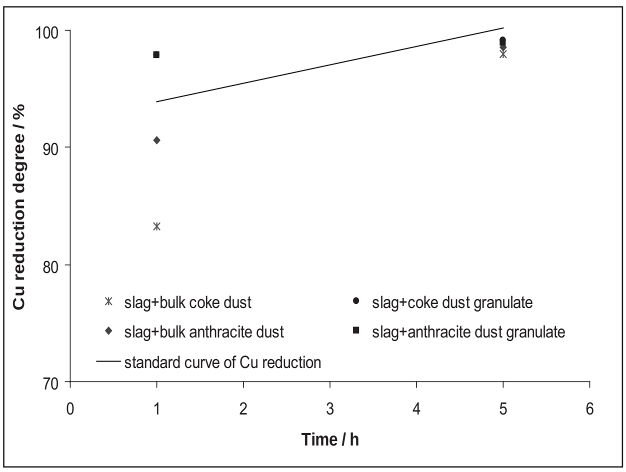

Figure 4 Results of copper reduction from industrial oxide slags

SUMMARY

The experiments demonstrated a potential use of granulates made of fine-grained carboniferous materials as reducers in the process of copper oxide slag smelting. However, it should be noted that with respect to application of these granulates, an appropriate agglomeration technology and studies on the granulate effects on the environment during their combustion should be developed and conducted, respectively.

Acknowledgements

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