

Study of technological parameters of ion exchange resins and technology of recultivation of off-balance uranium-containing dumps

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Abstract. The article presents the technology of uranium extraction, the results of uranium extraction from recultivative dumps, physicochemical and technological properties of applied resins, as well as the state of radiation and ecological situation in the area of uranium ore mining enterprise location around the town of Uchkuduk (Uzbekistan). Nowadays, worldwide scientific research is being conducted on the return of technogenic waste to the main processing, application of high-quality sorbents based on chloride ions in the process of obtaining the finished product, uranium recovery in the process of sorption, improvement of the main indicators of uranium production and processing of technogenic dumps by means of their return. In this regard, it is necessary to develop physicochemical and technological fundamentals of technogenic waste processing, recultivation of sites, study the properties of anionites sorbing uranium in the process of uranium waste processing with highly concentrated solutions of chloride ions, pay special attention to scientific research on uranium extraction under conditions of seasonal low temperatures in the process of sorption.

1 Introduction

One of the methods of uranium mining in the world is in-situ leaching (ISL), which makes it possible to reduce capital expenditures by 4 times in uranium production, reduce the time of preparation of quarries for mining, increase labor productivity several times, optimize workplaces and reduce the cost of the product. Today, the remaining reserves of ore deposits with high content of non-ferrous metals are practically depleted, hard-to-reach, difficult to process ores are involved in the development, and as a result of the implementation of resource- and energy-saving technologies, the use of technogenic waste, which contains a valuable component, is becoming important [1-3].

The theory of recultivation of off-balance uranium-containing dumps with the use of selective ion-exchange resins is proved by the coincidence of the results of theoretical and experimental studies, a significant amount of laboratory and industrial experiments,

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satisfactory convergence and quantitative confirmation of the main idea of the work on the processing of uranium dumps, significant positive results when using technological requirements of uranium sorption processes, as well as positive acts of laboratory and industrial tests [4-6].

The following criteria were used to evaluate the efficiency of anionites: I - particle size distribution; II - mechanical strength; III - specific surface area; IV - specific volume of ionites; V - selectivity of resins; VI - degree of regeneration.

To determine the place of anionite according to the total quality indicators the method was used, according to which the points are summarized by the places occupied and subtracted from the possible value (100%). The results of the research are given in Table 1.

The initial state of ion exchange material granules plays a major role in cryodestruction processes. Apparently, the stresses arising from free water freezing and thawing are not dangerous for ion exchange particles without physical defects.

2 Materials and methods

However, this assumption is valid only up to certain limits. Indeed, as shown in Table 2, the mechanical strength and particle size distribution of anionites VO-020, A-606 and AMP, having no visible defects (I) in the microscope field, having single defects (II) and having multiple defects (III) after freezing to -18.2°C , exposure for a day and subsequent thawing at $+20^{\circ}\text{C}$ for 24 hours, are significantly different.

Table 1. Research results, a range of ionite quality.

№	Name of ionite	Place in the range of criteria I-VI						Sum of items	A place in row
		I	II	III	IV	V	VI		
1	VO-020	1	2	1	5	1	4	14	1
2	AMP	2	1	2	2	4	6	17	2
3	BD-706	3	4	8	6	3	1	25	3
4	Resinacs	4	7	4	1	2	7	25	4
5	Amberlite IRA-120	6	6	6	3	6	2	29	5
6	Tulsion	7	5	5	4	5	5	31	6
7	Purolite A-606	5	3	7	7	7	3	32	7
8	Dowex 1	6	8	3	8	8	8	41	8

Table 2. Change of some properties of ionites after freezing.

Name of ionite	Sample	Mechanical strength, %		Average diameter pellets, mm	
		before	after	before	after
A-606	I	99.5	84	0.85	0.75
	II	97.5	81		0.65
	III	92	77		0.6
	IV	97.5	83		0.7
AMP	I	99.5	81.5	0.85	0.65
	II	98	76.5		0.55
	III	90.5	73		0.45
	IV	98	78		0.6
VO-020	I	100	86.5	0.95	0.85
	II	99	83.5		0.75
	III	98	81		0.7
	IV	99.5	85		0.8

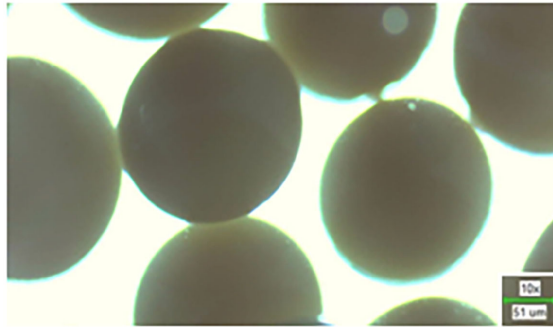


Fig. 1. State of anionite grains VO-020 under normal conditions.

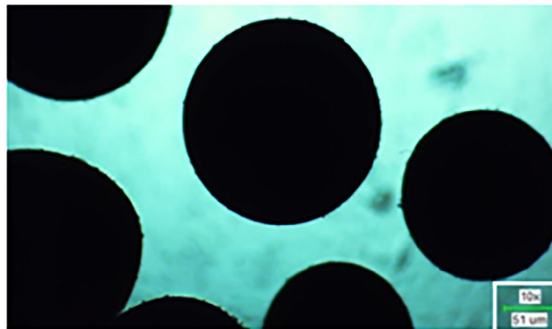


Fig. 2. State of anionite grains VO-020 with freezing (at -18.2°C).

The ion exchange resins were also photographed before freezing and after freezing to -18.2°C. The condition of ion-exchange resin VO-020 was studied on a binocular digital microscope with a built-in video camera.

The results of the studies are presented in Figure 1 and 2.

Observations were carried out, which allowed us to distinguish three granulometric fractions that differ sharply in grain stability: fractions of some domestic and foreign ionites less than 0.3 mm are the most stable and in the process of freezing consist only of whole grains; fraction 0.3-0.8 mm, containing, in addition to whole grains, split and cracked grains; fraction larger than 0.8 mm is the least strong and entirely composed of cracked granules. With increasing diameter of granules, internal stresses increase, leading to the destruction of grains.

3 Results and discussion

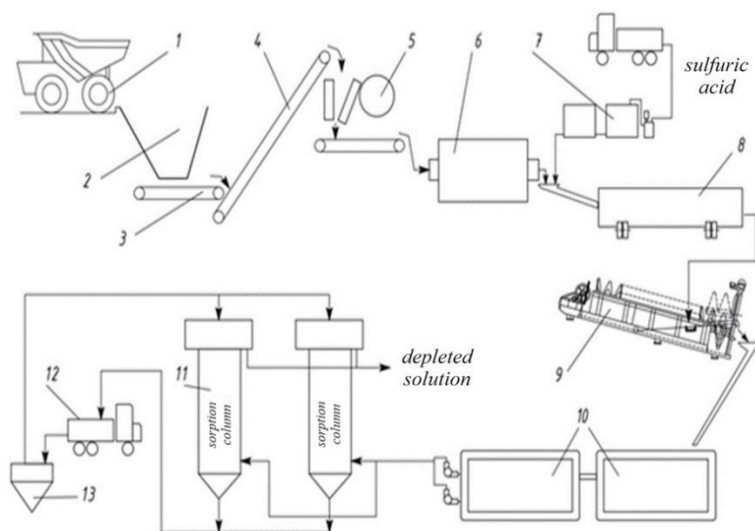
The obtained research results allowed us to draw an important practical conclusion: to keep mechanical strength of anionites it is necessary to remove water as much as possible during their transportation and storage at low temperatures (in winter).

A comprehensive assessment of the radioecological situation in the area where uranium production dumps are located (around the town Uchkuduk) was carried out. On the basis of experimental studies, the areas and components of natural ecosystems with increased content of natural radionuclides (NRN) were identified. The assessment of radiation doses and radiation exposure indices for environmental objects and population in the territory adjacent to the uranium mining enterprise was performed [7-10].

As a result of reclamation of dumps using the developed technology, the uranium content in the solid phase is reduced from 200-400 to 5-20 g/t; the average value of gamma activity is reduced to 0.46 $\mu\text{S/h}$, and the average value of total alpha activity is reduced to 15.0 kBq/kg. NMMC specialists have developed and implemented a technological scheme for recultivation of mining radioactive dumps with associated sorption recovery of uranium. The uranium dumps are processed according to the apparatus chain scheme shown in Figure 3.

Ore can be delivered to the receiving hopper of the processing complex by dump trucks, loaders, tractors with overhead equipment.

Initial ore of 350 mm in size is sent to the receiving hopper, then by belt feeder (25 t/h) ore is transported to the stage of crushing in the jaw crusher SMD-110. Ore crushed to -100 mm class falls on the belt conveyor, which is equipped with electronic scales to control the volume of ore processing, and then goes to the mill MShR 21x22.



- 1 - dump truck; 2 - receiving hopper; 3 - belt feeder; 4 - belt conveyor; 5 - jaw crusher SMD-110; 6 - mill MShR 21x22; 7 - acid tank; 8 - scrubber-bottom; 9 - spiral classifier type 1KSP-1,5; 10 - clarified cards; 11 - sorption pressure column SNK-1900; 12 - tar truck; 13 - tar hopper.

Fig. 3. Scheme of the apparatus chain of the recultivation site uranium-containing dumps.

An increase in the coarseness and strength of the initial ore leads to overloading of the mill and reduction of its productivity. When ore size decreases, the mill productivity increases both for the initial feed and the finished grade, which leads to a decrease in specific ball and power consumption.

Increasing the pulp density in the mill discharge above the recommended density leads to an increase in pulp viscosity and impedes its discharge. Reducing the pulp density leads to an increase in the velocity of its movement and, accordingly, to a decrease in the time of ore stay in the mill and a decrease in the degree of grinding.

The optimum degree of filling of the mill with ore and grinding balls is 35-40%. Increasing the degree of filling leads to overloading of the mill, decreasing - to underloading, which leads to a decrease in productivity. The slit size of the discharge grate is -18 ± 2 mm.

Mixing of ore and working solution is performed by rotation of the scrubber-drum from an electric motor.

Crushed ore in the form of pulp enters the scrubber by gravity through the pipe collector, where process water, sulfuric acid and "Beshbulak" water are supplied. The volume of

process water is up to 30 m³/h, sulfuric acid flow rate up to sulfuric acid concentration - 10-15 g/l.

Then the mixed product through the scrubber spigot goes to the classifier of 1KSP-1.5 type, from where it flows by gravity through the drainage flume to the settling tank No.1 for further leaching and clarification. Then the productive solution is transported by pumps to the lower part of the sorption pressure column SNK-1900. Figure 4 shows the sorption pressure column at the uranium-containing waste processing site.

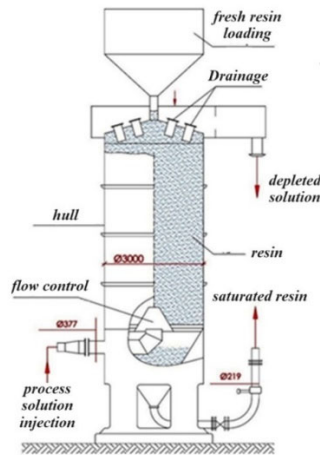


Fig. 4. Sorption pressure column.

4 Conclusion

Thus, a new technological scheme and circuit scheme of apparatuses for recultivation of off-balance uranium-containing dumps with application of sorption technology for uranium extraction, which was implemented in industrial conditions in Navoi Mining and Metallurgical Combine, was developed. The effects of subzero temperatures in the cold season and controlling the concentration of Cl⁻ during sorption process were taken into account (consideration). As studies of various resins have shown the most resistant to sharp temperature changes in winter time were resins of mark VO-020, which even after cooling to -18.2°C and the subsequent gradual heating retained mechanical strength of 82-87%, and the average diameter decreased by an average of only 19%. studies of changes in the properties of resins allowed us to draw an important practical conclusion: to preserve the mechanical strength of anionites it is necessary to maximize the removal of water during their transportation and storage at low temperatures (in winter). The results of the conducted research work are included in the technological regulations of the operating site.

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