AGGLOMERATION OF REFRACTORY CHROMITE ORE

A.A. Akberdin, A.S. Kim, R.A. Akberdin

Abishev Chemical-Metallurgical Institute
Karaganda, Kazakhstan, e-mail: akberdin_38@mail.ru

ABSTRACT

The results of studies of the effect of low-melting silicon - and boron-containing fluxes on the technical and economic performance and quality of chromite pellets. It is shown that the addition of 2% boron ore deposits of Inder and 5% basalt achieves strength fired pellets that meet the technical requirements for firing temperature 1300°C, which is below 100°C is used at Donskoy GOK Outokumpu Technology. Application of the technology of production of chromite pellets using basalt and borate fluxes at the Pellet Plant Donskoi GOK will significantly improve the technical and economic parameters and to bring it to full capacity.

KEYWORDS: *Chrome ore, pellets, fluxes.*

Given the shortage of high-quality raw lump to provide reliable resource base ferroalloy plants, all the more important is the task of engaging in the production of non-conforming by size chromite ore fines, which amount is 50% or more of the ore mined. However, questions of chromite ore fines agglomeration Donskoy Mining processing combine (MPC) to date remains current.

Complexity Kazakhstan ore sintering kilns methods due to their high melting point (1500°C and above) caused a refractory ore phase (chrome spinel) and the host rock, represented mainly by serpentine ($3MgO{\cdot}2SiO_2{\cdot}nH_2O$), passing by firing in forsterite $2MgO\ {\cdot}2SiO_2$, which has a melting point of ~ 1900°C. The chemical composition of mineral components of chromite ore deposits "40 years of the Kazakh Soviet Socialist Republic", which now form the basis of the ore base ferroalloy plants in Kazakhstan, are presented in table 1.

Table 1: Chemical composition of mineral components of chromite ore

Deposit	Name components chromite ore	Of components, mass%						
		Cr_2O_3	MgO	Fe_2O_3	Al_2O_3	FeO	SiO_2	$\frac{MgO}{Al_2O_3}$
"40 years of Kazakh SSR"	Cr-spinel	61,90	14,70	14,20	8,60	0,50	-	1,71
		61,20	13,70	13,70	8,10	0,40	-	1,69
		61,40	13,70	14,00	8,10	0,70	-	1,69
		61,20	14,20	13,90	8,25	0,50	-	1,72
	cementing breed	-	36,00	4,30	2,20	-	37,00	16,40
		-	37,80	5,30	0,50	-	37,30	75,60
		-	36,10	3,80	-	-	37,10	-
		-	38,50	4,60	1,80	-	37,40	21,38

Sintering of obtaining durable material agglomeration occurs at 1400-1500°C and above. However, increasing the firing temperature of pellets or temperature in the metropolitan area at the expense of increased fuel consumption leads to serious complications in the operation firing equipment. For this reason, has not yet been resolved by the output at full capacity at the factory for the production of chromite pellets Donskoy (MPC), working on Outokumpu Technology, with a firing temperature of 1400°C [1].

More effective to reduce the melting temperature of the charge, and thus the temperature of the process due to the introduction of different fluxing agents with low melting temepraturu, and contribute to the formation of low-temperature compounds in interaction with components of the ore phases. As the most widely used flux of silicon-and aluminum-containing materials [2, 3]. Their choice is justified by the fact that these components are used in the smelting of ferrochrome slag regime to regulate and eventually charge dilution with agglomeration of the main components is compensated in part or in full by reducing the amount of flux in smelting.

Us as such fluxes tested quartzite, borate ore and basalt rocks, which are mainly used as raw material in silicate industry. The chemical composition of the mixture components is presented in table 2.

Table 2: Chemical composition of the mixture components

Material	Content,%							
	Cr_2O_3	$Fe_{total,}$	SiO_2	Al_2O_3	CaO	MgO	B_2O_3	S
Chrome ore fines	51,9	9,72	5,81	7,76	0,13	19,4	-	-
Screenings of quartzite	-	0,97	96,5	1,72	-	-	-	-
Basalt	-	8,7	52,5	13,99	11,85	5,29	-	-
Borate ore	-	1,1	10,6	3,82	22,02	7,5	8,2	10,0

The reason for using basalt as binders due to the fact that the mineral composition of the vast majority of species of basalt rocks in the system $CaO-MgO-Al_2O_3-SiO_2$ sufficiently covers elementary tetraedr anorthite ($CaO \cdot Al_2O_3 \cdot 2SiO_2$) - diopside ($CaO \cdot MgO \cdot 2SiO_2$) - enstatite ($MgO \cdot SiO_2$) - SiO_2, where there is an extensive area of compositions with melting temperature 1200-1300°C [4]. Our proposed as siliceous flux basalt deposit "Dubersay" Aktobe region, the composition of which is shown in table 2, has a melting point of ~ 1450 ° C. However, the ratio of the components in it is that in the system $CaO-MgO-Al_2O_3-SiO_2$ MgO content increases to 10% of its composition falls in the low-temperature eutectic (CaO - 13-20%, SiO_2 - 55-60%, Al_2O_3 15 - 20%, MgO - 10-12%) with a melting temperature of 1200-1300°C. Development of this process will promote close contact finely flux and chromite ore host rock which contains 36-38% MgO, in the granulation process and as a result, the early formation of a liquid phase during sintering. Another important factor is the proximity of deposits of basalt from the consumer. For comparison, we also conducted experiments with screenings of quartzite and Inder boron ore deposits, the hallmark of which is the low melting temperature (1100-1200°C).

The experiments were conducted by pelletizing the industrial mix material (cake), containing in its composition than chromite ore, 0.7% bentonite and 2.5% of coke, which introduced additional skilled fluxes. Last crushed to -0.074 mm fraction of 80% in a ball mill dry. Number fluxes ranged from 0 to 10%. Pelletizers charge on belleville granulator 380 mm side height of 80 mm and angle of 42°. Rotation speed was kept constant - 26 tur/min. Pelletization time is 20-25 minutes. To assess the quality of pellets were collected fractions of 10-15 mm. To assess the quality of pellets were collected fractions of 10-15 mm. Drying of pellets produced in an oven at 105°C for 3 hours. Burned pellets in the chamber furnace at 1250 and 1300°C at a heating rate of 60°/min with time at a given temperature for 20 minutes. Strength values were determined as the average of the measurements of 15 pellets. Results of laboratory experiments are presented in table 3.

When entering into the charge 10% quartzite (table 3, experience 6) at low temperatures (1250°C) the strength of burnt pellets decreased, and only at temperatures above 1300°C firing has been an increase in strength compared to the reference pellets. In this case, the expected [5], the exchange reactions with the formation of low-temperature fayalite ($2FeO \cdot SiO_2$, t_m – 1205°C), enstatite ($MgO \cdot SiO_2$, t_m – 1557°C) c involving silica high forsterite ($2MgO \cdot SiO_2$, t_m – 1900°C) and diffuses from the metal chrome spinel phase ferrous iron at temperatures of firing 1250, 1300° C is inadequate to ensure the development of liquid-phase hardening.

Significant results using silicon fluxes were obtained by sintering of chromite ore fines sintering method [6], despite the short time of exposure to high temperatures sintered layer, with the same 10% silica fraction - 1 mm was achieved increasing the mechanical strength sinter from 52.3 to 69.5% and declining to 14.7 abrasion to 9.2% when the specific productivity 0,8-0,95 t/m^2 ·hour. Research thermoplastic properties of the original chromite ore agglomerates and experienced shown that almost at the same softening range (100-120°C), the temperature began to soften agglomeration material with 10% fines ~ quartzite below 200°C, which confirms the formation of new low-temperature phase with the participation of the additional introduction of the silicon flux.

Based on the theoretical analysis of interaction of high-temperature cementing rock chromite ore using a mathematical model of the phase diagram of six-component system CaO-MgO-FeO-Cr_2O_3-Al_2O_3-SiO_2 [7], which is the most low-temperature fayalite ($2FeO \cdot SiO_2$).

Table 3: Quality of experienced chromite pellets

№	Name charge materials	Crude pellets				Burned pellets	
		Weight,%	humidity W,%	toughness on discharge R_{reset}, time	toughness crushing R_{crus} time kg / pellet	1250°C toughness crushing R_{crus} time kg / pellet	1300°C toughness crushing R_{crus} time kg / pellet
1	Chromite concentrate	96,9	8,4	2-3	0,54	64,8	132,6
	Bentonite	0,6					
	Coke	2,5					
2	Chromite concentrate	93,9	8,2	3-4	0,705	118	160
	Basalt	3,0					
	Bentonite	0,6					
	Coke	2,5					
3	Chromite concentrate	91,9	8,0	3-4	0,698	153,1	198
	Basalt	5,0					
	Bentonite	0,6					
	Coke	2,5					
4	Chromite concentrate	89,9	8,2	3	0,721	121,4	224
	Basalt	7,0					
	Bentonite	0,6					
	Coke	2,5					
5	Chromite concentrate	86,9	8,4	3-4	0,680	168,9	219,1
	Basalt	10					
	Bentonite	0,6					
	Coke	2,5					
6	Chromite concentrate	87,9	9,1	3-4	0,820	39,0	166,4
	Basalt	10,0					
	Bentonite	0,6					
	Coke	2,5					
7	Chromite concentrate	91,9	8,88	5-6	0,683	166,3	198,0
	Basalt	5,0					
	Bentonite	0,6					
	Coke	2,5					

The formation of this compound confirmed the analysis phase, and the participation of divalent iron ore chrome spinel phase indicates enrichment of the glassy phase of FeO. The results of studies on the agglomeration of chromite ore fines were the basis of technological requirements for the design and construction of the sintering plant Aksu Ferroalloy Plant.

In the production of pellets effective was the introduction of basalt and boron ore with a low melting point. When the content in the charge of the fluxes in the amount of 5% (table 3, experiment 2 and 7) reduced the firing temperature from the set at Donskoy MPC 1400°C 1250-1300°C, ie 100-150°C, and achieve performance strength of 198 kg / approx as TI 150 kg / approx. [1].

Technology of production of boron-containing chromite pellet was pilot production testing in a pilot workshop SSOMPP. Chrome concentrate was ground to class size - 0.074 mm 82.0%. As boron flux was used Inder borate ore deposits containing in its composition 8.2% B_2O_3 content and particle size on the -0.074 mm fraction of 78%. Tests have shown that even with coarse concentrate with the addition of 2% boron ore achieved performance strength of the corresponding technical requirements in the firing temperature 1300°C (R_{burned} = 158 kg /pel.).

In connection with the use of boron as a flux Inder borate ores with high sulfur content (10%) were special experiments on the effect of boron oxide on the process of desulfurization. They showed that the presence of boron oxide in the mixture (0.2-0.4%) intensifies the desulfurization process and translates it into a region of lower temperature (100°C). Petrographic studies found that the desulfurization process is confined to the melt formation. Temperature range of intense sulfur removal is correlated with a melting point of boron ore (~ 1100°C). In the range of 1150-1200°C at the stage of formation of active melt desulfurization process ends. The degree of desulphurization with more than 95%, and the sulfur content is higher than in the baseline pellets.

Application of the technology of production of chromite pellets using basalt and boron ore pelletizing plant at Donskoy MPC will significantly improve the technical and economic parameters and to bring it to full capacity.

REFERENCES

[1] Loginov N.M., Vyhodtsev V.M., Utemisov B.K. Agglomeration of chrome resources – the solution of several problems of Donskoi MPC and Kazchrome. // Proceedings of the 4th Int. Scientific-practical conference. "Problems and the sustainable development of mining industry sectors." - Khromtau, 2007. - p. 680-685.

[2] Zayakin O.V., Halperin, A.P., Zhuchkov V.I. Possibility of processing small chrome ores in today // Bulletin of PSU. - 2003, № 5. - p. 80-82.

[3] Maksimov Y. S., Fedorenko N.V., Parshina R.F. Method of agglomeration of small chromite ore // Production of ferroalloys. - Novokuznetsk, 1986. – p. 56-62.

[4] Pashenko A.A., Myasnikov A.A., Myasnikova E.A., etc. Physical chemistry silicates. - M., Graduate School, 1986. – p. 368.

[5] Goroh A.V., Rusakov L. N. Petrographic analysis of the processes in the industry. -M.: Metallurgy, 1973. – p. 288.

[6] Kim A. S. Features agglomeration of chromite ore // Proceedings of the University, ed. KSTU, 2008, № 3. - p. 19-23.

[7] Akberdin A .A., Konurov U., Kim A.S., Sarekenov K.Z. Diagram of the system CaO-MgO-FeO-Cr_2O_3-Al_2O_3-SiO_2 and its mathematical model to calculate the phase composition of slag production chromium alloy.//Physical-chemical and technological issues of metallurgical production in Kazakhstan: Sat. scientific. Treatise CMI. - Almaty, 2002. - vol.30, book.2. - p.122-131.