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Ljubiša Balanović
Dejan Tanikić

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PREFACE

On behalf of the Organizing Committee, it is a great honor and pleasure to welcome all esteemed participants of the 54th International October Conference on Mining and Metallurgy (IOC 2023), scheduled to take place at the picturesque Bor Lake, Serbia, from October18th to 21st 2023.

The collaborative efforts of the University of Belgrade, the Technical Faculty in Bor, and the Mining and Metallurgy Institute Bor have meticulously organized this year's IOC. Our focus remains unwavering on showcasing the latest research findings and advancements in geology, mining, metallurgy, materials science, technology, environmental protection, and other engineering disciplines. Our primary objective is to foster a dynamic environment where academics, researchers, and industry professionals can come together to share their knowledge, experiences, and innovative ideas while exploring opportunities for collaborative research endeavors.

Our conference agenda is rich and diverse, encompassing plenary sessions, engaging invited lectures, technical presentations, enlightening oral and poster sessions, informative technical tours, a diverse exhibition, and memorable social gatherings. At the heart of this event lies our strong commitment to sustainable development within the mining and metallurgy sector. We are dedicated to exploring ecologically conscious methodologies, responsible resource extraction practices, and cutting-edge technologies that reduce the industry's environmental impact and enhance the well-being of local communities.

The conference proceedings comprise 129 papers authored by individuals from universities, research institutes, and industries in 22 countries. We are proud to welcome participants from Bosnia and Herzegovina, Bulgaria, Canada, China, Croatia, Germany, Greece, India, Iran, Kazakhstan, Libya, North Macedonia, Montenegro, Morocco, Romania, Russia, Slovakia, South Africa, Spain, Turkey, United States, and, of course, Serbia.

We are excited to host the 8th International Student Conference on Technical Sciences (ISC 2023) as part of IOC 2023. This event offers students from Serbia and the wider region a unique chance to showcase their research and discuss the future of their fields with experts.

We sincerely thank the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia for their generous financial support. In addition, we express our profound gratitude to all our sponsors, exhibitors, and friends of the Conference for their contributions and unwavering support for playing a pivotal role in ensuring the success of IOC 2023.

We would like to express our heartfelt thanks to all authors, committees, reviewers, speakers, and chairpersons for their invaluable contributions in shaping IOC 2023.

We look forward to welcoming you to the 55th International October Conference on Mining and Metallurgy (IOC 2024), which will be held in October 2024.

On behalf of the 54th IOC Organizing Committee,

Prof. dr Ljubiša Balanović

Љубиша Балановић

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DETERMINATION OF BOND ROD MILL WORK INDEX OF A VERY LOW-GRADE COPPER ORE

Ivana Jovanović, Vesna Conić, Dragan Milanović, Daniel Kržanović, Tanja Stanković, Daniela Urošević, Miloš Janošević

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Abstract

This paper presents the results obtained by determination of Bond rod mill work index (RWi), on a very low-grade copper ore, containing only 0.13% Cu. The standard Bond rod mill grindability test is performed in this research. RWi depends primarily on the mechanical properties of material conditioned by mineralogical composition and the desired particle size of the ground material. The mineralogical composition of the considered sample included the following metallic ore minerals: pyrite, chalcopyrite, hematite, magnetite, covelline, chalcocite, bornite, sphalerite and rutile. Tailings was presented by quartz, calcite, anhydrite, gypsum and clay minerals. The closing sieve size was 1,18 mm. The obtained value of RWi was 19 kWh/t, and therefore this ore can be classified as hard.

***Keywords**: Bond rod mill work index, grindability, low-grade copper ore*

1. INTRODUCTION

Comminution is an essential operation for the mining and mineral processing industry. Accordingly, the liberation of valuable minerals from the gangue is a fundamental requirement for all subsequent separation or extraction operations, and this is achieved through several stages of rock fragmentation, that is, by comminution of the ore [1]. Knowledge of the grindability behavior of solid materials can be considered as an important factor for the design of their grindability systems. Bond work index can be considered as one of the most important affecting factors in the design of grinding systems which indicates the value of energy consumed per ton of the ground ore [2]. The Bond rod mill grindability test is a widely used tool to estimate the response of ores to rod milling. The classical method used to predict the specific energy consumption in grinding ores in rod mills was proposed by Fred Bond and is based on the work index. The Bond rod mill work index (RWi) is measured using Bond's standard rod mill grindability test, which is conducted in locked-cycle mode to emulate the continuous closed-circuit operation. Test procedure typically requires from 5 to 10 cycles for reaching steady-state, and normally requires 8–20 kg of sample with 100% < 12.7 mm, containing less than 50% of material passing the screen selected for the test [3, 4]. RWi depends primarily on the ore mechanical properties (which depend on the mineral composition) and test sieve aperture [1, 2, 5].

2. EXPERIMENTAL

2.1 Sample characterization

In this testing a very low-grade copper ore sample was used (Figure 1). Chemical composition of this sample is presented in table 1, where it can be seen that content of copper is only 0.13%. The contents of precious metals are also not high (about 0.1 g/t Au and 1.6 g/t Ag).

Figure 1 – Initial sample of copper ore

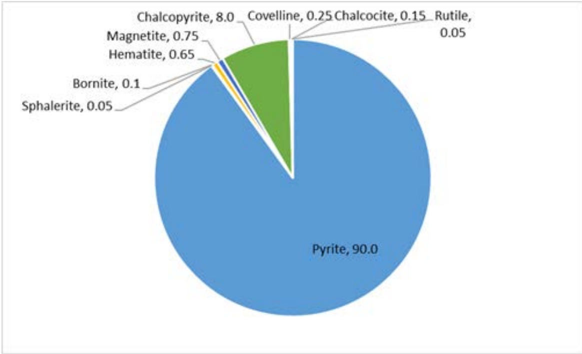

Figure 2 – Distribution of ore minerals in the sample. Values are in percentages per mass.

Table 1 – Chemical composition of copper ore sample

Component	Cu %	S %	Fe %	Au g/t	Ag g/t	Ti %	Al_2O_3 %	SiO_2 %	CaO %	MgO %	K_2O %
Value	0.13	6.04	3.92	0.1	1.6	0.23	13.51	58.31	6.10	2.67	2.43

Mineralogical analysis of the ore sample showed the following mineral composition: pyrite, chalcopyrite, hematite, magnetite, covelline, chalcocite, bornite, sphalerite, rutile, tailings minerals (quartz, calcite, anhydrite, gypsum, clay minerals). The tailings mineral content is 80%, while the ore mineral content is 20%. The distribution of ore minerals in percentages is shown in Figure 2.

2.2 Experimental procedure

Bond rod mil work index was done according to Bond's standard procedure. This test procedure firstly requires crushing of the representative sample to pass 12.7 mm and its sizing. The test then involves a series of batch grinds in a standard Bond rod mill. A Bond rod mill is 0.305 m by 0.610 m (Figure 3) with wave liners. The grinding media consists of 8 rods weighing a total of 33.38 kg. There are 2 steel rods with 44.45 mm of diameter and 6 rods with 38 mm of diameter.

Figure 3 – Bond rod mill

The mill rotates at 46 rpm on an axis that is positioned horizontally during most of the test, but that is tilted every 10 mill rotations (8 horizontal, one tilted forward 5° and one tilted backward 5°), in order to prevent sample segregation. The test is conducted targeting a 100% circulating load and each cycle finishes with the dry sieving of the entire mill contents with a chosen closing sieve P_k (in this case P_k = 1.18 mm). When steady-state conditions are reached, the sieve undersize is analyzed and the 80% passing size estimated (P80). The rod mill work index (in kWh/t) is then calculated by standard equation.

The particle size composition was determined by the standard procedure of dry sieving on a series of laboratory sieves.

3. RESULTS AND DISCUSSION

Figure 4 shows the particle size composition of the initial sample for the Bond grindability test (–12.7+0 mm), and Figure 5 shows the particle size composition of the undersize of chosen closing sieve.

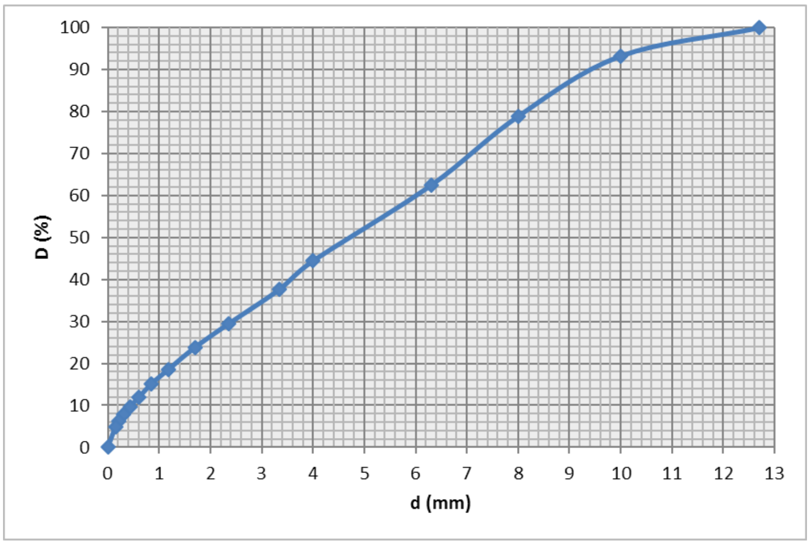

Figure 4 – Particle size composition of the initial sample for the Bond rod mil test, presented by undersize curve (D in %). Corresponding sieve aperture is denoted as d in mm.

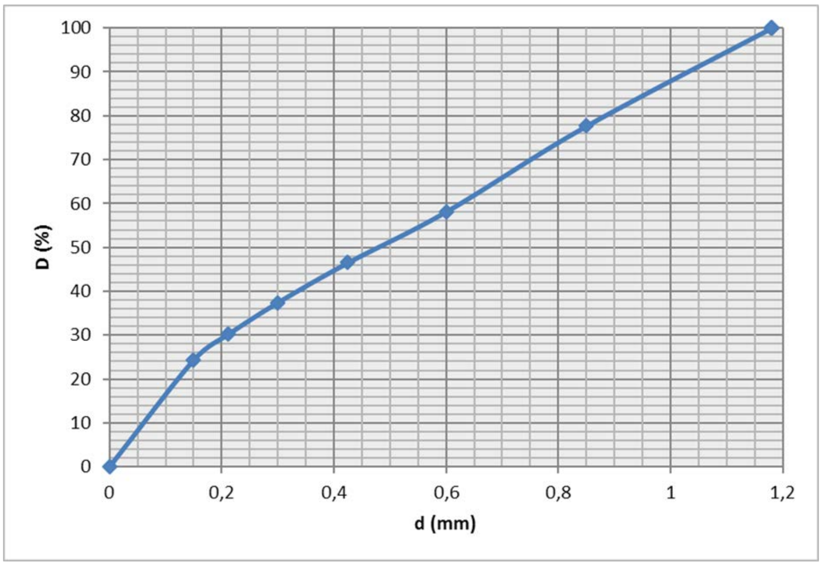

Figure 5 – Particle size composition of the chosen closing sieve undersize. Corresponding sieve aperture is denoted as d in mm.

The rod mill work index (in kWh/t) is then given by the following equation (1):

$$RWi = 1{,}1 \times \frac{62}{Pk^{0{,}23} \times G^{0{,}625} \times \left(\frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}}\right)} = 18{,}99\,\frac{kWh}{t} \qquad (1)$$

Where:
P_k = 1180 μm – closing sieve size
F = 8150 μm – 80% passing size in the feed
P = 870 μm – 80% passing size in the closing sieve undersize
G = 6,10 g/r – the average of the last three net grams of sieve undersize produced per one revolution

Based on the widely accepted classification, where depending on rod mill Bond work index, material can be classsified as soft (RWi = 7 – 9), medium (RWi = 9 – 14), hard (RWi = 14 – 20) and very hard (RWi > 20), this sample with RWi = 18,99 kWh/t, belongs to hard ores.

4. CONCLUSION

In accordance with the presented research, the following conclusions can be drawn:

- Chemical analysis showed a very low copper content in the tested sample, which is 0.13% Cu.
- Presence of ore minerals in the sample is 20%, and tailings minerals 80%. The most abundant ore mineral is pyrite.
- Bond rod mill work index is 19 kWh/t, which classifies the sample as hard ore.

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