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Belgrade, Serbia, June 17-19, 2015

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THE MODELS OF OPTIMIZATION FOR INCREASING OF COPPER AND GOLD RECOVERIES IN BUCIM MINE

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Abstract: The increasing in the chalcopyrite copper Bucim mine are gone forward to renewed reagent regime, including and involving new reagents for increased recovery of copper and gold. The optimization and mathematical linear are good example for improvement of industrial recoveries in flotation circuit. Nevertheless, the choice between flotation and new leaching or bioleaching method are challenge for future.

The optimization techniques, for matting the mathematical model and adequate model for carried out investigations, by means of tables and figures will show the optimal quantity in reagent regime (collectors), particle size, flotation time, rougher flotation, conditioning time etc.

Keywords: Collectors, Flotation time, Optimization, Reagent regime, Particle size.

1.General principles

The previous carried out laboratory investigations with application of the new collectors CYTEC and frothers confirmed that there is possibility for significantly improvement of the gold recovery with same copper quality and decreasing of the CaO consumption. The investigations with reagents Aerophine 3404, Aero XD 5002 and frother OP-F49 in the previous period (2010/11/12/13) were very short because of the low quality and variations of the ores. Variations of the ore from 0.15-0.22%Cu, instability of the flotation and other problems in the flotation process. The combination of the Aerophine 3404, KEX:KBX= 1:1, NaIPX, SKIK Bz 2000, in the different points of the flotation process gave significantly better results that early. The process was prolonged with pH=10.5 and the point of addition of CaO was at the hydro cyclone (70%) and 30% in the flotation process. The conclusions of these investigations were very heavy for sure confirmation, bur the obtained results were close to the previous results by standard conditions (specially for Au), may be better but not significantly. The Au content in the ore was од 0,19-0,29 gr/t, in the concentrate 8-12,3 gr/t, with Au recovery from 45-55% (some appearances up to 60%), but the copper recovery in the standard interval. Considering these investigations in laboratory and industrial real conditions may be concluded that:

- The instability and relative short period of investigations in the real conditions have contributed for obtaining the technological parameters closed to the standard conditions,
- As a result of the good regrinding, it was very heavy to clean the rough concentrate Cu/Au,
- Using higher pH, higher than standard in the rougher flotation (elimination of pyrite flotation) by Aerophine 3404, it will be expected higher quality and content of Cu/Au,
- In the existing real conditions of flotation at pH 11,0-11,6 and consumption of Aerophine 3404 (AP3404) from 18-22 gr/t, together with change of adaptive changeable reagent regime by different collectors (the combination from Aerophine 3404, KEX:KBX, NaIPX),
- The prolonged changes of the reagent regime with contemporary addition of new reagents (Bz 2000 = 4-8 gr/t + KEX:KBX=1:1 = 8-4 gr/t, total 12 gr/t) in the grinding cycle, together with addition of NaIPX in the condiotioner with 8-10 gr/t, in the flotation process (rougher and controlled flotation) with 2-4 gr/t, or total addition of 14 gr/t NaIPX,

The tests R1-R6 are related to the ore grindibility in the presence of the BZ2000 (7 gr/t), conditioning time (6 min.) with BZ2000 (5 gr/t) + DowF (10 gr/t) after 4 min., rougher flotation (4 min.), and scavenging flotation (4+4 minutes) (NaIPX 6+4 gr/t + DowF 5+5

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gr/t), pH=11.75 and collector 22 gr/t. The tests R7-R10 are related for the ore grinding in the presence of the KEX:KBX= 8 gr/t, conditioning time of (6 min.) with BZ2000 (4 gr/t) + DowF (10 gr/t) after 4 minutes, rougher flotation (4 min.), and scavenging flotation (4+4 minutes) (NaIPX 8+4 gr/t + DowF 5+5 gr/t), pH=24 and collector=24 gr/t. The tests R11-R18 are related for the grinding ore in the presence of KEX:KBX= 6 gr/t, conditioning time of (6 min.) with KEX:KBX= (4 gr/t) + DowF (10 gr/t) after 4 minutes, rougher flotation (4 min.), and scavenging flotation (4+4 minutes) (NaIPX 8+4 gr/t + DowF 5+5 gr/t). and variants with condition 6 minutes with BZ2000 (4 gr/t) + dispergator (50 gr/t), ph=11.8 and collector=22 gr/t or variant with BZ2000 in all existing phases: conditioning, rougher and control flotation. The tests R19-R26 are related for grinding ore in the presence of BZ2000 = 7 gr/t, conditioning time (6 minutes) with BZ2000 (5 gr/t) + DowF (10 gr/t) after 4 minutes, rougher flotation (4 minutes), and control flotation (4+4 minutes) (NaIPX 6+6 gr/t + DowF 5+5 gr/t), with variants with conditioning (6 minutes) with BZ2000 (4 gr/t) + dispergator (100 and 150 gr/t), pH=11.75 and collectors=24 gr/t (R-19 to R-22) and collectors=20 gr/t (R-23 to R-26), or variant with BZ2000 in all existing phases: conditioning, rougher and control flotation.

The group of tests (R1÷R-6), (R7÷R-10), (R11÷R-18) and (R19÷R-26) are carried out in the laboratory conditions showing the satisfactory results with increasing of the grinding time, but other results are at the level of the industrial obtained result (application of the different collectors and combination of the different types of collectors at the standard pH value). The tests A1-A16 are carried out in the different conditions and different reagent regime and collectors, conditioning, rougher and control flotation with the reagent regime shown at the tables.

Table 1. Investigated conditions for flotation for copper - plan experiments (DOE)

Test	Collectors, type	-200#, %	Time, min.
R-1	**BZ 2000+BZ2000+NaIPX**	42.90	15
R-2	**BZ 2000+BZ2000+NaIPX**	44.90	15
R-3	**BZ 2000+BZ2000+NaIPX**	48.10	18
R-4	**BZ 2000+BZ2000+NaIPX**	49.10	18
R-5	**BZ 2000+BZ2000+NaIPX**	54.30	21
R-6	**BZ 2000+BZ2000+NaIPX**	55.60	21
R-7	**KEX:KBX + BZ2025+NaIPX**	50.00	
R-8	**KEX:KBX + BZ2025+NaIPX**	50.00	
R-9	**KEX:KBX + BZ2025+NaIPX**	50.00	
R-10	**KEX:KBX + BZ2025+NaIPX**	50.00	
R-11	**KEX:KBX KEX:KBX+NaIPX**		
R-12	**KEX:KBX KEX:KBX+NaIPX**		
R-13	**KEX:KBX KEX:KBX+NaIPX**		
R-14	**KEX:KBX KEX:KBX+NaIPX**		
R-15	**BZ 2000+BZ2000+NaIPX**		
R-16	**BZ 2000+BZ2000+NaIPX**		
R-17	**BZ 2000+BZ2000+BZ2000**		
R-18	**BZ 2000+BZ2000+BZ2000**		
R-19	**BZ 2000+BZ2000+NaIPX**		
R-20	**BZ 2000+BZ2000+NaIPX**		
R-21	**BZ 2000+BZ2000+NaIPX+d**	d – dispergator 100gr/t	
R-22	**BZ 2000+BZ2000+NaIPX+d**		
R-23	**BZ 2000+BZ2000+NaIPX**		
R-24	**BZ 2000+BZ2000+NaIPX**		
R-25	**BZ 2000+BZ2000+NaIPX+d**	d – dispergator 150gr/t	
R-26	**BZ 2000+BZ2000+NaIPX+d**		

Table 2. Tests with a plan experiments on copper

Tests	Content, Cu%			Recovery, Cu%
	r	**k**	**j**	K
R-1	0.190	**2.40**	0.038	**80.90**
R-2	0.175	**3.42**	0.043	**78.40**
R-3	0.186	**2.16**	0.034	**83.80**
R-4	0.194	**2.22**	0.027	**87.10**
R-5	0.211	**3.38**	0.022	**90.10**
R-6	0.237	**3.82**	0.024	**90.45**
R-7	0.249	**4.00**	0.031	**88.25**
R-8	0.251	**6.40**	0.031	**88.00**
R-9	0.250	**4.60**	0.031	**88.20**
R-10	0.247	**4.82**	0.029	**88.80**
R-11	0.282	**8.60**	0.077	**76.30**
R-12	0.308	**8.40**	0.075	**76.30**
R-13	0.292	**8.00**	0.070	**76.70**
R-14	0.290	**8.40**	0.069	**76.80**
R-15	0.297	**7.60**	0.075	**75.90**
R-16	0.301	**8.40**	0.072	**76.70**
R-17	0.301	**5.40**	0.083	**73.50**
R-18	0.297	**8.20**	0.082	**73.60**
R-19	0.180	**3.40**	0.025	**86.70**
R-20	0.178	**3.46**	0.023	**87.60**
R-21	0.187	**4.88**	0.023	**88.10**
R-22	0.187	**4.22**	0.025	**87.10**
R-23	0.184	**2.10**	0.031	**84.40**
R-24	0.196	**3.30**	0.030	**85.40**
R-25	0.194	**3.52**	0.032	**84.00**
R-26	0.203	**3.64**	0.033	**84.50**

Table 3. Investigated conditions for flotation for gold - plan

Tests	Collectors, typ	Coll., gr/t
A-1	**BZ 2000+Naskol+NaIPX**	22
A-2	**BZ 2000+Naskol+NaIPX**	22
A-3	**KEX:KBX +NaIPX**	18
A-4	**KEX:KBX + NaIPX**	18
A-5	**KEX:KBX +NaIPX**	22
A-6	**KEX:KBX + NaIPX**	22
A-7	**KEX:KBX+BZ 2000 +NaIPX**	22
A-8	**KEX:KBX+BZ 2000 +NaIPX**	22
A-9	**Naskol+NaIPX**	22
A-10	**Naskol+ Nal PX**	22
A-11	**KEX:KBX + Naskol**	22
A-12	**KEX:KBX + Naskol**	22
A-13	**KEX:KBX + Nal PX**	16
A-14	**KEX:KBX + Nal PX**	16
A-15	**KAX + Nal PX**	22
A-16	**KAX + + Naskol + Nal PX**	22

Table 4. Tests with a plan experiments on gold

Tests	Content, (k ,r, j)			Recovery (K)
A-1	**5.700**	0.281	0.170	**40.60**
A-2	**4.200**	0.279	0.170	**40.60**
A-3	**4.800**	0.278	0.160	**43.90**
A-4	**5.200**	0.264	0.150	**44.30**
A-5	**5.500**	0.320	0.110	**66.00**
A-6	**5.800**	0.390	0.120	**70.10**
A-7	**4.300**	0.308	0.100	**69.10**
A-8	**4.200**	0.261	0.090	**68.80**
A-9	**4.000**	0.303	0.100	**68.60**
A-10	**4.000**	0.339	0.120	**66.90**
A-11	**3.600**	0.269	0.110	**63.90**
A-12	**4.200**	0.272	0.110	**63.00**
A-13	**4.900**	0.335	0.120	**65.80**
A-14	**5.100**	0.391	0.130	**68.60**
A-15	**3.400**	0.165	0.025	**85.80**
A-16	**3.700**	0.242	0.050	**85.90**

Table 5. Investigated conditions for flotation - plan experiments (DOE)-50% collectors 2013/14

Tests	Collectors, type	Coll., gr/t	pH
T – 1	**BZ+ KEX+ KBX+ NaIPX**	22	11.8
T - 2	**BZ+ KEX+ KBX+ NaIPX**	22	11.8
O'-1	**Aerophine (3404+5002)**	16	11.0
O'-2	**Aerophine (3404+5002)**	16	10.0
O'-3	**Aerophine (3404+5002)**	18	11.0
O'-4	**Aerophine (3404+5002)**	18	10.0
O'-5	**Aerophine (3404+5002)**	20	11.0
O'-6	**Aerophine (3404+5002)**	20	10.0
O'-7	**Aerophine (3404+5002)**	22	11.0
O'-8	**Aerophine (3404+5002)**	22	10.0
O'-9	**Aerophine (3404+5002)**	16	10.5
O'-10	**Aerophine (3404+5002)**	22	10.5

Table 7. Investigated conditions for flotation - plan experiments (DOE)-70% collectors 2013/14

Tests	Content, Cu%	Recovery, Cu%
	k	R_{Cu}
T – 1	2.3	83.4
T - 2	2.8	85.6
O-1	20.54	**88.20**
O-2	20.68	**87.60**
O-3	20.85	**87.60**
O-4	20.98	**89.00**
O-5	20.77	**91.45**
O-6	20.90	**90.10**
O-7	21.21	**90.00**
O-8	21.44	**92.30**
O-9	21.10	**92.90**
O-10	20.46	**92.90**

Table 8. Tests with a plan experiments on gold 2013/14

Tests	Content, (k)	R Au (%)
T – 1	1.40	56.1
T - 2	1.49	49.8
O-1	2.20	**40.80**
O-2	2.45	**44.20**
O-3	1.95	**46.60**
O-4	2.50	**38.40**
O-5	2.80	**40.00**
O-6	2.25	**39.60**
O-7	1.90	**51.05**
O-8	2.45	**45.00**
O-9	1.95	**42.50**
O-10	2.75	**42.70**

Table 9. Tests with a plan experiments on copper 2013/14

Tests	Content, Cu%	Recovery, Cu%
T – 1	2.3	83.4
T - 2	2.8	85.6
O'-1	20.55	**90.50**
O'-2	21.25	**89.75**
O'-3	20.70	**90.25**
O'-4	21.30	**91.50**
O'-5	21.70	**89.50**
O'-6	20.40	**89.60**
O'-7	20.75	**91.90**
O'-8	20.55	**90.50**
O'-9	22.80	**91.05**
O'-10	22.50	**91.70**

Table 10. Tests with a plan experiments on gold 2013/14

Tests	Collectors, type	Coll. gr/t	pH
T – 1	**BZ+KEX+KBX+NaIPX**	22	11.8
T - 2	**BZ+KEX+KBX+NaIPX**	22	11.8
O-1	**Aerophine 3404**	16	10.5
O-2	**Aerophine 3404**	16	9.5
O-3	**Aerophine 3404**	18	10.5
O-4	**Aerophine 3404**	18	9.5
O-5	**Aerophine 3404**	20	10.5
O-6	**Aerophine 3404**	20	9.5
O-7	**Aerophine 3404**	22	10.5
O-8	**Aerophine 3404**	22	9.5
O-9	**Aerophine 3404**	20	11.5
O-10	**Aerophine 3404**	22	11.5

Tests	Content Cu%	R Au (%)
T – 1	1.40	56.1
T - 2	1.49	49.8
O'-1	1.56	**39.90**
O'-2	1.49	**55.50**
O'-3	1.47	**49.80**
O'-4	1.49	**52.00**
O'-5	1.55	**52.10**
O'-6	1.78	**45.30**
O'-7	2.55	**38.80**
O'-8	2.15	**39.00**
O'-9	2.15	**37.70**
O'-10	1.95	**38.80**

3.Results and discussion

According to the previous investigations and obtained results from these investigations and tests for the Bucim mine ores, these particular investigation are carried out by means of experiment plans, laboratory investigations etc. These investigations show advanced approach for eventual optimization of the flotation process from useful raw material or chalcopyrite ores with possibility of obtaining the optimal results.

CONCLUSION

In this paper is shown practical applicative optimization techniques with formatting the model for adequate reagent regime for carried out investigations. Obtained tabular results will show the optimal quantity in reagent regime (collectors), particle size, flotation time for rougher flotation, conditioning time, some addition of special reagents etc.

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