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RESEARCH OF ELECTRICAL RESISTANCE AND BEGINNING SOFTENING TEMPERATURE OF HIGH-ASH COALS FOR MELTING OF COMPLEX ALLOY

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Preliminary Note – Prethodno priopćenje

The research results are demonstrated on the electrical resistance and beginning softening temperature of the high-ash coals of Saryadyr, Borly and Zhamantuz deposits (Republic of Kazakhstan). Such parameters of the charge in the ore-thermal furnace provide a low fraction of the charge conductivity, and thereby contribute to the release of a main energy fraction in a reaction zone of the furnace where a metal is formed. The research results showed that a value of the electrical resistance of the charge at the non-isothermal heating to the high temperatures depends on the chemical and mineralogical composition of the charges, and on processes of phase transformations in a sample.

Keywords: high-ash coals, electrical resistance, temperature, non-isothermal heating, Kazakhstan

INTRODUCTION

Since one of the most important values of the melting process of ferroalloys is an active useful capacity of the furnace closely related to the physicochemical properties of the used raw materials, in particular the electrical resistance of the charge, thus it is necessary to apply the reducing agents with an increased electrical resistance to increase the resistance of the furnace bath. If it is remembered that at the melting of the complex alloys in a slag-free (low-slag) method, a consumption of solid carbon in the charge will be almost twice as much as in processes of the slag melting, thus this parameter of the charge has a prevalent value [1-3].

Therefore, the effective power distribution and the maximum concentration of heat in the reaction zone are directly related to the electrical conductivity of the charge materials, since a part of the current passes through the charge in the ferroalloy furnaces.

The electrical resistance of the charge is determined mainly by a resistance of their ore part and the fraction of a carbonaceous reducing agent therein [4, 5].

The melting practice of the high-silicon alloys demonstrates that the rate of melting or partial melting of raw materials should not be ahead of the rate of the reducing reactions. Otherwise, the reduction process of the elements is disrupted with formation of difficult to reduce slags, as in the melting of complex alloys [6-8].

In the electrical melting of complex alloys, the selection of a reducing agent having an increased electrical resistance and the depth of implantation of electrodes in the charge plays an important role. The depth of implantation of electrodes depends on the melting point and the electrical resistance of the charge layer, where the main is an electrical resistance of a reducing agent. Since the charge in the melting of the complex alloy has 60 % or more of the carbonaceous raw materials containing a certain amount of carbon, thus the knowledge of the specific electrical resistance of the charge is important.

In this connection, it is necessary to research the electrical resistance of the charge materials for melting of a complex alloy with high-activity elements of Al - Mn - Ca - Si.

During the evaluating of the carbonaceous raw materials of the coal basin of the Central Kazakhstan, attention was paid to the chemical composition of ash, and capacity of deposits.

The previous laboratory tests of the high-ash coal varieties of the different coal open-pit mines showed that the coals of the Saryadyr, Borly and Zhamantuz deposits of the Teniz-Korzhunkolsky and Karaganda coal basins, and also the Zhamantuz group of deposits are interesting in their physical and chemical properties and industrial capacity [9].

EXPERIMENTAL PART

Three various types of the carbonaceous raw materials of the same fraction (2,5 - 5 mm) were subjected to measurement of the electrical resistivity in experiments in order to simulate the process close to the real process.

The electrical resistance of various types of carbonaceous raw materials was determined with using the well-known method of the Institute of Metallurgy of the Ural Branch of the Russian Academy of Sciences [10, 11], which permits to measure the electrical resistance

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of materials and charges at temperatures up to 1 800 °C in a bulk layer with the simultaneous fixation of the degree of their softening (shrinkage).

Pressure on the material was 0,02-0,04 MPa, a heating rate was 20 - 25 °C per minute, an internal diameter of an alundum tube was 0,04 m, and a height of the material layer was 0,07 m.

The coals of the Saryadyr, Borly and Zhamantuz deposits were researched on the specific electrical resistance and the beginning softening temperature.

The technical and chemical compositions of ash of the used materials are demonstrated in Table 1.

RESULTS AND DISCUSSION

Figure 1 shows the temperature dependencies of the specific electrical resistance of the tested coals of the Saryadyr, Borly and Zhamantuz deposits.

This graph demonstrates that the specific electrical resistance of the coals of the Saryadyr, Borly and Zhamantuz deposits in the temperature range of 500 - 650 °C is approximately the same.

In the temperature range of 700 - 950 °C, the electrical resistance of coal of the Zhamantuz deposit is more than the coals of the Saryadyr and Borly deposits.

The coal of the Zhamantuz deposit at 700 °C has the specific electrical resistance of 1,5 Ohm·m, while the coals of the Saryadyr and Borly deposits showed a value equal to 1,2 Ohm·m.

The high specific electrical resistance of the Zhamantuz deposit coal depends on the amount of the volatile substances.

During the increase in temperature from 700 °C to 950 °C, all coals are characterized by a monotonous decrease in the specific electrical resistance to a value of 0,7 Ohm·m.

This is caused by an intensive removal of the volatile substances and the beginning of the softening process.

It was determined that the coal of the Zhamantuz deposit begging from a temperature of 1 100 °C (the specific electrical resistance of 0.4 Ohm·m) monotonically reduces the resistance value and it loses resistance at 1 250 °C.

As it seen from the dependence graph of the specific electrical resistance on temperature, the coal of the Saryadyr deposit compared to the coals of the Borly and Zhamantuz deposits in the temperature range of 950 – 1 250 °C has a high specific electrical resistance.

In addition, the softening effect of the carbonaceous raw materials on their electrical resistance is manifested at high temperatures. The softening of the carbonaceous raw materials leads to a sharp decrease in the electrical resistance (Figure 2).

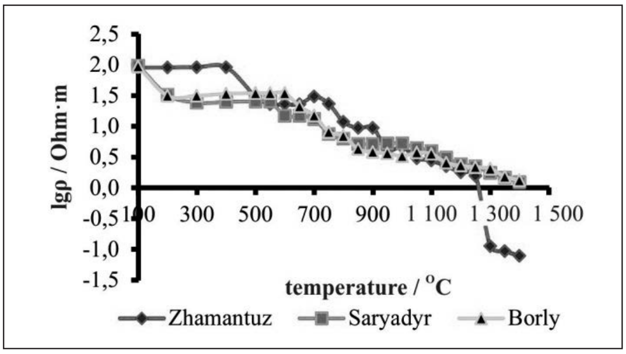

Figure 1 The comparative specific electrical resistance of coals of various deposits

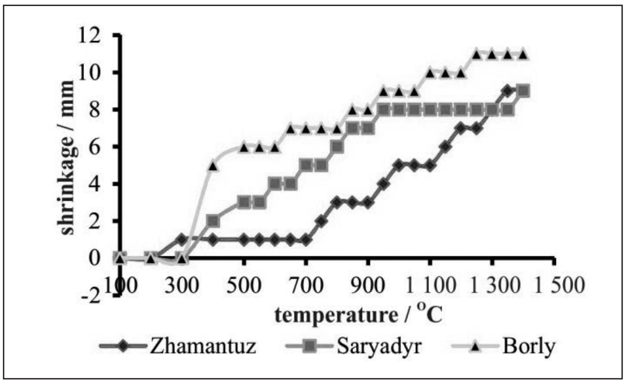

Figure 2 The softening curves of the tested coals of various deposits

The coal research demonstrated that a high value of the softening temperature has the coal of the Zhamantuz deposit.

The research results showed that the value of the electrical resistance of the charge during non-isothermal heating to the high temperatures depends on the chemical and mineralogical composition of the charges, and on the processes of phase transformations in a test sample.

The visual inspection of the coal samples after cooling showed that the upper layers of the coal column of the Saryadyr and Zhamantuz deposits were slightly baked, while most of the charge column was crumbled (Figures 3, 4).

For a coal sample of the Borly deposit after the complete cooling, the coal column absolutely baked.

The dependencies of the specific electrical resistance and softening of coals of Saryadyr, Borly and Zhamantuz deposits on temperature were obtained. In the temperature range of 700 - 950 °C, the electrical resistance of coal of the Zhamantuz deposit is more (1,5 Ohm·m at 700 °C) than the coals of the Saryadyr and Borly deposits.

Table 1 **The chemical and technical compositions of coals of various deposits / wt. %**

Deposit	A^c	V^c	W	SiO_2	Al_2O_3	CaO	MgO	$Fe_{gener.}$	$S_{gener.}$	$P_{gener.}$	TiO_2
Saryadyr	61,22	20,48	3,36	57,96	24,83	1,97	2,59	3,57	0,44	0,027	0,88
Borly	47,53	16,24	1,90	56,90	27,03	0,98	3,88	2,94	0,11	0,029	1,05
Zhamantuz	52,41	3,94	1,25	77,31	17,50	3,16	5,94	0,71	0,046	0,02	0,79

* where A^c – ash content of coal (^{C} on dry weight); V^c – volatile components; W – humidity.

a)

b)

a) coal of the Saryadyr deposit, b) coal of the Borly deposit

Figure 3 Coal samples after the specific electrical resistance

The high resistance was defined as 0,7 Ohm·m at 1 000 °C for the coal of the Saryadyr deposit, in contrast to the coals of the Borly and Zhamantuz deposits. At high temperatures of 950 – 1 250 °C, the coal of the Saryadyr deposit is characterized by the high specific electrical resistance, unlike the rest, thus it is a positive factor in the melting of the complex ferroalloy. Such charge parameters in the ore-thermal furnace provide a low fraction of the charge conductivity and thereby contribute to the release of the main energy fraction in the reaction zone of the furnace where the metal is formed.

CONCLUSIONS

The research results showed that a value of the electrical resistance of the charge during the non-isothermal heating to the high temperatures depends on the chemical and mineralogical composition of the charges, and also on the processes of phase transformations in the sample. Thus, the research of the specific electrical resistance in the charge materials for melting of a complex alloy revealed that properties of the high-ash coal are basic in the behavior of the charge materials in the electric melting. The research and its obtained results

Figure 4 Coal sample of Zhamantuz deposit after the specific electrical resistance

are basic and fundamental to perform the large laboratory tests in the low-capacity ore-thermal furnaces.

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Note: The responsible translator for English language is Yelena Volmer (Isakova), Karaganda, Kazakhstan