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STUDY OF SOFTENING TEMPERATURES OF MANGANESE ORES IN CENTRAL KAZAKHSTAN

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The article presents the results of studying the temperatures of the beginning, end and temperature range of softening, samples of manganese ores in Central Kazakhstan. For the study, samples of manganese ores from the Zhezdinsky, Karazhal, Keregetas, and Western Kamys deposits were taken. The temperature interval for the softening of ores was determined by the method of isothermal heating on a specially assembled installation.

Key words: manganese ores, chemical composition, ore softening temperature, siliceous ores, Kazakhstan

INTRODUCTION

The problem of developing an efficient technology for processing siliceous and ferromanganese ores has existed for a long time. Despite numerous attempts, rational technological solutions to this problem have not yet been proposed. At present, when the ferroalloy production of Kazakhstan has taken a strong position in the market of high-quality low-phosphorus manganese ferroalloys and continues to gain capacity, the reserves of rich manganese ores are practically exhausted. This raises the question of the continued existence of the production of manganese ferroalloys in Kazakhstan. Therefore, against the background of the reduction of reserves of rich manganese ores, the problem of involving siliceous and ferromanganese ores, which make up the majority of manganese reserves, into ferroalloy production is becoming highly relevant [1-3].

Moreover, this problem is also faced by all producers of manganese ferroalloys, which also have significant reserves of substandard siliceous and ferromanganese ores.

The use of domestic siliceous and ferromanganese ores for smelting standard manganese ferroalloys using current technologies is impossible due to the low manganese content and the high content of iron and silicon. Therefore, it is necessary to include in the technological scheme, along with enrichment, an additional stage for the removal of iron. The existing electrometallurgical method of removing iron by remelting into manganese slag and chemical enrichment methods are economically unprofitable when using substandard siliceous and ferromanganese ores [4, 5].

The processing of siliceous and ferromanganese ores by the high-temperature processing method mainly depends on the initial material composition and physicochemical properties of the materials under study. It is known that the temperature of the onset of softening of manganese ores depends on the content of manganese and silica in the ore. In this regard, experimental work was carried out to determine the softening temperatures of manganese ores in Central Kazakhstan for the smelting of manganese-containing ferroalloys and ligatures [6-8].

RESEARCH METHODOLOGY

The softening temperature measurements during heating of manganese ores from the Zhezdinskoye, Karazhal, Keregetas and Zapadny Kamys deposits were carried out in a Tamman high-temperature electric furnace in the temperature range of 25 - 1 500 °C, at a heating rate of 20 - 25 deg / min. This method of studying the softening point differs from the standard method of Zhuchkov V.I. and Agroskin A.A. [9] by the fact that the values were recorded every 30 seconds automatically in digital format in the computer memory. While according to known methods, measurements were made every 50 ºC, which reduces the information content of the data obtained. A schematic diagram of the installation for determining the electrical resistance of a material with simultaneous fixation of the degree of their softening (shrinkage) is shown in Figure 1.

The starting material 8 cm high is placed in the cavity of an alundum glass (5) (glass diameter 4 cm) installed in the Tamman furnace. A graphite electrode (9, 12) was installed on both sides of the material for supplying voltage with a hole for a thermocouple 8. The lower electrode is fixed motionless, the upper one can be lowered when the material shrinks under the action of the load. The weight (14) constantly presses the upper electrode against the material, thus ensuring a tight contact. The pressure on the material was 0,02 - 0,04 MPa. A thermocouple is

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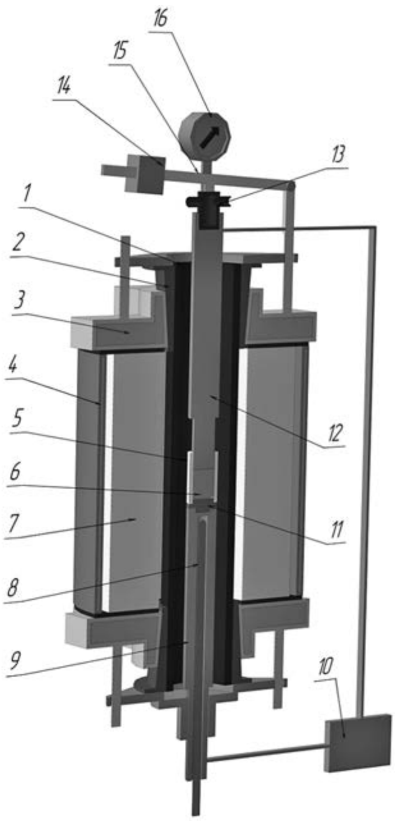

1 - carbon-graphite tube; 2 – copper compression ring; 3 – water-cooled cover; 4 - water-cooled housing; 5 - alundum glass; 6 – investigated mixture; 7 - protective lining; 8 - thermocouple; 9 – bottom electrode; 10 - Digital ohmmeter; 11 – graphite bottom for alundum glass; 12 – top electrode; 13 - water cooling; 14 - cargo; 15 - lever; 16 – Nutrimetric dial indicator.

Figure 1 Installation for determining the specific electrical resistance and shrinkage (in section)

placed in the lower electrode, placed in an alundum tube to isolate it from electricity. Data recording was carried out through converters of signals coming from thermocouple (8), electrodes (9, 12), as well as through the material softening meter [10-12].

The chemical composition of charge materials for an experimental study on the softening of manganese ores are shown in Table 1.

RESULTS RESEARCH

The results of the change in softening indices depending on the temperature are presented in the form of a graph in Figure 2.

Based on the results of measurements, it was found that in the temperature range of 1 070 - 1 195 °C, an intensive decrease in electrical resistivity occurs due to the onset of ore melting and the decomposition of brownite (Mn_2O_3) to hausmanite (Mn_3O_4). Based on the studies carried out to determine the electrical resistivity of the ore, it can be concluded that siliceous and ferromanganese ores can be classified as fusible. Table 2 shows the softening temperature of manganese ores.

The recorded changes in the electrical resistance during heating of the ore are explained by phase transformations. So, during the initial period, the electrical resistance increases slightly, then decreases, which is possibly due to dehydration processes. Further, with an increase in temperature of 280 °C, a gradual uniform drop in the electrical resistance of the ore begins, accompanied by slight changes in the temperature range

Table 1 **Chemical composition of manganese ores**

№	Manganese ore	Contents / %					
		$Mn_{general}$	$Fe_{general}$	SiO_2	CaO	MgO	Al_2O_3
1	Zhezdinskaya	16 - 18	4 - 7	40 - 46	2 - 4	0,73 - 2,1	10,2
2	Keregetas	20 - 25	20 - 25	17 - 23		1 - 3	1,2 - 2,0
3	Karajal	29 - 33	12 - 15	17,7 - 20	3,08 - 5	0,6	3 - 5
4	Western Kamys	15 - 17	5,16 - 7,45	36-41	1,46-3,01	1,25	5,92

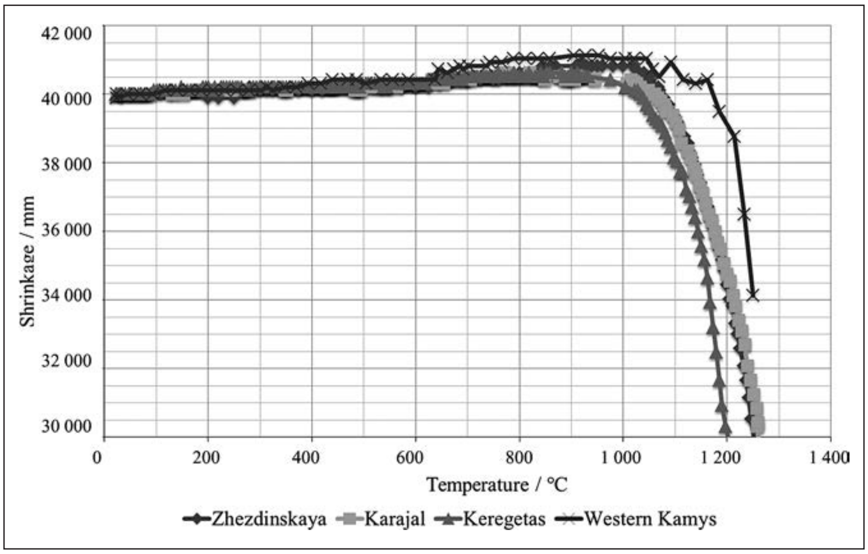

Figure 2 Dependence of ore shrinkage on temperature

Table 2 **Softening temperatures of manganese ores**

№	Manganese ore	The equation	$T_{melting}$/°C	T_{nr} °C	T_{cr} / °C	t_{Δ}
1	Zhezdinskaya	Y_1 = -76,261x + 124444 Y_2 = 0,7908x + 39875	1 120,56	1 054	1 140	86
2	Keregetas	Y_1 = -53,095x + 97752 Y_2 = 0,4326x + 40025	1 096,17	1 025	1 103	78
3	Karajal	Y_1 = -62,19x + 106001 Y_2 = 0,5403x + 40024	1 070,19	1 019	1 085	66
4	Western Kamys	Y_1 = -67,26x + 119162 Y_2 = 0,9826x + 39945	1 195,23	1 127	1 194	67

of 480 - 610 °C, due to the onset of the processes of dissociation and reduction of pyrolusite MnO_2.

CONCLUSION

Based on the conducted studies to determine the softening temperature of manganese ores, it can be concluded that the siliceous and ferromanganese ores of Central Kazakhstan are fusible, with low electrical resistance, the softening temperature is in the range of 1 070 - 1 195 °C.

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