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BENEFICIATION OF CHROME SLURRY TAILINGS AT DONSKOY MINING AND BENEFICIATION PLANT (DMBP) JSC TO PRODUCE HARD PELLETS

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The article is about the problem of beneficiation of finely dispersed chromium slurry tailings of "Donskoy Mining and Beneficiation Plant" JSC by chemical and gravitation methods. Chemical destruction of chromium spinelids by sulphation with a mixture of ammonium sulphate and sulphuric acid enables to transfer a part of magnesium oxide to a water-soluble state and further gravitation beneficiation on concentration tables to obtain a fine-grained rich chromium concentrate. Silica, calcium, and iron oxide additives are used to produce pellets from the fine chrome concentrate, serving as binding agents and enabling the production of hard chrome pellets during roasting. In the future, roasted pellets will be used in the smelting of high-carbon ferrochrome in electric furnaces.

Keywords: chrome oxide, slurries, chemical beneficiation of chromite, chrome pellet composition, crushing strength of pellets

INTRODUCTION

Over some years, TNC"Kazchrome" JSC has been working to improve chrome oxide extraction. The finely dispersed sludge generated in the grinding and beneficiation processes is processed in screw separators to produce the chrome concentrate. However, the beneficiation technology implemented at DMBP JSC does not enable to significantly increase the 45-50% extraction of chromium oxide in the rich chrome concentrates (45-50 % weight Cr_2O_3) due to the complexity of the mineralogical composition of chromites, the relative proximity of the specific gravity of minerals of chromites and minerals of host rocks with the inefficient scheme of gravity concentration. Total chromium oxide recovery does not exceed 66 % [1-3].

The use of acid technology with the transfer of impurities (mainly Mg0 compounds) was proposed in the destruction of chromium spinelides. Eastern Research Mining and Metallurgical Institute of Non-Ferrous Metals (VNIICVETSMET) ASU developed the technological regulations for the design of the plant intended to process slurries from DMBP beneficiation plant with obtaining chromium oxide beneficiated product and magnesium-containing target product [4] the following results were obtained:

- the -0,63 mm fraction of the chromium slurries is processed with a sulphuric acid solution. Sulphuric acid leaching is carried out at the initial stage at L:S = 2:1 (I stage of leaching) with subsequent dilution of the slurries with washing water to L:S = 3,5:1 (II stage). The pulp is heated to 90 – 95 °C by exothermic reactions;
- the leach cake is thoroughly washed with water (three-fold counter-flow washing on the filter), then pulverized in water and sent for gravity concentration. The cake is gravitationally beneficiated under DMBP's technology.

The plan is to produce a concentrate with a chrome oxide content of more than 50 % and a recovery of at least 80 - 85 %.

The solution after separation of the precipitate is subjected to hydrolytic purification, separation, and evaporation with separation of heptahydrate ($MgSO_4 \cdot 7H_2O$). The main disadvantages of the proposed technology are:

- significant consumption of expensive and deficient sulphuric acid, lime, soda ash, which makes this technology uneconomical;
- the large amount of magnesium sulphate crystalline hydrate produced, which is difficult to sell in volumes of about 900 000 tons;
- a significant amount of toxic waste is generated.

Scientists of IMOB JSC have developed a technology [5] for chemical beneficiation of DMBP JSC slurry tailings. The technological scheme of processing includes operations of preliminary activation of sludge tails in soda ash solution, sulphuric acid leaching in 30 % ammonium hydrosulphate solution, and gravitational beneficiation by a centrifugal separator.

As a result of processing chromite concentrate with content Cr_2O_3 59,2 % is obtained. This technological solution is accompanied by a significant transition of

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water-soluble chromium in a solution and by contamination of a solution with hexavalent chromium.

Some researches [6-7] are devoted to the removal of magnesium and calcium oxides from chromite by the influence of carbonic acid solutions with the formation of water-soluble compounds MgO and CaO.

The scientists of the Institute of Metallurgy and Ore Beneficiation JSC (Almaty) [8] suggested using a mixture of ammonium sulphate and sulphuric acid at sulphatization at t-300 ^{o}C, as a chemical compound for slurry destruction and further transfer of magnesium oxide into solution. Sulphatization enables further water leaching of the sinter to extract magnesium oxide into the solution without significant transfer of Cr_2O_3 into the solution. The Mohr's salt-ammochenite formed during sulphatization has a low solubility at temperatures below 35 ^{o}C and makes it easy to separate magnesium compounds from the leached sinter.

MATERIALS AND METHODS

Source chromite raw material is represented by slurries of tailing ponds of Dubersay DMBP JSC. X-ray fluorescence analysis of the slurries is given in Table 1.

Table 1 **X-ray fluorescence analysis of Dubersay tailing ponds slurries**

Element	Content/ %	Oxides	Content/ %
O	43,634	MgO	24,738
Mg	14,759	Al_2O_3	3,268
Al	1.696	SiO_2	25,732
Si	11,774	SO_3	3,128
S	1,217	Cr_2O_3	28,262
Cr	18,530	Fe_2O_3	9,470
Fe	6,242	NiO	0,279
Ni	0,206		

The slurries sulphation process flowchart is shown in Figure 1.

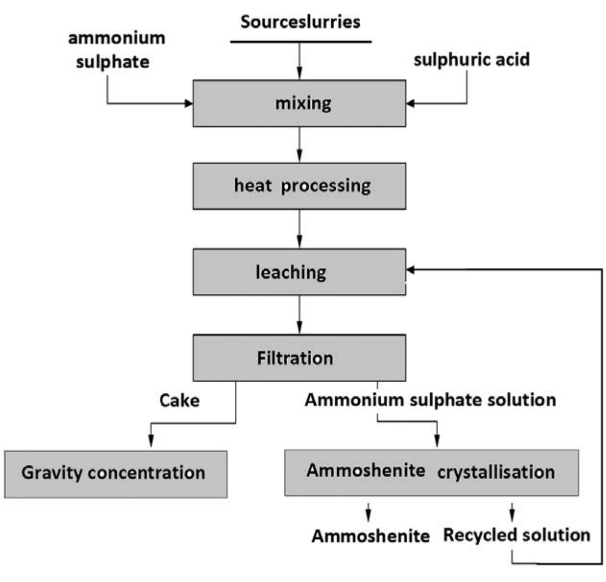

Figure1 Flowchart for slurries sulphation

In the experiments, 200 g of slurries were mixed with 88 g of ammonium sulphate $(NH_4)SO_4$ and 22 ml of concentrated sulphuric acid in a globe mill. The mixture was placed in an alundumina crucible and heat-treated at 250 – 350 °C in a muffle furnace. The sample was leached with distilled water at 95^{o} C in the thermostat for 60 minutes, L:S = 2:1. The hot pulp was filtered and the cake was dried. The solution after filtration was cooled down to room temperature, crystallization of ammoshenite occurred while cooling.

The results for MgO extraction from Dubersay slurry tailings are given in Table 1. The slurries after ammoshenite separation were beneficiated on the concentration table. The resulting chrome concentrate was sintered with fluxing agents. The crushing strength was measured on a laboratory press.

RESULTS AND DISCUSSION

Table 2 shows the results of the slurries sulphatisation studies.

Table 2 **Tailings pond slurries sulphatisation results**

Sulphation temperature/^{o}C	Cake weight/g	Ammoshenite weight/g	Degree of Mg0 extraction in ammoshenite	Cr_2O_3 content in slurries/ %
250	176,.9	108,30	27,55	36,68
300	165,4	108,33	32,4	38,54
350	157,6	56,06	31,00	39,95

The degree of MgO extraction into the water-soluble state increases up to 40 – 41 % by weight in the sulfated product at temperatures of 1 000 – 1 200 ^{o}C.

The classification of slurry tailings after chemical beneficiation was performed (Table 3)

Table 3 **Results of classification of source product after chemical beneficiation**

Product name	Yield/ %	Content Cr_2O_3/ %	Without grade +1 мм	
			Yield/ %	Content Cr_2O_3,/%
Source product	100	35,14	100,00	35,08
Grade +1 мм	0,20	31,90	-	-
Grade +0,16	15,69	33,42	15,72	33,35
Grade +0,071	25,42	39,49	25,47	39,41
Grade -0,071	58,69	33,73	58,81	33,66
including: T2 -0,071	32,83	39,49	10,61	39,41
T1 -0,071	10,59	30,89	32,90	30,83
T3 -0,071	15,27	23,29	15,30	23,24

The sample was subjected to 1mm, 0,16 mm, 0,071 mm. screen classification before being tested on the concentration tables. The + 1mm grade of 0,20 % was not included in the tests. Further tests on the concentration table were performed on fractions 1 + 0,16 mm, - 0,16 + 0,071 mm, and – 0,071+0 mm.

During the process of settling in the grade - 0,071 mm there was natural segregation in specific gravity,

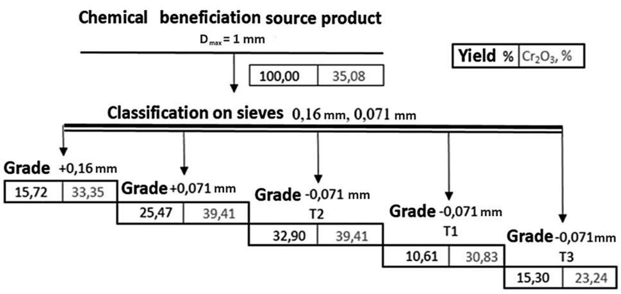

Figure 2 Classification scheme with results for Cr_2O_3yield and content

and as a consequence of separation in terms of content: sample T3 – 23,29%, T1 – 30,89%, T2 – 39,49 %. This fact predetermined separate beneficiation of T1, T2, and T3 samples.

Figure 2 shows the classification scheme with the results for Cr_2O_3 yield and content.

Experiments on concentration table beneficiation without pre-classification showed that it was not possible to extract chromium from the product, which has dimensions ranging from sand to slurry, on the concentration table. Hence a concentrate of Cr_2O_3 41,45 %, was obtained which is contaminated with coarse grains of waste rock. During gravity concentration, the presence of silvery light grains of the new mineral was visually observed, unlike the chrome tailings from the ore. It is because the source product under went chemical beneficiation with thermal processing.

Table 4 **Obtaining a batch of concentrate for pellet production.**

Product name	Weight, г	Yield/ %	Content Cr_2O_3/ %
Concentrate gr. +0,071	821	14,52	51,82
Concentrate gr.-0,071 T1	188	3,33	38,98
Concentrate gr. -0,071 T2	643	11,38	54,62
Concentrate n/a «+»	678	12,00	48,34
Concentrate n/a «-»	1187	21,00	48,23
Ultimate concentrate	3518	62,23	49,71

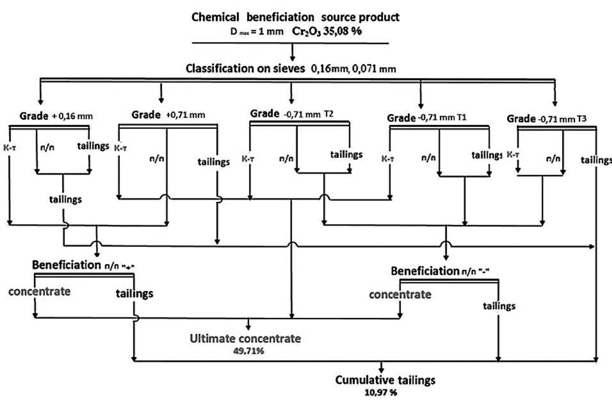

Figure 3 Schematic diagram of a concentrate table test of a chemically beneficiated product

Parallel beneficiation of the obtained five fractions by grain size classes was carried out on the concentration table. The flowchart and results of these tests are shown in Table 4

The Figure shows a schematic diagram of how a test is carried out on a concentration table of a chemically beneficiated product

Based on the rich chrome concentrate and fluxing agents, laboratory tests were carried out to produce hard roasted pellets, which will later be melted down to produce ferrochrome.

The following components were used as a source for the synthesis of a new type of binder: mineral part of refined ferrochrome slag (source CaO and SiO_2), ferrous forms of diatomite (source SiO_2 and FeO), fine special coke (source SiO2, regulator of pellet heating temperature), and liquid glass. Component composition of the mix, %: chromium concentrate-88.0; mineral part of slag RFCH-3,0; ferruginous diatomite-4,0; fines of special coke-3,0; liquid glass-1,0. Granules were made on the laboratory granulator. The size of crude granules is 6 to 10 mm. Unprocessed granules were kept at room temperature for 24 hours. The hardness of the crude pellets was 124.6 N / pellet. The batches of pellets were roasted in a laboratory muffle furnace at temperatures of 1 050, 1 100, 1 150, and 1 200 °C for 1 hour at a heating rate of 15 degrees / min.

Obtained roasted pellets (7 pieces in each batch) were tested for crushing strength on a laboratory press MIP-25R and the average strength was determined. Average strength at temperature of burning on pellet: at 1 050 ° C -2 854; at 1 100 ° C – 398 at 1 150 ° C - 4 500; at 1 200 ° C - 5 330 N / pellet.

CONCLUSION

1 The studies performed show that the use of chemical beneficiation for Dubersay slurry tailings with the application of ammonium sulphate and sulphuric acid as sulphation components enables to transfer up to 31 % w/w MgO in the form of Mohr's salt (ammochenite) into a water-soluble state and up to 41 % w/w in the case of preliminary slurry activation at 1 200 °C.

2 The chrome product obtained during chemical beneficiation and gravitation beneficiation of the obtained five fractions by grain size classes with middlings re-processing on concentration tables was preliminary classified. As a result of the tests performed the yield of the concentrate obtained at beneficiation on the concentration tables was 62,23 % with Cr_2O_3 content of 49,71 % with 88,19 % Cr_2O_3 recovery, and the yield of tailings -37,77 % with 10,97 % Cr_2O_3 content and with 11,81 % of metal loss into the tailings.

3 Studies on the production of roasted pellets from rich finely dispersed chrome concentrate and fluxing agents have shown the compressive resistance of the roasted pellets to 5 300 N/pellet that is 3 - 4 times higher than the compressive resistance obtained at DMBP JSC.

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Note: The person responsible for the English language is Kurash A. A., Almaty, Kazakhstan