B. KELAMANOV, S. SMAILOV, A. YERZHANOV,
A. APENDINA, R. ADILHANOV, S. KABYLKHANOV

ISSN 0543-5846
METABK 61(3-4) 771-773 (2022)
UDC – UDK 669.168:553.48:622.785:669.187:536.45=111

THE POSSIBILITY OF INVOLVEMENT IN FERROALLOY CONVERSION OF NICKEL ORES OF KAZAKHSTAN

Received – Primljeno: 2021-11-11
Accepted – Prihvaćeno: 2022-03-10
Preliminary Note – Prethodono priopćenje

The article considers the method of using substandard oxidized nickel ores of the Batamsha deposit and their suitability for sintering. Laboratory studies on the agglomeration of domestic nickel ores with different reducing agents were carried out for the metallurgical evaluation of nickel ores. Agglomeration was carried out according to standard technology, the layer height averaged 24 cm. The agglomeration process proceeded intensively at a discharge of 1 100 -1 200 mm Hg, the sintering temperature of which reached over 1 200 °C. To improve the mechanical properties of the obtained agglomerates, it is necessary to continue research with a change in the composition of charge materials and a metallurgical assessment with the smelting of nickel-containing intermediates.

Keywords: ferroalloy, nickel ores, agglomeration, electric melting, temperature.

INTRODUCTION

The Republic of Kazakhstan has huge reserves of nickel-bearing weathering crusts, which contain about 2,5 million tons of nickel with a content of 0,8 - 1,5 % Ni in ore. The most promising areas are the areas of the western side of the Turgai trough in Northern Kazakhstan (the fields of Shevchenkovskoye, Kundybayskoye, Dzhetygarinsky, Akkarginsky, Milyutinsky, etc.), Ekibaztuz-Bayanaulsky district in Central Kazakhstan (deposits of Adilbekskoye, Angrensorskoye, Balarkalyk, Promezhutochnoye, Bugor, etc.), and Charsky and Gornostaevsky belts of ultrabasic rocks in Eastern Kazakhstan (deposits of Belogorskoye, Karaul-Tobe, Kyzyltyrskoye, Gornostaevskoye, Bukor-skoye, etc.). There are also large deposits in the Aktobe region of Nikeltauskoye (1,21 % Ni), Batamshinskoye (0,87 % Ni), Rozhdestvenskoye (1,12 % Ni) and Kokpektinskoye (1,2 % Ni), whose reserves amount to 423,5 million tons. [1-5].

Melting of oxidized nickel ores in electric furnaces without preliminary preparation is accompanied by significant difficulties and is characterized by high-energy consumption. Wet, small fractions of these ores are caked, and in winter conditions they freeze, stick to conveyors and feeders, hang in bunkers, are poorly mixed, etc. In dry form, oxidized nickel ores dust heavily, which worsens the operation of equipment and sanitary working conditions. At foreign nickel plants using electric smelting for processing ore raw materials, the charge is subjected to agglomeration and pelletizing.

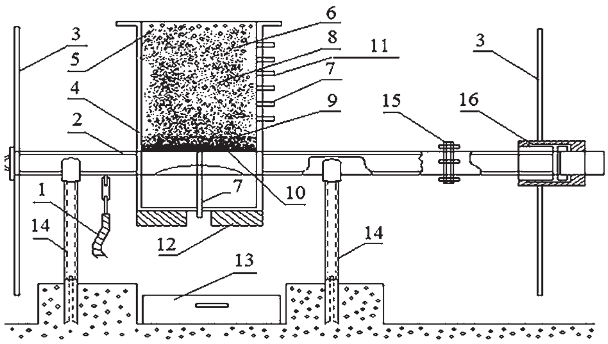
Rolling, briquetting and agglomeration are traditional methods of preparation of metallurgical raw materials, which remain important to date and have the prospect of further steady development. These methods of preparation make it possible to significantly reduce the consumption of electricity during smelting, improve technology, simplify the operation of furnace units and involve poorer ores (after preliminary enrichment) in the sphere of metallurgical processing [6-8].

RESEARCH METHODOLOGY

One of the possible ways to involve poor metallurgical raw materials in ferroalloy conversion is to prepare it with several types of caulking. As is known, when preparing nickel ores for metallurgical processing, a large amount of ore fines is formed. Direct loading of ore fines into metallurgical aggregates, without pre-caulking, leads to deterioration of technological modes of the furnace (removal of ore fines by waste gases during loading, formation of a large amount of dust, sintering of the grate, fistulas, etc.), as well as to deterioration of general technical and economic indicators. Complete processing of fine powdery charge is possible only if it is pre-dipped [7-9].

In order to determine the possibility of plating nickel ore with a grain size of 0 - 3 mm, agglomeration studies were carried out on a laboratory installation with a sinter with a height of 450 mm and a diameter of 250 mm. Iron ore pellets produced by SSGPO were used as a bed. The agglomeration plant included the following components: agglomeration bowl, field installer, extractor, gas pipeline system, control and measuring equipment. The complete scheme of the agglomeration plant is shown in the Figure 1.

B. Kelamanov (kelamanov-b@mail.ru), A. Apendina, R. Adilhanov, S. Kabylkhanov Aktobe regional of university named after K. Zhubanova, Aktobe, Kazakhstan.
S. Smailov, A. Yerzhanov, Karaganda Industrial University, Temirtau, Kazakhstan.



1 - hose to the U-shaped pressure gauge; 2 - gas pipeline; 3 - steering wheel; 4 - bowl; 5 - chips; 6 - ignition mixture; 7 - fitting; 8 - charge; 9 - bed; 10 - grate; 11 - thermocouple; 12 - sheet counterweight; 13 - baking; 14 - support; 15 - flange; 16 – coupling

Figure 1 Diagram of an agglomeration bowl with a rotary device

Figure 2 Produced nickel agglomerates

Nickel ore with a chemical composition was used to study the sintering process / % (Nigeneral - 1,12; Fegeneral - 16,98; Crgeneral - 2,30; SiO_2 - 48,19; MgO - 4,29; Al_2O_3 - 1,54), mixed with a semi-product of lumpy Shubarkol coal, which is a semi-coke in terms of technical composition (C - 87,24; V^c - 8,76; A^c - 2,11; W - 2,32). Agglomeration was carried out according to standard technology, the layer height averaged 24 cm. The agglomeration process proceeded intensively at a discharge of 1 100 mmHg, the sintering temperature of which reached over 1 200 °C.

RESULTS RESEARCH

The resulting agglomerate was divided into the size class 0 - 5 mm, 5 - 10 mm and + 10 mm, the fractional and chemical composition of the agglomerate is shown in Table 1. The duration of the agglomeration process averaged 25 - 28 minutes.

Fractions of + 10 mm were evaluated for strength by dropping twice from a height of 2 m onto a steel plate according to GOST 25471 - 82, it was found that the resulting agglomerate had high mechanical strength properties in structure (Figure 2). The fractional and chemical composition of the agglomerate and the results of strength tests are given in the Table 2.

To confirm the results obtained, an additional agglomeration of nickel ores was carried out with a chemical composition, % (Nigeneral - 1,12; Fegeneral - 16,98; Crgeneral - 2,30; SiO_2 - 48,19; MgO - 4,29; Al_2O_3 - 1,54), JSC Altay-coke with technical composition was used as a reducing agent, % (C - 85,24; V^c - 2,7; A^c - 10,11; W - 1,32) at a resolution of 1 200 mm Hg, the duration of the sintering process averaged 19 - 21 minutes. The resulting agglomerate was also divided into size classes, as in the previous process. The fractional and chemical composition is given in the Table 3.

Also, when studying the strength of the agglomerate, the method of dropping the agglomerate from a height of 2 m was used. The resulting agglomerate structure had higher mechanical properties in strength than the agglomerate obtained from nickel ores and semi-coke. The fractional and chemical composition is shown in Table 4. The total weight of the agglomerate without fines was 970 g. The maximum nickel content in the agglomeration experiments was up to 1,47 %, and the chromium content was 2,85 % (Tables 1 and 3). The resulting agglomerate had satisfactory strength in both cases. Since it had a high solid carbon content in the final agglomerate.

Table 1 **Fractional and chemical composition of agglomerate obtained from nickel ores and semi-coke [9, 10]**

Fraction / mm	Out / %	Content / %					Extraction / %			
		Nigeneral	Fegeneral	Crgeneral	C	Ni / Fe	Ni	Fe	Cr	C
+ 0 - 5	33	1,26	16,7	4,70	6,01	0,07	29,1	29,5	56,5	92,2
+ 5- 10	2	1,46	20,0	5,02	0,38	0,07	2,31	2,43	4,14	0,40
+ 10	65	1,47	19,0	1,62	0,24	0,08	68,6	68	39,3	7,43
Σ	100	1,40	18,3	2,69	2,11	0,08	100	100	100	100
+ 5 - 10 and + 10	67	1,47	19,0	1,73	0,24	0,08	70,9	70,4	43,5	7,83

Table 2 Fractional and chemical composition of the agglomerate after dropping from a height of 2m [9, 10]

Fraction / mm	Out / %	Content / %					Extraction / %			
		Nigeneral	Fegeneral	Crgeneral	C	Ni / Fe	Ni	Fe	Cr	C
+ 0 - 5	19	1,44	18,5	6,24	0,68	0,08	18,9	19,1	38,8	37,1
+ 5- 10	6	1,45	19,0	6,88	0,14	0,08	5,95	6,14	13,4	2,38
+ 10	75	1,44	18,2	1,94	0,28	0,08	75,1	74,7	47,8	60,5
Σ	100	1,44	18,3	3,05	0,35	0,08	100	100	100	100
+ 5 - 10 and + 10	81	1,44	18,2	2,30	0,27	0,08	81,1	80,9	61,2	62,9

Table 3 **Fractional and chemical composition of agglomerate obtained from nickel ores and Altay coke [9, 10]**

Fraction / mm	Out / %	Content / %					Extraction / %			
		Nigeneral	Fegeneral	Crgeneral	C	Ni / Fe	Ni	Fe	Cr	C
+ 0 - 5	31,7	1,18	15,9	4,29	11,8	0,07	28,3	29,1	34,1	93,8
+ 5- 10	1,2	1,37	18,7	1,78	1,71	0,07	1,16	1,21	0,50	0,48
+ 10	67,1	1,39	18,0	3,89	0,34	0,08	70,5	69,7	65,4	5,72
Σ	100	1,32	17,34	3,99	3,99	0,076	100	100	100	100
+ 5 - 10 and + 10	68,3	1,39	18,01	2,85	0,36	0,077	71,7	70,9	65,9	6,2

Table 4 **Fractional and chemical composition of the agglomerate after dropping from a height of 2m**

Fraction / mm	Out / %	Content / %					Extraction / %			
		Nigeneral	Fegeneral	Crgeneral	C	Ni / Fe	Ni	Fe	Cr	C
+ 0 - 5	10,8	1,40	18,0	6,80	0,96	0,08	33,1	32,6	49,7	26,6
+ 5- 10	2	1,41	18,5	1,86	2,36	0,08	33,3	33,5	13,6	65,4
+ 10	87,2	1,42	18,7	5,02	0,29	0,07	33,6	33,9	36,7	8,03
Σ	100	0,46	5,97	1,48	0,39	0,08	100	100	100	100
+ 5 - 10 and + 10	89,2	0,34	4,51	0,83	0,32	0,08	66,9	67,4	50,3	73,4

Table 5 **Technological indicators of agglomeration of nickel raw materials mixed with Shubarkol semi -coke and with coke of the Altay plant**

Indicators	Variants	
	Mixtures with semi - coke	Mixtures with coke
1. Content in the charge / % Fuel (semi-coke and coke) / % Reverse / %	 10 16	 11 17
2. Charge humidity (GOST 1276 4- 73) / %	 12 - 15	 12 - 15
3. Layer height / mm	350	350
4. Sintering indicators 4.1 Maximum temperature in the layer, °C 4.2 Shrinkage, mm 4.3 Yield of suitable agglomerate (GOST 25471 - 82) + 10 mm / %	 1100 55 67	 1100 50 68,3
5. Agglomerate quality 5.1 Content, % Ni Cr Fe	 1,47 1,73 19	 1,39 2,85 18,01
5.2 Granulometric composition / % + 0 - 5 mm + 5 - 10 mm + 10 mm	 33 2 65	 31,7 1,2 67,1
5.3 Strength according to GOST 27562 - 87 / % (+ 5 - 10 mm + (+ 10 mm))	 81	 89,2

From the obtained results of agglomeration, it can be seen that the bulk of the residual carbon is contained in a fraction of 0 - 5 mm, which is 33 % and 31,7 %, respectively, of the total weight (Tables 1 - 5). The high chromium content in the agglomerate obtained from nickel ores and semi-coke is mainly observed in the 5-10mm class, and in the agglomerate obtained from nickel ores and Altay coke, the high chromium content is in the 0 - 5 mm fraction. The nickel content in both cases is stable at an average of 1,3 - 1,4 % [9, 10].

CONCLUSION

To improve the mechanical properties of the obtained agglomerates, it is necessary to continue research with a change in the composition of charge materials and a metallurgical assessment with the smelting of nickel-containing intermediates. The experiments have shown the fundamental possibility of obtaining an agglomerate suitable for smelting nickel alloys with a nickel content within 2 - 4 %.

REFERENCES

[1] Kantemirov M.D., Pavlov A.V., Kenzhaliev B.K. About prospects, technical and technological features of the organization of nickel and cobalt production from oxide ores of Kazakhstan. KIMS (2003) 5, 23-28.

[2] Malyshev V.P., Teleshov K.D., Nurmagambetova A.M. Destructibility and preservation of conglomerates. - Almaty: SIC “Gylym”, 2003.

[3] Gran N.I., Onishchin B.P., Maisel E.I. Electric melting of oxidized nickel ores. - Moscow: Publishing House “Metallurgy”, 1971.

[4] Zayakin, O. V., Zhuchkov, V. I., Sheshukov, O. Yu., Orlov, P. P. Study of oxidation kinetics of Ni-containing melts. Rasplavy, (2001) 5, 14-17.

[5] Zayakin, O. V., Zhuchkov, V. I., Lozovaya, E. Yu. Melting time of nickel-bearing ferroalloys in steel. Steel in Translation 37 (2007) 5, 416-418.

[6] Elliott, R., Pickles, C.A., Peacey, J. Ferronickel particle formation during the carbothermic reduction of a limonitic laterite ore. Minerals Engineering 100 (2017), 166-176. DOI: 10.1016/j.mineng.2016.10.020

[7] Oliveira, R.P., Conceição do Nascimento, R., Feldhagen, H.G. Agglomeration and Characterization of Nickel Concentrate (MHP) Pellets for Ferronickel Production. Mining, Metallurgy and Exploration 37 (2020), 5, 1653-1665.

[8] Janwong, A., Dhawan, N., Vethsodsakda, T., Moats, M.S. Characteristics of nickel laterite crushed ore agglomerates. TMS Annual Meeting (2013), 125-139.

[9] Kelamanov B., Tolymbekov M., Kaskin K., Baisanov A. Thermal analysis of agglomerated nickel ore. Proceedings of the 12th International Ferroalloys Congress: Sustainable Future, Helsinki, 2010, 657-659.

[10] B. Kelamanov, Ye. Samuratov, A. Akuov, A. Abdirashit, A. Burumbayev, R. Orynbassar. Research possibility of involvement Kazakhstani nickel ore in the metallurgical treatment. Metalurgija 60 (2021) 3-4, 313-316.

Note: The responsible translator for English language is Kalilolayeva Aigerim, Aktobe, Kazakhstan