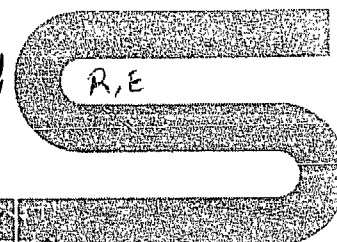


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**NON-FILTRATION METHOD OF PROCESSING
OF URANIUM ORES**

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Summary

The development of non-filtration sorption method made it possible to intensify processing of uranium ores, to improve considerably technological and economical characteristics of processes due to the elimination of labour-consuming multiple filtrations and repulpings of cakes, to involve in processing poorer uranium ores, and to isolate valuable by-components, e.g. molybdenum, vanadium, etc.

A considerable amount of experience on sorption from dense pulps with S/L = 1:1 has been accumulated in the industry. The productivity of existing factories has increased 1.5 - 3.0 times, the degree of uranium extraction has risen by 5 - 10%, the productivity of labour of operators has grown 2 - 3 times. The consumption of chemicals, auxiliary materials, power, and steam has become several times lower. A totally continuous process utilizing highly efficient equipment of elevated individual capacity for dense pulps has been created.

The development of uranium hydrometallurgy follows the path of drawing poor ores with high dispersion degree of uranium minerals into processing thus strongly hampering their preparation¹⁻³. The presence of energy and labour consuming operations of separation of pulp solid and liquid phases (filtering or counter-flow decanting) in standard processes and large losses of the component being extracted make the characteristics of the process considerably worse. The non-filtration sorption method of processing dense and viscous pulps elaborated in the USSR in 1953 is free from these shortcomings^{4,5}. The first commercial plant for uranium sorption from pulps was started in the USSR in 1954. Thus, there are more than two decades of experience of industrial operation of sorption from pulps in the USSR.

The essence of non-filtration sorption method is that a granulated sorbent (+0.63 -1.6 mm) selectively adsorbing uranium is introduced into a finely dispersed pulp (0.15 mm). The pulp and the sorbent move continuously from one apparatus to another in counter-flow with separation on a gauze between two apparatus. Counter-flow favours maximum saturation of the sorbent and the highest degree of exhaustion of the pulp with respect to uranium.

The process of sorption from pulps surpasses traditional filtering methods in its intensity several hundred and in some cases several thousand times. Thus, specific filtering rate in the case of separation of ore slurry from the solution obtained at uranium leaching by filtering is usually 0.5 - 1.0 tonnes per square metres of filtering surface per day;

on the other hand, in the process of sorption from pulps, 1 square metre of separating gauze participates in the processing of 50 - 100 tonnes of ore per hour. Sorption from pulps makes it possible to combine the separation of solid phase, concentration, and purification from admixtures.

The efficiency of sorption from pulps increases significantly in the case of combining the processes of sorption and leaching. The introduction of an ionite at the leaching stage increases the degree of uranium extraction and reduces substantially the total time of processing of ore material or concentrate. A considerable effect of sorption leaching takes place in all cases when diffusion hindrances occur in leaching or when in order to keep the extracted component in the solution the concentration of the leaching reagent has to be maintained at a high level because of pronounced sorption capacity of ore minerals (shales, coals, bentonites, montmorillonite, etc.).

The utilization of the process of sorption from pulps resulted in lower power consumption (2 - 3 times), higher productivity of labour (3 - 4 times), saved many millions of square metres of filtering fabrics and hundreds of thousands tonnes of acids, alkalis, and other chemicals, and increased several times the capacities of plants. The process of uranium sorption from pulps opened the way to the effective and all-round use of poor uranium ores, served as a basis of revision of specifications for uranium ores, and, owing to the reduction of the boundary content of uranium in a number of deposits, made it possible to increase practically mineable

reserves.

An important feature of the process of uranium sorption from pulps is the sharp reduction in water consumption (2 - 3 times). The process involves a closed water circuit preventing the discharge of wastes into the open hydrographic network, i.e. eliminates harmful effect of uranium factories on the environment.

Depending on the ionic state of uranium in the solution, various classes of sorbents (cationites, anionites, amphotites) are used for the extraction of uranium from pulps obtained from the digestion of ores with different leaching agents (carbonates, sulphates, nitrates, phosphates).

Strongly basic anionites in gel form (AM, AMII, BII-1A, BII-3A) and macroporous anionites on the same basis (AM/n, AMII/n, and BII-1A/n), di- and polyfunctional anionites (AM-2B, ЭДЭ-10n, АН-2Ф), medium basic anionites (AM-3, BII-1II/n), and also very promising carboxy amphotites (AMK, AMK-2', BIK) together with phosphorus- and nitrogen-phosphorus-containing ionites (amphotites АФII-5, АФII-7, BIIФ-1, and BIIФ-2) have been elaborated and are used with allowance for the salt composition of solutions, excessive acidity or carbonation, and the presence of valuable accompanying components (for the solution of problems of all-round processing of uranium-containing raw materials).

The major requirement which should be primarily taken into account in making ionites suitable for sorption from solutions and pulps is high mechanical strength ensuring application of ionites in continuous processes, particularly under

the conditions of high abrasive action of ore pulps.

The generalization of a large number of works on the mechanism, statics, kinetics, and dynamics of uranium sorption with ionites conducted in the USSR and in the world makes it possible to say that there is a clear-cut relationship between the basicity of an ionite and its affinity for various uranium complexes.

In most instances macroporous ionites have advantages in uranium sorption and desorption kinetics as against respective gel-form ionites.

Stereochemical factors are clearly manifested in a number of cases; this has been convincingly proved for copolymers obtained from α, β , or γ -vinyl pyridine with divinyl benzene. The use of medium-basic anionites AM-3/n and BII-1/n for the all-round processing of uranium-molybdenum, uranium-vanadium, and other ores and concentrates is very promising.

Uranium sorption from carbonate solutions and pulps is of great importance in uranium chemistry and technology. The USSR has many years of experience of commercial sorption of uranium from carbonate pulps only by means of strongly basic anionites of AM, AMII, and BII-1A/n types; the use of phosphonium and arsonium salts is possible in the future.

Almost two decades of use of anionites for uranium extraction from various kinds of raw materials in large-scale processes give good grounds to assert that prolonged operation with anionites does not lead to irreversible loss of sorption capacity with respect to uranium at the expense of adsorption of impurities. Anionites undergo temporary poisoning with

polythionates, elemental sulphur and silicic acid (silica).

In the process of uranium desorption sorbents undergo regeneration with various inorganic acids, ammonium carbonate, soda or mixtures of salts.

Fig.1 gives a typical scheme of processing of uranium ores with the use of uranium sorption from pulps⁶. Several versions of utilization of equipment in the process of sorption from pulps and solutions have been worked out.

1. Columns with suspended sorbent layer

When pulp is fed into a sorption column upwards, the immobile sorbent layer expands by a factor of 1.2 - 1.5 and transforms into a suspended layer with pulp penetrating it. The stable state of the suspended layer is reached at a moderate density of the pulp ($1.05 - 1.08 \text{ g/cm}^3$), viscosity 2 - 3 centipoises, and the velocity of ascending pulp flow 6 - 8 m/hr. The uniformity of pulp distribution over the cross-section is provided by means of special bottom distribution pipes (Fig.2).

In order to reduce the losses of sorbent carried away with the ascending pulp flow, the pulp is discharged through top receiving pipes with stainless steel or polypropylene separating gauzes. Columns with cross-section 5, 10, and 22 m² and 6, 10, and 12 m high are used in commercial practice⁷.

2. Sorption apparatus with mechanical stirring

Conditioning tanks with propeller agitators, widely used for the leaching of ground ores, can be also applied for

sorption processing of high-uranium pulps of different density and viscosity^{4,7}. In order to reduce slippage factor of untreated pulp, conditioning tanks of each sorption stage are joined into sections consisting of 3 - 6 apparatus with the total number of sections equal to 3 - 5 (Fig.3).

3. Columns with moving sorbent bed

The processing of pulp in a moving sorbent bed (CMB) is in many aspects similar to the processing in suspended layer. The method features the continuous conveying of a sorbent to the apparatus by means of a special system of air lifts. The velocity of downward sorbent motion is 0.3 - 1.0 m/hr and that of upward motion of pulp is 6.5 - 7.5 m/hr (see refs. 4,7).

Considerable longitudinal mixing of sorbent and channeling should be placed among the shortcomings of the CMB type column; as a result of this, the columns are to be installed in groups of 4 - 6. The column of continuous sorption-regeneration of the CCSPR type is characterized by these disadvantages to a smaller degree (Fig.4).

Columns with working volume 10, 12, and 30 m³ and diameter 1.5 and 2.0 m were tested recently⁹. The duration of process in CCSPR apparatus is 2 times less than in CMB; this results in lower inventory of sorbent in the process and in reduction of capital investments.

4. Apparatus with pneumatic mixing

The equipment is intended for the processing of pulps with density up to 1.5 g/cm³, i.e. up to S/L = 1:1 at ore

dispersion degree 95% for the -0.15 mm class. These apparatus feature units for mixing pulp with sorbent, air lifts for sorbent conveying, top discharge tubes for the separation of sorbent and pulp, and overflow pipes for the gravity transporting of pulp through the apparatus of the sorption circuit. Fig.5 shows an apparatus with joint air lift for the mixing of pulp and its supply to the separating outlet. In order to reduce the load of the discharge screen, special ports for the partial return of transported mixture of pulp and adsorbent into apparatus are cut in the upper part of air lift tube.

Continuous pulp processing in apparatus with pneumatic mixing is characterized by small inventory of sorbent, the possibility of increasing the volume of the apparatus up to 500 - 1000 m³, and the simplicity of equipment for pulps of practically any density and viscosity. Compared to the method of pulp processing in suspended layer, this method is characterized by slightly higher energy consumption and mechanical losses of ionite.

Flow diagram of continuous sorption from pulps is given in Fig.6.

The further improvement of pulp sorption processes was connected by various researchers with the possibility of utilization of liquid ionites or extragents.

For a number of ores and concentrates the methods of non-aqueous extraction leaching seem to be promising.

The results of experiments on a pilot plant comprising uranium extraction from pastes have demonstrated that standard equipment can be used in the process.

However, for the time being extraction processes cannot compete with the process of sorption from pulps.

New possibilities are shown for hydrometallurgy by new processes combining the advantages of sorption methods with the advantages of the method of extraction with liquid ionites.

One of these methods comprises the use of porous pellets impregnated with an organic solvent and the desorption from solid ionites by liquid ionites or neutral extragents.

References

1. Tekhnologiya atomnogo syrya (Technology of atomic raw materials), Selected papers of foreign participants at the 2nd international conference on peaceful use of atomic energy (Geneva, 1958), Moscow, Gosatomizdat, 1969.
2. Harrington, N., Ruele, A., Technology of uranium production (Russ. transl.), Moscow, Gosatomizdat, 1961.
3. The Recovery of Uranium, Int. Atomic Energy Agency, Vienna, 1971.
4. Laskorin, B.N., Atomnaya Energiya, 9, 286, 1960.
5. Laskorin, B.N., Zefirov, A.P., Nevskii, B.V., *ibid.*, 11, 153, 1961.
6. Kovda, G.A., Laskorin, B.N., Nevskii, B.V., Sovetskaya atomnaya nauka i tekhnika (Soviet atomic science and technology) Collected works, Moscow, Atomizdat, 1967, p.222-240.
7. Laskorin, B.N., Tokarev, N.N., Vodolazov, L.I., Ionobmennaya tekhnologiya (Ion exchange technology), Collected works, Moscow, Nauka, 1965, p.55-62.
8. Laskorin, B.N., Goldobina, V.A., Sakharov, A.Yu., et al, Ekstraktsiya i sorbtsiya v metallurgii nikelya, kobal'ta i medi (Extraction and sorption in nickel, cobalt, and copper metallurgy), Moscow, TsNIIinform and TSETsvetmet, 1970, p.17 - 25.
9. Laskorin, B.N., Tokarev, N.N., Ilyushin, L.M., Shatalov, V.V., Ekstraktsiya i sorbtsiya v metallurgii molibdena, vol'frama i reniya (Extraction and sorption in molybdenum, tungsten, and rhenium metallurgy), Moscow, Tsvetmetinformatsiya, 1971, p.206 - 210.
10. Fedulov, Yu.N., Alekseeva, V.V., Vodolazov, L.I., Laskorin, B.N., Tsvetnyie metally, 2, 49 - 51, 1970.

Figures

Fig.1. Typical scheme of uranium ore processing:

1 - silicate ore; 2 - crushing; 3 - grinding; 4 - thickening; 5 - drain; 6 - pulp; 7 - leaching; 8 - pH adjustment; 9 - uranium sorption; 10 - ionite; 11 - pulp; 12 - elution; 13 - eluate; 14 - neutralization; 15 - tailings storage; 16 - drain; 17 - uranium extraction; 18 - aqueous phase; 19 - organic phase; 20 - reextraction; 21 - U_3O_8 preparation.

Fig.2. Sorption column with suspended sorbent layer and inlet distribution pipes; cross-section is of square shape: C - sorbent; П.с. - sublayer; П - pulp; Т.д. - distribution pipes.

Fig.3. Scheme of train of equipment for pulp sorption processing in apparatus with mechanical stirring and regeneration of saturated sorbent in columns with moving bed: 1 - 4 - groups of sorption processing of pulp; 5 - separating screens; 6 - hopper with screw feed for sorbent proportioning; 7 - head tanks for pulp; 8, 9 - pumping stations for sorbent; 10 - dewatering screens in desorption cycle; 11 - desorption columns with moving bed; 12 - collector for washing water; 13, 14 - sumps and tanks for eluents and eluates; 15 - sand pumps; P.c. - regenerated sorbent; И.п. - initial pulp; C.п. - discharged pulp; Т.п. - final regenerate (eluate).

Fig.4. General view of CCSPR apparatus:

1 - lid with baffle and collecting chute for sorbent; 2 - cylindrical housing; 3 - conical central charge pipe; 4 - bottom drainage; 5 - hydroseal with sleeve; 6 - air; 7 - resin inlet;

8 - solution; 9 - resin outlet; 10 - final regenerate.

Fig.5. General view of sorption apparatus with joint air lift for mixing and feeding of pulp to the circular type separating outlet:

B - air; II - pulp; C - sorbent; 1 - top view.

Fig.6. General view of CMB type apparatus:

1 - head sleeve; 2 - level controller; 3 - drainage chute for eluate; 4 - top drainage; 5 - bottom drainagr; 6 - sorbent withdrawal; 7 - solution inlet pipe.

Fig.6. Scheme of continuous process of pulp extraction:

1 - sorption apparatus; 2 - pulp distributor; 3 - screens; 4 - column for sorbent washing from pulp; 5 - regeneration column; 6 - column for sorbent washing from regenerating solution; 7 - pulp; 8 - resin; 9 - to dump; 10 - washing water; 11 - drain; 12 - cake to sorption; 13 - water; 14 - regenerate; 15 - acidic solution.

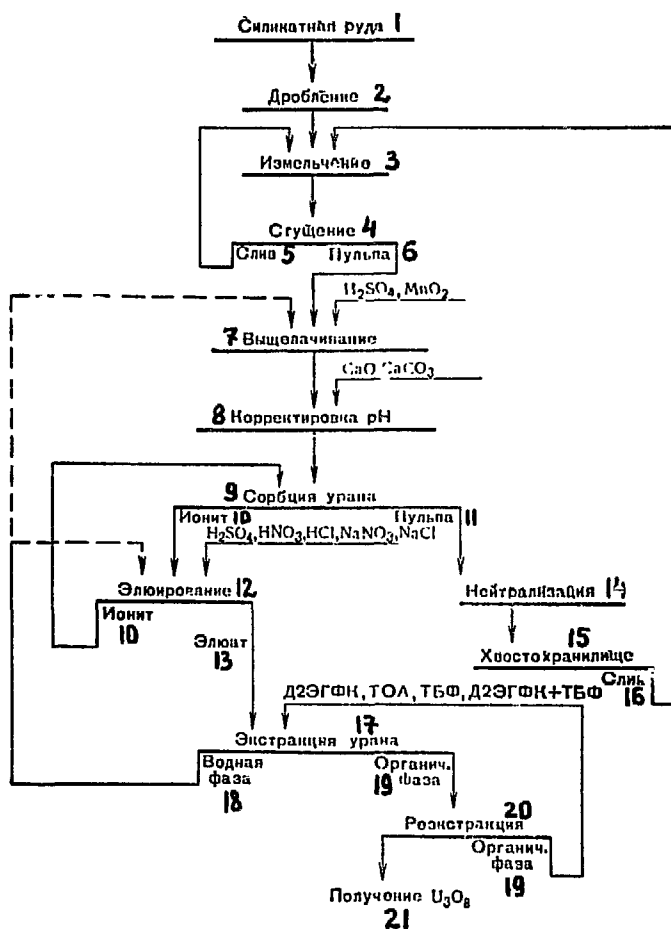


Fig.1.

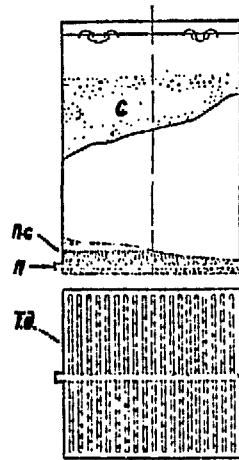


Fig. 2.

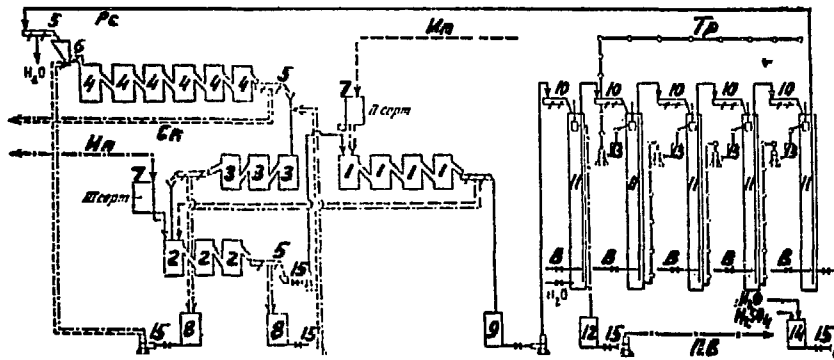


Fig. 3.

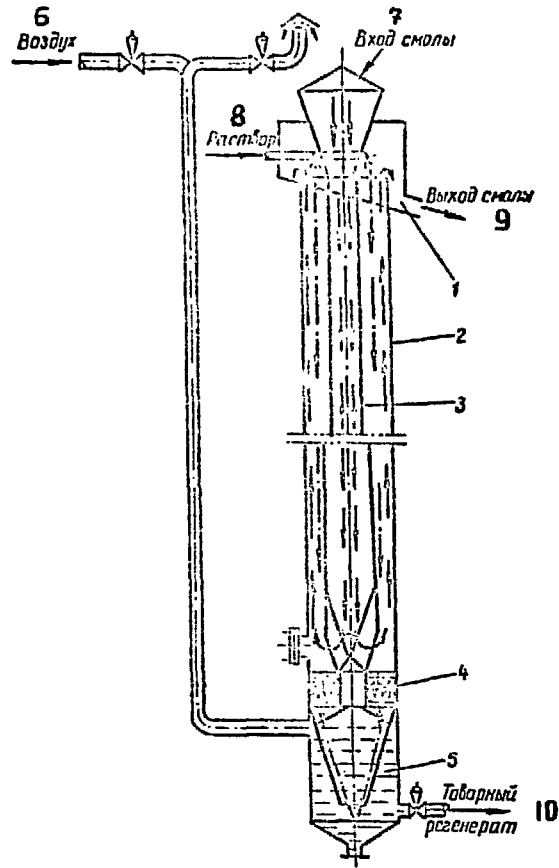


Fig. 4.

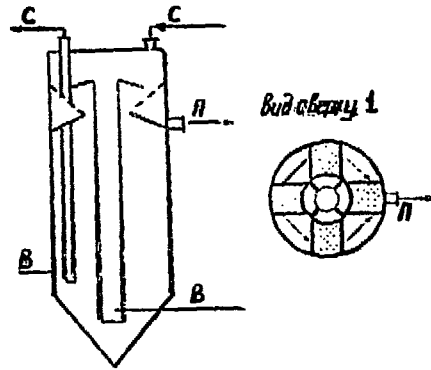


Fig. 5.

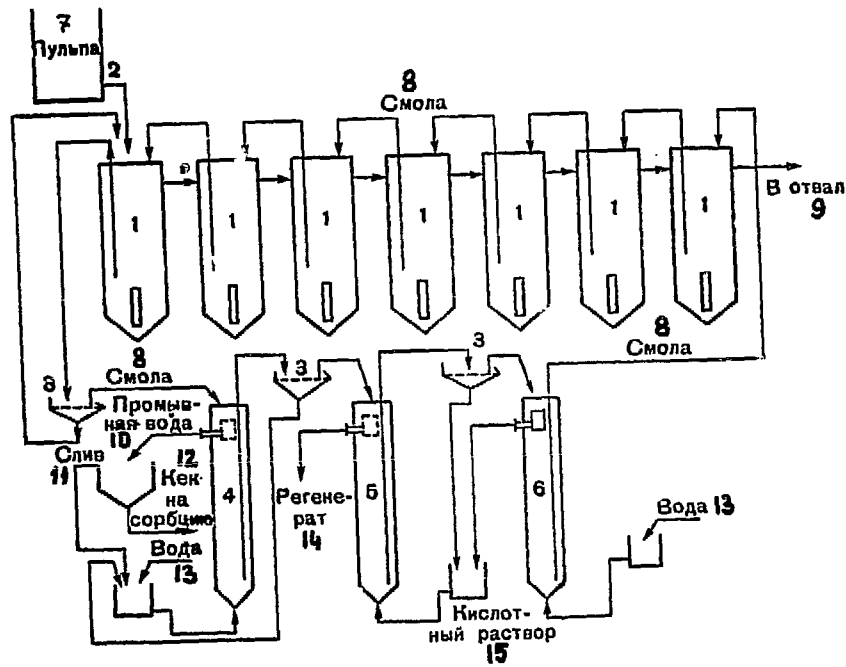


Fig. 6.

