UNIVERSITY OF BELGRADE

TECHNICAL FACULTY BOR

52nd International October Conference on Mining and Metallurgy

PROCEEDINGS

Edited by

Saša Stojadinović

and

Dejan Petrović

November 29th – 30th 2021

Bor, Serbia

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on Mining and Metallurgy, IOC 2021

PUBLISHER:
UNIVERSITY OF BELGRADE - TECHNICAL FACULTY IN BOR, BOR, NOVEMBER 2021

FOR THE PUBLISHER:
DEAN: Prof. dr Nada Štrbac

EDITORS:
Prof. dr Saša Stojadinović
Doc. dr Dejan Petrović

TECHNICAL EDITOR
Pavle Stojković, MSc.

PRINTED BY:
»Štamparija Atlantis d.o.o.« Niš

CIRCULATION: 100 Copies

CIP – Каталогизација у публикацији –

Народна библиотека Србије, Београд

622(082)
669(082)

INTERNATIONAL October Conference on Mining and Metallurgy (52 ; 2021 ; Bor)
Proceedings / 52nd International October Conference on Mining and Metallurgy - IOC 2021, November 29th - 30th 2021 Bor, Serbia ; [organizer] University of Belgrade, Technical Faculty in Bor ; [co-organizer Institute for Mining and Metallurgy Bor] ; edited by Saša Stojadinović and Dejan Petrović. - Bor : University of Belgrade, Technical Faculty, 2021 (Niš : Atlantis). - V, 228 str. : ilustr. ; 25 cm

Tiraž 100. - Bibliografija uz svaki rad.

ISBN 978-86-6305-119-5

а) Рударство -- Зборници б) Металургија -- Зборници

COBISS.SR-ID 52072201

ORGANIZER:

UNIVERSITY OF BELGRADE – TECHNICAL FACULTY IN BOR

Co-ORGANIZER:

INSTITUTE FOR MINING AND METALLURGY BOR

Under the Auspice of:

The Ministry of Education, Science and Technological Development of the Republic of Serbia

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TABLE OF CONTENTS

Aleksandra Milosavljević

THE COMPLEXITY OF SEM-EDS – WHAT AFFECTS THE QUALITY OF OBTAINED RESULTS? 1

Zoran Karastojković, R Perić, M Srećković

LASER QUENCHING OF CUTTING TOOL STEELS - A REVIEW 5

Slavica Miletić, D Bogdanović, E Požega

IMPACT OF EXTRAORDINARY SECURITY MEASURES TO EMPLOYEES DURING THE PANDEMIC COVID-9 15

Daniela Grigorova, R Paunova

KINETIC STUDY OF SOLID-PHASE REDUCTION OF POLYGRADIENT IRON-CONTAINING MATERIAL 19

Emina Požega, D Simonović, S Marjanović, M Jovanović, L Gomidželović, M Mitrović, Z Stanojević Šimšić

PART I: WHAT MAKES A GOOD THERMOELECTRIC 23

Emina Požega, D Simonović, S Marjanović, M Jovanović, L Gomidželović, M Mitrović, S Miletić

PART II: WHAT MAKES A GOOD THERMOELECTRIC 27

Dragan Manasijević, Lj Balanović, I Marković, M Gorgievski, U Stamenković, K Božinović, D Minić, M Premović

STUDY OF MICROSTRUCTURE AND THERMAL CONDUCTIVITY OF THE Ag–Bi–Sn ALLOYS 31

Vladimir S. Topalović, S Matijašević, S Grujić, J Stojanović, J Nikolić, V Savić, S Zildžović

THE INFLUENCE OF THE PARTICLE SIZE ON CRYSTALLIZATION OF GLASS POWDERS FROM THE SYSTEM Li_2O-Al_2O_3-GeO_2-P_2O_5 35

Vesna Marjanović, R Marković, V Krstić

TECHNOLOGIES FOR PHYSICAL TREATMENT OF WATER CONTAINING SELENIUM: A REVIEW 39

Vesna Marjanović, R Marković, V Krstić

TECHNOLOGIES FOR BIOLOGICAL TREATMENT OF WATER CONTAINING SELENIUM: A REVIEW 43

Milenko Jovanović, M Mikić, M Maksimović, D Kržanović, R Rajković, E Požega

USAGE SPECIFICS OF GEOGRIDS 47

Srećko Manasijević, Z Zovko Brodarac, N Dolić, M Djurdjević, R Radiša

INTERMETALLIC BONDING BETWEEN A RING CARRIER AND AN ALUMINUM PISTON ALLOY **51**

Snežana Šarboh

PATENTED INVENTIONS OF LJUBOMIR KLERIĆ **55**

Miomir Mikic, M Jovanović, R Rajković, D Kržanović, E Požega

DEGRADED AREA OF VELIKI KRIVELJ QUARRY RECULTIVATION **59**

Dragana Adamović, D Ishiyama, H Kawaraya, O Yasumasa

EFFECTS OF TAILINGS ON GROUNDWATER ALONG BOR AND BELA RIVERS IN THE BOR MINING AREA, EASTERN SERBIA **63**

Ana Kostov, Z Stanojević Šimšić, A Milosavljević,

CHARACTERIZATION OF ALLOYS CuAlAu0.5 **67**

Marija Milenković, V Jovanović, J Paunković, V Krstić

MULTICRITERIA ANALYSIS OF THE LEVEL OF SUSTAINABLE DEVELOPMENT OF THE TOPLICA DISTRICT USING THE ELECTRE METHOD **71**

Daniel Kržanović, R Rajković, D Stevanović, M Mikić, M Jovanović, S Petrović

LONG-TERM PLANNING OF MINING THE LEAD AND ZINC ORE DEPOSIT IN THE BRSKOVO ORE FIELD, THE REPUBLIC OF MONTENEGRO **75**

Radmilo Rajković, D Kržanović, M Mikić, M Jovanović

CALCULATION OF SAFETY DISTANCE FOR THE OPERATION OF MINING EQUIPMENT IN THE WORKING ENVIRONMENT WITH WEAKENED CHARACTERISTICS AT THE OPEN PIT "NORTH MINING DISTRICT" OF THE COPPER MINE MAJDANPEK **79**

Zdenka Stanojević Šimšić, A Kostov, A Milosavljević, E Požega

HARDENSS, MICROHARDNESS AND ELECTROCONDUCTIVITY OF ALLOYS WITH VARIABLE Cu CONTENT IN Cu-Al-Ag SYSTEM **83**

Miodrag Banješević

STRATIGRAPHY AND AGE OF ROCK UNITS AND MINERALIZATION IN THE TIMOK MAGMATIC COMPLEX ANDTHE BOR METALLOGENIC ZONE – A REVIEW **87**

Milan Radivojević, Z Stević, M Tanasković

DUALPHASED FOURWAYINTERSECTION REGULATED BY TRAFFIC LIGHTS WITH FIXED AND ADAPTIVE MOD OF OPERATION **93**

Filip Gramić, N Rančić, S Filipović, J Đorđević

USE OF COPPER TAILING AND COPPER SLAG IN D PRINTED CONCRETE PROCESSES **97**

Filip Gramić, N Rančić, S Filipović, J Đorđević,

POSSIBILITY OF USING MINING WASTE IN THE PRODUCTION OF BRICK PRODUCTS **101**

Stepan O. Vydysh

GOLD-SILVER ALLOYS ANODIC DISSOLUTION RESEARCH IN HYDROCHLORIC ACID ELECTROLYTES **105**

Milan Gorgievski, M Marković, D Božić, Vr Stanković, N Štrbac, V Grekulović, M Zdravković

ADSORPTION ISOTHERMS FOR COPPER IONS ADSORPTION ONTO WALNUT SHELLS **109**

Miljan Marković, M Gorgievski, N Štrbac, V Grekulović, A Mitovski, K Božinović, M Zdravković

pH AND CONDUCTIVITYCHANGE DURING THE RINSING AND ADSORPTION OF COPPER IONS ONTO WALNUT SHELLS **113**

Vesna Grekulović, A Mitovski, M RajčićVujasinović, N Štrbac, M Zdravković, M Gorgievski, M Marković

ELECTROCHEMICAL BEHAVIOR OF COPPER IN CHLORIDE MEDIUMIN THE PRESENCE OF WALNUT SHELL MACERATE **117**

Marija Šljivić-Ivanović, S Dimović, I Jelić,

EXPERIMENTAL DESIGN APPROACH IN RADIONUCLIDE SORPTION **121**

Ivana Jelić, A Savić, M Šljivić-Ivanović, S Dimović

INFLUENCE OF SILICA FUME ON SCC CONCRETE PROPERTIES **125**

Milan Radovanović, A Simonović, M Petrović Mihajlović, Ž Tasić, V Nedelkovski, M Antonijević

L-LYSINE AS CORROSION INHIBITOR OF STAINLESS STEEL IN RINGER'S SOLUTION **129**

Dragana Marilović, M Trumić, M Trumić,Lj Andrić

THE INFLUENCE OF CALCIUM IONS ON DEINKING FLOTATION RECOVERY UNDER DIFERENT CONDITIONS **133**

Dragana Medić, S Milić, S Alagić, M Nujkić, S Đorđievski, A Papludis

OPTIMIZATION OF CATHODIC MATERIAL LEACHING PROCESS IN ACID-SULPHATE SOLUTION **137**

Milijana Mitrović, D Gusković, S Marjanović, BTrumić, E Požega, U Stamenković, J Petrović

OBTAINING MULTILAYER COPPER STRIPS BY ARB (ACCUMULATIVE ROLL BONDING) ROLLING PROCESS **141**

Nataša Đorđević, S Mihajlović, N Obradović, A Peleš, S Filipović

THE INFLUENCE OF HIGH COMPACTION PRESSURE ON CORDIERITE-BASED CERAMICS **145**

Nataša Đorđević, S Mihajlović, M Sokić, B Marković

SEM AND X-RAY ANALYSES OF SINTERED MgO / Bi_2O_3 BINARY SYSTEM **149**

Ivana Ilić, J Sokolović, M Trumić, Z Stirbanović

COMPARATIVE RESULTS OF COPPER FLOTATION FROM SLAG BEFORE AND AFTER THE PROCESS OF MAGNETIC CONCENTRATION **153**

Daniela Grigorova

FERROSILICON OBTAINING USING IRON-SILICATE –FAYALITE **157**

Slavica Mihajlović, M Jovanović, N Đorđević, A Patarić, M Vlahović, V Kašić

THE CLAY PRELIMINARY TESTING FROM MUNICIPALITY AREA OF REKOVAC **161**

Milan Milosavljević, M Premović, D Minić, Dn Mansijević, Ar Đorđević, M Kolarević

EXPERIMENTAL AND THERMODYNAMIC STUDY OF ISOTHERMAL SECTIONS AT 600 °C AND 400 °C OF TERNARY Bi-Cu-Ge SYSTEM **165**

Aleksandar Đorđević, D Minić, M Premović, D Mansijević, M Milosavljević, V Ristić

STUDY OF TEMPERATURE PHASE TRANSFORMATION OF THETERNARY Bi-Cu-Ge SYSTEM **169**

Aleksandar Savić, I Jelić, M Šljivić-Ivanović, S Dimović, N Pudar, A Pfandler

RECYCLED COARSE AGGREGATE AND FLY ASH EFFECT ON COMPRESSIVE STRENGTH OF SELF-COMPACTING CONCRETE **173**

Vladan Kašić, D Životić, V Simić, A Radosavljević-Mihajlović, J Stojanović, S Mihajlović, M Vukadinović

FORECAST RESOURCES OF ZEOLITHIC TUFFS OF SERBIA **177**

Vladan Kašić, A Radosavljević-Mihajlović, S Radosavljević, J Stojanović, S Mihajlović, M Vukadinović

GEOLOGICAL AND MINERAL CHARACTERISTICS OF ZEOLITHIC TUFF TOPONICA DEPOSITS NEAR KOSOVSKA KAMENICA **181**

Konstantin Petkov, V Stefanova, P Iliev

METHOD FOR UTILIZATION OF THE SULFURIC ACID OBTAINED DURING AUTOCLAVE DISSOLUTION OF PYRITE CONCENTRATE **185**

Stefan Đorđievski, D Ishiyama, Y Ogawa, Z Stevanović, O Osenyeng, D Adamović, V Trifunović

MONITORING OF pH VALUE AND CONCENTRATION OF COPPERIN RIVERSDOWNSTREAM FROM BOR MINE IN PERIOD 2015-2021 **189**

VišaTasić, M Cocić, B Radović, T Apostolovski-Trujić

CHEMICAL COMPOSITION OFPARTICULATE MATTER IN THE INDOOR AIRAT THE TECHNICAL FACULTY IN BOR (SERBIA) **193**

Snežana Ignjatović, I Vasiljević, M Negovanović

DEFINING STRUCTURAL CORRELATION USING OF TOTALHORIZONTAL GRADIENT **197**

Velizar Stanković, M Janošević

INCREASING THE CAPACITY OF THE COPPER SMELTING COMPANY IN THE COMPANY "SERBIA ZIJIN COPPER" - CHALLENGES AND CONSEQUENCES TO THE ENVIRONMENT **201**

Vladimir Jovanović, D Todorović, B Ivošević, D Radulović, S Milićević, D Nišić

CHARACTERIZATION OF PELLET SAMPLES OBTAINED BY PELETIZATION OF LIMESTONE AND SEAWEED **205**

Vanja Trifunović, L Avramović, R Jonović, S Milić, S Đorđievski, M Jonović

HYDROMETALLURGICAL TREATMENT OF ELECTIRIC ARC FURNACE DUST IN AIM OF ZINC SEPARATION **209**

Jovana Bošnjaković, N Knežević, N Čutović, M Bugarčić, A Jovanović, Z Veličković, S Manasijević

EVALUATION OF ADSORPTION PERFORMANCE OF PHOSPHATES REMOVAL USING CELL-MG HYBRID ADSORBENT **213**

Dragan Radulović, Lj Andrić, D Božović, V Jovanović, B Ivošević, D Todorović,

POSSIBILITY OF USING LIMESTONE FROM "PJEŠIVAČKI DO"-DANILOVGRAD DEPOSIT AS FILLER IN VARIOUS INDUSTRY BRANCHES **217**

Predrag Stolić, J Ivaz, D Petrović, Zoran Stević

ADVANTAGES OF MINING ENGINEERING CURRICULUM REALIZATION USING SOLUTIONS BASED ON FREE SOFTWARE **221**

Slađana Krstić, E Požega, S Petrović, S Magdalinović, D Urošević, S Miletić, Z Stojanović Šimšić

QUALITY INVESTIGATION OF SAND FOR THE PRODUCTION OF AGGREGATES ON VINOGRADI LOCALITY (DELIBLATSKA PEŠČARA) **225**

Saša Marjanović, D Gusković, M Mitrović, E Požega ,B Trumić, U Stamenković

INFLUENCE OF COLD ROLLING AND ANNEALING ON HARDNESS OF BIMETALLIC STRIP Cu– Al **229**

The 52nd International October Conference on Mining and Metallurgy
November 29th – 30th , 2021
www.ioc.tfbor.bg.ac.rs

THE INFLUENCE OF CALCIUM IONS ON DEINKING FLOTATION RECOVERY UNDER DIFERENT CONDITIONS

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Abstract

Deinking flotation is the most commonly used method in recycling paper process. Better understood of the interactions between added surfactant and the solid surfaces of ink can be accomplished by studying the fundamental mechanism. The effect of reagents on the flotation of offset paper was investigated for the purpose of efficiency removing the toner particles and fiber purification under different pH values in the presence of calcium ions. The results showed that calcium ions in combination with oleic acid remove toner particles with high efficiency in a short flotation time.

***Keywords**: deinking flotation, offset paper, calcium ions, toner recovery.*

1. INTRODUCTION

The use of secondary raw materials has several advantages, which are reflected in the conservation of natural resources and the reduction of environmental pollution and energy consumption [1]. Recycling of old paper is based on a combination of different technologies used to remove toner particles from the paper used for printing. When the particles are mechanically separated from the fibers, they are separated from the pulp by various operations. These operations include washing, screening, flotation, or a combination of these methods [2]. Many scientists have researched this area and made the conclusion that deinking flotation is most commonly used to remove ink from printed paper [3-5]. The mechanism of deinking flotation is similar to the flotation of mineral resources. Hydrophobic, non-wetting particles attach to the air bubbles and together with them float as aggregates to form a foam which is mechanically removed, while the hydrophilic fibers remain in the aqueous phase [6-8]. Practically, deinking flotation is a two-stage process which includes detaching of ink from the fibers and fillers and separation of ink particles from fibers and fillers. Deinking flotation of offset paper was researched throw experimental and simulations [9,10,11,12].

2. EXPERIMENTAL

2.1 Materials and methods

The pulp was formed from synthetic samples of white unprinted offset paper and toner cartridge from a laser printer. The pH value was regulated by 0.1 M HCl and 0.1 M NaOH. Flotation was performed with the oleic acid collector (125g/t) and $CaCl_2$ (35 kg/t). Distilled water was used for the flotation experiments. Before pulping, paper was mechanically fragmented in paper shredder into 4 mm x 40 mm. The paper type was MAESTRO standard A4, 80 g/m^2.

Figure 1 Shredded paper sample

After shredding, the sample needed to be soak in the liquid phase to allow the fibers swell for more efficient disintegration. The solid phase was soaked with about 200 ml of distilled water heated to 40 °C followed by the disintegration phase in the blender. To accelerate the swelling process of the cellulose fibers, another 200 ml of heated distilled water was added to the disintegrated sample and the cellulose fiber sample was allowed to stand for 17 hours. Synthetic toner sample was prepared by melting toner from an HP LaserJet CB435A cartridge, for 60 min at 100 °C, to provide a representative realistic sample.

Figure 2 Toner sample before melting

Flotation was performed using the oleic acid collector (125 g/t) and $CaCl_2$(35 kg/t) added to the pulp during the conditioning phase.The operating conditions for the toner flotation phase were adopted based on the values of optimal conditions from the literature [1, 11, 12, 14] and were the same for all experiments: rotation speed 1100 rpm, air flow 270 dm^3/h, pulp temperature 21-23 °C, solid phase content in pulp 1 %, conditioning time 15 min. The samples were extractedfrom the froth at 2, 4, and 20 min and then were filtered on ash less filter paper. The filter pads was transferred to an oven at 525 □ for at least two hours. The ash was analyzed by X-ray fluorescence to determine the total iron concentration.The efficiency of the process was monitored through the toner recovery in the foam product (It) and the fiber recovery in the sink product (Im).Optimization of the flotation process should provide recoveries greater than 90 % [11].

3. RESULTS AND DISCUSSION

Table 1 shows the flotation results of toner and fiber recovery for all tested conditions. The obtained results show that the greater impact of pH value is on the toner recovery than on fiber recovery.

Table 1 - Results of deinking flotation under different conditions

Flotation time t (min)	2		4		20	
pH	It (%)	Im (%)	It (%)	Im (%)	It (%)	Im (%)
3	66.03	94.51	68.40	91.46	68.71	88.21
5	69.81	93.71	71.38	90.39	71.45	86.67
7	83.38	92.22	84.50	88.67	84.81	85.97
9	68.12	93.42	69.39	91.72	69.79	88.29
12	***98.28***	***90.96***	98.95	86.80	99.38	81.01

From Table 1 can be seen that after 20 minutes of flotation in a very acidic condition (pH 3) to weakly basic (pH 9) environment, or after 4 minutes in a neutral conditions (pH 7), there is a reduced fiber recovery to about 88 %. With extended flotation time, there is a loss of fibers in the foam product. The loss of fibers from sink products to the foam layer is greatest in the highly alkaline environment, where after 20 minutes of flotation fiber recovery is 81 %. At shorter flotation times, up to 2 minutes, in a highly acidic to slightly alkaline environment, value of toner recovery increased by about 4 % on average, while in a strongly alkaline environment this increase is about 30 %. Generally, maximum values for toner recovery are reached at all pH values after 4 minutes of flotation. These results indicate a negligible effect of pH on the rate of separation of toner particles into the foam product under shorter flotation times. The highest recovery values under the given conditions were reached after 2 minutes of flotation in a strongly alkaline medium(pH = 12; Im = 98.28 % It = 90.96 %).The results are showed on Figure 3.

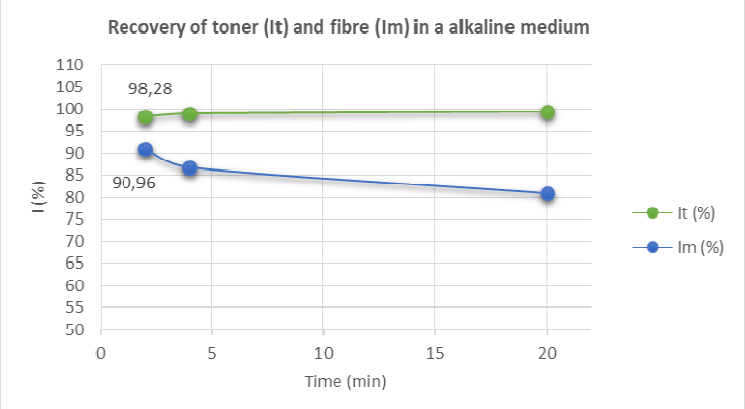

Figure 3 Toner (It) and fibre (Im) recovery at pH 12

Analyzing the maximum values obtained for fiber and toner recovery under the tested conditions in the presence of calcium chloride, it can be concluded that the optimal toner flotation time is 2 minutes. With increasing flotation time, toner recovery remains constant while fiber recovery decreases. The analysis of the results can confirm the statement of many researchers [11,13, 14]that with the increase of alkalinity under optimal conditions in the flotation process the efficiency of the toner particles flotation also increases.Comparing with the results obtained in the experiments without the addition of calcium ions [15], may say that the addition of $CaCl_2$ has an effect on the toner flotation. At the shortest flotation time at all pH values, without the addition of calcium ions, the toner recovery was less than 60 % except at pH 9, and with the addition of calcium chloride toner recovery was over 66 %. Fatty acid and calcium soap are good combination of reagents because of their mechanism. Primary mechanisms imply calcium soap precipitation which creates a layer around the toner particles through a hetero-coagulation mechanism, followed by a bubble-ink capture step [14].

4. CONCLUSION

The paper describes influence of calcium ions under different conditions on deinking flotation process. Previous flotation experiments were performed at different pH values using only oleic acid as a collector. In this research experiments were done with addition of $CaCl_2$ and by analysis the toner and fiber recovery, it has been confirmed that the calcium has a positive effect on deinking flotation of offset paper. It showed that the addition of calcium ions reduces the flotation time at alkaline conditions. In experiments performed without the addition of calcium ions, toner and fiber recovery over 90 % was not achieved. Addition of calcium ions achieved a toner and fiber recovery greater than 90 % at shorter flotation time.

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ISBN 978-86-6305-119-5