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DEVELOPMENT OF THE REGENERATION TECHNOLOGY OF AM-2B ION EXCHANGE RESIN IN THE PROCESS OF SORPTION OF GOLD RECOVERY FROM POLYCOMPONENT GOLD-BEARING SOLUTIONS

Abstract. The principal technological scheme of desorption of gold and accompanying metal-impurities from the AM-2B resin phase used for the sorption processing of gold-bearing ores is considered. The proposed combined scheme, involving the use of two independent traditional methods of gold elution, involves desorption of metal impurities from the resin with alkaline solutions of sodium thiocyanate, and gold - with sulfuric acid solutions of thiourea.

The results of studies of the gold elution and impurity metals from anionite saturated with the following components are given, mg/g: Au = 2.6; Cu - 3.5; Zn - 1.3; Ni - 2.9; Co - 3.3. It is shown that the main amount of impurity metals is desorbed from the resin under its thiocyanate treatment, while the transition of gold into the eluate is negligible. The composition of the eluate in the thiocyanate treatment of saturated resin, mg/l: Au - 14.66; Cu - 669.2; Zn = 222.1; Ni - 493.0; Co - 412.6. Subsequent processing of the resin with sulfuric acid solutions of thiourea makes it possible to transit 98.67 % of gold from the ionite containing a small amount of impurities to the eluate. The resulting eluates containing ~ 377 mg/l of gold are target solutions for obtaining a valuable metal.

The ion exchanger resin was regenerated by washing with water and treating with an alkaline solution of sodium to convert it to an OH^--form, at which sorption of gold from cyanide solutions of heap leaching takes place.

Residual contents of components in the resin after regeneration were, mg/g: Au - 0.06; Cu - 0.02; Zn - 0.02; Ni - 0.01; Co - 1,2, which allows the successful use of the regenerated resin at the next stage of sorption.

Keywords: elution, desorption, combined technology, anion exchange resin, thiocyanate solutions, acid thiourea solutions.

Introduction. Gold-bearing productive cyanide solutions formed during heap leaching, in addition to gold, contain complex cyanide compounds of silver - $NaAg(CN)_2$ and metal impurities, of which the most characteristic are cyanide copper compounds $NaCu(CN)_2$, $Na_2Cu(CN)_3$ and $Na_3Cu(CN)_4$, of zinc $Na_2Zn(CN)_4$, nickel $Na_2Ni(CN)_4$, iron $Na_4Fe(CN)_6$ and cobalt $Na_4Co(CN)_6$ [1-4]. In this regard, saturated ion-exchange resins, along with gold and silver, contain impurity metals, which mass content in the resin is sometimes 2-3 times higher than the content of noble metals.

In the process of regeneration of anion exchange resin, it is necessary to achieve the most complete desorption of both noble metals and impurities. The impurities remaining on the resin when it is reused in the sorption process deteriorate the kinetics of the process, reduce the resin capacity of noble metals, and increase the loss of dissolved gold in the liquid phase of tails. As practice shows, the content of residual components in the anion exchange resin after regeneration can be: gold - no more than 0.1-0.3 mg/g, impurities - no more than 3-5 mg/g of air-dry sorbent [5].

Analysis of technologies for the desorption of gold from saturated ion-exchange resins showed that among the tested eluents the most suitable are alkaline solutions of zinc cyanide [6], sodium thiocyanate and ammonium [7], as well as solutions of thiourea in the presence of mineral acids [8].

However, zinc tetracyanate is effective as an eluent only for anion exchangers having guanidyl groups. The anion exchangers used in the CIS contain other functional groups, and zinc cyanide has low values. To reuse anion exchangers, a deep removal of zinc from the resin, which is carried out by solutions of mineral acids, is necessary. The process is ineffective and has not found industrial application [9-11].

On an industrial scale, mainly thiocyanate and thiourea solutions are used, while the latter is given preference in terms of technical and economic indicators. The costs of reagents for thiourea technology are 1.91 times lower than the costs of thiocyanate technology.

Acid-thiourea technology of gold desorption and resin regeneration includes several operations, the main ones are the treatment of the resin with a hot cyanide solution to remove iron and copper, sulfuric acid for desorption of zinc and nickel, sorption of thiourea, desorption of gold and silver directly with thiourea sulfuric acid solution, thiourea washing and transferring the resin to the OH-form by treatment with sodium hydroxide. All operations, except for aqueous washing of slurries, alkaline treatment and washing of alkali are conducted at a temperature of 55-60 °C and atmospheric pressure [5, 12].

In the operation of acid-thiourea resin processing technology, its serious drawbacks were revealed: when using strong hot cyanide solutions for desorption of copper and iron, gold and silver are partially desorbed from the ion exchanger; zinc and iron are incompletely desorbed and almost no cobalt is extracted. In this regard, zinc, iron and cobalt are accumulated in the ion exchange resin, which leads to a deterioration of its sorption properties; complexity and multi-operation scheme; a long duration of the sorption-desorption-regeneration cycle (250-300 hours) [5].

In order to eliminate these shortcomings, a study of the combined processing technology of saturated anionite proposed by the authors has been conducted. This technology includes three stages of desorption: the first and the second - selective elution of impurity metals, the third one - gold elution with the use of specific complexing reagents at each stage, and the regeneration of the ion exchanger with an alkali solution.

Instead of using strong hot cyanide solutions for desorption of copper and iron, it is suggested to use weak alkaline thiocyanate solutions that successfully desorb these impurity metals but leave gold in the resin [13], then desorb zinc and nickel with a solution of sulfuric acid with simultaneous conversion of the resin from thiocyanate form into sulphate, and then desorption of gold with the acid solution of thiourea. Also, the task was to maximally desorb cobalt from the resin, which according to the existing technology is almost not extracted.

The implementation of the combined technology will eliminate the shortcomings of the existing industrial technology and ensure the production of high-quality gold-bearing eluate without accompanying impurities, which will improve the quality of the finished product.

Methods of the research

Researches used the AM-2B resin produced by GC "Smoly" (Ukraine) [14]. AM-2B anionite is a macroporous ion-exchange resin based on styrene copolymer with divinylbenzene containing strong and weakly basic functional groups in its structure.

Studies on the combined technology of gold desorption and resin regeneration were carried out in dynamic conditions in a laboratory sorption column with a height of 160 mm and a diameter of 40 mm. The height of the resin layer was maintained to 140 mm, the volume of the resin was 60 ml. All the process steps were carried out by passing the solution through the resin layer in the bottom-up column. The flow rate of the solution was 100-120 ml/h, which corresponds to a specific load (SL) of 2-2.4 h^{-1}. The proposed technological scheme of the combined technology of gold desorption and resin regeneration is presented in figure 1.

After completion of the gold elution from the resin phase, the ion exchanger is regenerated by its successive washing with water at an elevated temperature of 55 °C and room temperature. Then alkaline treatment of the ion exchanger (3 % NaOH) is carried out in order to neutralize the sulfuric acid residues and transfer the resin to the OH^- -form, which is most favorable for the gold sorption from alkaline cyanide heap leaching solutions. Spent solutions from alkaline treatment are combined with solutions from acid treatment and aqueous washing from thiourea and are sent for neutralization.

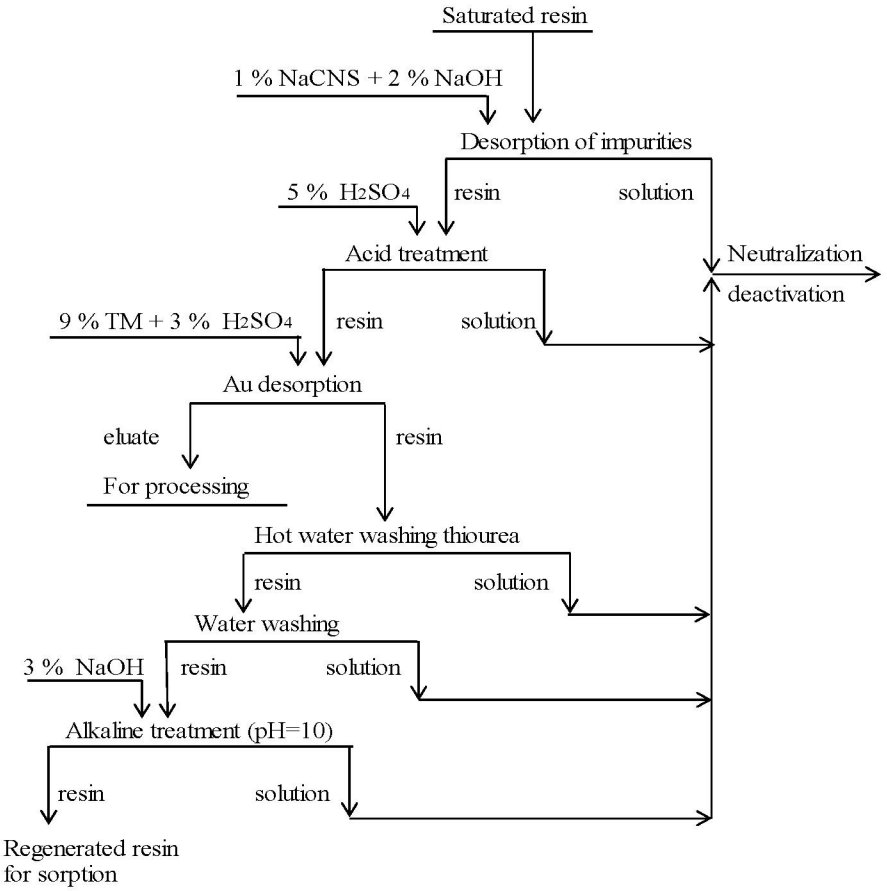

Figure 1 – Principal flow chart of the combined technology of gold desorption and AM-2B resin regeneration

Results of tests of combined thiocyanate-thiourea resin regeneration technology

Volume of the passed solution, sp.v.		Metal content in solution, mg/l					Residual metal content in the resin, mg/g				
in operation	in aggregate	Au	Cu	Ni	Zn	Co	Au	Cu	Ni	Zn	Co
Desorbing solution of 1 % NaSCN and 2 % NaOH											
1,97	1,97	1,45	589,0	184,0	192,5	296,0	2,59	0,45	1,95	0,30	1,77
1,97	3,93	4,87	65,10	220,0	18,4	62,0	2,57	0,11	0,81	0,21	1,45
1,90	5,83	4,80	5,88	65,0	4,0	11,0	2,54	0,09	0,48	0,19	1,39
0,47	6,30	3,54	9,21	24,0	7,2	43,6	2,54	0,07	0,45	0,18	1,34
Processing 5 % H_2SO_4											
1,93	1,93	0,98	1,13	6,80	0,09	3,28	2,53	0,07	0,42	0,18	1,32
2,17	4,10	0,0	1,38	35,60	3,90	0,14	2,53	0,06	0,22	0,16	1,32
0,40	4,50	0,0	0,37	16,2	2,10	0,05	2,53	0,06	0,20	0,15	1,32
Desorbing solution of 9 % $CS(NH_2)_2$ and 3 % H_2SO_4											
2,47	2,47	194,0	1,95	7,50	2,00	0,17	1,27	0,05	0,15	0,14	1,32
2,70	5,17	122,0	1,24	2,00	3,50	0,11	0,41	0,04	0,14	0,12	1,32
2,40	7,57	34,0	0,73	1,20	3,70	0,02	0,19	0,03	0,13	0,09	1,32
2,37	9,93	15,5	1,13	3,40	3,18	0,13	0,10	0,03	0,11	0,07	1,32
2,03	11,97	6,5	0,70	4,05	2,88	0,13	0,06	0,02	0,09	0,06	1,32
2,07	14,03	2,65	0,58	3,30	2,68	0,08	0,05	0,02	0,07	0,04	1,32
2,50	16,53	1,95	0,55	3,03	2,98	0,08	0,03	0,02	0,05	0,02	1,32
Washing H_2O											
2,00	2,00	0,84	0,24	1,53	2,20	0,02	0,03	0,02	0,04	0,01	1,32
2,50	4,50	0,30	0,04	0,33	1,50	0,00	0,03	0,01	0,04	0,01	1,32
Processing 3 % NaOH											
2,00	2,00	0,18	0,25	0,19	1,29	1,58	0,03	0,01	0,04	0,01	1,31
Note: The content of ions of metal-impurities in the regenerated resin, mg/g: Au = 0.06; Cu - 0.02; Ni - 0.01, Zn - 0.02; Co - 1.2.											

Results and their discussion

The results of the experiments are shown in table and in figures 2 and 3.
Figures 2 and 3 show graphical data on the desorption of metals by different eluting solutions.

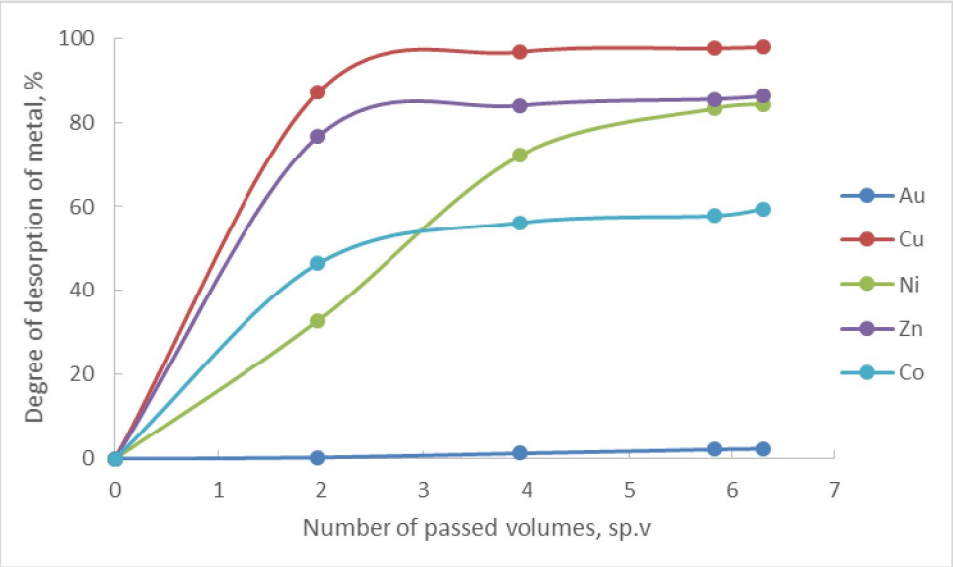

Figure 2 – Dependence of metal desorption on the volume of the passed solution upon desorption of metals-impurities with solutions of 1% NaSCN and 2% NaOH

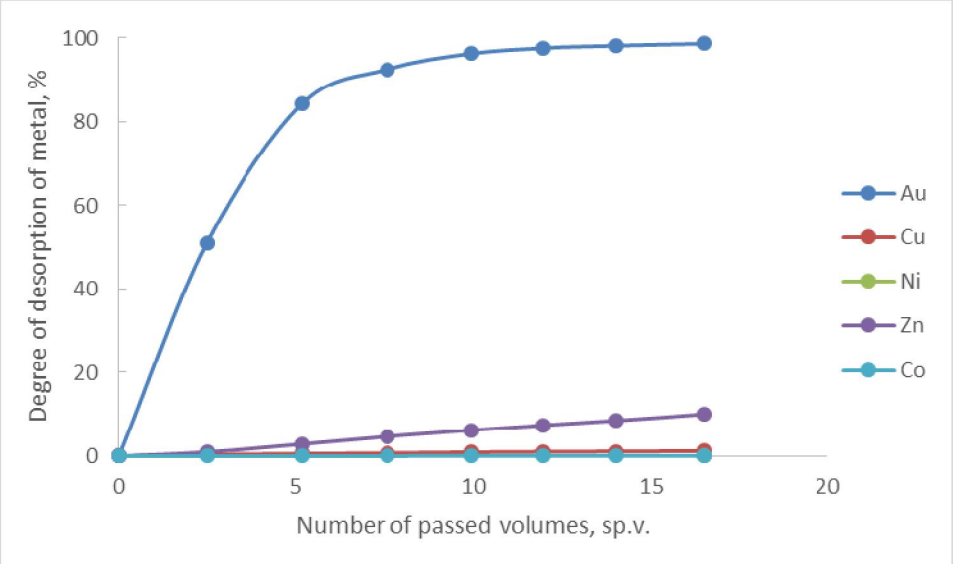

Figure 3 – Dependence of metal desorption on the volume of the passed solution upon desorption of metals-impurities by solutions of 9 % $CS(NH_2)_2$ and 3 % H_2SO_4

From the presented data, it can be seen that the majority of the metal impurities are desorbed using an alkaline thiocyanate solution. At the same time, to the eluate there are transferred, %: copper 97.88, nickel 84.32, zinc 86.18, cobalt 59.43. Further acid treatment of the ion exchange resin allows to desorb mainly nickel (from 84.32 % to 93.10 %) and zinc (86.18 % to 88.10 %).

Figure 3 shows the data using the acidic thiourea solution (9 % $CS(NH_2)_2$ and 3 % H_2SO_4) as the eluent. It can be seen that the metals-impurities are not desorbed practically, and gold is desorbed to 98.67 %.

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ПОЛИКОМПОНЕНТТІ АЛТЫНҚҰРАМДЫ ЕРІТІНДІЛЕРДЕН АЛЫНҒАН ШАЙЫРЛАРДАН АЛТЫНДЫ ДЕСОРБЦИЯЛАУ ЖӘНЕ ШАЙЫРДЫ ҚАЛПЫНА КЕЛТІРУ БАҒЫТЫ БОЙЫНША БІРІККЕН ТЕХНОЛГИЯСЫНДАМЫТУ

Аннотация. Алтынқұрамды кендерден алтынды АМ-2Б маркалы шайырынан десорбциялау және шайырды қайта өңдеудің біріккен технологиясын қолданудың негізгі технологиялық сұлбасы ұсынылған. Бұл сұлба алтынды десорбциялық өңдеуде қолданылатын екі дәстүрлі технологияны қамтиды.

Шайырлардан қоспа металдарды сілтілік роданидті ерітінділермен десорбциялау және алтынды қышқыл тиомочевинді ерітінділермен десорбциялауды қамтитын ұсынылған біріккен технологияны қолдану кезінде қоспа металлдардың әрекеті зерттелді.

Зерттеулер алтынды десорбциялау және ион алмастырғыш шайырды қалпына келтіру бағытында ұсынылған аралас технология бойынша өткізілді. Келесі компоненттермен қаныққан ион алмастырғыш шайыр пайдаланылды, мг/г: Au – 2,6; Cu – 3,5; Zn – 1,3; Ni – 2,9; Co – 3,3. Қалпына келтірілген ион алмастырғыш шайырдың қалдық құрамы, мг/г: Au – 0,06; Cu – 0,02; Zn – 0,02; Ni – 0,01; Co – 1,2.

Қоспаметалдардың басым мөлшері мен алтынның аз мөлшері сілтілі роданидті ерітінділерді қолдану кезінде элюатқа өтетіні көрсетілді. Роданидті өңдеу кезінде элюаттағы металдардың құрамы, мг/л: Au – 14,66; Cu – 669,2; Zn – 222,1; Ni – 493,0; Co –412,6. Ионит құрамындағы алтынның 98,67 % алтынқұрамды ерітінділерге өтеді, ал элюат құрамындағы алтынның құрамы 376,6 мг/л дейін барады.

Түйін сөздер: десорбциялау, біріккен технология, анион алмастырғыш шайыр, роданидті ерітінділер, қышқыл тиомочевинді ерітінділер.

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РАЗРАБОТКА ТЕХНОЛОГИИ РЕГЕНЕРАЦИИ ИОНООБМЕННОЙ СМОЛЫ МАРКИ АМ- 2Б В ПРОЦЕССЕ СОРБЦИОННОГО ИЗВЛЕЧЕНИЯ ЗОЛОТА ИЗ ПОЛИКОМОНЕНТНЫХ ЗОЛОТОСОДЕРЖАЩИХ РАСТВОРОВ

Аннотация. Рассмотрена принципиальная технологическая схема десорбции золота и сопутствующих металлов-примесей из фазы смолы марки АМ-2Б, используемой при сорбционной переработке золотосодержащих руд. Предлагаемая комбинированная схема, предусматривающая применение двух традиционных независимых друг от друга способов элюирования золота, включает десорбцию металлов-примесей со смолы щелочными растворами роданида натрия, а золота – сернокислыми растворами тиомочевины.

Приведены результаты исследований элюирования золота и примесных металлов из анионита, насыщенного следующими компонентами, мг/г: Au – 2,6; Cu – 3,5; Zn–1,3; Ni – 2,9; Co – 3,3. Показано, что основное количество металлов-примесей десорбируются со смолы при ее роданидной обработке, при этом переход золота в элюат незначительно. Состав элюата при роданидной обработке насыщенной смолы, мг/л: Au – 14,66; Cu – 669,2; Zn – 222,1; Ni – 493,0; Co – 412,6. Последующая обработка смолы сернокислыми растворами тиомочевины позволяет перевести в элюат 98,67 % золота от содержавшегося в ионите с небольшим количеством примесей. Полученные элюаты, содержащие ~ 377 мг/л золота, представляют собой целевые растворы для получения ценного металла.

Проведена регенерация ионита путем промывки водой и обработки щелочным раствором натрия для перевода ее в OH^- - форму, при которой осуществляется сорбция золота из цианидных растворов кучного.

Остаточные содержания компонентов в смоле после регенерации составили, мг/г: Au – 0,06; Cu – 0,02; Zn – 0,02; Ni – 0,01; Co – 1,2, что позволяет успешно использовать регенерированную смолу на следующий стадии сорбции.

Ключевые слова: элюирование, десорбция, комбинированная технология, анионит, роданидные растворы, кислые тиомочевинные растворы.

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