ISBN 978-86-82673-10-1

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Proceedings of
XVI BALKAN MINERAL PROCESSING CONGRESS
Belgrade, Serbia, June 17-19, 2015

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I

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Edited by

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Igor Miljanović, Ivana Simović

MINING INSTITUTE BELGRADE
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2015

XVI BALKAN MINERAL PROCESSING CONGRESS
BOOK OF PROCEDINGS

Editors: Prof. Dr. Nadežda Ćalić, Academy of Engineering Sciences of Serbia

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Congres Organizers and Publishers:

MINING INSTITUTE BELGRADE
11080 Belgrade, Batajnički put 2
Tel: + 381 11 21 99 277, fax: + 381 11 26 14 632,
e. mail: direktor@ribeograd.ac.rs, http://www.ribeograd.ac.rs

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e. mail: kabinet@rect.bg.ac.rs, http://www.bg.ac.rs

For the publishers: MSc Milinko Radosavljević, director, Mining Institute Belgrade

Printed by: Colorgrafx, Belgrade

Issued in: 2015.

Circulation: 300

ISBN: ISBN 978-86-82673-10-1 (MI)

CIP - Каталогизација у публикацији -
Народна библиотека Србије, Београд

622.7(082)

BALKAN Mineral Processing Congress (16th ; 2015 ; Belgrade)
Proceedings of XVI Balkan Mineral Processing Congress, Belgrade, Serbia, June 17-19, 2015. Vol. 1 / [congress organizers] Mining Institute Belgrade [and] Academy of Engineering Science of Serbia [and] University of Belgrade ; edited by Nadežda Ćalić ... [et al.]. - Belgrade : Mining Institute : Academy of Engineering Science of Serbia : University of Belgrade, 2015 (Belgrade : Colorgrafx). - VII, 589 str. : ilustr. ; 30 cm

Tiraž 300. - Str. VII: Foreword / Nadežda Ćalić. - Bibliografija uz svaki rad. - Registar.

ISBN 978-86-82673-10-1 (MI)

1. Ćalić, Nadežda [уредник] [аутор додатног текста]
2. Mining Institute (Belgrade)
а) Руде - Припрема - Зборници

COBISS.SR-ID 215731468

XVI BALKAN MINERAL PROCESSING CONGRESS

HELD UNDER THE AUSPICES OF THE MINISTRY OF MINING AND ENERGY, AND FINANCIALLY SUPPORTED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGICAL DEVELOPMENT OF REPUBLIC OF SERBIA

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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

The XVI BMPC Chair

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COPPER MINERALS FLOTATION COLLECTOR SELECTION FOR PROCESSING OF THE ORE FROM PYRITE–RICH PARTS FROM „VELIKI KRIVELJ“ DEPOSIT

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Abstract: Some parts of porphyry copper ore deposit "Veliki Krivelj" (Bor, Serbia) carry a high content of pyrite, which, with the existing technology of selective flotation, using potassium ethyl xanthate as copper minerals collector, results in low copper grade of final copper concentrate. Laboratory flotation tests were performed, with main goal to replace potassium ethyl xanthate, using other, more selective against pyrite collectors, while retaining other technological parameters under the existing flotation process. In this paper, the part of results from those experiments, using isopropyl ethyl thionocarbamate as collector to compare them to potassium ethyl xanthate, are presented. The study included the flotation experiments with different doses of collectors at different pH values, as well as experiments of flotation kinetics and cleaning of rough concentrate. Selectivity of those two collectors was measured watching sulfur grade and recovery in rough copper concentrate, obtained under the same conditions. Sulphur recovery in copper rough concentrate, produced using potassium ethyl xanthate was over 80% and Cu grade was 1,29%, while only 12-18% of sulphur recovery with about 3% of Cu grade was optained using isopropyl ethyl thionocarbamate, even at lower consuption. Both collectors produced rough concentrates with the similar Cu recovery, so this kind of selective collectors must be considered in case of processing this tipe of ore.

Keywords: copper, flotation, selective collectors, high pyrite content.

INTRODUCTION

Characteristics of ore from upper levels of the open pit "Veliki Krivelj" (Bor, Serbia) are different from the typical total ore deposit characteristics, especially from a technological point of view. The chemical composition of the mentioned parts causes major problems in prosessing, resulting the lower quality and recovery of the final product than the planned one. Although the content of copper is in the range of the average of the total deposit, a significant difference occurs in the much higher content of sulfur in the ore from the upper levels of the open pit "Veliki Krivelj" from average (over 4%).

The high content of sulphur points to the increased content of pyrite, which is very difficult to depress during flotation of copper minerals using potassium ethyl xanthate (PEX) as collector. All the above directly affects the efficiency of the flotation process to produce the required quality Cu concentrate. In order to examine the possibility of replacing the PEX with another collector, laboratory flotation tests were performed on upper level ore sample. The possibility of applying contemporary collector structures with increased selectivity on copper minerals against pyrite in flotation process was investigated by performing ore sample characterization and, later, crushing, grinding and flotation tests.

The possibility of applying contemporary collector structures with increased selectivity on copper minerals against pyrite in flotation process was investigated by performing ore sample characterization and, later, crushing, grinding and flotation tests. Selective collectore structures, applied in laboratory flotation tests to compare to PEX, have been suggested by investigators from chemical companies CYTEC, FloMin and FLORREA. In this paper, the part of results from those experiments, using isopropyl ethyl thionocarbamate (IET), with molecular formula $C_3H_7OCSNHC_2H_5$ as one of the best, are presented.

CHARACTERISTICS OF ORE SAMPLE

Ore sample was obtained by drill cutting material sampling method, from drills that were taken from pyrite-rich parts of deposit. Crushing was carried out through three stages, using jaw, con and roll laboratory crushers, to produce 100%-2mm grain size as laboratory ball mill feed. Crushed sample particle size distribution is presented in Table 1.

Grinding tests were performed for both 1kg and 3kg laboratory mill to produce 58%-0,075mm particle size. Those results are presented on Figure 1 and 2.

Part of sample was crushed to 95%-3,5mm grinding tests in standard Bond mill to determine Bond work index.

Physical properties of ore sample

-moisture W=5%

-density γ=2,750g/cm^3

-particle size distribution after crushing:

Table 1. Particle size distribution of crushed sample

Fraction, mm	M,%	ΣM,%↓	ΣM,%↑
+1,6	2,80	2,80	100,00
-1,6+0,83	15,66	18,46	97,20
-0,83+0,3	32,54	51,00	81,54
-0,3+0,1	21,04	72,04	49,00
-0,1+0,075	2,25	74,29	27,96
-0,075+0,053	4,13	78,42	25,71
-0,053+0,037	0,58	79,00	21,58
-0,037+0	21,00	100,00	21,00
Feed	100,00		

-Bond work index W_i=13,14kW/t

-grinding kinetics test were performed with 68% of solids, using both laboratory mills.

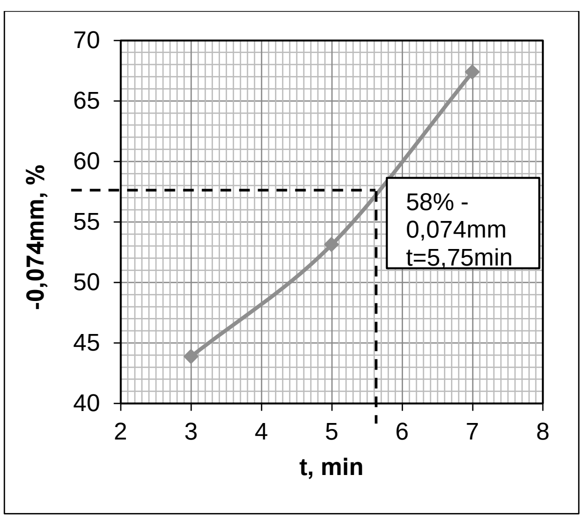

Figure 1, Grinding kinetics, using 1kg laboratory ball mill

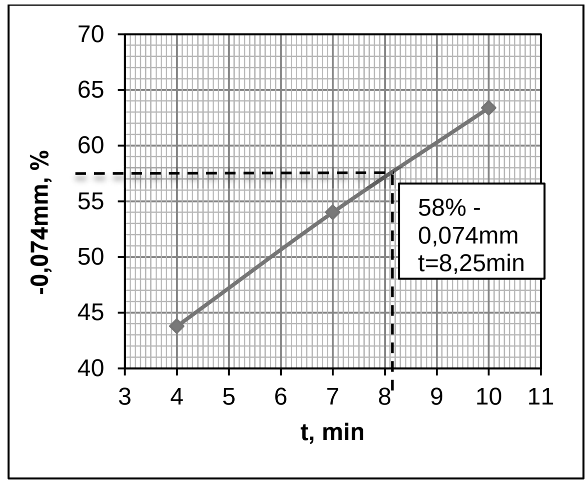

Figure 2, Grinding kinetics, using 3kg laboratory ball mill

Chemical properties of ore sample

-pH, 100%-2mm, 68% of solids, pH=4,1

-chemical composition:

Table 2, chemical composition of ore sample

Ore sample from pyrite-rich parts of deposit			
Component	Cu	S	Fe
Content,%	0,21	5,81	6,12

As it can be seen from table 2, low copper content and high content of sulphure and iron indicate the high content of pyrite, since pyrite and chalcopirite are the main sulphide minerals presented in this ore.

Mieneral composition

According to mineralogical microscopic investigations, mineralogical composition of this rich-pyrite ore sample is: pyrite, chalcopyrite, chalcocite, bornite, covelline, cuprite, magnetite, pyrrhotite, hematite, rutile, molybdenite, limonite, sphalerite, galena, cassiterite, malachite and gangue minerals (mostly feldspar and quartz with a content of about 86%). The most abundant sulphide mineral is pyrite (~14%), while chalcopyrite is presented with amount of 0,7%.

EXPERIMENTAL

Main goal of performed laboratory flotation tests was to determine the possibility of replacement potassium ethyl xanthate (PEX) as copper minerals collector using other, more selective against pyrite collectors, while retaining other technological parameters under the existing flotation process. In this paper, the part of results from those experiments, using isopropyl ethyl thionocarbamate (IET) as collector to compare them to PEX, are presented.

Experimental procedure

Preliminary flotation tests were carried out to produce rough copper concentrates using PEX and IET under the same technological conditions, see Figure 3. Total collector consumption was 30g/t in flotation tests using PEX, and 22g/t while using IET. Lime and frother were added in the quantity required to achieve a given pH of the pulp and stable froth.

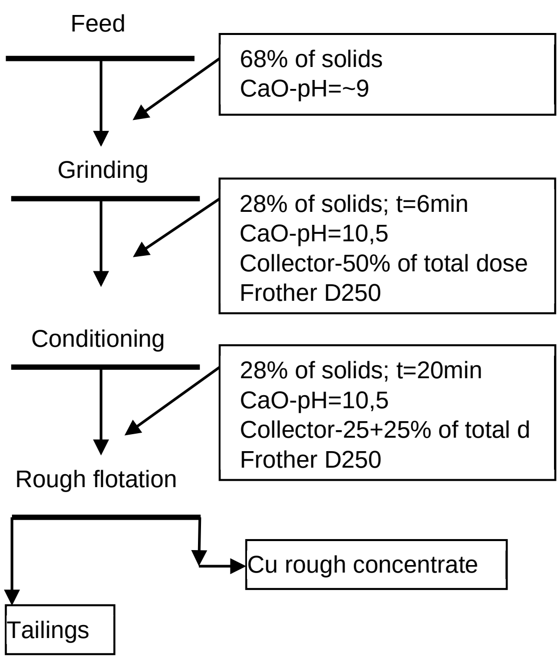

Figure 3, Experimental procedure

Technological results achieved performing flotation tests with different collectors are presented in Table 2 and 3.

Table 2. Material balance – collector PEX

Product	Feed	Cu RC	Tailings
M, %	100,00	12,40	87,60
Cu,%	0,21	1,29	0,06
S,%	5,81	37,79	1,28
Fe,%	6,21	43,65	0,81
Cu rec.,%	100,00	76,18	23,82
S rec.,%	100,00	80,66	19,34
Fe rec.,%	100,00	88,45	11,55

Copper, sulphur and iron recovery, produced using both collectors are presented on Figure 4.

Figure 3 shows mass of rough collectors and content of Cu and S that were achieved using collectors PEX and IET.

Table 3. Material balance – collector IET

Product	Feed	Cu RC	Tailings
M, %	100,00	5,40	94,60
Cu,%	0,21	2,91	0,06
S,%	5,81	19,99	5,00
Fe,%	6,21	27,76	4,88
Cu rec.,%	100,00	74,83	25,17
S rec.,%	100,00	18,58	81,42
Fe rec.,%	100,00	24,49	75,51

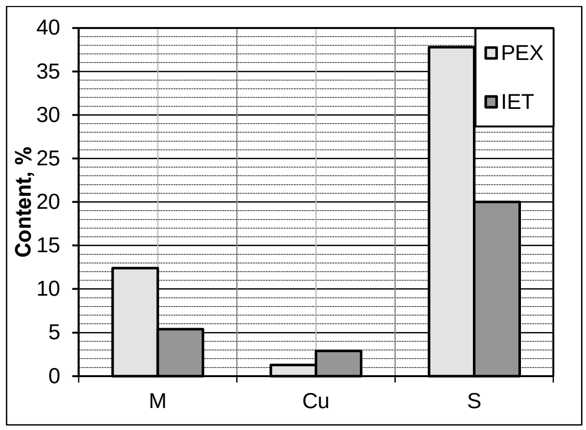

Figure 3, Mas, Cu and S content.

Much lower mass of rough concentrate, higher quality and lower content of sulphur (witch points to low content of pyrite), point us to the conclusion that collector IET is much better than PEX for processing this kind of ore at the same pH range (10,5), even at about 30% lower consumption (22g/t) then PEX (30g/t).

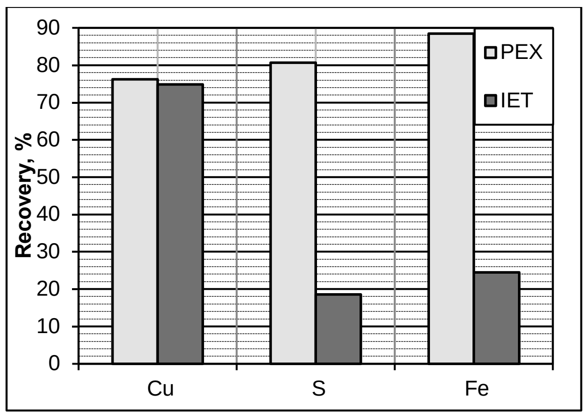

Figure 4, Cu,S and Fe recovery.

Regarding copper recovery in rough concentrates (Figure 4), it is practically the same for both collectors. If we, beside the aforementioned, note much higher recovery of sulphur and iron in rough Cu concentrates using PEX, that all undoubtedly leads to the conclusion that isopropyl ethyl thionocarbamate is as good copper collector as PEX, but it has a very strong selective against pyrite properties, which is very important if pyrite is undesirable in flotation cleaning circuit.

CONCLUSIONS

The high content of pyrite which occurs occasionally in Veliki Krivelj flotation plant causes low copper content in final concentrate while using PEX as copper minerals collector. Main goal of performed laboratory flotation tests was to determine the possibility of replacement PEX as copper minerals collector using other, more selective against pyrite collectors.

As one of the best collectors for processing this type of ore shows isopropyl ethyl thionocarbamate, which is as good copper collector as PEX, but it has a very strong selective properties. Sulphur recovery in copper rough concentrate, produced using PEX was over 80% and Cu grade was 1,29%, while only 12-18% of sulphur recovery with about 3% of Cu grade was optained using isopropyl ethyl thionocarbamate, even at lower consuption. Both collectors produced rough concentrates with the similar Cu recovery, so this kind of selective collectors must be considered in case when processing this tipe of ore.

Acknowledgements

These investigations were conducted under the Project 33007, “Implementation of new technical, technological and environmental solutions in the mining and metallurgical operations RBB and RBM”, funded by the Ministry of Science and Technological Development of the Republic of Serbia.

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