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VOLUME I

Edited by

Nadežda Ćalić, Ljubiša Andrić,
Igor Miljanović, Ivana Simović

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Congres Organizers and Publishers:

MINING INSTITUTE BELGRADE
11080 Belgrade, Batajnički put 2
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ACADEMY OF ENGINEERING SCIENCE OF SERBIA
Department for Mining, Geology and Systems Sciences
11000 Belgrade, Kraljice Marije 16
Tel: + 381 11 3370652, +381 64 11 27 533,
e. mail: ains@ains.rs, http://www.ains.rs

UNIVERSITY OF BELGRADE
11000 Belgrade, Studentski trg 1
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Foreword

Practically, all human societies depend on the availability and use of mined products. Mining and mineral processing has played a vital part in the history and economy of the Balkans.

In the world, mineral processing was an art till the 1920s, when it started to become a science. The achievements of fundamental science enabled the explanation of phenomena in the processes of mineral processing, or they started from fundamental science to come to an appropriate solution in mineral processing. In many respects mineral processing becomes fundamental science.

Balkan countries have more or less rapidly accepted innovations in the field of mining and mineral processing.

Generations of professionals from Balkan trained on the tradition of mining schools, afterward universities, (Schemnitz established 1702, Jachimov 1716, Banska Štiavnica 1725, Jekatarinburg 1730, L' Ecole Polytechnique 1794 in Paris, Politehnika in Prague, and certainly the most famous Bergakademie Freiberg founded in 1765, and much later, universities in the United States and Soviet Union) contributed to today's level of development of mineral processing, and contributed to the quality of studies of mineral processing, both in the world, and so in the Balkans.

After the Second World War in the Balkans a large number of universities, faculty, institutes and laboratories of mining industry with special departments for mineral processing were opened. In many Balkan countries remarkable impact on development of mineral processing had Russian and American schools.

A great number of researchers and specialists in Balkan area were occupied for more decades by the research in mineral processing. The goal of this research was establishment of concentration process in industry, capacity enlargement, optimization of processes, increase the energy efficiency of processes and devices, introduction or construction of new machines. Based on those activities, Balkan mining has been evolving and continuously operates up to nowadays. As a result, in the Balkan countries appeared a significant number of successful researchers in the field of mineral processing. They founded the first Balkan mineral processing Committee (1973), and then the Balkan Academy of Mineral Technology.

Balkan Congress on Mineral Processing is beening held for 40 years. Participation in the work of the Committee of the Balkan mineral processing is a strong link between the development of the science and profession with global trends, and it provides the possibility of establishing direct contacts between researchers, designers, equipment manufacturers and investors from the region and around the world. It has already become tradition to hold every second year an international event, "Balkan Mineral Processing Congress," in which participate, not only Balkan experts, than experts from the whole world.

Maintenance XVI Balkan Congress on Mineral Processing in Belgrade from 16 to 21 June 2015 is held under the auspices of the Ministry of Mines and Energy of Serbia, with the financial assistance of the Ministry of Republic of Serbia. Incomparably greater financial support Congress had from sponsors who strongly support the mineral processing industry all over the world.

Prof. dr Nadežda Ćalić

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SOLID WASTE AND WASTE WATER TREATMENT and SOIL REMEDIATION

THE POSSIBILITY OF APPLYING CONTEMPORARY FLOTATION COLLECTORS TO IMPROVE THE TECHNOLOGICAL EFFECTS OF PROCESSING COMPLEX ORE WITH PYRITE HIGH CONTENT FROM THE UPPER LAYERS DEPOSIT " VELIKI KRIVELJ”

***Jelena Čarapić, *Vladan Milošević, *Zoran Bartulović, *Dejan Todorović, *Sonja Milićević**

*Institute for Technology of Nuclear and Other Mineral Raw Materials, 86 Franchet d’Esperey Blvd, 11000 Belgrade, Serbia

Abstract:

This paper presents part of a complex technological flotation investigations of copper ore from the upper layers deposit "Veliki Krivelj". Ore copper content is in the average range and sulfur content is significantly higher than usual. High content of sulfur derives from the increased content of mineral pyrite, which is very difficult to depress in flotation. Because of this, it is very difficult to control and to stabilize flotation process and technological results are below the planed one. In order to increase the flotation process efficiency and the copper concentrate quality, technological laboratory tests were conducted in the ITNMS Mineral Processing laboratory. Investigations were undertaken with an aim to examine the possibility of applying new collector structures (manuf. Flomin) which are implemented effectively for the ores with similar features in the World. The results in paper presents technological effects achieved by applying the tested collector and compared to the reagent that is used in the Flotation Plant "Veliki Krivelj ".

Because of the good results, which showed that the tested collector has a high selectivity for copper, it was decided to be tested on an industrial scale.

Key words : flotation,copper, Veliki Krivelj,colectors, Flomin

INTRODUCTION

To maximize the exploitation and increased processing capacity of open pit „Veliki Krivelj“ there is a need for mining ore from this deposit upper layers. Ore characteristics from the open pit "Veliki Krivelj" upper layers are different from the deposit other part ore characteristics, especially from a technological point of view. The chemical composition from this parts causes major problems in prosessing, and resulting the final product lower quality and recovery than the planned ones. Although the copper content is in the whole deposit average range, a significant difference occurs in the much higher sulfur content in the open pit "Veliki Krivelj"upper layers ore from whole deposit average content (over 4%).

The high content of sulphur points to the increased content of mineral pyrite. This mineral is very difficult to depress during copper minerals flotation process and all the above directly affects the the flotation process efficiency to produce the required quality Cu concentrate.

This paper presents part of a complex technological flotation investigations on copper ore from the deposit "Veliki Krivelj" upper layers. Investigations were undertaken with an aim to examine the possibility of applying new collector structures with high selectivity for copper. During the tests the following reagents are applied : PEX collector (currently in use), collector manufacturers Flomin C 2440 and D-250 as frother.

The results achieved during the tests and suggestions for improving the copper ore concentration technological process from the deposit upper layers in Flotation Plant " Veliki Krivelj " are presented in this paper.

CHARACTERISTICS OF ORE SAMPLE

All technological tests were performed in the Mineral processing laboratory ITNMS on the sample which represents geological exploration drilling core from deposit “Veliki Krivelj” part intended for exploitation in the following period.

Physical properties of ore sample

- density **γ** = 2750 kg/m^3;
- pH, 68% of solids, pH=4.1
- moisture W=5 %;
- Bond work index W_i = 13.14 kWh/t;
- particle size distribution after crushing (Figure 1).

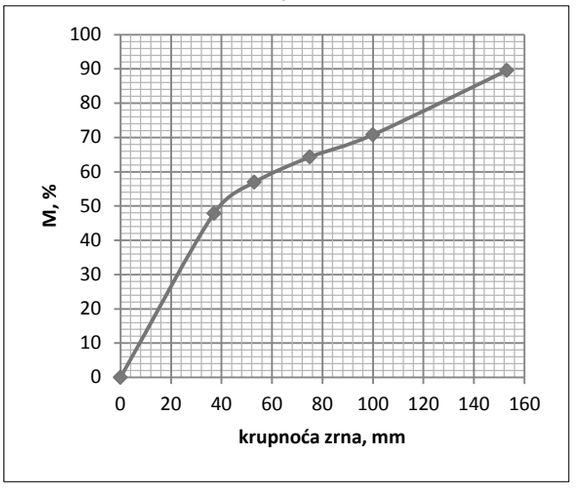

Figure 1 Granulometrijski sastav izlaza iz mlina – kumulativna kriva proseva

Chemical composition

Table 1, Chemical composition of ore sample

Ore sample from pyrite-rich parts of deposit			
Component	Cu	S	Fe
Content,%	0.21	5.81	6.12

Mineral composition

Mineralogical analysis was performed with immersion method , microscopic ore method and the method of electron microscopy scanning at the following size class: -0.037+0 mm; -0.053+0.037 mm; -0.075+0.053 mm; -0.1+0.075 mm; -0.3+0.1 mm; -0.83+0.3 mm; -1.6+0.83 mm; +1.6 mm).
Mineralogical composition of this ore sample is: pyrite, chalcopyrite, chalcocite, bornite, covelline, cuprite, magnetite, pyrrhotite, hematite, rutile, molybdenite, limonite, sphalerite, galena, cassiterite, malachite. Gangue minerals are feldspar (K-feldspar and plagioclase), quartz.
The most abundant sulphide mineral is pyrite 13,7, chalcopyrite is presented with amount of 0,7% and other ore minerals are presented in the sample to 0.2%.

EXPERIMENTAL

During the implementation of technological laboratory tests on ore samples it was performed several series of flotation test using the following flotation reagents :
• Collector PEX which is currently in use, and this test is labeled as "zero " , test which is a standard for comparison
• collector manufacturer Flomin 2440

Experimental procedure

A. Grinding

- sample mass Q = 680.0 g
- 68.0 % solids
- tm = 5.75 min
- grinding fineness 58.0 % - 0.074 mm
- pH= 9.2

B. Conditioning

- t_k = 6.0 min
- 28.0% solids
- pH = 10.5

reagents consumption

- collector PEX 50 % of total dose
- collector C - 2440 50 % of total dose 15.0 g / t

C. Rough flotation

- tf = 20.0 min
- pH= 10.5

reagents consumption

- frother DOW 250
- collector PEX 25+25% %(5,10 min) of total dose 15.0 g/t
- collector C - 2440 25+25% % (5,10 min) of total dose 7 g/t

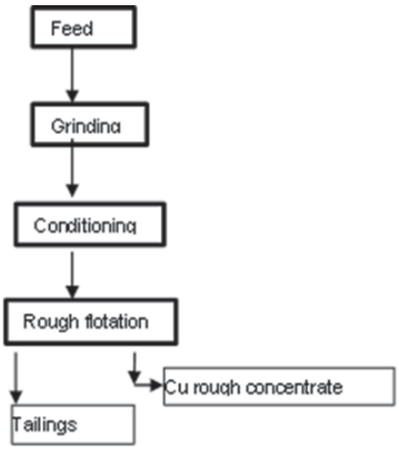

Figure 2, Experimental procedure

Technological results

Mass content of the product concentration , copper recovery , sulfur distribution, copper content , sulfur content , iron content obtained in "zero " flotation test are presented in Table 2.

Table 2. Material balance – collector PEX

Prod.	M, %	Cu, %	S, %	Cu rec.,%	S rec.,%	Fe,%
Feed	100.00	0.21	5.81	100.00	100.00	6.21
Cu RC	12.40	1.29	37.79	76.18	80.67	43.65
Tail.	87.60	0.06	1.28	23.82	19.33	0.81

From the series of experiment, made in order to improve the technological results, experiment which gave the best results was isolated, and that results are presented in Table 3.

Table 3. Material balance – collector Flomin 2440

Prod.	M, %	Cu, %	S, %	Cu rec.,%	S rec.,%	Fe,%
Feed	100.00	0.21	5.81	100.00	100.00	6.21
Cu RC	5.76	2.78	15.29	76.24	15.15	29.88
Tail.	94.24	0.05	5.23	23.76	84.85	4.67

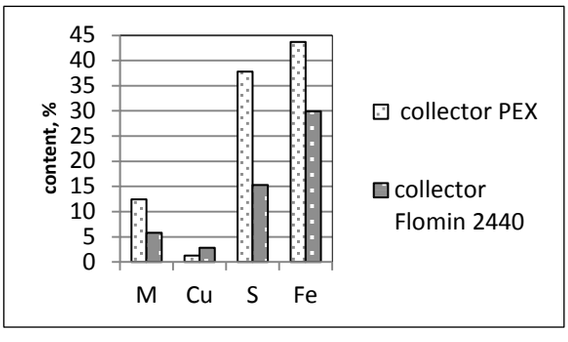

Figure 3, Mas, Cu, S, and Fe content

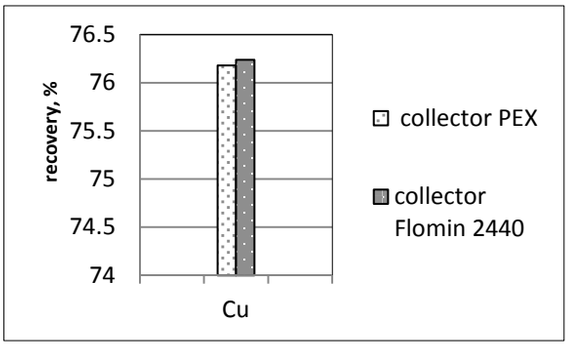

Figure 4, Cu, recovery

Rational mineralogical analysis of both concentrates (based on the chemical analysis of copper, sulfur, iron and mineralogical composition of ore sample) is present in Table 4 and Figure 5.

Table 4. minerals, content

Product	*collector PEX*	*collector Flomin 2440*
Cu RC		
$CuFeS_2$,%	3.73	8.03
FeS_2,%	91.09	58.78

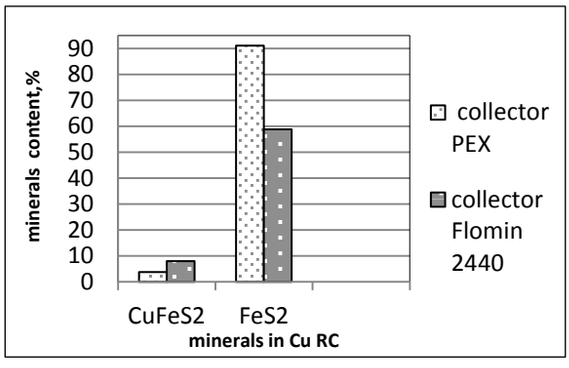

Figure 5, minerals, content

DISCUSSION

After completed laboratory tests and technological results analysis, it can be concluded as follows:

The sample physico-chemical characterization indicates that: the sample is typical for ore deposit „Veliki Krivelj“; physical properties within the projected values range; considering chemical aspect, very poor copper with a very high sulfur and iron content. Due to these characteristics, this ore type is very problematic for copper sulphide minerals flotation concentration.

Increased sulfur and iron contents originating from pyrites, which was confirmed by mineralogical analysis. Processing practical experience of ores with such characteristics, indicates a continuing problem and considerably poorer copper mineral concentrations technological indicators, using the projected technological schemes and reagent regime. The main reason for this is significantly higher pyrite content of the projected value and physico-chemical processes at phase boundaries in flotation pulp which are a consequence of the collector affinity towards the sulfur hydrophobization in pyrite.

Ore flotation laboratory testing, according the technological scheme and conditions in flotation plant "Veliki Krivelj", confirm the quite poor

results and technological indicators for ore processing with high sulfur content. Zero experiment was performed using the collector KEX, following plant current scheme technological parameters. Achieved technological parameters are as follows:

- ✓ rough concentrate weight is 12,40%
- ✓ the rough concentrate copper content is 1,29%
- ✓ the rough concentrate sulfur content is 37,79%
- ✓ the rough concentrate copper recovery is 76,19%
- ✓ the rough concentrate sulfur distribution is 80,67%
- ✓ final concentrate copper content is 10,33%
- ✓ final concentrate copper recovery is 45,09%

It is obvious that the rough concentrate weight is extremely high ie. almost double the projected value. Having regard low copper and high sulfur content and sulfur distribution, it is clear that this rough flotation concentrate mass is a consequence of flotation sulfur carrier minerals i.e. pyrite. Satisfactory copper recovery is a concentrate mass participation product. Copper minerals concentration effects are extremely bad, as evidenced by the copper content and copper recovery in final concentrate. It can be stated that the use of xanthate based colectors for copper minerals concentration from ore with a high pyrite content can not be achieved better technological parameters from the displayed. The reason for this is the fact that xanthate based collectors thanks to its strong affinity towards sulphide minerals and may not be sufficiently selective. Therefore the optimal copper minerals concentration from this raw material can not be achieved.

Applying collector Flomin C2440 were achieved more favorable technological results from aspects of concentration process technical and technological conditions. Correlation between the concentration products mass proportion, copper and sulfur content in them and their distribution at process end are the primary advantage of this collector application. Achieved technological parameters are as follows:

- ✓ rough concentrate weight is 5,76%
- ✓ the rough concentrate copper content is 2,78%
- ✓ the rough concentrate sulfur content is 15,29%
- ✓ the rough concentrate copper recovery is 76,22%
- ✓ the rough concentrate sulfur distribution is 15,15%
- ✓ final concentrate copper content is 13,24%
- ✓ final concentrate copper recovery is 46,53%

CONCLUSIONS

- Technological results presented in this paper, definitely confirm that the application of current "Veliki Krivelj" technological plant schemes, in no case can not achieve better technological effects. It is concluded that, to improve the techno-economic parameters of this raw material processing, technological scheme that is designed and implemented at the facility "Veliki Krivelj" must be changed from the aspect reagent regime.
- Remarkable copper minerals flotation results were achieved by applying collectors from manufacturer Flomin, with a commercial label C 2440.
- Achieved results by applying of these collectors are much better than the results obtained in the plant by the designed scheme, and to some extent better than achieved results by use of all other tested collectors. The main reason for the achieved results difference by applying these collectors in relation to the other, lies in their high selectivity for copper minerals holders in relation to the pyrite. The essence is that their action mechanism is based on the affinity towards copper and not to the sulphide minerals, where belongs pyrite.
- Despite the fact that achieved results were significantly better by these collectors use than all the others, they do not reach the technological indicators optimal values level. The reason for this is, among other things, low copper content and high sulfur content in the feed ore. It is very interesting that all technological indicators values that are lower than projected and optimal, are consequences of primary concentrate low mass portion. This suggests that by these collectors application and the mass concentrates correction with quite high copper content and the concentration degree, can expect better techno-economic effects in the plant, where it is easier to perform certain products mass participation correction.

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