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ELECTRICAL CHARACTERISTICS OF CHARGE MIXTURES FOR MELTING RICH TITANIUM SLAG (RTS)

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Preliminary Note – Prethodno priopćenje

The article deals with the selection of reducing agent and preliminary preparation of raw materials for melting rich titanium slag (RTS) from ilmenite concentrates of the Shokash deposit. In determining the electrical resistivity of ore-coal briquettes with different reducing agents the authors have found that the most specifically suitable reducing agents for melting (BTSS) are special coke and coal, as briquettes with them, have the maximum electrical resistivity in the range of temperatures of solid-phase reduction.

Keywords: rich titanium slag, carbon reducing agent, temperature, briquette, electrical characteristics

INTRODUCTION

The selection of a reducing agent plays an important role in the electro-carbothermic production of rich titanium slag (RTS), from powdered or pelletized charge. Various carbon-containing materials, such as anthracite, metallurgical, pitch and petroleum coke, various hard coals and special types of coke, can be used as reducing agents [1].

In the process of smelting RTS in an ore-thermal electric furnace, carbonaceous reducing agents must have the following basic properties [1]:

- high reactivity (chemical activity);
- low electrical conductivity (high electrical resistance - ER);
- low ash content;

and must be relatively inexpensive and not in short supply.

RESEARCH METHODOLOGY

Of the listed properties, in addition to chemical activity, specific electrical resistance, and depending on the specifics of metallurgical processing, the amount and composition of ash are of particular importance. In case of RTS smelting, it is best to use low ash reducing agents, as most of the oxides constituting its ash (SiO_2, Al_2O_3, CaO and MgO) pass into slag, thus depleting the target product - slag. Low electrical conductivity of the reducing agent provides an overall high electrical resistance of the charge, deep electrode fit, stable electric mode and uniform operation of electric arc furnace. According to the results of research [2], as the reducing power to titanium concentrates decreases, the reducing agents are placed in the following order: charcoal - gas charcoal - anthracite - petroleum coke.

It is known that melting of RTS from powder charge is accompanied by some difficulties. The matter is that the most part of iron monoxide in composition of ilmenite concentrate is reduced in a liquid phase, i.e. in diffusion conditions. It is caused by the fact, that the process of concentrate melting accompanied by initial slag formation is ahead of the process of its reduction [3-5, 7-8]. It was noted in [4] that reduction to a greater or lesser degree affects the primary slagging of raw materials. In this connection, pre-powdered charge materials are used to increase the refractoriness of the charge in the metallurgical practice of RTS production [1, 3, 5, 9-11].

It is known that the use of the most common method of pelletizing in metallurgy - sintering - does not give satisfactory results. The method of briquetting the charge is widely used in metallurgy of briquettes. However, processing of charge consisted of 100 % ore-coal briquettes is accompanied by sintering and cementing of briquettes on the furnace grate with boiling melt, which subsequently leads to a violation of the gas permeability of the grate. Therefore, it is recommended to melt briquetted and powder charge (the amount of powder charge varies from 20 to 50 %) [6]. In this case the technical and economical parameters of the process increase and the gas-dynamic characteristics of the charge are improved.

RESULTS RESEARCH

In view of the above, the task of this research was to measure the electrical resistivity of ore-coal briquettes consisting of Shokash concentrate and various carbonaceous reducing agents, according to the methods [12-14]. Chemical composition of ilmenite concentrate is pre-

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Table 1 **Technical composition of the used reducing agents / wt. %**

Reducing agent	Carbon	Ash	Volatile	Moisture
Gas coal	54,25	3,55	39	3,2
Special coke	92,64	3,08	2,5	1,96
Metallurgical coke	76	13	3	8
Petroleum coke	87,8	0,11	7,9	4,2

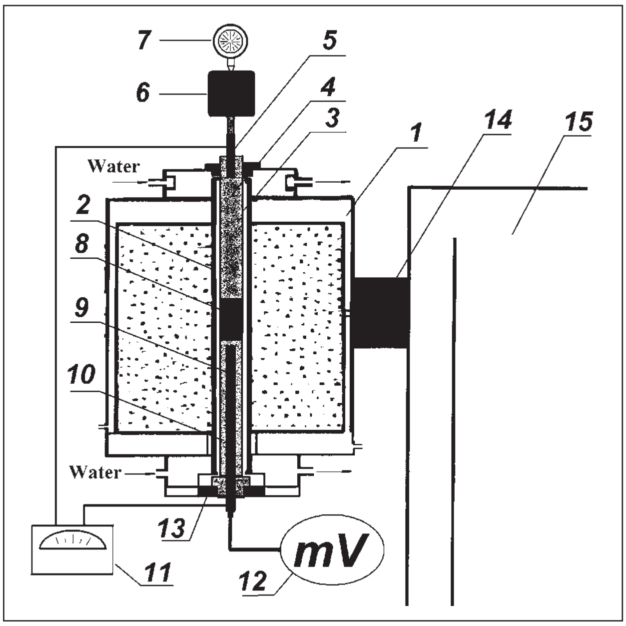

Figure 1 Unit for measuring the electrical resistance of materials
1 - resistance furnace; 2-graphite tube; 3-Alund tube; 4-top graphite electrode; 5-copper electrode tip; 6-loading; 7-indicator; 8-type; 9-thermocouple; 10-lower graphite electrode; 11-ohmmeter; 12-potentiometer (PP-63); 13-asbestos tile; 14-copper bars; 15- furnace transformer.

sented by the following data % of mass: TiO_2 - 53,7; FeO - 33,9; Al_2O_3 - 1,89; SiO_2 - 3,46; ZrO_2 - 0,16; Cr_2O_3 - 1,65; P_2O_5 - 0,06. Technical composition of carbonaceous reducing agents is given in Table 1.

Experimental conditions: pressure on the sample 2kgc / cm^2, heating rate 25 - 30 deg/min, inner diameter of alundumina tube 0,02 m, height of material layer 0,005 m. Heating is accompanied by sample shrinkage, which is fixed by the indicator with an accuracy of 0,01 mm.

Briquettes d = 20 mm, were made on laboratory hydraulic press, under a pressure of 120 - 140 kgf / cm^2. 50 % solution of liquid glass (SiO_2 = 35,0 %, Na_2O = 10,5 %), added in an amount of 5 % of the charge mass, was used as a binder. The reducing agent in the charge for making briquettes was set in an amount needed to selectively reduce all the iron from the concentrate. Obtained briquettes were dried in a muffle furnace at temperature 300 °C for 2 hours. Before loading the briquettes into the alundumina tube, they were crushed to the 0 - 8mm class. The experiments to measure the electrical resistance (ER) of ore briquettes were performed on the laboratory unit presented in Figure 1.

Temperature dependence of shrinkage of studied ore-coal briquettes is shown in Figure 2. The Figure

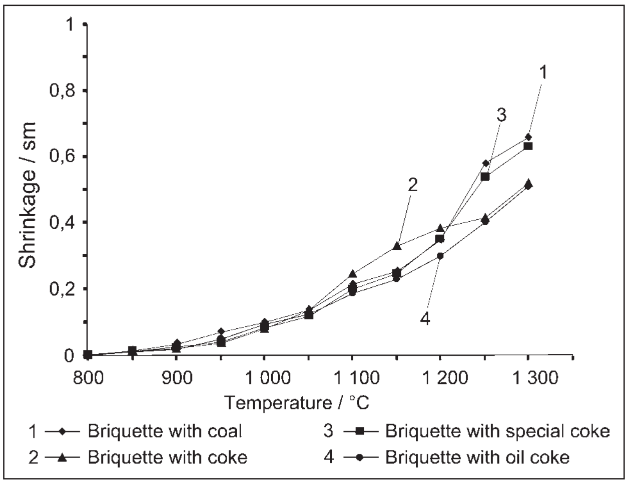

Figure 2 Temperature dependence of shrinkage of ore briquettes

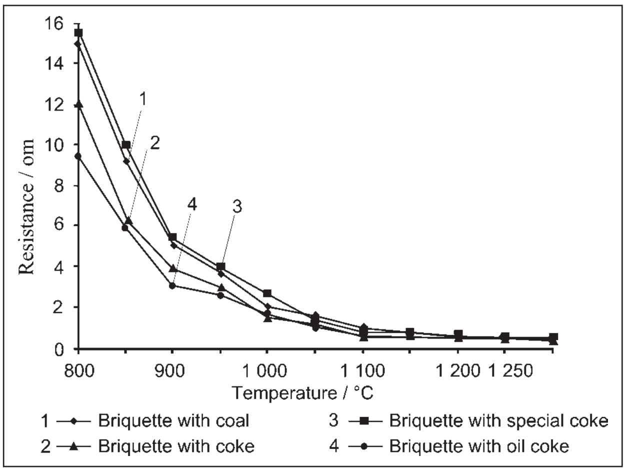

Figure 3 Temperature dependence of electrical resistance of ore-coal briquettes

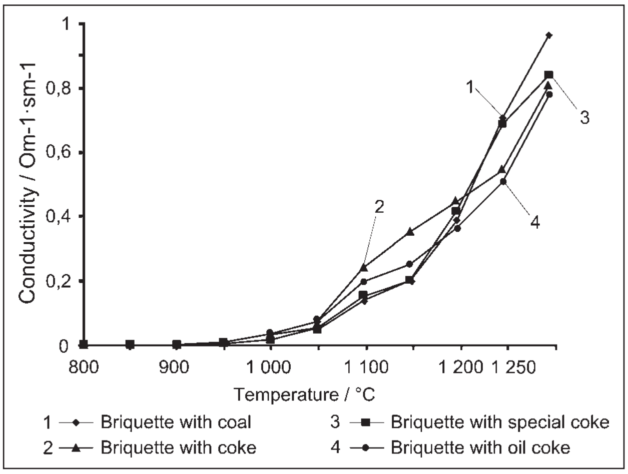

Figure 4 Temperature dependence of electrical conductivity of briquettes

shows that oil-coke briquettes have relatively low shrinkage during heating. The established value directly depends on the content of volatiles and residual moisture of carbonaceous reducing agent.

Figure 3 shows the temperature dependence of the absolute electrical resistance (ER) of ore-coal briquettes with different reducing agents. It is shown that in the temperature range of solid-phase reduction of 800 - 1 150 °C, concentrate briquettes with special coke and coal have the highest resistance. When comparing the resistance curves of briquettes, it is obvious that they extend almost in parallel up to 1 050 °C, after which the rate of resistance decline decreases. At higher temperatures of 1 200 °C, the resistance of all briquettes is relatively the same. This is due to the formation of the liquid conductive phase, i.e. primary ferrous slag.

Figure 4 shows the temperature dependence of electrical conductivity. From the graph we can see that briquettes with special coke and gas coal have the lowest electrical conductivity in the temperature range of 900 - 1 200 °C. At these temperatures there is a solid-phase reduction of free and bound iron oxides in ilmenite. Special coke and gas coal have a visible positive effect on the processes of ilmenite concentrate reduction to the melting of ore-coal briquettes. At temperatures above 1 200 °C, the electrical conductivity of the latter sharply raises and equalizes to the rest, this is explained by the fact that the formation of reduction products of FeO and metallic iron occurs, i.e. melt droplets are nucleated.

CONCLUSION

Based on the results of experiments, it can be argued that special coke and coal are the most specifically suitable reducing agents for smelting RTS, as briquettes with them have the greatest ER in the range of solid-phase reduction temperatures, and they are characterized by low ash content. Application of these reducing agents contributes to improvement of iron monoxide reduction conditions and prevents formation of fusible primary slag.

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Note: The responsible translator for English language is Yersaiynova Albina, Aktobe, Kazakhstan