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Researching the Possibility of Hydrometallurgical Processing of Hard-Enriched Gold Ores and Their Enrichment Products at the Amantau Mine

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ABSTRACT: The article presents the results of hydrometallurgical processing of hard-enriched gold ores of the Amantaytau mine and their products on the basis of the results of researches in the field of search of non-traditional solvents of gold it was found out that solutions of thiourea and chloride can be used together to dissolve gold and silver and it was determined that the extraction of gold was 73,2-81,5%, and that of silver was 61.9-75.3%. Furthermore, it was discovered that cyanide is complex based on scientific and practical results obtained in cyanide of gold ore enrichments.

KEYWORDS: material composition, analysis, valuable component, gold, mineral, gravity, concentrate, alotation.

I. INTRODUCTION

The cyanidation process is carried out in a special chemical glass container with a design capacity of 0.75 dm3 IRGIREDMET by mechanical, pneumatic mixing of the plant. 50-200 g of product is placed in a container, the required amount of protective alkali is added and an aqueous solution of sodium cyanide is poured. Process control is performed by determining the concentration of sodium cyanide and protective alkali in the liquid phase of the bush. The amount of ash resulting from the burning of the mineral-solid residual rare metals in the initial raw materials and final products of cyanidation was determined chemically using Perkin-Elmer atomic absorption spectrometer.

II.RELETED WORK

A sample of cyanide ore is found in the following amounts of rare metals in them. The results are presented in Table 1.

Table 1. Initial quantities of rare metals in the samples

Name of the mine	Amount in ore, g / t		Volume in gravitational waste, g / t	
	Au	Ag	Au	Ag
Amantaytau	6,7	3,04	1,6	1,73

The following parameters affecting the extraction of rare metals have been established on the basis of studies on the selection of optimal cyanidation conditions: the size of the milled product of the sample before cyanide; the concentration of cyanide solution; the melting time in the cyanide solution.

III. OBJECTS AND METHODS OF RESEARCH

The experiments were performed according to the scheme shown in Figure 1. The mass of the ore is 200 g, S: Q = 2: 1 and the concentration of CaO (lime) of the protective alkali is 0.02%. During the experiments, the parameters were

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changed in the following range: the crushing size of the product ranges from 70 to 95% - 0.074 mm; sodium cyanide concentration from 0.04 to 0.25%; melting time in zinc solution is 12 to 48 hours.

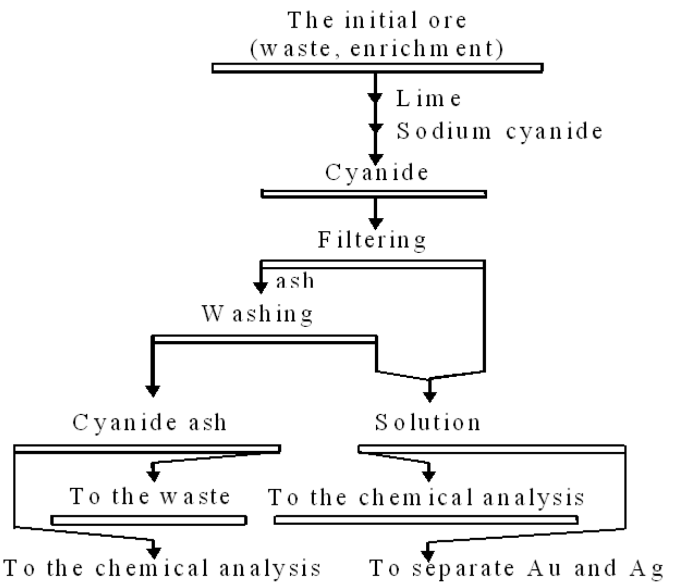

Figure 1. Cyanide scheme of ore and enriching products

The availability of carbonaceous substances and soluble copper compounds in the ore is explained by the presence of carbonaceous substances and soluble copper compounds in the ore, according to the data provided in Table 2, as indicators of the ore cyanide process in the optimum order analyzed rare metals from sulphide ore are lower than the extraction indicators. To eliminate the effect of these factors on the cyanidation process, sorption selective leaching of the ore and sorption selective leaching experiments after acid treatment were performed.

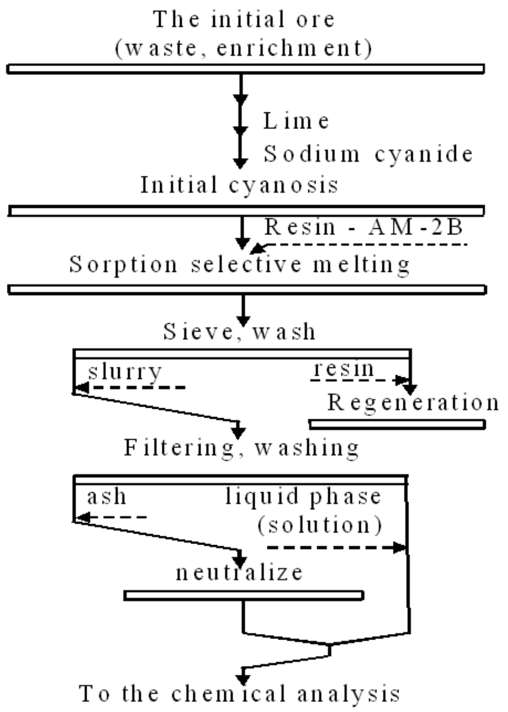

Figure 2. Sorption selective melting scheme of the ore and enrichment products

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Sorption in selective melting, CN-type AM-2B resin was added to the slurry in the amount of 5% of the sludge volume (in ore experiments) and 3% (in waste experiments) of CN-type AM-2B resin (Figure 2).

IV. RESULTS OF THE RESEARCH

Table 2. Indicators of cyanide treatment of initial ore and enrichment wastes in optimal order

Name of the mine	Amount: The initial product		Amount: Cyanide ash		Solution decomposition, %		Optimal conditions of cyanide: Minced product size, % –0.074 mm	Cyanide time, hour	NaCN concentration, %	General parameters
	Au	Ag	Au	Ag	Au	Ag				
Initial ore										
Omontaytov	6,56	3,5	4,06	2,24	38,0	36,0	100	24	0,1	J:T=2:1 C_{CaO}-0,02%
Gravity waste										
Omontaytov	1,52	1,68	1,3	0,97	36,2	35,2	100	24	0,08	J:T=2:1 C_{CaO}-0,02%
Flotation waste										
Omontaytov	0,93	0,96	0,50	0,49	46,5	48,6	90	18	0,08	J:T=2:1 C_{CaO}-0,02%

For individual enrichments, sorption selective melting was used because of their sorption activity. The amount of resin to be added (in%) to the volume of the slurry is given in Table 3. Gravity and flotation fertilizers were subjected to oxidative combustion, dissolved in sulfuric acid and nitric acid. In addition, ore enrichments and initial ore from the Omontoytov deposit were sent for bioremediation. Cyanidation was carried out according to the scheme shown in Figures 1 and 2 in the ratio S:Q=2:1, conducted at a concentration of 0.02% lime. The concentration of NaCN and the amount of resin to be added were changed.

The two-stage oxidative firing was carried out for 2 hour at a temperature of 500–6000 C. The ash obtained as a result of firing was dissolved in 3% H2SO4 for 1 hour at a temperature of 85-90oC in the ratio S:Q=5:1. Processing in nitric acid with 28% HNO3 was carried out for 2.5 hours at a temperature of 85-90oC in the ratio S:Q=5:1. The concentrate was poured into a 1 l glass, then a little nitric acid was added. The total consumption of nitric acid was 450 ml. The slurry was then filtered and the ash resulting from the burning of the mineral washed with water. The volume of the filtrate is 1.7 l with wash water. The yield of gravity enrichment consisted of 50.75 %.

According to the data presented in Table 3, cyanide faced the greatest difficulties in the processing of concentrates obtained from the ores of the Omontoytov mine.

In addition, experiments were carried out on the scheme of selective dissolution of gravity-floto enrichment in nitric acid.

Nitric acid selective dissolution experiments were carried out with a mixer in a heat-resistant glass. The following constant conditions were maintained: initially heating the slurry to 800 C, adding acid for 30 minutes. The total processing time in the acid is 2.5 hours S:Q=5:1; the HNO3 concentration is 28%. The slurry was then filtered in a nutch filter and washed. During the experiments, air was blown all the time through the boot. In the process of selective dissolution in nitric acid, the main concentrators of gold - pyrite and arsenopyrite - are decomposed. Sulfur and arsenic are oxidized to form sulfuric and arsenic acids. Dissolves in the form of ferrous sulfates. The ash resulting from the burning of the mineral is enriched with gold and silver.

Similar experiments were performed on gravity and flotation enrichment from the mines under research. The amounts of rare metals in the enrichments (in g / t) and the experimental conditions are given in Table 3.

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Table 3. Indicators of sorption selective melting process in optimal order

Product name	Amount, g/t				Extraction into solution, %		Optimal conditions of cyanide				
	The initial product		Cyanide ash				The size of the mincing product is 0.074 mm	Cyanide time, hours	NaCN concentration, %	The resin to be added, % relative t the total volume of the slurry	General parameters
	Au	Ag	Au	Ag	Au	Ag					
Gravity-enrichment	35,1	14,3	29,2	10,5	16,7	26,7	95	48	0,15	5,0	S:Q=2:1 C_{CaO}-0,02%
Floto-enrichment	22,2	9,13	16,1	5,61	27,4	38,6	95	48	0,15	5,0	S:Q=2:1 C_{CaO}-0,02%
Gravity-enrichment ash	46,2	19,1	4,3	6,55	90,7	65,7	90	48	0,15	3,0	Burning T=550-600°C, t=2 hour
Floto-enrichment ash	26,7	12	2,3	3,9	91,4	67,5	95	36	0,1	3,0	Burning T=550-600°C, t=2h
Selective melting ash resulting from the burning of the mineralin sulfuric acid											
Gravity-enrichment	49,6	22,4	2,1	6,5	95,8	71,0	95	24+24	0,15	5,0	Work on 3% H_2SO_4 for 1 hour, S:Q=5:1, T=85-90°C
Floto-enrichment	28,7	12,9	1,26	1,1	95,6	91,5	95	36	0,1	3,0	
Selective melting ash resulting from the burning of the mineralin nitric acid											
Gravity-enrichment	65,2	29,6	4,76	2,22	92,7	92,5	95	24+24	0,15	5,0	28%HNO_3 t=2,5 s, S:Q=5:1 T=85-90°C
Floto-enrichment	28,6	12,9	1,23	1,1	95,7	91,5	95	36	0,1	3,0	
Selective melting ash resulting from the burning of the mineralusing bacteria											
Ore	6,56	3,5	1,52	1,17	76,9	66,5	85	36	0,1	3,0	3% H_2SO_4 t=192s, S:Q=4:1, T=16-22°C
Gravity-enrichment	35,5	14	5,82	4,81	83,6	65,6	85	36	0,15	5,0	
Floto-enrichment	22,4	9,18	1,7	4,3	92,4	53,0	85	36	0,1	3,0	

The amount of gold in the gravity enrichment hydrosulfation ash resulting from the burning of the mineral was 65.24 g / t, the amount of silver was 29.6 g / t. The amount of gold in the flotation enrichment hydrosulfate ash resulting from the burning of the mineral is 28.67 g / t, silver - 12.9 g / t. In the sorption cyanide of these cakes, 92.68-95.58% gold and 91.47-92.23% silver pass into the resin. According to the selective melting scheme in nitric acid, the total extraction of gold is 92.23% and that of silver is 83.68% (Figure 3).

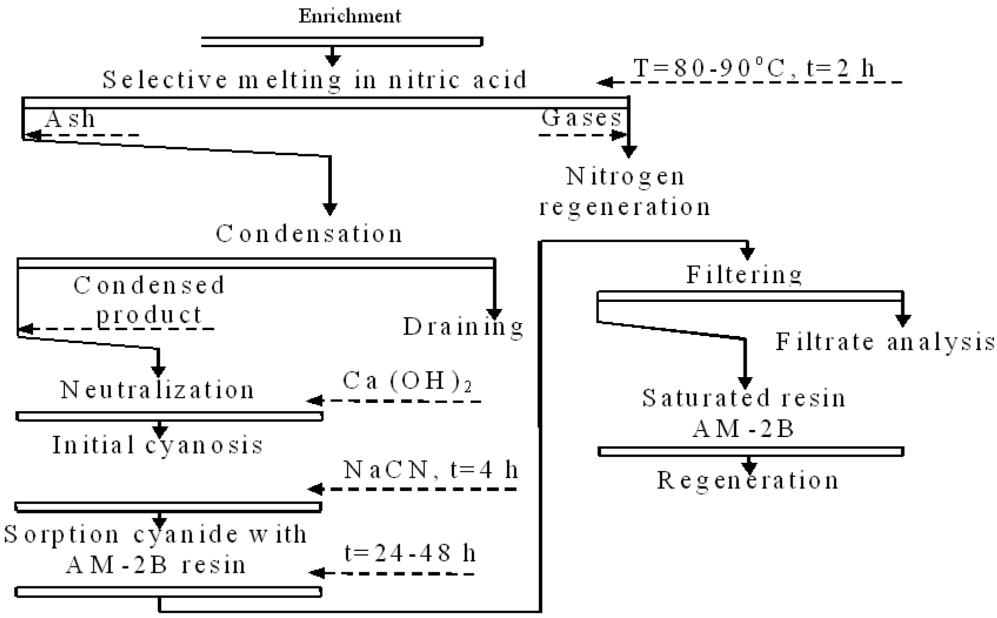

Figure 3. Scheme of selective processing of enrichments in nitric acid

The process of biodegradable melting of gravity and flotation enrichment at S:Q=4:1 at a temperature of 16-22oC for 192 hours is described in detail. The product is fermented to pH = 1-2 using sulfuric acid before biotransformation. The bio transformer was selectively dissolved in sorption at a concentration of 0.15% NaCN for 36 h after the ash resulting from the burning of the mineral was neutralized with lime.

Resin was added in the amount of 3-5% of the volume of the slurry. 76.9% of gold and 66.7% of silver were extracted from tar ore, 83.6% of gold and 65.6% of silver were extracted from gravity enrichment; 92.4% of gold and 53% of silver were extracted from the flotation enrichment. Under this scheme, the total extraction of gold was 81.17% and that of silver was 56.69%.

Literature shows that acid solutions of thiourea, alkali metal chlorides with oxidants, ketone and alcohol solvents with the addition of elementary halogens, humic compounds and microorganisms can be used as solvents for rare metals.

Many researchers believe that thiourea is a promising solvent, and their acid solutions can replace cyanide due to its non-toxicity and sufficiently high dissolution efficiency. Selective solution of thioureaCS2(NH2)2, 1-3% H2SO4 and 0.3-0.4% Fe2(SO4)3 is used for selective dissolution. One of the reasons why thiourea is not widely used on an industrial scale is its increased consumption due to its high tendency to oxidize. Moreover, ores containing acid soluble minerals are treated with acid before selective dissolution in thiourea. The most environmentally friendly way to dissolve metals are oxidizers of chloride solutions - calcium or sodium hypochlorite in the concentration of 10-12%, chloride ions (in the form of alkali metal chlorides), sodium hypochlorite 0.1-1%, pH solution 8-13 melting. The chloride method is preferably used for ores with sulphide content of no more than 1-1.5% as they are capable of forming divalent iron sulphates that return gold from solutions. There are also methods to convert 25 g / l of table salt and 5 g / l of sulfuric acid into a solution containing a complex soluble in gold.

Table 4.2 shows the results of experiments with a mixture of sodium chloride solution. The obtained results demonstrated that solutions of thiosulphate, thiourea and chloride together with oxidizing agents can be used for dissolving gold and silver. Meanwhile, gold extraction made up 73,2-81,5%, silver - 61,9-75,3%.

Thiosulfate solutions require a very complicated time of selective melting (60-72 hours), with gold emission not exceeding 68-72.3% and silver emission 55.5-62.4%. The division of rare metals in chloride solutions is not very high.

V.CONCLUSION

The extraction of gold and silver components from the sample of sulfide ore was low on the basis of results of hydrometallurgical processing of gravity-flotation enrichments products obtained from hard-to-enrichment gold ores, following the results of experiments with cyanide ore in optimal order, presence of carbon substances and soluble

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copper compounds in a sample of sulfide ore. As the optimal scheme was chosen selective melting of gravity-flotation enrichments products from a sample of gold ore in nitric acid, and according to this scheme, the total extraction of gold was 81.17% and silver - 56.69%.

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