

## Conference Paper

# Technological Schemes for Preparation and Deep Beneficiation of Technogenic Waste Containing Fine Slimes Environmental Component

**K. V. Bulatov. and G. I. Gazaleeva**

OJSC «Uralmekhanobr», 87, Khokhriakov Street, Ekaterinburg 620144, Russia

### Abstract

This article evaluates a new procedure for choosing special methods of disintegration for technogenic rock materials with fines and slimes. The article describe different examples of beneficiation technology for chromium-containing slime tails of the Donskoy beneficiation plant (Republic of Kazakhstan), hematite tails of Magnitogorskiy Metallurgical Plant, and tin waste with fines particles.

**Keywords:** fine slimes, environmental component, technological schemes, Preparation technogenic waste

Corresponding Author:

G. I. Gazaleeva  
 gazaleeva\_gi@umbr.ru

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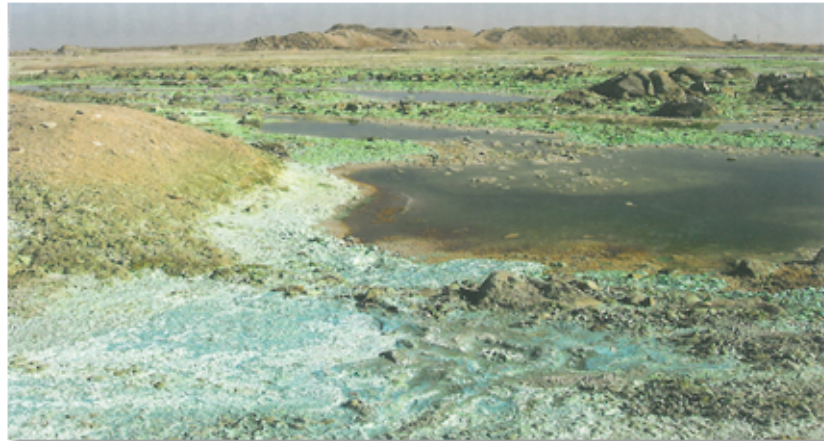
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Recently, great attention has been paid to the environmental safety of mineral processing and the efficient processing of technogenic deposits in Russia. Technogenic raw materials are mineral deposits, the accumulation of which took place as a result of industrial enterprises activities in the last century. Modern technologies and equipment make it possible to partially or fully recover useful metals and (or) minerals from technogenic raw materials. Features of technogenic raw materials are various environmental hazard; occurrence on the surface; the presence of modified minerals and compounds; small particle size.

The environmental and economic efficiency of processing technogenic raw materials depends on the completeness and complexity of its use. The complexity of the use of technogenic raw materials is not only in the recovery of useful components (metals and minerals), which make up a small fraction of its composition, but in the use of these wastes as construction materials or other consumer goods as well. These are the tasks for researchers, manufacturers and investors when the situation of developing a technogenic deposit takes place. When choosing a technology for processing technogenic raw materials, the environmental issue is of high priority. According to Professors Chanturia V.A. and Shadrnova I.V. [1] at industrial enterprises of the Russian Federation, 7 billion tons of industrial waste are generated annually (Figure 1).

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**Figure 1:** General view of the tails of the Balkhash Beneficiation Plant (BP)

The criteria for the environmental safety of technologies are an important aspect in choosing a technology for waste beneficiation in general and slime tails from beneficiation plants in particular. We can distinguish the following environmental safety criteria for the processing of slime tails of beneficiation plants. They are maximum tails processing to produce finished products and minimize waste; maintaining or reduction of the hazard class of the resulting waste during processing; the complexity of using tails; the choice of the optimal technologies for economic advantages and environmental safety; the use of a full water turnover in the technology. An important moment in the technologies development for the deep beneficiation of technogenic raw materials is the assessment of their composition and properties by modern analytical methods [2]. First of all, this is the study of the particle size distribution, chemical and phase composition of technogenic raw materials. For their researches, Uralmekhanobr OJSC uses Helos-KR diffraction laser particle size analyzer (Sympatec, Germany), which has a particle size range from 0.5 to 2000 microns. According to the granulometric analysis of the samples, the number of fractions less than 50 microns and 5 microns is determined, which, at present, is considered to be a characteristic of the slime degree of technogenic wastes, including tails of beneficiation plants.

The granulometric characteristics of the slime tails of the beneficiation plants depend on the ore preparation technology used in the plant designs and on the natural properties and slime tendency of useful minerals. The granulometric composition of the slime tails does not provide sufficient information about the distribution of elements. Therefore, in each size class, the content of the target element and the presence of free grains of useful minerals and their splices with other minerals are determined. Table 1 presents the result of such an assessment for chromite tails CPP-1 (the crushing and

processing plant 1) of the Donskoy beneficiation plant (Kazchrome company, Republic of Kazakhstan) [3].

TABLE 1: Granulometric composition of slime tails of CPP-1

Size class, mm	Fraction, %	Content of Cr <sub>2</sub> O <sub>3</sub> , %
+5,0	1,0	4,67
-5,0+3,0	0,6	2,79
-3,0+2,0	1,3	3,61
-2,0+1,0	3,9	6,32
-1,0+0,5	6,6	5,98
-0,50+0,20	15,6	9,45
-0,200+0,071	15,0	25,47
-0,071+0,040	17,8	40,40
-0,040+0,026	8,8	37,90
-0,026	29,4	29,61
Total	100,0	25,28

An analysis of the data presented shows that there are particle size classes with a high Cr<sub>2</sub>O<sub>3</sub> content, which should be distinguished for subsequent beneficiation. Therefore, in the size class less than 0.20 µm, the Cr<sub>2</sub>O<sub>3</sub> content ranges from 9.59 to 30.02%, with an average content of 25% in the initial tails. Some tails with a particle size of more than 0.20 µm are not significant for the Cr<sub>2</sub>O<sub>3</sub> recovery.

Based on similar studies, Uralmekhanobr OJSC has developed and implemented technologies for the deep beneficiation of slime tails from beneficiation plants. The presented options correspond to environmentally friendly technologies according to one or more criteria.

**Ore dressing tails at Donskoy BP.** In laboratory and semi-industrial conditions, 5 variants of schemes for processing chromium-containing slime tails of CPP-1 of the Donskoy beneficiation plant (Republic of Kazakhstan) have been developed. As a result of researches, 2 technological schemes were selected for technical and economic comparison: gravity-flotation and gravitational [4].

The initial operations of both compared schemes are the same: washing class + 2.0 mm in a washing drum; screening in the class of - 0.2 mm; class allocation + 0.2 mm in the tails; double classification of a class of less than 0.2 mm in hydrocyclones with the release of a discharge of the second classification into tails; screw separation of hydrocyclone sands with the release of high-quality chrome concentrate (Cr<sub>2</sub>O<sub>3</sub> content of more than 50%) and light fraction, sent to fine screening in the class of 0.16 mm. Further, the operations of the compared schemes are different. The gravity-flotation scheme includes the main, control flotation and two cleaning flotations, after which the flotation concentrate is cleaned on the concentration table with the release of

the final concentrate and tailings. The following technological indicators were obtained according to the flotation scheme: 38.95% concentrate yield, 49.20% Cr<sub>2</sub>O<sub>3</sub> content, 75.80% recovery; 61.05% tailings yield, 10.0% Cr<sub>2</sub>O<sub>3</sub> content.

Next, a more detailed comparative technical and economic calculation of the considered technology options was carried out. The technical and economic indicators of the compared options have high values, but the gravity-flotation scheme has an advantage in terms of profits and the payback period. From the point of view of a massive reduction in the volume of slime tails and finished products, both options can reduce the number of tails by 37-39%. From the point of maintaining or reducing the hazard class of waste, the gravitational scheme has advantages over the gravity-flotation one. The latter does not change the hazard class of waste, while the former, due to the use of acids and other hazardous substances in the flotation process, increases the hazard class of secondary waste. In the considered options, a complete water turnover is assumed. However, water mixed with harmful reagents requires significant costs for cleaning and clarification. Based on this, when choosing the final version of the technology for processing slime tails, the enterprise (JSC Donskoy GOK) adopted a more environmentally friendly version of gravity beneficiation. Currently, the factory is being built according to the proposed technology.

**Hematite Beneficiation Tails of Magnitogorskiy Metallurgical Plant (MMP).** According to the chemical composition, the initial slimes contain 29.5% total iron, 1.31% sulfur, and 0.068% phosphorus. The results of the phase analysis of the initial slimes of metallurgical plant are presented in table 2.

TABLE 2: The Phase Composition of the Initial Slime

Forms of iron display:	Content, %	
	absolute	relative
Common iron	29,5	100,0
Iron related with:		
magnetite	5,51	18,68
martit	5,72	19,39
hematite	4,97	16,85
metal	0,38	1,29
carbonates	0,38	1,29
pyrrhotite	<0,01	–
silicates	6,74	22,84
getite hydroxides	5,80	19,66

The potential recovery of iron is 54.92%, including 18.68% from magnetite-related, 19.39% from martite-related; 16.85% from hematite-related.

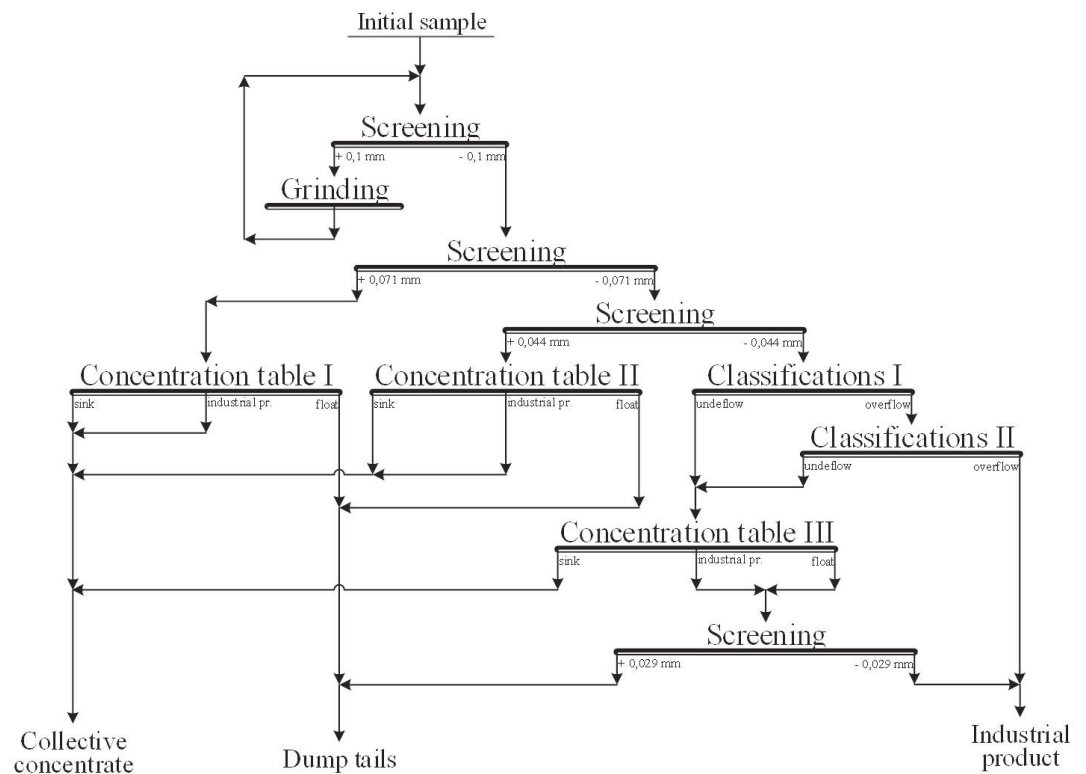
The tails storage features of a metallurgical plant are the storage duration of the initial slime tails [5]. In this regard, they contain frozen particles for wintertime, clay and various organic residues. Disintegration of the initial slimes is required for the destruction of frozen and compressed aggregates of iron ore to obtain a natural particle size of less than 2.0 mm. The disintegration process is carried out in a screw crusher with a wet scrubber. Sand washing and sludge removal are carried out in a spiral classifier. Wet magnetic separation is performed on the original tails of natural size (-2.0 + 0.0 mm) with a 1500 E magnetic field of the separator. This mode provides the transfer to the magnetic product of minerals: magnetite, magnetite - hematite and magnetite - goethite aggregates. During the research, the iron content in magnetite concentrate varied from 61.5 to 62.6%. The results of wet magnetic beneficiation are presented in table 3. The average iron content in magnetite concentrate is 61.8%, the concentrate yield is 20.0%, and the iron recovery in the concentrate is 42.92%.

TABLE 3: The Results of Magnetic (1500 E) Beneficiation of MMP Slime

Beneficiation products	Yield, %	Iron content, %	Iron recovery, %
Concentrate (magnetite)	20,00	61,80	42,92
Tails	76,00	20,85	55,01
Slimefree initial product	96,00	29,38	97,93

Subsequent experiments were performed in order to obtain a conditioned iron concentrate from hematite. The considered options are high-gradient wet magnetic separation and a combination of high-gradient wet magnetic separation with gravity operations on screws. In the first option, the results are not satisfactory. However, the high-gradient wet magnetic separation mode was selected for subsequent beneficiation on screws. Ultimately, iron concentrate was obtained from iron-containing slime tails of MMK with a yield of 25.5%, total iron content of 59%, and recovery of 52.24%. According to the project of Uralelectromedb OJSC, a slime beneficiation section was built, which is in the state of launch. From the point of view of environmental safety, the technology meets the main criteria: it allows to reduce the volume of slime tails by 25% to obtain finished products; it does not increase the hazard class of the tails; it involves a complete closed cycle of using recycled water; it considers the variability of the approach in the development of the technological scheme. As for disadvantages, it should be pointed out that there is not any integrated use of raw materials and incomplete use of the entire volume of waste.

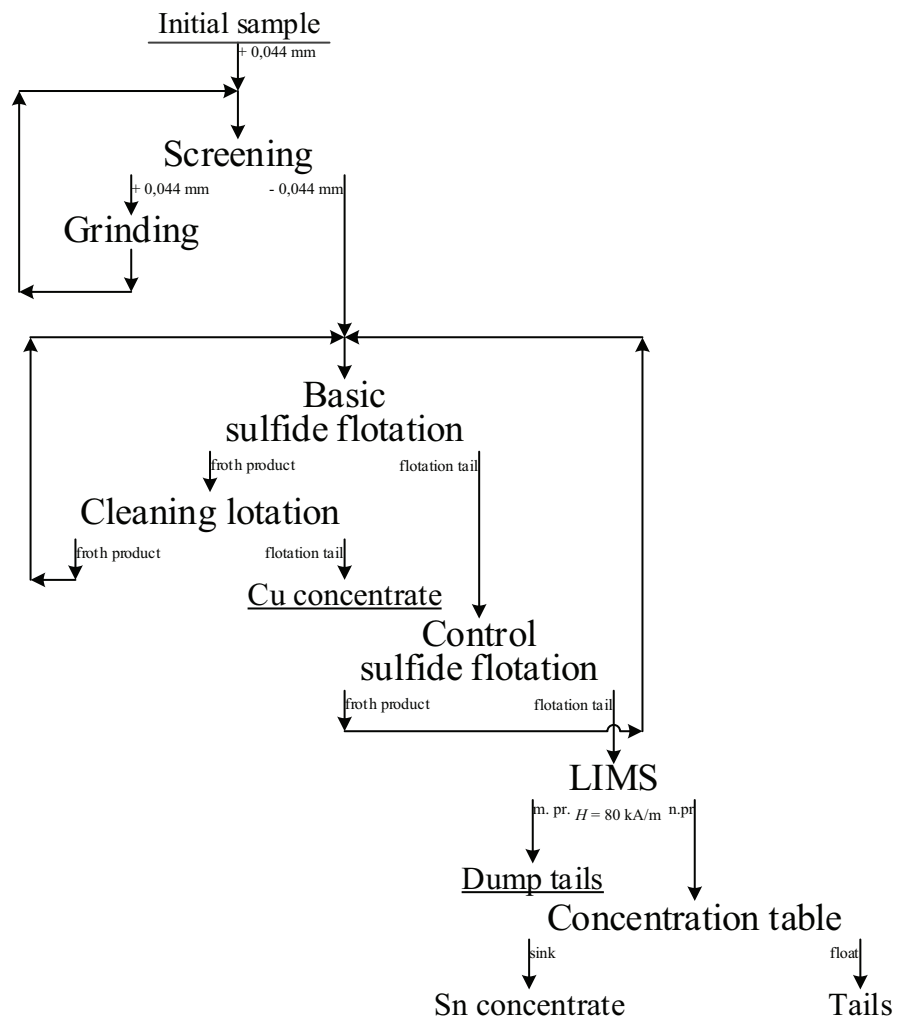
The beneficiation tails the Solnechny BP are a typical complex object with a high content of slimes, including useful minerals. The development of this technology is an example of the deep beneficiation of fine slimes. Beneficiation schemes for tin ores



**Figure 2:** Scheme for the Production of Collective Concentrates from Tin-containing Slime Tails of the Solnechny BP - hf – heavy fraction; lf – light fraction; ip – industrial product.

represent complex technological objects. The recovery of tin from them rarely exceeds 55%. In the case of multicomponent ores with the presence of tungsten, arsenic, and sulfide minerals, the beneficiation schemes have an even more complex configuration. The total tin content in the initial tails is 0.33 - 0.47%, copper content is 0.37 - 0.46%. Figures 2 and 3 show the technological schemes [6, 7] for the beneficiation of tin-containing slime tails of the Solnechny beneficiation plant: a collective scheme for producing rough concentrates (Figure 2) and a scheme for cleaning grain collective concentrate (Figure 3).

The results of an experimental verification of the developed scheme showed the following: copper concentrate (1.29% yield) contains 18.28% copper, its recovery is 60.48%. The arsenic content in the concentrate is 1.98 - 2.04%. Tin concentrate (1.3% yield) contains 11.35% tin, its recovery of 50.88%. From a more detailed technical and economic calculation of the proposed technology for the processing of tin-containing slime tails from the Solnechny BP, it follows that it is cost-effective, and the simple payback period is 7 years. The customer has begun to implement the project. As for the environmental criteria for the beneficiation of slime tails, it follows that the scheme has less efficiency in comparison with others. Only 2.6% of the mass of dump tails goes



**Figure 3:** Scheme for the Production of Copper and Tin Concentrates from Grain Collective Concentrates  
 hf – heavy fraction; lf – light fraction; ip – industrial product.

into finished products, the rest is returned to the tail storage. The hazard class of the tails is increased due to the use of Chinese flotation reagents in the technology.

The environmental advantages of the scheme include the use complexity of raw materials and the use of full water turnover. Additional studies on the possibility of using collective tails as construction materials have shown the possibility of a significant increase in the environmental efficiency of the technology with utilization of up to 47% of the dump tails mass.

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