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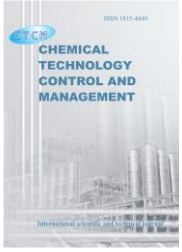

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RESEARCH OF A NEW TECHNOLOGICAL FLOWSHEET PARAMETERS FOR URANIUM MINING FROM TECHNOGENIC URANIUM ORES

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Abstract: *This paper presents the results of a study of the parameters of a new technological scheme for the extraction of uranium from technogenic uranium ores. The results of the analytical determination of the concentration of parent - ^{238}U and daughter radionuclides - ^{234}U , ^{230}Th , ^{226}Ra , ^{222}Rn , ^{218}Pa , ^{214}Pb , etc. are presented . in the studied technogenic uranium ores. The principal scheme of the new uranium extraction technology from technogenic uranium ores is presented. The use of the classifier in a new scheme for separating granules of technogenic uranium ores is justified. Based on the conducted research of the parameters of the new technological scheme for uranium extraction from technogenic uranium ores, a reduction in uranium concentration and specific effective activity (Aeff) in technogenic uranium ores by up to 30% has been achieved, along with an additional uranium extraction of up to 70%. It is shown that, based on the research carried out and the results obtained, it is possible to solve a complex social issue associated with the harmful effects of ionizing radiation on personnel working in uranium production and on the environment. The results of the reclamation of secondary uranium-containing ores are provided. The effective aspects of the proposed new technological scheme for the extraction of uranium from technogenic uranium ores are shown.*

Keywords: *Technological scheme, uranium mining methods, technogenic uranium ore, classifier, granule separation, uranium concentration, specific effective activity - A_{eff}, additional uranium mining, social issue, reclamation of secondary uranium-containing ores.*

Annotatsiya: *Ushbu maqolada texnogen uran rudalaridan uran ajratib olishning yangi texnologik sxemasi parametrlarini o'rganish natijalari keltirilgan. O'rganilayotgan texnogen uran rudalarida mavjud bo'lgan, asosiy radionuklidlar - ^{238}U, qo'shimcha radionuklidlar - ^{234}U, ^{230}Th, ^{226}Ra, ^{222}Rn, ^{218}Pa, ^{214}Pb va boshqa elementlar kontsentratsiyasini analitik aniqlash natijalari keltirilgan. Texnogen uran rudalaridan uran olish yangi texnologiyasining prinsipial sxemasi keltirilgan. Yangi sxemada texnogen uran rudalarining granulalarini ajratishda klasifikatordan foydalanilganligi asoslangan. Uranni ajratib olishning yangi texnologik sxemasining parametrlarini o'rganish natijasida texnogen uran rudalaridagi uran konsentratsiyasi va solishtirma effektiv faollikni (A_{eff})30% gacha kamaytirish hamda qo'shimcha ravishda 70% gacha uran ajratib olishga erishilganligi aniqlangan. O'tkazilgan tadqiqotlar va olingan natijalar asosida ionlashtiruvchi nurlanishning uran ishlab chiqarishda ishlaydigan xodimlarga va atrof-muhitga zararli ta'siri bilan bog'liq murakkab ijtimoiy masalani hal qilish mumkinligi ko'rsatilgan. Ikkilamchi uranli rudalarni tiklash bo'yicha natijalar keltirilgan. Texnogen uran rudalaridan taklif etilgan uran olishning yangi texnologik sxemaning afzalliklari ko'rsatilgan.*

Tayanch so'zlar: *Texnologik sxema, uranni qazib olish usullari, texnogen uran rudasi, klassifikator, granulalarga ajratish, uran kontsentratsiyasi, solishtirma effektiv faollikni - A_{eff}, qo'shimcha uran qazib olish, ijtimoiy masala, ikkilamchi uran rudalarni tiklash.*

Аннотация *В работе приведены результаты исследования параметров новой технологической схемы добычи урана из техногенных урановых руд. Приведены итого аналитического определения концентрации материнского - ^{238}U и дочерних радионуклидов - ^{234}U, ^{230}Th, ^{226}Ra, ^{222}Rn, ^{218}Pa, ^{214}Pb и т.д. в исследуемых техногенных урановых рудах. Приведена принципиальная схема новой технологии добычи урана из техногенных урановых руд. Обосновано применение классификатора в новой схеме для разделения гранул техногенных урановых руд. На оснований исследования параметров новой технологической схемы добычи урана из техногенных урановых руд достигнуто уменьшение концентрации урана и удельной эффективной активности - $A_{эфф}$ в техногенных урановых* *рудах до 30% и дополнительного добычи урана до 70%. Показано, что на основание проведенных исследований и полученных результатов можно решить сложный социальный вопрос, связанный с вредным воздействием ионизирующего излучения на персонал работающих на урановом производстве и на окружающую среду. Приведены результаты рекультивации вторичных урансодержащих руд. Показаны эффективные стороны предложенной новой технологической схемы добычи урана из техногенных урановых руд.*

Ключевые слова: *Технологическая схема, методы добычи урана, техногенная урановая руда, классификатор, разделение гранул, концентрация урана, удельная эффективная активность - $A_{эфф}$, дополнительной добычи урана, социальный вопрос, рекультивация вторичных урансодержащих руд.*

Introduction

Any technological process ends with the formation of secondary waste [1-10]. In the same way, the technological process of uranium production is associated with the formation of secondary waste [11-18]. This waste is a low-grade technogenic uranium waste and contains small quantities of uranium [19-25].

The Republic of Uzbekistan is among the top ten countries in the world that are considered world leaders in uranium production. In its half-century history of uranium production, the Navoi Mining and Metallurgical Combine - NMMC (now the state-owned enterprise Navoiuran) has been and is engaged in uranium mining [26-30]. From the late 60s of the last century until the beginning of the 21st century, all uranium mined at NMMC was produced by underground mining. In these processes, many million tons of uranium-containing secondary technogenic waste was generated at the industrial sites of the NMMC. The technogenic waste found in dumps, tailings, and temporary storage locations are considered promising secondary technogenic ores. The technogenic secondary uranium ores formed in the processes of uranium extraction through geotechnological and mining methods contain a low amount of uranium, up to 250 g/t, compared to the uranium content in technological ores, which should be at least 300 g/t [31-38].

Application of the classical method of uranium extraction technology from these technogenic secondary uranium ores is not effective. Since the classical method of uranium mining technology is multi-stage and very expensive. In addition, from the point of view of economic considerations, the classical method of uranium mining technology requires the processing of ore with a uranium content of at least 300 g/t.

As indicated by the regulations of the uranium extraction technology from ores with a uranium content of at least 300 g/t, the process does not even cover the cost of the final product obtained [39-48].

To develop an effective technological scheme for the extraction of uranium from technogenic uranium ores, it is required to analytically determine the concentration of the parent - ^{238}U and each daughter radionuclide a - ^{234}U , ^{230}Th , ^{226}Ra , ^{222}Rn , ^{218}Pa , ^{214}Pb and additionally, research is needed to determine the parameters of this new technological scheme. The novelty of this article lies in the first-time exploration of the parameters of a new technological scheme for uranium extraction from technogenic uranium ores and the development of methods for the analytical determination of the concentration of the parent isotope - ^{238}U, and the daughter radionuclides - ^{234}U, ^{230}Th, ^{226}Ra, ^{222}Rn, ^{218}Pa, ^{214}Pb in them

Techniques and Experimental Methods.

As known, technogenic uranium ores are secondary deposits and are radioactively hazardous objects. These technogenic uranium ores contain all the daughter radionuclides - ^{234}U , ^{230}Th , ^{226}Ra , ^{222}Rn , ^{218}Pa , ^{214}Pb , etc., formed from the parent - ^{238}U , in the process of radioactive decay .

The concentrations of these radionuclides were determined by the X-ray fluorescence method using X- ray spectrometers - type ARF-7 and EDX -7000, by the radiometric method using the Gamma-progress device, and by the alpha spectrometric method using the CANBERRA device.

The presence of these radionuclides in technogenic uranium ores determines its degree of radioactive contamination. Extracting uranium from these ores provides the opportunity to obtain uranium while simultaneously purifying it from radionuclides to meet the established norms in international and national regulatory documents

For the extraction of uranium from technogenic uranium ores, a new technological scheme has been developed, shown in Fig. 1.

As seen in Fig. 1, the schematic technological diagram for uranium extraction from technogenic uranium ores consists of the following operational units and components: 1 - bunker for collecting technogenic uranium ores; 2 - classifier; 3 - conveyor belt for removing empty gangue after separation; 4 - collector for fine fraction; 5 - agitator for mixing the solid phase with the working solution; 6 - fabric filter for separating the solid part from the liquid uranium-containing solution; 6' - fabric filter with the solid part; 7 - purified solid part; 8 - tank for collecting unsaturated uranium-containing solution; 9 - tank for collecting saturated uranium-containing solution; 10 - water tank; 11 - acid tank; 12 - pump for transferring liquid working fluids.

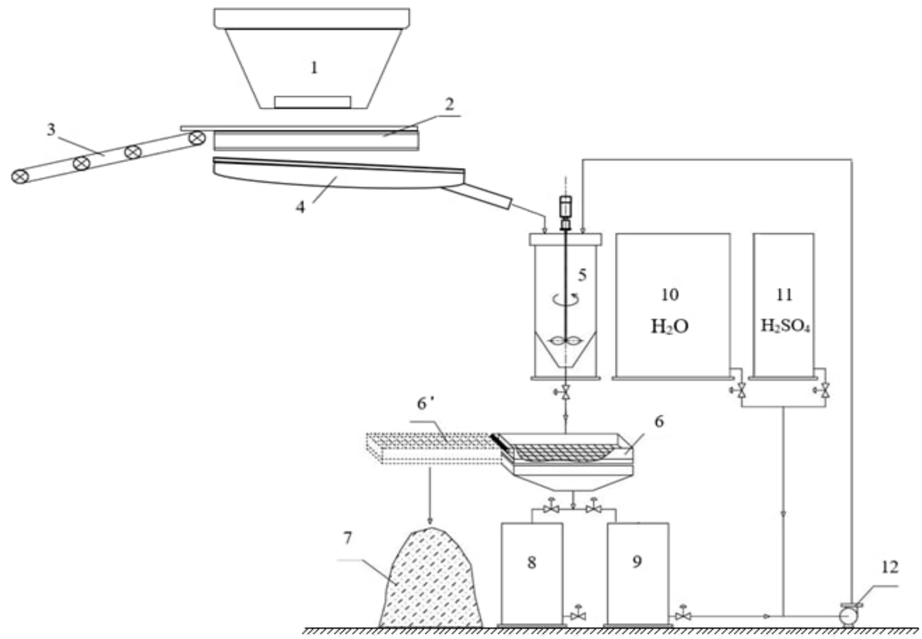

Fig. 1. ***Principal technological scheme of uranium extraction from technogenic uranium ores.***

The operating principle of this technological scheme shown in Fig. 1 occurs in the following sequence: technogenic uranium ores containing the following radionuclides - ^{238}U, ^{234}U, ^{235}U, ^{232}Th, ^{226}Ra, etc. uranium decay chains are loaded into a bunker (1), using a classifier (2) large classes are separated from small ones; using a conveyor belt (3) large classes with low uranium content are removed; small class ore with high uranium content is collected into the collector tank (4); a small class of uranium-containing ore is sent to the pack (5) for mixing with the working solution; from a container (10) of water and from a container (11) of acid, prepare a working solution with a concentration of 10 g/l of acid - H_2SO_4 and fill the pack (5) in the ratio T:L (1: 3); after 0.5 hours of mixing the solid part with the working solution, the resulting uranium-containing pulp is sent to a fabric filter (6) to separate the solid part from the liquid; the solid part of the uranium-containing ore is collected on a fabric filter (6') and placed in a dump (7); the liquid part of the pulp is collected in a container (8) to collect the unsaturated uranium-containing solution; after reusing this unsaturated uranium-containing solution three times, a saturated uranium-containing solution is obtained and this solution is collected in a container (9); a pump (12) is used to pump liquid working fluids and waters.

Uranium is extracted from all other batches of technogenic uranium ores using the above-mentioned sequence. After three cycles of reusing the unsaturated uranium-containing solution, this solution becomes saturated and is sent to tank (9) for further processing in the productive solution processing area (PSPA).

To study the suitability of this technological scheme for real samples, samples were taken from secondary technogenic uranium ores. Based on the above technological scheme, 18 samples of technogenic uranium ores were processed. The results obtained for determining the concentration of uranium and specific effective activity - A_{eff} in the initial samples and in samples after processing, using this technological scheme, are given in table. 1.

From the results presented in Table 1, it is evident that the uranium concentration and specific effective activity (A_{eff}) in the 18 initial samples varied within a certain range. Specifically, the uranium concentration changed on average from 129.7 g/t to 243.5 g/t, and the values of specific effective activity - A_{eff} varied within the range of 38.8 Bq/kg to 56.2 Bq/kg. The uranium concentration in samples after processing technogenic uranium ores changed on average from 43.2 g/t to 69.6 g/t, and the values of specific effective activity - A_{eff} in them changed on average from 12.4 Bq/kg to 18.6 Bq/kg. The background value of specific effective activity - A_{eff} for this region is 1.2 Bq/kg. The Clarke content of uranium in soils is 80 g/t. From the obtained results, it is evident that in samples after processing technogenic uranium ores, the uranium concentration ranging from 43.2 g/t to 69.6 g/t is significantly lower than the Clarke content. Additionally, the values of specific effective activity - A_{eff} in them are much higher, ranging from 12.4 Bq/kg to 18.6 Bq/kg, compared to the background value.

Table 1

Results for determining uranium concentration and specific effective activity -A_{eff} in 18 initial samples and in samples after processing using this technological scheme

Sample no.	Uranium concentration in initial samples - g/t	Specific effective activity of initial samples - A_{eff}, k Bq/kg	Uranium concentration in samples after processing - g/t	Specific effective activity - A_{eff} after processing, to Bq/kg
1	243.5	56.2	72.4	18.7
2	234.2	54.4	69.2	18.5
3	209.3	54.2	64.6	18.1
4	205.1	51.1	59.7	17.5
5	198.6	50.2	62.4	16.9
6	193.4	49.5	61.1	16.9
7	189.8	49.2	57.5	16.4
8	189.3	48.3	58.3	16.4
9	188.6	47.7	57.9	16.2
10	176.5	47.3	53.8	15.2
11	175.6	46.2	52.7	15.3
12	171.2	44.9	54.1	14
13	159.7	44.1	47.3	13.4
14	147.1	43.3	46.7	13.4
15	143.4	42.6	42.3	14.1
16	142.2	41.3	44.4	13.3
17	137.7	39.4	43.7	13.3
18	129.7	38.8	37.6	12.4

As indicated by the results in Table 1, after processing technogenic uranium ores, the uranium concentration and values of specific effective activity - A_{eff} in them decrease on average by 70%.

Based on the results obtained, a histogram in Fig. 2 was constructed. changes in uranium concentration in initial samples and samples after processing using the proposed technology in relation to Clark.

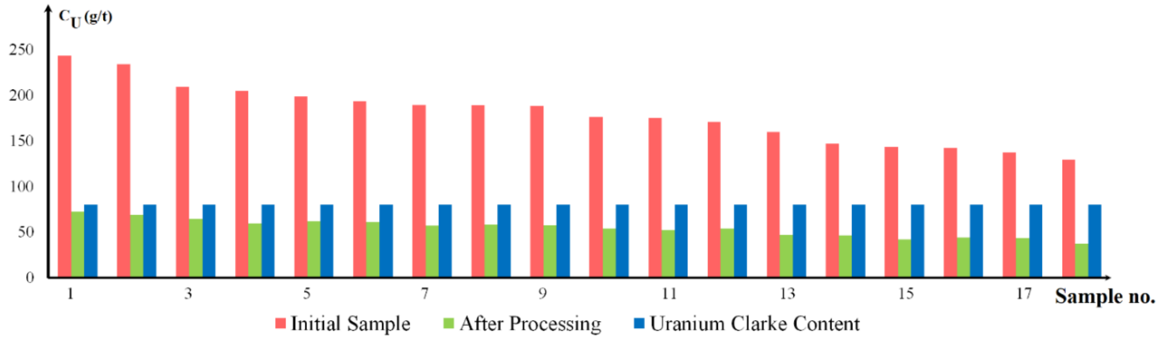

Fig. 2. ***Changes in uranium concentration in the initial samples and samples after processing using the proposed technology relative to the Clarke content.***

As can be seen from Fig. 2. changes to uranium concentration in the original samples, the uranium concentration ranges from 129.7 g/t to 243.5 g/t, and in the samples after processing, the uranium concentration ranges from 37.6 g/t to 72.4 g/t. The green column indicates the Clarke uranium content – 80 g/t.

Additionally, based on the conducted research and obtained results, a histogram (Fig. 3) was constructed depicting changes in specific effective activity - A_{eff} values in the initial samples and samples after processing using the proposed technology relative to the established norm.

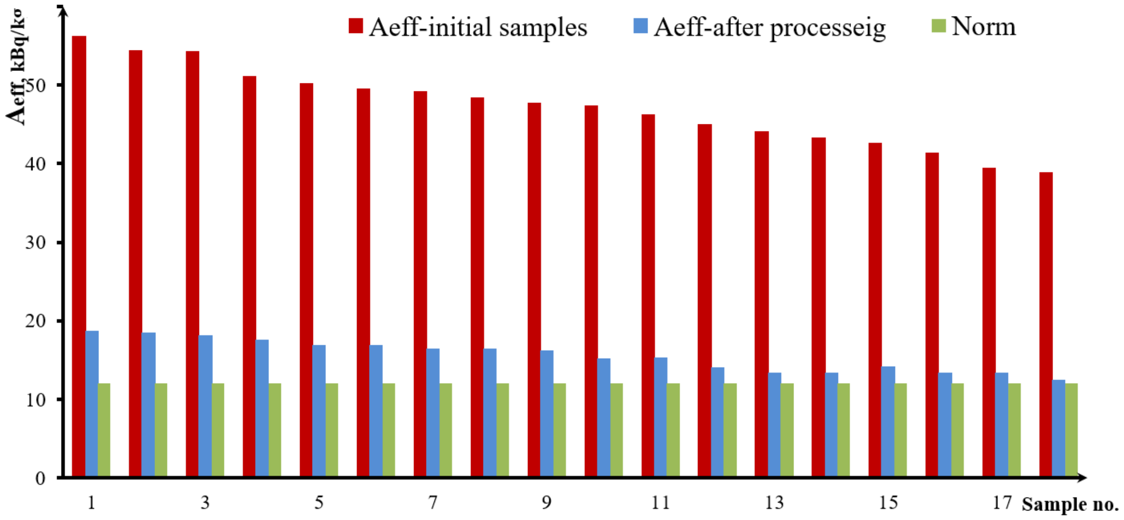

Fig. 3. ***Changes in specific effective activity - A_{eff} values in the initial samples and samples after processing using the proposed technology relative to the established norm.***

As seen in Fig. 3, changes in specific effective activity - A_{eff} values in the initial samples range from 38.8 Bq/kg to 56.2 Bq/kg, while in samples after processing, the values of specific effective activity - A_{eff} range from 12.4 Bq/kg to 18.7 Bq/kg. The established norm of 1200 Bq/kg is indicated by the green-colored column.

In all selected samples, uranium distributions at different depths were investigated. To determine the uranium concentration values in the collected samples, specific effective activity - A_{eff} was determined. In each sampling point of technogenic uranium ore samples, cores were collected at various depths starting from the surface and at different depths (0.25 m, 0.5 m, 0.75 m, and 1 m). The values of specific effective activity - A_{eff} were determined in these cores. Based on these results, a dependence of specific effective activity - A_{eff} values on the sampling depth was constructed (Fig. 4)

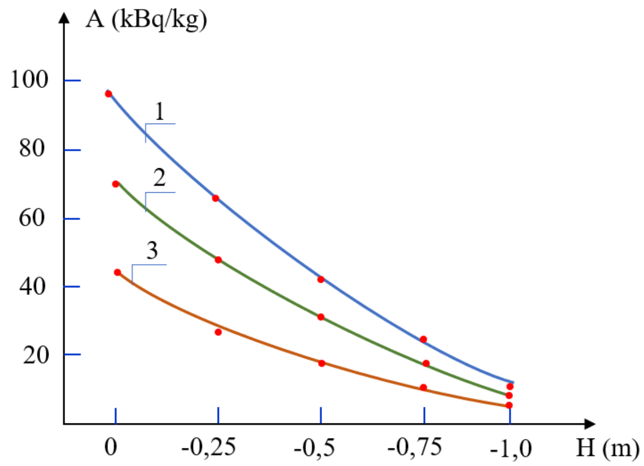

Fig. 4. ***Dependence of the values of specific effective activity - A $_{eff}$ on the depth of sampling.***

As evident from Fig. 4, with an increase in the sampling depth, the value of specific effective activity - Aeff decreases within the following ranges: for Sample 1, from 98 Bq/kg to 19 Bq/kg; for Sample 2, from 75 Bq/kg to 15 Bq/kg; and for Sample 3, from 42 Bq/kg to 10 Bq/kg. This fact confirms that all samples were collected from the area of technogenic uranium ores, formed through the geotechnological method of uranium extraction. Since the soil in these areas is contaminated due to the geotechnological uranium extraction method.

Conclusion

Based on a study of the parameters of a new technological scheme for the extraction of uranium from technogenic uranium ores, it was established that this scheme is suitable for processing technogenic uranium ores. Using this proposed technological scheme, it is possible to reduce the concentration of uranium in the initial samples and the effective activity - A_{eff} on average to 70 % .

The proposed technological scheme for uranium extraction from technogenic uranium ores is suitable for additional uranium extraction, considering the conducted reclamation of secondary uranium-containing ores. Moreover, the proposed technological scheme provides an opportunity to address the social issues of the region and reduce the radiation impact on personnel, the population, and the environment.

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