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OBTAINING OF STRONG CHROMIUM PELLETS WITH THE USE OF A FERROSILICON-CALCIUM BINDER

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Preliminary Note – Prethodno priopćenje

The article presents the results of research on the synthesis of strong chrome pellets based on concentrates obtained by enrichment of chrome sludge. To obtain strong fired pellets from the concentrates, it is proposed to use a ferrosilico-calcium reagent as a binder, which makes it possible to increase the strength of the pellets by 2-3 times in comparison with the technology operating at "Donskoy Ore Mining and Processing Plant". This excludes the supply of fluxing reagents during electric arc smelting of raw materials to high-carbon ferrochrome. Pellets from concentrates obtained during the processing of tailings from the Dubersay sludge storage have increased strength up to 5 330 N/pellet at a roasting temperature of 1 200 °C.

Keywords: slimes of chrome production, ferrosilico-calcium binder, chrome pellet composition, crushing strength of pellets, X-ray research

INTRODUCTION

The problem of processing fine chrome slimes from Donskoy Mining and Benefication Plant stems from the fact that there are no efficient technologies of their benefication and that chromium oxide losses into different middlings are exceedingly high. For years, the JSC TNC "KasChrome" management and Kazakhstani scientists have been involved in works on improving fine chrome raw materials and middlings benefication and pelletizing technology aimed at increasing technical and economic performance of the processes [1-4].

A shop was built at the Aktobe Ferroalloys Plant (a branch of JSC TNK "KazChrome"), in which finely dispersed chromium concentrates are melted without their pelletizing before the technological process.

However, melting capacity of the shop makes no more than 20 % of total industrial capacity of JSC TNC "KasChrome" and it needs modern technologies of benefication and pelletizing to obtain pellets and to melt them in alternating current electric arc furnace (EAF).

Primary researches of Kazakhstani scientists and specialists were aimed at slag structure stabilization with borium compounds and re-extraction of metal concentrate from them. However, the problem, of utilizing their mineral part was left unsolved.

The currently used technology for pelletizing chrome concentrates to produce chrome pellets at Donskoy mining and processing plant (DMPP) and agglomerate at Aksu Ferroalloys Plant (branches of JSC TNK "KazChrome") uses bentonite clay as a material for pelletizing finely dispersed chrome concentrates.

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Bentonite clays have been used as a pelletizing material for quite a long time, giving a certain strength to the pelletized product. Moreover, they practically do not participate in the chemical processes of interaction with chromite minerals. The agglomeration of materials using bentonite clay requires rather high firing temperatures – 1 300 - 1 350 °C, fired chrome products have a crushing strength of about 1 900 N/pellet), the process of obtaining agglomerated material is accompanied by a significant yield of substandard material (shatters yield ≥ 10 %).

Russian scientists proposed and tested technology for agglomeration of iron ore minerals, where cheaper Callovian clays are used as a material for agglomeration.

A theoretical substantiation of the synthesis of ferrosilico-calcite fluxes, the so-called FSCF, was proposed in [5, 6] for technologies for producing iron ore pellets using Callovian clays as binders, the main component of which is a mixed-layer mineral-like illite-smectite – 58 %, mass fraction of montmorillonite component – 12 %, kaolinite – 6 %, quartz – 14 %, calcite – 10 %.

The authors propose to use a furnace charge that includes in its composition industrial wastes - slags from the production of refined ferrochrome, available natural raw materials - ferruginous diatomites as an analog of Callovian clays. A furnace charge mixture formulation was calculated and research on the production of hardened pellets using a new binder was performed.

This way two problems are solved simultaneously: utilizing environmentally harmful of processing of refined ferrochrome (RFC) slags mineral part and sharp increase of pellets strength.

The idea of using silica-containing wastes as fluxes to obtain strong chrome pellets is presented in work [7, 8].

The article [9] presents the results of a study on the effect of the granulometric composition of chrome ore on the properties of burnt pellets. The particle size of chromium raw materials is a factor to control the strength and porosity of pellets due to particle packing and bond formation during melting of the waste rock during high-temperature sintering.

There is no environmentally safe technology of processing of RFC slags, which both aggravates ecological situation in Aktobe and leads to losses of metallic chrome and other valuable mineral components of chrome ore materials.

The authors of this article obtained complex pellets based on chrome concentrate, RFC slags mineral parts, ferriferous diatomites and special chark processed at 1 050 - 1 200 °C.

They possess unique strength (up to 5 325 N/pellet), do not absorb moisture and so do not lose mechanical strength when wetted due to formation of cementing glass phase. There is no need for disintegration of the components to 0, 07 mm, 0, 25-0,1 mm is enough, as high strength is achieved by forming fluxing ferrosilico-calcium glass phase.

Relevance of the work lies in necessity of developing a modern and ecologically friendly technology of RFC slags processing. The authors of the project suggest use them to obtain a construction product close in composition to Sorel cements and to use mineral part of RFC slags as furnace charge in obtaining burnt pellets at DMPP [10, 11].

The technology now under development of obtaining strong iron-ore pellets allows obtaining chrome pellets of additional collapsing strength and to use inexpensive natural raw materials such as ferri-ferrous diatomites as well as middlings and wastes of chrome production (special cokes braize, mineral parts of refined ferrochrome slags and limestone calcining furnace braizing) as fluxing agents.

MATERIALS AND METHODS

The study aimed to obtain hardened chrome pellets of optimal composition for melting in an electric arc furnace using ferrosilico-calcium binders.

The composition of the pellets includes a chromium concentrate with a Cr_2O_3 content > 50 %, obtained during the gravitational enrichment of the tailing dump sludge Dubersay.

The following components were used as a source for the synthesis of a new type of binder: the mineral part of slags from the production of refined ferro-chromium (source of CaO and SiO_2), ferrous diatomite (source of SiO_2 and FeO), finely dispersed special coke (source of SiO_2, pellet heating temperature regulator), liquid glass.

For the experiments on obtaining strong complex pellets the following chrome concentrate was developed by benefication on concentration tables with the composition given in Table 1.

Table 1 **Chemical composition of Chrome concentrate**

Components	Content / %
Cr_2O_3	51,0
SiO_2	7,0
P	0,05
S (for size classes 2–6)	0,05
Cr_2O_3 / FeO = 3,5	
Size (for size classes 2–6) – 70 %	

Table 2 **Composition and main chemical and physical properties of special coke from «Sary-Arka» JSC**

Chemical and physical properties	Parameters
Size / mm	5,0…40,0
Sulphur content / %	≤1,0
Ash content / %	6,0…10,0
Volatile content / %	4,0…7,0
Structural porosity / %	67,4
Humidity / %	15,0…20,0
Specific surface, m^2/g	3,0
Porosity / %	22,0…25,0

Table 3 **Composition of ferriferous diatomites from Zhalpak deposit / wt. %**

Diatomites	Al_2O_3	SiO_2	SO_3	Cr_2O_3	Fe_2O_3
High ferriferous	3,76	25,85	3,66	0,03	27,44
Ferriferous	8,03	66,98	0,58	0,02	10,30

Composition and main chemical and physical properties of special coke from «Sary-Arka» JSC are given in Table 2.

Chemical composition of high ferriferous diatomite from Zhalpak deposit, Aktobe region, is given in Table 3.

Solid components of the charge were disintegrated in a laboratory blender and sieved on laboratory test sieve with mesh 0,25 mm.

Equivalence ratio in the charge was / wt. %: chrome concentrate 88,00; mineral part of RFC slag 3,00; ferriferous diatomite 4;0; coke 3,00; liquid glass 1,0.

RESULTS AND DISCUSSION

The pellets were obtained on a laboratory pelletizer. Size of raw pellets was from 6 to 10 mm. Raw pellets were kept at room temperature for 24 hours. Strength of temperate raw pellets was. 124,6 N/pellet. Pellet batches were burnt in laboratory blind roaster at 1 050, 1 100, 1 150 and 1 200 °C for 1 hour at heating speed 15 degrees /min.

The obtained hardened pellets (7 items in each batch) were tested for squashing on laboratory press MIP-25R and mean strength was defined. Average strength at burning temperature was per pellet: at 1 050 °C – 2 854; at 1 100 °C – 3 980 at 1 150 °C – 4 500; at 1 200 °C – 5 330. Figure 1 shows a party of pellets obtained at 1 150 °C.

Chemical composition of the obtained pellets wt. %: 46,0 Cr_2O_3; 6,12 Al_2O_3; 12,65 SiO_2; 10,85 FeO; 1,42 CaO; 9,90 MgO; 5,79 the rest. The composition of the

Figure 1 Photo of calcined pellets

Table 4 **X-ray phase analysis of the chrome pellets burned at 1 150 °C**

Name of minerals	Formula	Contents / %
Chromium oxide	Cr_2O_3	10
Chromo-magneite	$Mg(CrO_4)$	14
Chromite	$(FeO_{0,632}MgO_{0,358}Mn_{0,01})(Al_{0,45}Fe_{0,283}MgO_{0,022}Cr_{1,201}Ni_{0,004}Ti_{0,03})$	26
Quartz	SiO_2	15
Magnezial helenbergite	$Ca(Fe,Mg)Si_2O_6$	15
Paragonite-2M1	$NaAl_2(AlSi_3)O_{10}(OH)_2$	12
Periclase	MgO	5
Chloritoide-A	$FeAl_2SiO_5(OH)_2$	5

burnt pellets is close to average composition of charges from Shop № 3 JSC «Akrobe Ferroalloy Plant». X-ray phase analysis of the pellets obtained at Table 4.

The following phases were detected in the composition of burnt pellets by X-ray phase analysis: Magnezial helenbergite, Paragonite-2M1, and Chloritoide-A. The formation of these compounds contributes significantly to the mechanical crushing strength of pellets.

The technology of obtaining strong burnt pellets from fine concentrates made by benefication of slimes from Dubersay tailing dump allows:

– to solve the problem of pelletizing of fine chrome concentrates obtaining pellets suitable for melting in electric arc furnace;
– to solve the problem of dispersiveness of initial materials (fine chrome concentrates, sieve residue of overground special coke);
– no longer necessity of quartzite delivery and adding iron turnings to regulate the charge composition in the furnace tank to obtain metal and slag of demanded properties;
– to increase the pellets high fusibility while decreasing electric power costs on melting when melting high-carbon ferrochrome;
– exclude disturbance of arc furnace work, diminish dusting and dirt in melting shops.

The authors suggest a technology of obtaining ferrosilico-calcium reagent to be used as fixant to obtain strong burnt pellets, which allows to increase the pellets' strength three or four times compared to the technology currently used at DGOK This technology also allows to avoid adding fluxing reagents for melting in electric arc furnace to obtain high-carbon ferrochrome.

Pellets from the concentrates obtained from Dubersay slime dump tailings processing possess high strength up to 5 330 N/pellet at the burning temperature of 1 200 °C, non-congelation, dust eject resis-tance. Using strong pellets decreases power costs at electric arc furnace melting due to lower melting temperature.

Comparatively low temperature of burning allows performing the process of pelletizing, for example, in simple and inexpensive tunnel or muffle furnaces. All the other technological equipment (mills, screeners, disk pelletizers) also have numerous industrial analogues.

CONCLUSION

The results of the studies have shown the possibility to obtain hardened chromium pellets based on enriched fine chromium sludge and a new formulation of the ferrosilicon-calcium binder.

The optimum charge mixture composition for synthesizing the binder and producing strong chrome pellets is proposed.

The proposed composition of the charge for the production of pellets can significantly reduce the firing temperature, simplify the hardware design of the firing process, reduce the yield of substandard fired pellets.

Reducing the temperature of the "green" pellets allows you to abandon expensive flexible belt calcining machines and use more cheap tunnel kilns.

By increasing finely dispersed chromium oxide in chromium concentrates and reducing emissions into the atmosphere, it is expected to reduce emissions and improve the ecological atmosphere near the "Donskoy Ore Mining and Processing Plant".

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