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THE RESEARCH ON REACTIVITY OF ALTERNATIVE CARBON REDUCERS

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Preliminary Note – Prethodno priopćenje

The research involved measuring of the speed of zinc oxide with carbon reducers. Samples weighing between 60 and 100 mg were tested with the use of thermogravimetric analysis within the range of temperatures up to 1 100 °C in nitrogen atmosphere. The speed of heating was 20 deg min^{-1}. The research involved also reducers normally used in reduction processes. The results obtained prove that some of the alternative reducers may be used for industrial purposes.

Keywords: carbon reducers, previous metals, secondary raw materials, recovery metals.

INTRODUCTION

Pyrometallurgical technologies for obtaing zinc and lead both from raw and recycled materials are based on reduction processes [1-3]. Quick coke and anthracite are the most frequently used reducers. In recent years there has been a marked increase in the price of coke on world markets, which may generate interest in partial or total replacement of this traditional reducer. While retaining the adequate technological parameters, it will allow for lowering of the cost of production of these metals [4-7].

Among many types of waste products generated in Polish extractive, chemical and metallurgical industry plants there are also products containing a considerable amount of carbon. Therefore, it is expedient to explore the possibility of using such carboniferous waste products in industrial non-ferrous metal production processes.

Apart from delivering the appropriate amount of heat to the reactor, pyrometallurgical technologies of obtaining metals require auxiliary substances, which ensure the appropriate course of the process.

Among these substances there are: a reducer, fluxing agents and slug-forming substances. [1] What is important from the point of view of production costs is the quantity of the additives used up in the process. Most pyrometallurgical processes connected with the production of metals, whether from raw or recycyled material, require the use of carbon in order to ensure suitable reduction conditions. [8-10]. Coke is the reducer most frequently used in pyrometallurgical processes.

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RESEARCH MATERIAL AND METHODOLOGY

Analytically pure zinc oxide (ZnO) was used in the tests, which was mixed in the 2:3 weight proportion with chosen carbon materials which had been degassed at the temperature of 1 100 °C. Three alternative reducers were used in the tests (soot, anthracite dust and flotation concentrate derived from enriching fine coal), as well as three other materials: blast furnace and petroleum coke and charcoal.

The measurements of the speed of zinc oxide reduction with carbon reducers was conducted using a Netzsch calorimeter. The reaction mixture in the amount of 60 to 100 mg was poured into an aluminum oxide crucible and heated to the temperature of 1 100 °C with the speed of 20 deg/min in nitrogen atmosphere.

RESULTS

Figure 1 presents mass decrement curves for the six samples of zinc oxide mixtures with particular carbon materials. Total (final) mass decrement amounts to about 50 %, which means total zinc reduction and evaporation of zinc taking place as a result of the following reaction

$$ZnO + C = Zn(g) + CO \tag{1}$$

The theoretical mass decrement - assuming that as a result of the reaction pure carbon oxide is formed and that the initial composition of the mixture mass is 40 % ZnO and 60 % carbon material - amounts to:

$$40\,\% \cdot \left(1 + \frac{12}{81,4}\right) = 45,6\,\% \tag{2}$$

This value (45,6 %) corresponds to the intentional mass decrement, which falls within the range of 43 to 49 %.

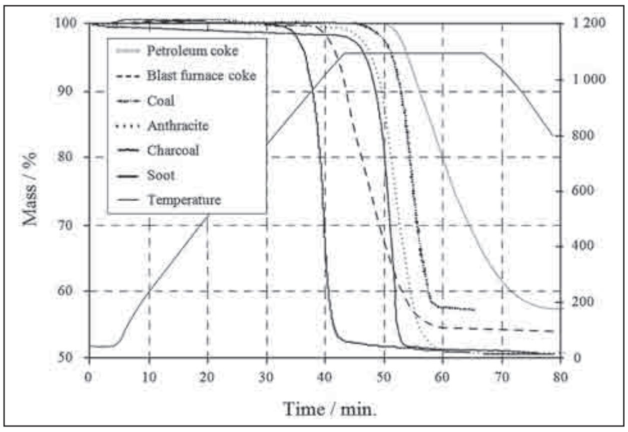

Figure 1 Mass decrement in the samples of carbon material with zinc oxide in nitrogen atmosphere during heating.

Figure 2 presents the change in the mass decrement in function of temperature, which increases with the speed of 20 deg/min to 1 100 °C. From the presented data it follows that the two most reactive materials (soot and charcoal) reduced the zinc oxide completely before reaching the temperature of 1 100 °C. In the case of the two least reactive materials (petroleum coke and blast furnace coke) the mass decrement in the non-isothermal part allowed for the reduction of about a half of the zinc oxide content.

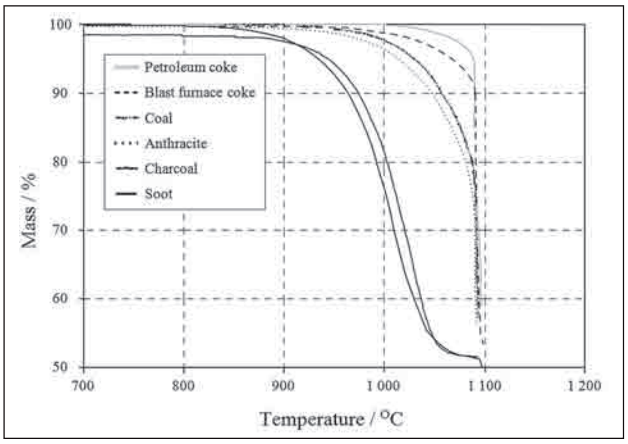

Figure 2 Mass decrement in the samples of carbon materials with zinc oxide in nitrogen atmosphere in function of temperature

Figure 2 presents the change in the mass decrement in function of temperature, which increases with the speed of 20 deg/min to 1 100 °C. From the presented data it follows that the two most reactive materials (soot and charcoal) reduced the zinc oxide completely before reaching the temperature of 1 100 °C. In the case of the two least reactive materials (petroleum coke and blast furnace coke) the mass decrement in the non-isothermal part allowed for the reduction of about a half of the zinc oxide content.

Figure 3 demonstrates kinetic curves of zinc oxide reduction reaction for the first 20 % of mass decrement in order to determine the temperature at which the mass decrement reached the initial value of 5 % in each of the samples (Table 1). Figure 4 presents also the curve of zinc vapour pressure.

Initial gasification temperature may be considered as a criterion of carbon material reactivity, similarly to the speed of gasification at a given temperature (Figure 4). The apparent activation energy gives the idea of the kinetic control of the process

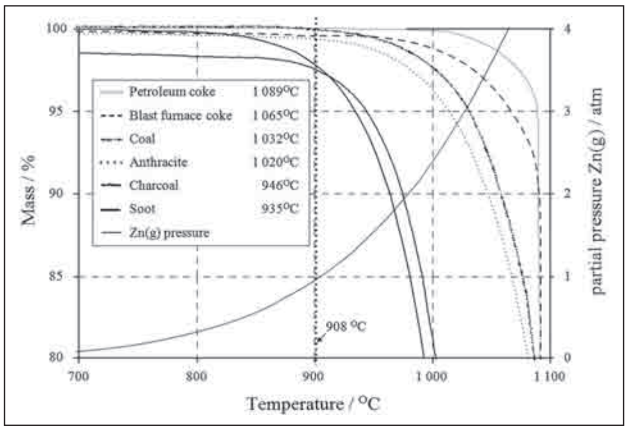

Figure 3 Determining the initial carbon material gasification (ZnO reduction) temperature

Table 1 **Temperature at which the sample mass decrement reached 5 %**

Reducer	Soot	Charcoal	Anthracite	Coal	Blast furnace coke	Petroleum coke
T °C (for x= 5 %)	935	946	1 020	1 032	1 062	1 089

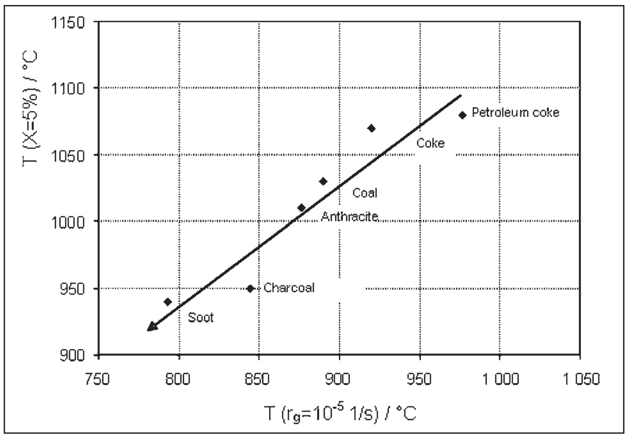

Figure 4 Correlation between the initial gasification temperature and the temperature at which the observed mass decrement reached 5 %.

CONCLUSION

The laboratory research conducted on the speed of zinc oxide reduction using carbon reducers showed that all the carbon materials used allow for zinc oxide reduction in the analyzed range of temperatures. Soot and charcoal yielded

the best results in this respect. The results obtained require conducting research on semi-technical scale in order to fully confirm the usefulness of alternative raw materials for industrial scale purposes. The quality of the product received, as well as the level of environmental impact, is a significant criterion for the choice of components for the metallurgic charge. In the light of ever more rigorous environmental norms and regulations the benefits of using cheaper raw materials may not consist a sufficient economic stimulus.

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