The increase of the gold heap leaching effectiveness on Archangelskoye field

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Abstract: Problems and prospects of development of gold mining and organizational actions for increase in economic efficiency of production of gold in Russia are presented. The technology of production of gold by methods of the geo-technology on an Archangelskoye field is shown. There is an often situation in the practice of goldfields development when gold ore, taking that it is rich but little, can be adequately processed at GRP (gold recovery plant) instead of in-place heap leaching performing. In order to maintain the stable work of GRP and provide the loaded coal desorption from heap leaching, the optimal variant is to buy the additional desorption and electrolysis plant, similar to one already running at the current GRP.
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1. Introduction

Gold mining is conducted in many countries [1-4]. Active search of the effective technologies is conducted in mining in ores with low concentration of gold.

In order to increase the recovery of gold out of product solutions and to provide the needed productivity of heap leaching the chain of sorption is being installed. This chain consists of 3-6 columns (according to the growth of productivity). The riser flow maintained optimal speed in columns is 25-30 m^3/h what provides the proportion of feed line diameter and column, columns' level difference and original solution feed volume control. The standard operating procedure foresees the control of effectiveness of gold precipitation onto the carbon, according to the content of gold in sorption areas. With the increase of gold concentration in those areas more than 0,1mg/lit is planned to reshuffle the carbon with the output of loaded carbon from the main column and the load of new carbon into the last column.

The order of heap leaching dump forming on Archangelskoe field is accepted as follows (Fig.1): The mineral comes from the pelletizer unloading bin upon the truck conveyer to heap leaching area.

Just in front of the production are a pelletized ore is poured into the pneumatic-tired portable conveyer type KLP (КЛП)-650(800)-3,0 (GOST R 51803-2001). Then with the system of similar portable conveyers the ore comes on the stacker. The radial spreader forms then the fragment of spoil dump with the height of 3 meters and 1200 full-circle. After wards with the shift of telescopic boom the layer from 3 to 6 meter is being formed. At the closing stage of dumping the pile layer of 6-9meter is being formed.

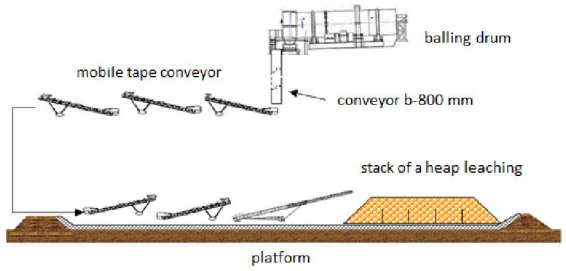

Fig.1. The packing scheme of ore pile with the usage of stacker and portable conveyers

Such a sequence of ore packing is aimed at the reducing of material segregation and achieving of pile homogeneity. When the forming of U-shaped segment with the width of 4-5 meters and height 9 meters is finished, the portable conveyers are being shifted, the stacker is removed to the pile formation axis and the packing cycle repeats itself.

Operational delays of ore processing, connected to the shift of transporters and stacker, can be significantly decreased by the usage of special transporter of "hopper" type; however there is no fully-featured "Hopper" user experience in Russia.

The principal technological scheme of heap leaching is demonstrated on Fig. 2.

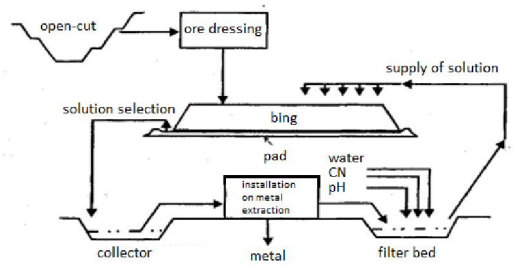

Fig .2. The principal technological scheme of gold heap leaching.

One of the ways of heap leaching improvement is the size reduction of buck material that correspondingly leads to the need of shift to the autogenous grinding mills from standard ones. Such a grinding mill of type "Barmac" provides grinding granularity of 3,5 mm and less. This type of mill is wide leased in "McLein" opencast, Nevada State.

Grinding stage hard ware circuit is demonstrated on Fig.3.

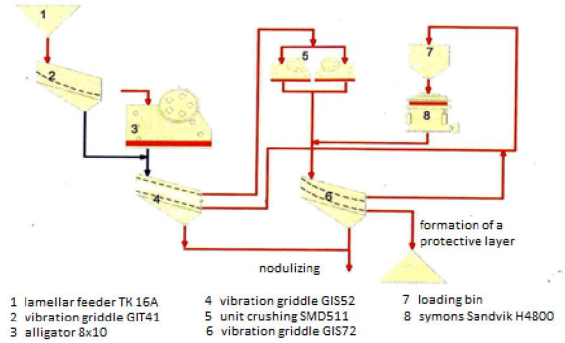

Fig .3. Grinding stage hard ware circuit

"KND Humboldt SegarAG" (Germany) has recently put in to service gyratory breakers which not only mill material, but also make tiny fractures in the ore, what leads to the increase of leaching speed and to the escalation of gold recovery. In comparison with other grinders they consume less energy. Their usage also helps reduce flow of binding substance and get sustainable flow roll.

The grinders work open-cycle and in front of them there are banana-type screens of "Nordberg" Company installed (in order to preliminary remove fine material). The screens of this type are characterized by the high work effectiveness within significantly fluctuating loads.

The presence of special buffer store for shattered ore (with the capacity of 41 000 t) between first and second ragging stages minimizes the delays of winning and processing equipment.

Within the ore processing scheme, the ore will undergo the two-staged granulation of minus 10 mm class with the binding substance - cement, after what the prepared ore substance is being packed by stacker on the read-made water-proof basement. Such water-proof basement consists of earthen-membranous screen, as well as of underlying layer of protective sandy soil.

The enormous progress is achieved in methods of heap leaching piles formation [5]. The processes of pile formation, as well as ore processing und moistening are the main factors of the successful leaching performance. When imperfect processes of pile formation are used, the strong material segregation takes place and firm ore areas emerge that leads to the increase of leaching time and stipulates low gold and silver recovery.

In practice there are 3 ways of pile packing to be used depending on the raw material type. Firm material that doesn't contain a big quantity of fine sizes demands the method of filling by hoppers accompanied by heavy crawler dozer which aligns the surface after what the subsoiling is performed.

In case if ore is unsound and pelletized the method of accurate filling is practiced. After the leaching of first layer within the frames of both methods the further layers would be packed. The most implied are the methods of conveyer processing which were initially mastered at the "Ortiz" mine in New Mexico. The material is being unloaded from the bunker or drum granulator onto the main conveyer, from where with the help of intermediate conveyers it goes to the self-powered packing conveyer.

The last method is used for the same type of ore which is used for the accurate filling method. The system influences the ore mass being packed into pile minimally. As for the USA´s practice experience, the pile there is frequently filled in with 50 up to 300 thousand tones of ore. Several sites exploit permanently increasing grounds with the height of pile 30-50 m. The productivity of heap leaching machines is usually hovers around from 30-50 thousand to 0,5-1,0 million tones of ore annually, and in specific cases to 10-18million tones annually ("Gold Quarry", "Round Mountain" mines, USA).

In order to create the ground of heap leaching piles one needs to perform following digging works (Tab.1).

The basement of pile is being layered with the product solution gathering facility, which consists of several collectors providing the removal of drained solutions from under the pile [6].

These collectors are connected with the main gravity collectors, which lead to the collectors of gold-containing solutions.

Already with the filling of first piles, the montage of through-irrigation system, meant for the

supply and random distribution of irrigated solution over the surface takes place. Within the further filling the system of irrigation will be increased.

Table 1. Digging works

work package	quantity of work	operations period 2010
Construction of technological and on-site roads		
Dumping of technological drives by overburden breeds	50 thousand m^3	50 thousand m^3
Heap leaching map construction		
Mechanical loosening of soil of 1-4 categories. Movement by the bulldozer on distance to 50 m	200 thousand m^3	200 thousand m^3
Mechanical loosening of soil of 1-4 categories. Movement by the bulldozer on distance to 100 m	100 thousand m^3	100 thousand m^3
Loam production	60 thousand m^3	60 thousand m^3
Loam transportation from a pit. Transportation length – 14 km	60 thousand m^3	60 thousand m^3
Alignment and loam consolidation	60 thousand m^3	60 thousand m^3
Sand delivery for formation of a protective layer. Sand laying by the wheel loader. Layer alignment manually.	10,5 thousand m^3	10,5 thousand m^3
Construction of soil capacities		
Mechanical loosening of soil of 1-4 categories	80 thousand m^3	80 thousand m^3
Loading by the excavator (the return shovel). Driving in two ledges on three meters. Depth – 6 m. Slope bias – 1:3.	35 thousand m^3	35 thousand m^3
Soil transportation on distance of 1 km	35 thousand m^3	35 thousand m^3
Construction of shop of hydrometallurgy, warehouses, auxiliary constructions		
Mechanical loosening of soil of 1-4 categories	18 thousand m^3	18 thousand m^3
Movement by the bulldozer on distance to 50 m	14 thousand m^3	14 thousand m^3
Loading by the excavator (the return shovel)	4 thousand m^3	4 thousand m^3
Soil transportation on distance of 0,5 km	4 thousand m^2	4 thousand m^2

At the same time it is planned to use the system of sub-artesian emitters (drop irrigation). The main advantage soft his system are the opportunity of precise regulation of solution input on to the ore pile, its random distribution upon the pile surface and operational integrity.

Gained in the process of ore cyanation gold-containing solutions will be given in sorption columns for the gold's layer up on the active coal [7-10]. The columns are equipped with the drainage valves, regulating the feeding of solutions and with the air-lifts, moving-in the coal.

In order to increase the recovery of gold out of product solutions and to provide the needed productivity of heap leaching the chain of sorption is being installed. This chain consists of 3-6 columns (according to the growth of productivity). The riser flow maintained optimal speed in columns is 25-30 m^3/h what provides the proportion of feed line diameter and column, columns' level difference and original solution feed volume control.

The standard operating procedure foresees the control of effectiveness of gold precipitation onto the carbon, according to the content of gold in sorption areas [6]. With the increase of gold concentration in those areas more than 0,1mg/lit is planned to reshuffle the carbon with the output of loaded carbon from the main column and the load of new carbon into the last column.

Barren solutions after the preliminary screening as well as the sodium cyanide and pH correction with be led to the weak solutions container and then to the ore pile irrigation. Loaded with gold coal will be ordered to GRP JSC "Vasil'evskiy rudnik" to the factory site of desorption and regeneration.

Based on heap leaching technical regulations with the given effectiveness of 500000 tones annually, the quantity of loaded carbon for the process of desorption at GRP JSC "Vasil'evskiy rudnik" will amount to 1 tone a day.

According to the year 2009´sstatisticsthedesorption plant productivity amounted to 460 tones of carbon, that is 1,3 tones a day, correspondingly the average gold grade is 1 kg pro tone.

Here with the plant productivity of 1,3 tones a day is maximum in the process of desorption.

There is an often situation in the practice of goldfields development when gold ore, taking that it is rich but little, can be adequately processed at GRP instead of in-place heap leaching performing.

In order to maintain the stable work of GRP and provide the loaded coal desorption from heap leaching, the optimal variant is to buy the additional desorption and electrolysis plant, similar to one already running at the current GRP. The producer is – ZHANG GOLD TECHNOLOGY CO LTD (CHINA).

Besides, there is a need to buy and install the following additional equipment:

1. Acid treatment storage tank, type SXL-1000 – 1piece
2. Disrober V-2,1m3 JKZ 7545 – 1piece
3. Electrolysis cell type DIC 2120 – 1piece
4. Electrical heater 60 kW PRQ 32-50-160 – 2 pieces.
5. Filter GLQ-1500.
6. Circulatory pump PBCG 32-50-160 – 2 pieces
7. Isolation valves
8. Pipelines
9. Desorption and electrolysis control boxes.

The production plan is given in Table 2.

Table 2. The production.

		2011	2012	2013	2014	Total
Backfilling	Thousand t	500	500	500	419	1919
Gold content	g/t	1,13	1,56	1,78	1,17	1,42
Gold content	kg	567	782	889	489	2726
Recovery	%	70	70	71	74	71
finished metal	kg	395	551	633	361	1940

GRP conditioning tank sallow desorption process take place in two installations. Acid

treatment and reactivation of coal will be performed on the current GRP equipment.

Throughout recovery of metal from the ore, given to the plot for 2011 and 2012 years, will amount to 70%, and further according to the order - 71%.

The ore is out in to the plot from the mid May till October (Table 3).

Table 3. The ore is out in to the plot from the mid May till October.

Cyaniding		2011								
		May	June	July	Aug.	Sept.	Okt.	Nov.	Des.	Year
Phase 1	%	15,13	30,72	30,71	30,71	30,70	15,11	-	-	27%
Phase 2	%	-	26,34	53,47	53,46	53,45	53,45	26,30	-	47%
Phase 3	%	-	-	33,06	67,12	67,11	67,10	67,09	33,01	59%
Phase 4	%	-	-	-	37,54	76,22	76,21	76,20	76,19	67%
Phase 5	%	-	-	-	-	40,34	81,91	81,90	81,88	73%
Robbed-out (gold)	Kg	15,13	41,92	60,19	71,59	79,00	66,28	39,62	21,50	395,23

The end product of heap leaching is the gold-contain coal, meant for the further gold recovery and coal regeneration at GRP capacity in place.

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