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THE PROCESS OF BENEFICIATION OF FINE CHROME SLUDGES ON CONCENTRATION TABLES

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Processing industrial products and technogenic waste is an urgent task in mining and metallurgical industry. In Kazakhstan, processing of chrome ores of the Kempirsay group of deposits creates more than 15 million tons of sludge tailings with a chromium oxide content of up to 30 wt. %. The best results of processing fine chrome raw materials are demonstrated by Turkish enterprises that use sludge separation by size classes and enrichment on concentration tables. The authors performed a research on Dubersay tailing dump chromium sludge enrichment (Kazakhstan) using similar technological approaches, which allowed to obtain concentrates containing 51 wt.% Chromium oxide and increase the yield of rich fine chromium concentrates by 14 % compared to the existing enrichment scheme.

Keywords: sludges of chrome production, impact on the environment, beneficiation of chrome sludges, beneficiation a concentration table, Cr_2O_3

INTRODUCTION

Nowadays utilization and diminishing of deleterious influence of industrial wastes has got particular importance in the view of general aggravation and globalization of ecological problems. Total contents of valuable materials contained in waste accumulated within 20-30 years matches and sometimes even exceeds their amount extracted annually from the ores.

Every year 1,5-2,0 billion tons of solid natural resources are extracted in Kazakhstan. However, no more than 10 % of them is turned into final products, making around a half in ferrous metallurgy and only 1-2 % in non-ferrous.

Waste is technogenic (secondary) mineral formations with re-extractable ferrous, non-ferrous and precious metals in them, as well as rare and trace elements, sulphur, barium sulphate, etc [1-5].

All waste is situated within borders of industrial sites of mining, processing and me-tallurgical plants. Developing these objects makes sense with participation of functio-ning plants which have proper infrastructure, laboratory facilities and engineering and technical staff [1].

Chromite ores processing wastes and middlings contain significant amounts of chrome oxide and can be re-extracted for further industrial use now or in the nearest future with scientific and technical progress moving on and environmental conditions changing to the better. During Chrome ores beneficiation tailings are formed that are granulometrically mainly fine classes and contain over 20 % of Chrome oxide.

The task of many scientific and tech-nical researches is obtaining commercial Chrome concentrate from slime tailings with their further pelletizing fir melting in ferroalloy production.

In Kazakhstan, over 15 mln ton of slime tailings is accumulated after processing of Chrome ores from Kempirsay group of deposits with Chome oxide content 27-35 % mas. Slime tailings procession in JSC "Donskoy mining and processing plant" (DMPP) is not efficient as total Chrome oxide recovery never exceeds 66 wt. %.

Much better results in quantity and quality of extraction can be reached using experience of beneficiation plants that process chromite ores in Turkey, Russia, South African Republic as well as applying innovational equipment for fine classes' beneficiation.

It appears more rational to combine gravity and flotational concentration with the technology of chemical extraction of valuable components, which allows, apart from rich chrome concentrate, to obtain magnesium salts (Tutton's salt) and magnesium silicate, or forsterit, which is a high temperature refractory material, as additional commercial products. Complex processing using this combined technological benefication scheme can also help to improve technical-and economic index and to guarantee no-waste production.

DMPP, branch of JSC TNC "Kas-Chrome" has been producing chrome concentrate of different marks for several decades. Chromite ores benefication process causes significant formation of fine chrome concentrates obtained by gravity, flotation and in some cases by magnetic methods. These concentrates cannot be efficiently processed by melting due to their low porosity and high level of dust losses in furnaces.

For years, different fine slime beneficiation technologies have been studies and applied at DMPP using devices like scrubber-washing trammel, spiral and

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magnetic separators and so on. However, they have not provided high chrome oxide extraction into final product.

These days JSC TNC "KasChrome" is trying to solve the problem of fine concentrates by pelletizing them or melting them in direct current furnaces in Shop 4 of JSC "Aktobe Ferroalloy plant". However, the authors believe that applying this super-high temperature chrome melting technology that has not been properly tested anywhere in the world can cause the equipment and furnaces often to get out of order and even to be damaged [6, 7].

As a technological solution for fine chrome concentrates benefication, some technologies of chemical benefication have been studies such as processing fine chromites with sulphuric acid [8].

Y.R. Murthy etc. offer a method of chro-me-containing slimes processing that ptovides selective separation of chrome and magnesium-containing products by dividing slimed up to their particle sizes and their further benefication on concentration tables [9].

One of the prerequisites of the idea of using sulphuric acid to extract magnesium compounds from raw chromite materials is destroying minerals to release chrome dioxide to increase its contents in the compounds for further gravity benefication. The drawback of this technology is significant formation of water-soluble chrome compounds and necessity of boiling down the solution to provide chrystallization with further separation of Magnesium sulphate crystals.

Our scientists have performed several researches on chemical and gravitational beneficiation of Chrome slimes from JSC "Aktobe Ferroalloy Plant" that allows to extract 95,2 wt. % Chrome oxide and 98,3 wt. % Magnesium oxide, obtaining, apart from rich Chrome concentrate, double sulphate salt of Ammonium Magnesium – Tutton's salt ($(NH_4)_2SO_4{\cdot}MgSO_4{\cdot}6H_2O$) (mi-neral fertilizer) and Magnesium silicate – forsterite (high-temperature refractory material) [10, 11].

Table 1 **Chemical analysis of the tailings coarse and fine fractions**

Component	Content / % for coarse actions)	Content / % for fine fractions
Cr_2O_3	10,24	16,72
FeO	7,69	8,32
SiO_2	27,00	23,62
Al_2O_3	3,41	4,06
CaO	0,32	0,36
MgO	35,75	33,03
Ni	0,230	0,197

Table 2 **Technological data**

Products	Yield / %	Cr_2O_3 / %	
		Content	Extraction
Concentrate	27,0	48,00	77,92
Tailings	73,0	5,00	22,08
Initial feeding	100,0	16,56	100,0

MATERIALS AND METHODS

One of the leaders in processing slime tailings of chromite ores benefication are Turkish plants such as Turkmaadin Factory A.S. Kavak Krom Lonstatre Tesisi (Turkey).

The factory has been working since 2009 up to the project of Merta. The new factory works on the stored tailings. Chemical analysis of the tailings coarse and fine fractions is given in Table 1.

The scheme of the chain of devices for large size tailings benefication includes classification screen of stage 1, a mill in a closed cycle with classification screen of stage 2 screen throughs go to six-chamber hydrosizer, working with 4 chambers, then it goes to concentration tables where concentrates, tailings and middlings are obtained; the latter goes back through cone-shaped slimmer and joins with the mill spillway.

The tailings with humidity of 15-20 %, are dehydratized in the slimmer and frame press filter and then transported to the dump. The concentrate is dehydratized in the cone and vibrator.

For 0,045 mm slime tailings benefication the scheme is similar to the one for coarse tailings excluding the mill and classification screens 2 changed for cyclone separators. The following technological data were reached (Table 2).

Below is the example of chrome ore gravity benefication tailings with high data achieved. The tailings are finely milled and have chrome concentration in class minus 0,2 mm, mainly in class minus 0,038 mm. Cr_2O_3 distribution by size class at the benefi-cation factory Turkmaadin A.S. Kavak Krom Lonstatre Tesisi (Turkey, Yeskishekhir) (Table 3).

Technological scheme of tailings beneficiation allows to achieve high technological data on the account of preliminary classification of the initial raw materials into narrow classes in size and separate beneficiation of each class on the concentration table. In other words, for gravity separation up to specific weight to be successful it is better to operate on the material of the same particle size.

Table 3 **Size class distribution of Cr_2O_3 at benefication factory Turkmaadin A.S. Kavak Krom Lonstatre Tesisi (Turkey, Yeskishekhir)**

Particle size / mm	Yield / %	Total yield / %	Cr_2O_3 / %	
			Content	Distribution
-2+1	1,8	100,0	11,51	1,3
-1+0,5	3,1	98,2	9,38	1,8
-0,5+0,3	1,7	95,1	6,65	0,7
-0,3+0,212	2,7	93,3	4,73	0,8
-0,212+0,150	5,1	90,7	4,36	1,3
-0,150+0,106	4,9	85,6	5,00	1,5
-0,106+0,074	5,8	80,7	7,26	2,5
-0,074+0,053	11,6	74,9	15,40	10,8
-0,053+0,038	2,5	63,3	24,88	3,8
-0,038	60,8	60,8	20,60	75,6
Total	100,0		16,57	100,0

Classification can be performed on cyclone separators or on Derik classification screens etc. for fine classes. Especially interesting is a Turkish hydrosizer of Merta Company. It allows separating slime flow into several products according to their size, max. 8, without demanding electric energy or spare parts.

RESULTS AND DISCUSSION

For fine classes benefication two-tier slime concentration tables are suitable, on which, unlike spiral separators used at DMPP separation goes along all the lenghth of the deck and it is possible to get several products by contents (concentrate, middling, tailing).

Within the frame of scientific and research work together with Turkish partners some beneficiation works were performed aimed at producing chromite concentrate from the sample of chrome ore beneficiation tailings from DMPP. For that works have been performed to define physical, chemical and mineralogical properties of tailing samples. Chemical composition of samples from slime tailings dump Dubersay of DMPP is shown in Table 4.

According to mineralogical analysis, the tailings sample mainly consists of serpentine ultrabasic rock, which has lost wholeness as a result of physical splitting under the influence of superficial conditions. Most of it is short-grained sandstone, some part of it is slimy material. In a thin section of the sample the following components were found: fragments of serpentine, antigorite, lizardrite and chrizotil serpentine minerals with minor part of olivine residuals and dolomite- calci-spar -containing carbonat materials and small amount of talcs. Chromites ($FeCr_2O_4$), that are the most widely spread ore mineral in the sample, are presented by aleurite-sandy serpentine minerals in the form of semi-autoamorphous or autoamorphous typically dispersed grainy particles with mostly crystal components. Particle size of chromite minerals are between 0,002 and 0,75 mm, while the main fraction has sizes between 0,01 and 0,50 mm. It was found out, that some chromite samples with smaller sizes can preserve their initial form and are formed in a fragment along their cracks in their own structure.

Thus, the tailing sample being regarded as valuable mineral includes chromite, as no-ore rock includes serpentine and its altered products such as antugorite, lizardrite and chrizotil, with smaller amounts of such carbon-containing minerals as olivine, calci-spar, dolomite and talk minerals. Chromite particle size is between 0,5 and 0,01 mm; Cr_2O_3 content depends on the size of the fraction. To define granulometrical composition size-measuring tests were taken together with tests on Cr_2O_3 content in each size class of the sample. Gramulometric analysis and Cr_2O_3 distribution in each size class are shown in Table 5. According to Table 5 about 99 % of chromite is below 0,2 mm. As a result of benefication on concentration tables preceded by size classification, the yield of Chrome concentrate makes 48 % from the initial material and allows to obtain concentrate containing 51 % of Cr_2O_3 and to achieve 80,63 % extraction. The results of bene-ficiation at the beneficiation plant are shown in Table 6.

Table 4 **Chemical composition of samples from slime tailings dump Dubersay of JSC "Donskoy mining and processing plant"**

Component	Content / %
Cr_2O_3	29,15
Fe_2O_3	10,46
CaO	0,53
MgO	27,19
Al_2O_3	4,59
SiO_2	19,10

Table 5 **Granulometric composition and fractions distribution of Cr_2O_3 in the waste sample**

Particle size / mm	Yield / %	Total yield / %	Cr_2O_3 / %	
			Content	Distribution
+2	1,1	100,0	7,23	0,3
-2+0.5	0,4	98,9	9,42	0,1
-0.5+0.212	1,0	98,5	7,70	0,3
-0.212+0.106	12,2	97,4	16,39	6,6
-0.106+0.074	10,1	85,2	27,58	9,2
-0.074+0.053	13,6	75,1	34,84	15,6
-0.053+0.038	7,5	61,6	39,46	9,8
-0.038	54,0	54,0	32,46	58,1
Total	100,0		30,21	100,0

Table 6 **Results of slime beneficiation at DMPP**

Products	Yield / %	Cr_2O_3 / %	
		Contents	Extraction
Concentrate	48,0	51,00	80,63
Tailings	52,0	11,20	19,37
Initial sample	100,0	30,21	100,0

Comparative analysis of tailings granulometrical composition from the benefication factory Turkmaadin A.S. Kavak Krom Lonstatre Tesisi (Turkey, Yeskishehir,) and benefication tailings from DMPP demonstrates that generally speaking it is possible to use the Turkish technology at DMPP with some correction as to the scheme of disintegration and middlings recycling. The tests performed show that applying Turkish technology of slime separation by size class and further beneficiation of each class on concentration tables allows to achieve 14 % increase in Cr_2O_3 extraction, and to decrease its content in tailings several times compared to the beneficiation technology used at DMPP. As for environmental benefits, processing of stale slime tailings allows to twice decrease the areas of tailing dumps and, as a result, to decrease the amount of dusty areas.

CONCLUSION

Modern technologies of fine chrome ore materials have been reviewed in order to choose the most efficient technological solutions. The best technical and economic data in this area are demonstrated by chrome ores process-

ing plants of the Turkish Republic. The authors have performed research of Dubersay tailing dump chrome slimes beneficiation up to particle size on concentration tables. Applying this technology for slime beneficiation allows to increase the yield of rich fine chrome concentrates by 14 % compared to existing beneficiation scheme. The suggested technology of fine classes chrome raw materials beneficiation allows to diminish harm to environment by decreasing the area of the tailing dump twice, and, as a result, to decrease dusting areas.

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