BENEFICATION OF OFF-GRADE CHROMITE ORE FOR PRODUCTION OF INORGANIC SUBSTANCES

Kurmanbek Zhantasov
South Kazakhstan state university named after M.Auezov
Chemical-technological faculty
160008 Kazakhstan, Shymkent city,
Zhylkyshiev street 11,
k_zhantasov@mail.ru
+77017825447

Erkebulan Kocherov
South Kazakhstan state university named after M.Auezov
Chemical-technological faculty
160012 Kazakhstan, Shymkent city,
Tauke khan street 5
erkebulan083@mail.ru
+77058504177

Manap Zhantasov
South Kazakhstan state university named after M.Auezov
Mechanical-building faculty
160008 Kazakhstan, Shymkent city,
Zhylkyshiev street 110,
manapjan_80@mail.ru
+77017562487

Altybayev Zhaxylyk
South Kazakhstan state university named after M.Auezov
Chemical-technological faculty
160021 Kazakhstan, Shymkent city,
Baitursynov street 59A,
arsenal_575@inbox.ru
+77785001747

Turakulov Bakhriddin
South Kazakhstan state university named after M.Auezov
Chemical-technological faculty
160000 Kazakhstan, Shymkent city,
Akpan batyr street 48
ajina_91@mail.ru
+77021548298

Abstract

The aim of the research is an elimination of impoverishment of primary batch mixture and reduction of fuel and energy costs on roasting process and roasting temperature above the layer of chromite pellets with saving its strength properties. Off-grade chromite ore and internal overburdens of coal-mining industry are used as primary raw materials. The chemical composition of primary raw materials is shown in article.

Data of experimental researches on receiving the enriched chromite pellets in the process of roasting of off-grade raw materials and waste of the coal-mining industry are quoted.

Key words: chromites, charge materials, internal overburdens, mine refuse, waste, pelletization, roasting, strength, time, temperature

1 Introduction

Development of Kazakhstan economy is connected with the consumption of many types of products in different industrial branches, in particular chemical and metallurgical industries.

Chrome and its compounds are widely used in various economic branches. For instance, metallurgical industry produces special chrome steel, which has high mechanical strength, heat-resistance and anticorrosion properties. Chrome compounds are widely applied in production of chrome-magnesite and other refractories in metallurgical and other industrial branches.

Chromic oxide is a raw material for production of metal chrome, chromium carbide, polishing compounds and paints, which are resistant to light, fire and atmospheric oxygen. Besides, it is applied in nonorganic and organic synthesis of chrome catalysts.

Raw material for chrome production is a chromite and chromic iron, being the insoluble salt of chromous acid $HCrO_2$.

Significant volumes of chromite ore are situated in Aktyubinsk region of the republic of Kazakhstan. Rich chromites are exposed by fusing in electric furnaces and the ferrochrome is produced. This ferrochrome is used as an additive during melting chromium steels and other.

Basic product in production of chrome salts is a sodium bichromate, which is produced from dustlike chromite, exposed by oxidizing roasting in the mix with sodium carbonate and calcium lime. During this process, the sodium monochromat is produced, which is leached from calcined batch mixture and transited into sodium bichromate by introduction of acid into solute on [1]. This type of alkaline chromite calcination with its oxidation by atmospheric oxygen is an effective during processing high-grade ore with low content of silica.

For complex use of low-grade chromite ore the acid methods are applied [2]. Also the methods of getting cakes from off-grade ore are used [3-5]. This ore is exposed by process of leaching and production of solution of sodium monochromat [6], or chromous sulphide [7].

With the purpose of reduction of fuel and energy costs on the process of production chromite pellets, also increase of inwall operating age of heat aggregates – roasting machines of conveyor type, we propose the technology of production of chromite pellets with using carbon-bearing materials, such as shungites, slates, internal overburdens of coal-mining industry, oil sludge, coke and coal fines in content of batch mixture [8].

In the process of preparation of off-grade chromiferous raw material to metal conversion, for production of ferrochrome, various methods of chromite ore lumping with introduction of additives and further high-temperature processing pellets before technological conversion are known.

2 The primary research tasks

The aim of the research is an elimination of impoverishment of primary batch mixture and reduction of fuel and energy costs on roasting process and roasting temperature above the layer of chromite pellets with saving its strength properties.

The designed task is achieved by production of roasted pellets from off-grade chromite ore with using as a bonding agent the sludge of class less than 0,043 mm in a quantity of 5-7% created in the process of concentrate production. The internal overburdens of coal-mining industry or other carbon-bearing solid materials in a quantity of 5-10% from batch mixture mass are used as a flux. Introduction of internal overburdens of coal-mining industry or other carbon-bearing solid materials provide the reduction of natural gas rate till 30% in the process of roasting by means of sucking through oxygen-containing heat agent downward.

Use of sludge allows to increase the strength of raw and roasted pellets because of presence of fine impurities, contributing to creation liquid-phase eutectics in the roasting process.

Off-grade chromite ore and internal overburdens of coal-mining industry are used as primary raw materials.

Chemical composition of charge materials and bonding agents is showed in Table 1.

Table1 - Chemical composition of charge materials and bonding agents

Name of material	Content of components, in % of mass.								
	Cr_2O_3	CaO	MgO	SiO_2	Fe_2O_3	$SO_{3com.}$	Al_2O_3	$C_{free.}$	moisture
1. Chromite ore, off-grade	38,9	0,26	19,27	22,78	10,11	0,02	6,76	-	1,9
2. Internal overburdens of coal-mining industry	traces	5,1	2,3	32,7	9,9	1,8	12,8	35,4	-
3. Sludge of sizer	41,11	0,4	19,4	17,49	10,2	0,02	6,6	-	4,78

3 Experimental part

During tests off-grade chromite ore and internal overburdens of coal-mining industry were preliminary exposed by grinding in ball drum to class less than 0,1 mm. Then from certain proportions of charge materials we accepted the raw pellets with humidity of 11-12 %, on installation with dished grainer of 1 m diameter and reducing gear of rotary speed change. During granulating batch mixture the sludge of sizer, creating in the process of chromite concentrate production and containing solid particles of class less than 0,043 mm, was used as bonding agent.

The produced raw pellets with diameter of 10-20 mm and humidity of 11-12 % were dried and roasted on experimental installation "roasting pot", working on natural gas.

The preliminary drying of pellets was carrying out at a temperature 300-400 ^{0}C during 15 min, then the temperature was raised to 1200 ^{0}C. In roasting the pellets were holding at a temperature 900-1200 ^{0}C during 20-25 min. After reaching the temperature of 1200 °C in layer between 100-200 mm we reduced natural gas rate in gas burners with excess of atmospheric oxygen which is necessary for carbon combustion in pellets, containing internal overburdens.

It was determined that with this mode the temperature in low layers is about 1200 °C, and allows to reduce natural gas rate to 50%.

Results of the research on changing strength and chemical composition of roasted pellets are listed in the Tables 2 and 3. For comparing physico-chemical and mechanical properties we took the tests of pellets from off-grade chromite material, free of internal overburdens.

Table 2 – Changing strength of roasted pellets from batch mixture composition, time and temperature of roasting

№	Batch mixture composition, % of mass			Temperature, ^{0}C		Time, min		Strength, kg/pellet
	Off-grade chromite ore	internal overburdens	Sludge of sizer	drying	roasting	drying	roasting	
1	94	-	5-7	400-500	1250	15	25	126
2	89	5	6	300-400	900	15	25	135
3	86,5	7,5	6	300-400	1000	15	25	269
4	85	10	5	300-400	1100	15	25	330
5	89	5	6	300-400	1200	15	25	270 partial alloying
6	92,5	7,5	-	300-400	900	15	25	230
7	95	5	-	300-400	1000	15	25	172
8	90	10	-	300-400	900	15	25	287

Table 3 – Chemical composition of calcined chromite pellets, containing carbon

№	Component content, % of mass.							
	Cr_2O_3	CaO	MgO	SiO_2	Fe_2O_3	SO_3	C_{free}	CO_2
1	51,0	0,26	14,0	24,46	10,11	0,07	-	0,1
2	49,4	0,6	14,0	27,4	7,82	0,06	0,62	< 0,1
3	49,7	0,6	14,1	28,0	6,61	0,05	0,84	< 0,1
4	49,8	0,55	13,85	28,6	6,12	0,05	0,93	< 0,1
5	49,2	0,7	13,9	28,2	7,35	0,04	0,51	< 0,1
6	49,0	0,7	15,32	24,3	9,8	0,06	0,72	< 0,1
7	49,1	0,73	15,1	24,0	10,28	0,05	0,64	< 0,1
8	48,7	0,72	14,7	24,6	10,26	0,06	0,86	< 0,1
Average	49,49	0,605	14,4	26,2	8,5	0,055	0,65	< 0,1

In the period of carrying out experimental tests on roasting chromite pellets the process of changing temperature according to height of pellet layer was studied. The results of research are listed on picture 1; temperature in roasting pot is 900 ^{0}C.

4 Results and conclusions

1. Analysis of statistic data allows to conclude that in granulating batch mixture, including off-grade ores, internal overburdens and sludge of sizer of chromite ore, with pellet humidity of 11-12 % the raw pellets with compression strength of 2,3-3,2 kg/pellet are produced.

2. Roasting chromite pellets, containing 84-89 % of chrome oxide and 2-3,5 % of carbon of internal overburdens, in different temperature and time characteristics, was realized. It was determined that in the process of roasting carbon-bearing chromite pellets in comparison with free of carbon chromite pellets, the time of thermal processing decreases in 1,5 times, that is explained by process of carbon elimination in pellets.

3. Chromite pellets with compression strength of 130-220 kg/pellet and containing 44-46 % of chrome oxide and 1,2-1,7 % of carbon.

Rise of concentration Cr_2O_3 in pellets till 6-7 % is explained by increasing extraction of chrome oxide into batch mixture by means of chrome oxides, which are contained in sludge, also by removal of volatile and organic substances from batch mixture composition, exposed by thermal processing.

4. During the thermal processing carbon-bearing chromite pellets, we determined the reduction of natural gas rate to 50 %, comparing with roasting free of carbon chromite pellets. This is explained by elimination of 50 % of carbon in pellets.

During visual examination of fragment of roasted pellets it was determined that it consists of 2 zones: peripheral – light and inner – dark color. Chemical method of analysis showed that in the peripheral zone the content of carbon achieves 0,1 %, in the inner zone it is 20 % from primary, that allows to decrease the quantity of reducing agents in the process of production of ferrochrome from chromite pellets in non-ferrous metallurgy.

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Figure 1: Changing temperature according to height of clean chromite pellets and pellets, containing carbon in roasting process