Technology Improvement of Refractory Chromiteores Clotting

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Annotation

The research results on using boron ore and basalt in production of chromite pellets are given here. Their influence on the quality of wet, dry and burnt pellets is researched. It is shown that the use of basalt let us fully take out bentonite and cox from the furnace charge, make the temperature of burning lower by using in practice the temperature of 1673 to 1523-1573K, produce the burnt pellets according to the technical requirements.

Key words: *chromitite, pellets, boron ore, basalt.*

In mining and processing of chromitites 75-80% of small items less than 10 mm are formed and about 30% of ore is in a powder and dust condition. The necessity of clotting such ore is evident. Concerning the ores in Kazakhstan, a number of researches on the clotting have drawn the results given in [1]. The ways of agglomeration, clotting, briquetting using flaxes, liquid glass, calcium lingosulphanate and other additions were suggested. But they were not realized in industry.

Chromitites clotting is widely spread in a number of countries. But this experience cannot be used in Kazakhstan as the ores of these countries are relatively fusible [2]. The Kazakhstan ores have high temperature of melting which is concerned because of refractoriness of ore phase and deads [3]. That is why special actions have been taken in the factory on clotting operations (Chrometau city, Kazakhstan). They include additives to furnace charge from the concentrate and bentonite as well as coke and supporting of burning temperature on the line at the level of 1673 K. Some disadvantages related also to negative influence of high temperature on the equipment operational characteristics were discovered. To solve this problem we have tried to lower the temperature of furnace charge melting.

The first experiments (chart 1) using Kazakhstan boron ores containing (mass, %): $Fe_{total.}$-1,1, SiO_2–10,6, Al_2O_3-3,82, CaO-22,02, MgO-7,5, B_2O_3 - 8,2, S - 10,0 were made following the example of successful researches with iron ores [4, 5]. From the data given we can see that at the burning temperatures usual for production line machines (1523-1573K), for pellets from the pure chromite concentrate and for those with the addition of bentonite (1%) the required [6] solidity for compression (150 kg/p) is not reached. But at 1623K which is connected with difficulties in the operation of burning equipment the pellets with bentonite can reach this level.

Adding 2% of boron ore let us have pellets with the strength to pressure of 203-291 kg/p at the burning temperature 1523-1573K, so not proper for industrial use. Despite the high sulfur congregation with boron ore, its concentration in pellets is very low (Table 1).

Table 1. Quality of raw and burnt chromite pellets

Furnace charge structure, %				Raw pellets					Burnt pellets		
Chromite concentration	Bentonite	Boron ore	Burnt. colemanitte	W, %	R, kg/p	n, times	R_{brunt}, kg/p	$T_{encaus.}$ K	R, kg/p	Cr_2O_3, %	S, %
100				11.0	1.18	>20	3.59	1273	16	50.3	0.015
								1373	20	50.2	0.005
								1423	39	50.2	<0.001
								1473	45	50.1	0.004
								1523	61	50.3	0.002
								1573	69	50.6	<0.001
								1623	139	50.6	<0.001
99.0	1.0			12.3	1.02	>20	5.0	1273	31		
								1373	50		
								1423	54		
								1473	99		
								1523	104		
								1573	134		
								1623	223		
98.0		2.0		11.1	1.21	>20	5.0	1273	33	49.2	0.110
								1373	65	49.8	0.015
								1423	84	50.7	0.002
								1473	133	50.4	<0.001
								1523	203	50.3	<0.001
								1573	291	50.1	<0.001
								1623	374	49.9	<0.001
99.5			0.5	11.0	1.23	>20	3.2	1523	155		<0.001
								1573	271		<0.001

Realization of this technology and those analogous for iron ore with the use of Kazakhstan boron ore is possible at the condition of emissive sulfur utilization by the schemes given. But there are high-quality Turkish boron raw materials available in the market. The best results (chart 1) of four researched types were reached at the use of annealed (eliminated hydrate moisture) colemanite (mass, %): SiO_2 – 3,67, CaO – 33,64, MgO - 2,75, B_2O_3 – 55,46, S - 0,25. At the burning temperature of 1523-1573K and only 0,5% of colemanite in the charge we can get the pellets of high strength (155-271 kg/p). It should be noticed that on the base of industrial experiments data the presence of boron in the charge let us improve technical and economical indexes of chromite ferroalloy burning [7,8].

Not to further complicate the process, to avoid ecological problems and to get more available raw materials it was decided to make the flux of necessary content and characteristics for the deads of chromite ores oxides. The analysis of the four-component system diagram $CaO-SiO_2-Al_2O_3-MgO$ has shown that it can be done at the low temperature eutectic (CaO – 13-20%, SiO_2 – 55-60%, Al_2O_3 15-20%, MgO – 10-12%) with the melting temperature of 1473-1573 [9]. Basalts are the closest to these structures of all the natural materials. Chemical analysis of two basalts on the main components (mass, %) is given below:

No.	SiO_2	Al_2O_3	CaO	MgO	Fe_{total}	$T_{smel. end.}$K
1	47.4	16.2	9.45	8.1	10.4	1700
2	52.5	13.99	11.85	5.29	8.7	1713

The first of them is Novosibirsk (Russia), the second is from Kazakhstan, Dubersay of Aktyubinsk region (Chrometau) where it is mined, fractionated and delivered to construction industry enterprises. We can see that to get better fusible condition both basalts require the extension of manganese oxide content in it. The one from Novosibirsk requires less and Duserbay more of it.

Using the electrical vibration viscometer we have found the melt viscosity of these materials and with its help we have found the temperature of melting to understand the possibility of its use as fusible additive at pellets production.

We have studied the influence of MgO additives on these features. The viscosity characteristics are given in the figure below.

We can see that basalts are refractory and have the high viscosity even at high temperatures. That is why we cannot think about getting the liquid melt in pellets at usual burning temperatures (1523-1573K). But it is changed by addition of manganese oxide to it (dolomite). The burning temperature of Novosibirsk basalt falls from 1700 to 1603 and 1573K by adding of 10% and 20% dolomite to it. Observing its chemical content, the addition of dolomite in Dubersay basalt was discovered at a level of 28%. Its temperature of burning got lower from 1713 to 1553K. At temperatures given the basalt melts with dolomite viscosity is not higher than 3 Pa/sec. Both these factors contribute to lower the burning temperature and accelerate the charge assimilation.

Thus, combining flux with basalt dolomite we can see the effective addition to improve the chromite pellets burning. But the addition to charge of two extra fluxes can be negative for the chrome content in pellets and complicate the raw materials weight burdening.

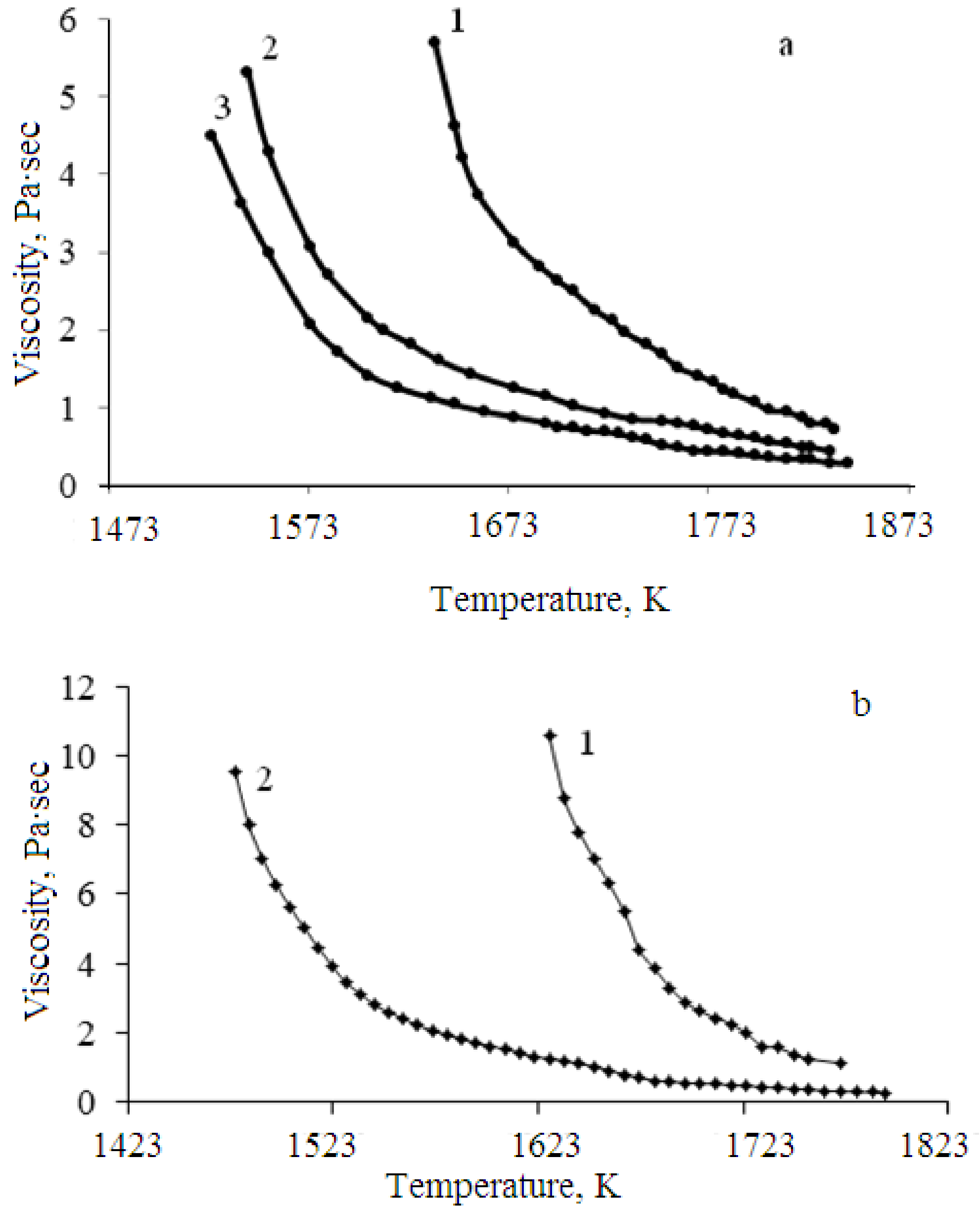

Fig. 1. Viscosity temperature dependence on basalt melts with different dolomite content
a) 1 – basalt, 2 – 10% - dolomite, 3 – 20% dolomite
b) 1 – basalt , 2 – 28% dolomite.

That is why we have decided for the future to take out bentonite and coke from the furnace charge and as a source of MgO to try using manganese oxide of cement breed of the chromite ore (Table 2) instead of dolomite. It is contained there in the structure of serpentine which is decomposed at water heating (vapour), forsterite and manganese silicate and not in a free condition (as in basalts).

Table 2. Minerals chemical structure of chromite ores

Deposit	Components names of chromite ore	Components content , % mass						
		Cr_2O_3	MgO	Fe_2O_3	Al_2O_3	FeO	SiO_2	$\frac{MgO}{Al_2O_3}$
"40 years of Ka-zakh SSR"	chromshpinelids	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
	cement ores	-	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

We have checked these data by making experiments on the pellets production. Chromite concentrate contained (mass, %): 51,9Cr_2O_3, 5,81SiO_2, 7,76Al_2O_3, 0,13CaO, 19,4MgO, 9,72$Fe_{gen,}$. Its size on the class minus 0,071 mm is 79.5%. Specific surface area is 1621 sm^2/g. Furnace charge clotting were done in the laboratory drum grainer with the diameter of 600 mm, length of 200 mm; drum speed rotation was 27 turns per minute (equivalent speed rotation of industrial drum with the diameter of 2,8 m is 12 turns per minute).

The pellets were burnt with one layer in the laboratory tube electric furnace with silicon-carbide heaters. The pellets burning procedure is the heating temperature of 100^0 per minute, cooling 70 ^{0} per minute, the temperature in the burning area is 1523 and 1573K, isothermal tenacity 20 minutes. The strength to pressure of burnt pellets was calculated by the tearing machine of P-0,5 type.

The basic charge was the one contained 96.9% of chromite concentrate, 0.6% bentonite and 2,5% coke. The experiment demonstrates the following data. The strength of raw pellets to pressure was 0,54 kg/p, they stand about 2-3 downcasts. The strength of pellets burnt at 1523K was 65 and at 1573 it was 133 kg/p. At this charge the technical requirements (150 kg/p) can be reached at high burning temperatures that was done (1673K) in the working factory.

Three types of experimental charges were researched: with bentonite and two compositions of basalt. The additives efficiency was marked by raw pellets grading, the strength of raw and burnt pellets. The results are given in the Table 3.

Table 3. The pellets quality

Index	Units	Figures		
Charge content: concentrate	%	99.4	95	97.5
Bentonite		0.6		
Basalt		-	5	2.5
Raw pellets : moisture		10.60	9.61	9.74
Grainy: +16 mm		0.0	1.1	0.0
14-16mm		1.8	5.2	5.8
12-14mm		61.6	61.5	64.6
10-12mm		30.7	21.6	25.9
5-10mm		5.8	3.7	3.5
0-5mm		0.1	6.9	0.2
Strength: average	kg/p	0.87	1.11	1.16
Amount of downcast.ch=300mm	times	68	45	44
Strength of raw ones: average	kg/p	3.51	3.08	3.89
Strength of burnt :	kg/p			
$T_{burnt.}$ = 1573K		100	221	246
$T_{burnt.}$ = 1523K		-	196	171

We can see that use of bentonite only in charge as flux does not provide required strength even at the burning temperature of 1573K. That is why in industry coke is added to the charge and increase the temperature to 1673K. There is no need to use bentonite and coke in the charge and hold the temperature at 1673 K while adding basalt to the charge. For example, adding 2,5% basalt to the charge the pellets burn in the charge at the temperature 1523K have the strength to pressure 171kg/p and at 1573 it is 246 kg/p that is higher than technically required for 21 and 96kg/p. Requirements to the strength of raw pellets (not less than 2 kg/p) are higher 1,5-1,9 times (Table 3).

Thus, the suggested technology allowed us:

- taking out bentonite and coke of the charge;

- reducing the burning temperature from 1673 to 1523-1573K;
- using only basalt located in the area of pellets factory as flux;
- producing burnt pellets strong to pressure 171-246 kg/p according to technical requirements (150 kg/p).

We should note that the burning way reducing the melting temperature in the charge adding flux [10] is good not only for refractory but also for usual ore materials as it let us avoid low strength of the lower layers where there is usually lack of heat because of the temperature overfall on the height of pallet.

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